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THE INTERNATIONAL SOCIETY FOR MODAL TESTING AND ANALYSIS

I am pleased to announce that a new technical society has been formed. This new society will be dedicated to the advancement of modal analysis technology. It is called the International Society for Modal Testing and Analysis (ISMTA). The new society will be formally introduced at the 2nd International Modal Analysis Conference (IMAC-II) to be held this year in Orlando, Florida, on February 6-9, 1984. IMAC-I was held in Orlando in November, 1982. I attended that conference, and I was very impressed with the quality and quantity of papers presented. The large number of vendors in the exhibit area was also a positive feature of the conference.

During the past two decades, there has always been a loyal following of modal test and analysis advocates present at technical meetings such as the Shock and Vibration Symposium and the annual meeting of the Institute of Environmental Sciences. But the modal test and analysis advocates have never had their own meeting nor their own society. Well, this technical field has finally come of age and in February, 1984, the International Society for Modal Testing and Analysis will become a reality.

The ISMTA, which will be announced at IMACS-II, will soon be publishing a quarterly journal, "Modal Analysis," probably six months after the end of IMACS-II. The ISMTA will also be publishing an "Annual Directory of Modal Analysis Hardware, Software and Services." This will be a one-volume, desk-top reference book.

Congratulations are in order to the members of Union College, Schenectady, NY, who have sponsored the IMAC Conferences and assisted in the creation of this important new technical society. I wish this new society every success in its new venture, and I know it will be a great asset to the shock and vibration community. For information about the International Society for Modal Testing and Analysis, please contact:

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J.G.S.

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**See inside back cover for details.*

EDITORS RATTLE SPACE

COMPUTATIONAL TECHNOLOGY COMES OF AGE

A recent review of the literature leads me to the conclusion that computational technology has come of age. The motivation for better application of computer technology has various roots: a genuine desire for higher performance equipment, cost effective products, better computer hardware and software, better understanding and definition of phenomena, better testing techniques, and belief in the computer's capabilities.

Computationally-oriented engineers are beginning to find needed solutions to equipment design, development, and evaluation problems. It would seem that analytical tools are thus no longer forcing engineers to compromise in their representations of physical systems so as to fit the computational process. In other words the computational process is no longer restricting the modeling process.

Twenty years ago only a limited number of design problems were solved on the computer. A lack of available hardware and software restricted model sizes, and models were usually linear. Vibration models were available only for steady-state phenomena.

Today these restrictions are gone; hardware and software are capable of performing nonlinear, transient analyses on large systems. Although many physical phenomena have not yet been quantified for mathematical models, progress is being made with direct and indirect testing.

Modal testing and parameter identification techniques have also come of age. The application of these techniques to physical systems is beginning to yield the data we need for first class modeling.

Improved test techniques and instrumentation have resulted in better modeling because it is possible to check computations. Test data provide necessary means for validation and modification of mathematical models. Such checks have promoted growing confidence in the use of computers.

Confidence in the advantageous use of computation technology has increased asymptotically in the last two or three years. The fact that engineers can now effectively use computers in the design process rather than follow the build and test philosophy in turn has motivated better computational technology.

R.L.E.

LATERAL FORCES ON PUMP IMPELLERS: A LITERATURE REVIEW

R.D. Flack* and P.E. Allaire**

Abstract. Previous research regarding hydraulically generated lateral forces in pumps is critically reviewed. Included are both theoretical and experimental work. Flows in impellers and volutes are considered, as are pressures and forces arising from orbiting impellers and blade passing. The purpose of this paper is to review available literature so that a practicing engineer can estimate forces on a given pump impeller using current technology.

Present techniques for the design of pumps rely heavily on empiricism and previous designs. In recent years pumps have been extended to higher capacities, heads, and overall efficiencies. In many cases designs for these larger pumps are nothing more than proportionally larger versions of smaller older pumps. As a result, any problems with smaller pumps are magnified, and new problems sometimes arise.

Two major problems exist with present pump designs. First, few fundamental data are available to assist a designer in predicting the hydraulic performance of a pump before it is built. Also, there are few fundamental data available for improving a design after a prototype is built. Second, in many cases hydraulic forces are generated.

The forces can be static, dynamic, or both. Dynamic forces consist of subsynchronous, synchronous, and supersynchronous frequencies. In general subsynchronous frequencies can be attributed to partial flows generated by the hydraulic action of the pump or associated with destabilizing forces. Synchronous forces are due to impeller offsets or nonuniformities in the impeller manufacturing process. Supersynchronous forces are generally due to the finite number of impeller blades and thus blade passing hydraulic action.

Any or all of these forces can cause a machine to fail prematurely. At present no method is available to reliably predict the forces (particularly the dynamic forces) before a machine is built. Estimating the forces at partial flows or off-design conditions is even more difficult. It is the intention of this paper to review pertinent literature that will allow estimates to be made on these forces. After such forces are estimated, dynamical analyses can be made for a machine; these analyses are also discussed. The basic literature reviewed is for pump flows found in the nuclear power industry. Some literature for compressor flows is also reviewed, and is readily applicable to pump flows.

GENERAL INFORMATION

Some partial reviews and summaries of the literature have already been published [1-6]. Thompson [1, 2] reviewed the literature and postulated a mechanism that can self excite an uncontrollable vibration. He attributed this unsteady force to circumferential perturbations in the mass flow rate into the impeller. These perturbations induce a force that results in larger vibrations; these cause larger perturbations and forces and so on. He presented case studies and indicated the level of system damping that would be required for stability for the case studies.

Makay [3] reviewed a portion of the literature and classified hydraulic instability mechanisms. He postulated flow patterns in different components that could result in destabilizing forces. Most of his discussions are generalities; sufficient data are not available to verify his postulations. He presented several curves from which estimations of forces, frequencies, and load directions are possible but did not adequately describe the origin of the dia-

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grams. As a result, the uncertainty of the estimates cannot be established.

Allaire and Flack [4] also presented a partial review of the literature on lateral impeller forces. They considered case studies for coolant pumps and boiler feed pumps. Two different sets of earlier data were used to estimate static, synchronous, and blade-passing forces on the different pumps.

Childs [5] presented a summary of many types of forces that can occur in a turbomachine. These include seal forces, axial flow, hydraulic forces, rolling element bearing stiffnesses, and spline couplings, as well as a brief review of impeller forces. He did not include important papers, however.

Lund [6] also summarized the different types of destabilizing forces in rotating machinery. His thrust was for rotor dynamics; impeller forces were not given full attention. Furthermore, several developments have occurred since this paper was published.

Vance [7] summarized the implications of aerodynamic generated destabilizing forces. He presented results from a simple laboratory test rig documenting the existence of these forces. However, he indicated that the forces are not quantitatively understood.

Brown [18] reviewed different mechanisms whereby vibrations can be generated in pumps. He included forces on impellers and presented some pressure spectra for a boiler feed pump. He indicated that particularly large low frequency components are present at low flow rates and in many cases could be destabilizing. Once again, however, no method for reliably predicting these pressures on forces is available.

Several case studies have been published in which aerodynamic centrifugal impeller forces were problems [9-11]. All of the studies used modified support bearings to reduce the resulting vibrational problems. However, none of the studies was able to reduce the exciting force itself. In another case study Duncan [12] presented data that indicated aerodynamic forces were not a problem. Once again, these studies point to the fact that it is not presently possible to predict a priori if a machine will vibrate due to aerodynamic forces.

Estimating forces when cavitation occurs is even more difficult. Studies have not yet been presented in which this variable is controlled. Schäfer and his coworkers [13] considered the problem and presented vibrational data for one case study in which the pump cavitated. However, not enough data are available to allow generalized conclusions.

Finally, as alluded to earlier, the rotor dynamics of centrifugal pumps are well developed and understood except for the fluid forces acting on the shaft. After all of the forces can be predicted, several techniques are available for predicting the response and stability of the rotor system [14-18]. Because this review paper deals with impeller forces, the category of rotor dynamics is not discussed in detail.

PRESSURE MEASUREMENTS

The primary aim of this paper is forces, but literature on pressures in pumps is also of concern. Pressures on impellers help produce the forces. In this section papers dealing with the experimental measurement of pressures in pumps are reviewed.

One of the first papers published was by Binder and Knapp [19] in 1936. They measured velocities with Pitot-static probes; static pressures in a double suction centrifugal process pump and a single suction single volute centrifugal process pump were studied. Circumferential traverses were performed. For the latter pump they integrated the static pressures to obtain the static pressure force acting on the impeller. They did this for 19%, 100%, and 142% of flow capacity. They also calculated the momentum force by integrating velocity profiles. Vectoral addition was used to calculate the total static force on the impeller. The maximum force was at 19% capacity, and the minimum was at 100% capacity. Directions of the forces are also given. No attempts were made to generalize the results.

Other early work was by Bowerman and Acosta [20]. They studied the effect of volute shape on the hydraulic performance of a laboratory double discharge pump. Flow passages were rectangular cross sections; head capacity curves were generated for different volutes; and circumferential static pressure profiles and velocity profiles (using a Pitot probe) were obtained. The emphasis of this paper was on hydraulic performance; force information was not obtained.

Another centrifugal process pump was experimentally studied by Iversen and coworkers [21]. They instrumented the volute with static pressure taps and probes and measured the force on the impeller (discussed in the next section). They integrated the pressures to obtain static forces but, because they did not account for velocity, momentum nonuniformities were not calculated. As a result, these forces did not agree with directly measured forces. They also performed a simple one-dimensional analysis to predict the circumferential pressure variation and obtained qualitative agreement.

Worster [22] also measured the steady state static pressures in a centrifugal process pump. He studied the effect of tongue length on hydraulic performance and pressure distribution and measured pressures that were strongly dependent on circumferential position. He compared results to simplified perfect fluid flow (electrolytic tank results) but never described the perfect simulation. Nor did he attempt to estimate forces. Overall, although the paper contains a great deal of basic information for one pump (with modifications), the author attempted to include too much information. As a result, none of the documentation and results receive the attention they should.

Murakami and coworkers [23] used a yaw probe to measure the pressures and velocities in two rotating centrifugal impellers. They also used flow visualization (oil surface flow) in the impeller. They observed velocity profiles for three and seven bladed impellers and different radial positions and found that three blades were insufficient for smooth profiles. They did not attempt to obtain forces.

Kanki et al [24] used pressure sensors on two impellers and in double volute/single discharge and vaned diffusers and observed both static and fluctuating pressures for concentric and eccentric impellers. At 100% flow they measured a nearly uniform pressure distribution in the double volute pump. At 17% flow, however, they obtained very low pressures at the tongues. Large circumferential variations of pressures were observed for the vaned diffusers (at the vane spacial frequency), but variations for the eccentric impeller were even larger. They also showed the frequency content of the pressures at the diffuser inlet and that synchronous fluctuation is four times the static value at 83% flow and half the static value at 17%. The static value increased by four times from 83% to 17% flow capacity.

STATIC FORCE MEASUREMENTS

A pump can fail as a result of static or dynamic forces. Experimental measurements of static forces, which were studied before dynamic forces, are reviewed in this section.

Stepanoff [25] reported experimental results for impeller forces in 1957. He measured the static deflection of the impeller running at on- and off-design flow rates for a single volute/single discharge centrifugal process pump. He calibrated a shaft with known static weights and determined the load on the shaft during operation. For the one pump he correlated the data to fit the curve:

$$F_r = K\, H\, D_2\, B_2\, /2.31$$

and

$$K = 0.36[1 - (Q/Q_n)^2]$$

where H = head (ft), D_2 = impeller diameter (in.), B_2 = width of impeller including shrouds (in.), Q = any capacity, Q_n = the normal capacity, and F_r = radial force (lb_f).

He indicated that the correlation for K is dependent on pump type and geometry but that the general equation for F_r should hold for any pump.

Iversen et al [21] measured static forces as well as pressures. They used strain gages attached to symmetric bearing mounts with the impeller in between and measured the impeller force for one pump; they did not attempt to generalize their results.

Agostinelli et al [26] extended the work of Stepanoff. They tested 16 different pumps -- both single and double volute-single discharge pumps -- at different specific speeds. Strain gages calibrated by applying known loads at both nonrotating and rotating conditions were used on a specially designed bearing housing to measure two components of force. Results are presented for flow rates from 0° to 170% of design conditions; forces are also given. The authors fit their data to the general equation of Stepanoff and found that K was a function of both capacity and specific speed. They presented a chart for this dependence.

Biheller [27] used the same test rig as Agostinelli [26] to test 18 different pumps with both shrouded and unshrouded impellers. The objective was to determine the effect of impeller/case concentricity on radial forces. Eleven had single volutes, three had fully concentric volutes, and four had semi-concentric casings. The author presented a semi-empirical equation curve to fit the experimental data for static forces for the three different types of pumps. Errors with the equation are usually less than 20%.

Domm, Hergt, and others [28-31] also used a pump test rig to measure static forces; the data were nondimensionalized. The impeller was on an overhung rotor, and the two support bearing pedestals were instrumented with strain gages. Resulting forces on the pedestals were related to forces on the impeller. Data were obtained for normal and eccentric operations of impellers in log spiral volutes and in pumps with guide vanes. Unfortunately, the information given is insufficient to fully document the geometries of the pumps studied.

Uchida et al [32] used an overhung rotor with strain gages on a pedestal to measure static and dynamic forces on a pump with six different tongue shapes and sizes. They presented static force measurements in raw data form (amplitude and direction) and did not nondimensionalize or attempt to correlate the data. The rig is well documented, however, so that a reader can nondimensionalize the results.

Meier, Grein, and others [33, 34] used strain gages mounted on a shaft to measure static forces. They applied known loads at the impeller position to calibrate the strain gages. Signals were transmitted from the rotating shaft by slip rings. They studied two pumps (vaned diffuser and pump turbine) and measured the static forces. They nondimensionalized their data as done by Stepanoff but did not analyze it.

Meier-Grotrian [35] used an overhung rotor with strain gages on two bearing pedestals to measure radial forces. He tested one single laboratory volute – constructed so that its shape could be varied – with four different impellers. He tested four different volute shapes including a log spiral. Unfortunately, he did not document the shape well and made no attempt to correlate data from different tests.

Schwarz and Wesche [36] studied six different volute/impeller combinations; all of the pumps had double entries and single volutes. They used symmetric pedestals instrumented with strain gages around the impeller to measure the load. Data were reduced to nondimensional coefficients. The results from the six tests differed; the authors discussed the differences but did not attempt to correlate the differences to controlled variables.

Kanki et al]24] also measured static and dynamic forces. They used an overhung rotor with strain gages mounted to the shaft. Data were transmitted with a slip ring. For static forces they studied flow rates from 17% to 120% of the design values for the different rigs. They presented raw data and did not nondimensionalize or correlate it. They did, however, document their rigs and geometries.

Thus, a significant amount of experimental data is available for static forces in pumps. Although much of these data have been correlated with semi-empirical curve fits, they do not necessarily apply to all pumps and operating conditions. For example, the data need not apply to any future fundamentally different pump designs. Furthermore, the static force is the least important force acting on a pump. Dynamic forces (discussed in the next section) are far more important in pump operation. Thus, the primary use of static force data in the future will be for benchmark comparisons of theoretical predictions of forces.

DYNAMIC FORCE MEASUREMENTS

Destructive dynamic forces can be subsynchronous, synchronous, or supersynchronous. Experimental measurements of these time-varying forces are reviewed in this section.

One of the first papers to address these forces was by Hergt and Krieger [29]. They used the same rig to measure static and dynamic forces. A pump with guide vanes was tested; the impeller was operated in concentric and eccentric modes. Dynamic forces were measured as described earlier. The authors found that dynamic loads became significant for flows of 30% and less of the design value and occurred at approximately 1/10 of rotational speed. They were largest when the impeller was operated concentrically. The forces were nondimensionalized, but the rig is not adequately described. Furthermore, results are for only one test rig.

Uchida et al [32] measured dynamic forces and presented results for one tongue shape and size. Flow rates from 0% to 139% of capacity were studied; frequency components from 30% to 800% of running speed are presented. The synchronous frequency and blade pass frequency produced the largest forces. Data were not nondimensionalized or correlated. A major concern was with the synchronous force. No balancing procedure was described, so generation of the synchronous force is not clear. It could have been mechanical, hydraulic, or both. Nevertheless, this paper contains some of the only data available for the frequency content of dynamic forces.

A facility for measuring dynamic forces on full-scale test rigs has been described [37, 38]. The rotor was overhung and strain gages were mounted to the shaft; signals were transmitted by slip rings. Systematic tests were not reported, but typical data for two pump turbines are presented. Frequency spectra for the strain gage signals indicate the primary frequencies. The objective of this paper was to document instrumentation, not to present results. It is hoped that useful information will be generated with this facility in the near future.

Schwarz and Wesche [36] briefly examined dynamic forces to complement static ones. They did not do a frequency analysis on the forces. The data represent total variation from steady-state volume for a range of flow rates. However, because of the lack of information on frequencies, the data are of little use.

Chamieh, Acosta, and others [39-41] have recently developed a laboratory facility for measuring dynamic forces. Their rig includes the capability to orbit the impeller by known amounts at orbit speeds different from the synchronous speed. Forces were measured with a strain gage system. Dynamic stiffnesses can be calculated if the orbit is known and the dynamic forces can be measured. The authors present results for a pump running at speeds from 600 to 2000 RPM at an orbit speed of 3 RPM. Because the ratio of orbit to synchronous speed is so small, results must be treated with caution. However, the current rig is being modified to orbit at larger speeds. This rig over the next few years has the potential to provide good dynamic force data.

Kanki et al [24] have presented dynamic force data for four rigs. Low frequency data and blade pass frequency data are not nondimensionalized, and no balancing procedure is described. Thus, the synchronous component of force can be a combination of mechanical and hydrodynamic forces. But few other data on the frequency content of forces are available.

Ohashi et al [42] developed a test facility similar to that of others [39-41]. They can force an impeller to orbit by a fixed amount, from 0 to 100% of synchronous speed. Forces on the shaft are measured with load cells attached to a roller bearing. The rig is well documented; results are presented for two impellers in a laboratory diffuser. Stiffnesses are given for various flow rates, orbit sizes, and orbit frequencies. The authors showed that the stiffnesses are strongly dependent on orbit frequency. Although the results are for a rig that does not represent a real pump, the rig should provide invaluable information on dynamic forces in the future.

Aerodynamic loading effects are the most predominant destabilizing components in many high pressure systems. In the design stage the designer needs to estimate the level of equivalent aerodynamic loading so that the rotor will have an adequate stability margin. Wachel and von Nimitz [43] developed an empirical formula for estimating the level of aerodynamic cross coupling on several instability problems.

Dynamic forces have not been studied experimentally in as much detail as static forces. Only two sets of data are available for the frequency content of dynamic forces in real pumps. A review of the literature indicates that much more work is needed in this area. The recently developed test rigs [39-42] should provide invaluable information.

STATIC FORCE PREDICTIONS

In this section theoretical static force literature is reviewed. Iversen et al [21], among the first to predict static forces in pumps, used a simple one-dimensional flow analysis to predict static pressures. They integrated the pressures to obtain the forces. Although correlation between their predictions and measurements was of a correct order of magnitude, they did not obtain good results.

Csanady [44] analyzed the potential flow in a logrithmic spiral volute with the aid of conformal mapping. He assumed that the total head was constant around the impeller periphery and calculated the static load on the impeller. The last assumption is not true, however, particularly at off-design flows, but his results compared favorably with those of others [21].

Another calculation for the static force [30] used potential theory with a vortex source. Good correlation with experimental results was obtained for eccentric but not orbiting impellers.

Senoo [45] used potential flow theory to predict the pressures in volute pumps. He replaced the impeller periphery with a straight line and the volute with a wedge shape and obtained qualitative agreement with the data of Stepanoff [25] for pressure distributions.

Kurokawa [46] theoretically studied frictionless flow in a two-dimensional logrithmic spiral volute by integrating the equations of motion. He presented velocity profiles and compared them to the data of others [20]; results are in qualitative agreement. He also calculated the static pressure and force, which compared well with the data of others [21].

DYNAMIC FORCE PREDICTIONS

From the stability and dynamic response viewpoint, dynamic forces are much more important than static ones. Prediction of dynamic forces is discussed in this section.

Alford [47] was among the first to predict dynamic forces. He used a simplistic model of an axial flow machine and related the local circumferential efficiency and torque to blade tip clearances. He showed that small perturbations in blade tip clearances can result in destabilizing forces and presented equations. Although simplistic, this paper is very popular for predicting dynamic forces.

Zotov [48] discussed imbalance forces occurring at blade pass frequencies. In this translation of the paper equations are not presented; therefore, the reader cannot calculate the force levels. The author does indicate how the forces can be minimized, however.

In a related paper Kumar and Rao [49] used a method of singularities to analyze flow through a two-dimensional impeller. They did not consider any interaction with the pump volute and obtained fair agreement between theoretical and experimental pressures within the impeller.

A study of aerodynamic forces on centrifugal impellers, published by Colding-Jorgensen [50, 51], involved calculating the impeller force caused by rotor eccentricity as well as the associated stiffness and damping coefficients. A uniform flow velocity was imposed over the impeller and volute to obtain the forces by the theorem of Joukowski. Unfortunately this produces the force acting on the outside of the volute rather than on the impeller.

Shoji and Ohashi [52] calculated fluid forces on a centrifugal impeller using unsteady potential theory. Incompressible, two-dimensional flow was assumed; the rotating axis whirled at constant speed. Other assumptions included shockless entry at the leading edges of the blades and the Kutta condition at the trailing edges. Free vortices were assumed to be shed from the trailing edges and carried downstream with steady velocities along steady streamlines; blade thickness was neglected. The forces acting on the impeller were calculated by integrating the pressure distribution on the blades.

Imaichi et al [53] studied the unsteady flow of an impeller in a volute casing. Pressure fluctuations on the casing wall due to both potential flow and a viscous wake were predicted using an integral method. The authors found that the fluctuating load due to blade passing can be of the same order as the steady-state value. They did not present any equations that can be used to estimate the force for a general pump, however.

Krämer [54] developed a simple technique by which the dynamic forces on a pump can be estimated from field vibration data. This technique is basically the inverse of other methods [14-18]. A full-scale pump is needed, however, so that the technique defeats the purpose of present goals; i.e., to predict forces before a machine is built.

Iino's work [54] dealt with potential interaction between a centrifugal impeller and a vaned diffuser. The dynamic load on the impeller blades due to this interaction was examined. Unsteady flow was analyzed using the method of singularities and assuming two-dimensional, potential flow and infinitely thin blades. The unsteady Bernoulli equation for a rotating coordinate system was used to solve for the unsteady pressures. Pressure distributions were examined for various impeller configurations. Load distribution on diffuser blades was related to pressure fluctuations; the dynamic load on impeller blades was affected by consideration of this load distribution.

Branagan [56] and Sato [57] used a finite element model of a full two-dimensional impeller including all passages. Under synchronous orbiting, a circumferential variation in the fluid velocity entering the impeller created changes in linear momentum and pressure of the fluid. A purely kinematic analysis of this was presented by Allaire et al [58]. Changes in momentum and pressure produced radial forces that act on the impeller and can be represented as stiffnesses for vibration analysis.

This review of the literature indicates that no dependable method is currently available for predicting dynamic forces. Analytic work [58] and ensuing work will probably be the successful method for general pumps. Coupled with experimental work [41, 42] the analytic work should become the most reliable method in the future.

SUMMARY

Literature on static and dynamic lateral forces on pump impellers was reviewed in this paper. Both experimental work and theoretical work were included. Specific conclusions are:

1. A significant amount of work has been done on the experimental measurement of steady-state pressures and forces in pumps. Many different geometries have been considered. Much of the data has been curve fit and can be used to obtain a reasonable estimate of forces on other pumps of similar geometries but different sizes.

2. Very little fundamental work on the experimental measurement of dynamic forces is available. Two papers contain data for specific pumps [24, 32]. This data can be scaled for pumps of different sizes to obtain order of magnitude estimates of dynamic forces. Two other test rigs have recently been developed [41, 42] that should aid immensely in understanding these forces. More work is needed in this area.

3. Several papers that have been published for predicting static forces do reasonably well in predicting these forces.

4. Very few papers are available that provide information for predicting the dynamic forces on pumps. The few that are available do not compare well with experimental results. Fundamental work [58] is most promising for predictions in the future. Of the four basic areas covered in this paper dynamic force prediction needs the most attention by researchers.

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about underwater acoustic modeling techniques and eigenvalue methods for vibration analysis.

Mr. P.C. Etter of ODSI Defense Systems, Inc., Rockville, Maryland reviews progress in the area of underwater acoustic modeling techniques since 1980. Emphasis is placed on developments of general interest to the Navy sonar modeling community.

Professor A. Jennings of Queens University of Belfast, Northern Ireland updates a previous review of methods for solving dynamic equations to determine characteristic response. In particular numerical methods for eigensolution as they apply to the analysis of undamped and damped systems are considered.

UNDERWATER ACOUSTIC MODELING TECHNIQUES

P.C. Etter*

Abstract. ***This article reviews progress in the area of underwater acoustic modeling techniques since 1980. Emphasis is placed on developments of general interest to the Navy sonar modeling community. They include: model refinements, bottom interaction modeling, model operating systems and trainers, and specialized modeling applications in shallow water and Arctic environments.***

The first review article in this series [1] addressed a broad range of underwater acoustic modeling topics including propagation loss, noise, reverberation, and active sonar models. The present review updates the previously reported efforts. Moreover, the scope is modestly expanded to include selected topics that have been a focus of attention since 1980: model operating systems and trainers, bottom interaction modeling, and specialized modeling applications in shallow water and Arctic environments. Accordingly, this review should be considered in conjunction with the earlier article. Two reference books of general interest to underwater acousticians that have been introduced since 1980 address theoretical [2] and practical [3] aspects of modeling.

ENVIRONMENTAL MODELS

Environmental models are usually empirical or semi-empirical models used to generate inputs to acoustic models. Such inputs as sound speed and absorption are derived from directly observable parameters including water temperature, salinity, and acoustic frequency. New environmental models have been developed for sound speed [4, 5], absorption [6-12], and bottom interaction [13] since 1980.

PROPAGATION LOSS MODELS

An earlier article [1] introduced a comprehensive classification scheme for propagation loss models. Basically, all such models can be categorized according to five theoretical derivatives of the wave equation: ray theory with corrections, multi-path expansion techniques, normal mode solutions, fast field theory, and parabolic approximations. Recent progress in underwater acoustic modeling techniques is summarized below according to these five categories; see also the Table. A general interest tutorial paper describing different modeling techniques, together with sample outputs, will also be of interest to those new to the field [14].

Ray theory with corrections. The FACT model has received numerous improvements and has come under configuration management control. Updated documentation has also been introduced [15]. A

Table. Summary of Recent Developments in Underwater Acoustic Propagation Loss Modeling

Modeling Technique	Range Independent	Range Dependent
Ray Theory with Corrections	*FACT [15]	MEDUSA [16]
Multi-Path Expansion Techniques	*RAYMODE [20, 21] NEPBR [22] FAME [23]	
Normal Mode Solutions	NEMESIS [25] NORM2L [26] COMODE [27]	CUPYL [27, 28]
Parabolic Approximations		Wide Angle PE [27] IFD [34] 3DPE [35]

*Updated Documentation

*ODSI Defense Systems, Inc., 6110 Executive Blvd., Rockville, MD 20852

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new range-dependent model MEDUSA [16] has been developed. The increased use of complex range-dependent models has prompted the issuance of cautionary notes [17] concerning proper application and interpretation of results. Continued interest in the development of three-dimensional ray-tracing techniques is demonstrated by the appearance of ECTRACE [18] and also by a comprehensive survey of such techniques [19] with application to range-dependent propagation loss modeling.

Multi-path expansion techniques. The RAYMODE model has undergone many revisions and has been brought under configuration management control. New documentation has also been promulgated [20, 21]. A modified version NEPBR has also been developed [22] to model the received acoustic spectrum of signals that have undergone frequency smearing by the ocean medium. A new multi-path expansion model FAME has recently been introduced in the literature [23]. Range-dependent developments have also been reported [24].

Normal mode solutions. Three range-independent normal mode models have recently been developed: NEMESIS [25], a two-layer model NORM2L [26], and COMODE [27]. COMODE treats bottom attenuation exactly using complex eigenvalues. Some effort has been focused on the development of range-dependent versions such as CUPYL [27, 28], which uses mode coupling. General theoretical treatments of interest address aspects of normal mode theory in range-dependent environments [29, 30]. One notable development is that of high-frequency adaptations to normal mode theory [31]. Specifically, invoking simplifying assumptions with regard to the complexity of the ocean environment permits achievement of upper frequency limits in the multi-kilohertz region, as opposed to the more typical upper limit of approximately 500 Hz. The development of normal mode theory for application to trapped modes, leaky modes, and interface waves has also been described [32].

Fast field theory. The only notable development in this technique has been the application of the Fast Field Program (FFP) to the solution of parabolic approximation models [33].

Parabolic approximations. The most intense interest over the past three years has been directed at further refinements of the parabolic approximation to the wave equation. This solution, also called the parabolic equation (PE) technique, has met with wide success in the field of underwater acoustic modeling at frequencies below about 500 Hz. Several new models have been introduced: IFD [34] including a wide-angle version [27], and a three-dimensional PE model referred to as 3DPE [35]. A variety of associated mathematical techniques have appeared in the literature [36-39], and the proceedings of a recent workshop [40] document comprehensive comparisons among several different PE techniques.

BOTTOM INTERACTION

One area of concern to all types of propagation loss models is the phenomenon of bottom interaction. This topic was the theme of a recent international symposium [41] and has also been the subject of several analytical studies [42-44]. Because refinements to the PE technique have dominated recent model developments, it is not surprising that intense interest has been focused on methods that best represent the ocean bottom in these models [45, 46]. The next-generation bottom loss treatment for models of underwater acoustic propagation used in naval applications will assume a geoacoustical basis. One developmental product called BLUG, or Bottom Loss Upgrade, is a modular upgrade designed for incorporation into existing and future propagation loss models [47].

NOISE MODELS

Developmental efforts in the area of underwater noise modeling have been the subject of a recent international symposium [48] and a review paper [49]. Advances in noise modeling are sometimes achieved by combining the capabilities of existing models [50]. No new stand-alone noise models are known to have been developed since 1980.

ACTIVE SONAR AND REVERBERATION MODELS

Theoretical techniques for the modeling of reverberation can be categorized as cell scattering and point scattering models. Cell scattering models assume that the scatterers are uniformly distributed throughout the ocean. Thus, the ocean can be divided into cells, each containing a large number of scatterers. Summing the contribution of each cell yields the total average reverberation level as a function of time after transmission. A backscattering strength is used to approximate the target strength per unit area or volume. Point scattering models are based on a statistical approach in which the scatterers are assumed to be randomly distributed throughout the ocean. The reverberation level is then computed by summing the echoes from each individual scatterer. A brief overview of mathematical techniques used in modeling reverberation has been provided elsewhere [51]. REVMOD [52] is a recently documented reverberation model based on the cell scattering technique described above.

A new active sonar model, ACTIVE RAYMODE [53, 54] is, as the name implies, an adaptation of the passive propagation loss model RAYMODE. The GENERIC SONAR MODEL has benefited from improved documentation [55] and elucidation [56]. A review of stochastic theories applicable to active sonar modeling has recently appeared in the literature [57].

MODEL EVALUATION

Model evaluation is a critical but frequently overlooked aspect of model development. Recent publications have addressed various theoretical and practical procedures for model evaluation [58-60]. The results of evaluation studies have been described for both propagation loss [61] and reverberation models [62].

MODEL OPERATING SYSTEMS AND TRAINERS

The trend toward modular designs in computer programs of underwater acoustic models is evidenced by the recent development of model operating systems. Such systems provide a framework for the direct linkage of data management software with computer-implemented codes of acoustic models. These systems facilitate comparative model evaluations by standardizing hardware and software configurations of different modeling techniques [63]. The resulting uniformity, which encourages a higher degree of configuration management control, is viewed as a positive step in the direction of disciplined model evaluation.

In related developments, designers of trainers have incorporated sophisticated range-dependent acoustic models into their software in order to provide more realistic training environments for the operators of sonar equipment. Because of requirements for near-real-time program execution, creative modeling techniques and advanced programming skills must be employed in much the same manner as model operating systems [64, 65].

SPECIALIZED MODELING APPLICATIONS

Specialized acoustic modeling applications of interest to the naval sonar modeling community include shallow water and Arctic environments.

Shallow water acoustics. Acoustic propagation in shallow water is characterized by repeated interactions with both surface and bottom boundaries. The complexity of environmental boundary descriptions required for satisfactory operation of most acoustic modeling techniques in shallow water has prompted recent modeling efforts to make recourse to empirical or semi-empirical models [66, 67] that characterize shallow water areas according to robust environmental-acoustic parameters. Such parameters are relatively insensitive to details of the bottom structure and sea-surface roughness. It is claimed that one recent development based on ray theoretical calculations [68] is as good as normal mode solutions for practical calculations in shallow water.

Arctic acoustics. The Arctic acoustic environment is characterized by two unique features: a positive sound-speed gradient that creates upward-refracting propagation conditions, and an ice canopy with irregular underice surfaces. The resulting repeated underice reflections coupled with a general lack of understanding of important ice characteristics renders most present acoustic modeling techniques inadequate for Arctic applications. Two basic approaches are currently being pursued: empirical or semi-empirical models [69] and application of ice scattering coefficients and roughness parameters to existing acoustic propagation loss models [70]. However, a recent intercomparison of these techniques has revealed large, unresolved discrepancies [70].

Arctic ambient noise characteristics (sources, levels, directionality) differ markedly from those of open ocean areas [71]. Moreover, underice reverberation is complicated by the presence of numerous, irregular underice ridges that present false targets to active sonar systems [71]. Thus, Arctic noise and reverberation models are not yet well developed.

CONCLUDING REMARKS

A review of recent progress in underwater acoustic modeling techniques has evidenced a maturing technology in which developmental efforts are largely directed at refining existing capabilities. However, modeling technology will certainly benefit from increased data collection efforts emphasizing statistical descriptions of parameters in place of the more traditional mean values. In conclusion, current research directions should be able to meet anticipated naval requirements for sonar system design and performance prediction support.

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EIGENVALUE METHODS FOR VIBRATION ANALYSIS II

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Abstract. This article updates a previous review of methods for solving dynamic equations to determine characteristic response. In particular numerical methods for eigensolution as they apply to the analysis of undamped and damped systems are considered.

If it is assumed that the displacement form of a freely vibrating undamped structure is a linear combination of n separate displacement functions, the resulting mathematical equations requiring solution take the form [1]

$$\underset{\sim}{K}\underset{\sim}{x} = \omega^2 \underset{\sim}{M}\underset{\sim}{x} \tag{1}$$

$\underset{\sim}{K}$ and $\underset{\sim}{M}$ are n x n symmetric stiffness and mass matrices respectively; $\underset{\sim}{x}$ defines the displacements in the n variables corresponding to a frequency of vibration ω. An early method of solution adopted for small order equations was to premultiply this equation by

$$\frac{1}{\omega^2}\underset{\sim}{K}^{-1}$$

giving

$$(\underset{\sim}{K}^{-1}\underset{\sim}{M})x = \frac{1}{\omega^2}\underset{\sim}{x} \tag{2}$$

Hence the frequencies can be computed from the eigenvalues of the dynamic matrix $\underset{\sim}{K}^{-1}\underset{\sim}{M}$; furthermore, because the lowest frequencies correspond to the largest eigenvalues, the power method and extensions of it can be used to obtain the lower frequencies of the system.

In the 1950s, with a surge of interest in numerical techniques, powerful transformation methods were developed for eigensolution of matrices. These methods, which culminated in the Householder and the QR methods for symmetric and unsymmetric matrices respectively, are particularly effective at obtaining all the eigenvalues of matrices not of large order (say $n < 100$), particularly densely populated ones.

However, the most favored method for formulating structural analyses on computers is the finite element method. It produces stiffness matrices of large order and sparse and mass matrices that are usually of similar form or in some cases more sparse or even diagonal. In addition, the order of the equations tends to be much greater than the number of required frequencies, so that a partial eigensolution suffices. There has thus been a strong need to develop numerical techniques well suited to partial eigensolution of large order sparse equations of type (1).

UNDAMPED EQUATIONS -- DEVELOPMENT OF POWERFUL VECTOR ITERATIVE METHODS

The first method used to solve large order eigenvalue problems was the Guyan reduction, otherwise known as the eigenvalue economizer or mass condensation method. The equations are transformed to a set of equations of sufficiently low order that standard eigenvalue techniques can be used. The choice of the reduced set of variables is crucial to the accuracy of the method; it is for this reason that Shah and Raymund [2] proposed an automatic method for selecting the master displacements. Their method is based on the sizes of diagonal elements in the mass and stiffness matrices. Although they show that their method works well for some cases, they do not prove that it should always work well.

Thomas [3] derived an approximate method for estimating a bound on the errors. Other investigators [4, 5] used extra interior displacement functions; by pre-elimination these functions yield a quadratic rather than a linear generalized eigenvalue problem.

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In the early 1970s simultaneous iteration – also known as subspace iteration -- methods were developed. They are similar to the Guyan reduction in that a lower order eigenvalue problem is created by using a reduced set of functions. However, the results from one such eigensolution are used to predict better functions and set up iteration sequences. Therefore, in contrast to Guyan reduction, results of any required accuracy can be obtained with fewer trial functions and with less worry about whether the accuracy is satisfactory.

A 40% reduction in the cost of the basic subspace iteration has been reported with an acceleration technique [6]. This technique should be compared with Chebychev methods for accelerating simultaneous iteration originally proposed by Rutishauser [7] and implemented by others [8, 9].

Arora and Nguyen [10] described a subspace iteration method in which the structure is split into substructures for the purpose of solving the stiffness equations. It does not seem to be recognized that Guyan reduction, simultaneous iteration, and subspace iteration can be implemented if the stiffness equations are solved by any technique already available for linear static analysis problems -- provided the technique can cope with multiple loading cases – rather than by separate techniques [11].

LANCZOS METHODS

The Lanczos method can be thought of as an alternative method to simultaneous iteration of extending and accelerating the power method. It retains the single vector iteration sequence of the power method. But the vector sequence is not made to converge to the dominant eigenvector; rather, the vector sequence is arranged to form an orthogonal set from which a set of dominant eigenvalues can be extracted by a tridiagonal eigensolution process. As with the related conjugate gradient method for solving simultaneous equations, it has taken some years for the advantages of the method to be appreciated.

A simple implementation of the Lanczos method for equations of the form of (1), in which $\underset{\sim}{K}$ is nonsingular, can be initiated by defining a matrix $\underset{\sim}{T}$ such that

$$\underset{\sim}{K}^{-1}\underset{\sim}{M}\underset{\sim}{Y} = \underset{\sim}{Y}\underset{\sim}{T} \tag{3}$$

$\underset{\sim}{Y}$ comprises a set of vectors that are orthogonal to the masses according to

$$\underset{\sim}{Y}^T\underset{\sim}{M}\underset{\sim}{Y} = \underset{\sim}{I} \tag{4}$$

It can be shown that $\underset{\sim}{T}$ is a similarity transformation of $\underset{\sim}{K}^{-1}\underset{\sim}{M}$ and thus, according to equation (2), has eigenvalues $\lambda_i = 1/\omega_i^2$. Furthermore, from equations (3) and (4)

$$\underset{\sim}{Y}^T\underset{\sim}{M}\underset{\sim}{K}^{-1}\underset{\sim}{M}\underset{\sim}{Y} = \underset{\sim}{T} \tag{5}$$

Hence $\underset{\sim}{T}$ is symmetric. If $\underset{\sim}{Y} = (\underset{\sim}{y}_1\,\underset{\sim}{y}_2\,\ldots\,\underset{\sim}{y}_n)$ and

$$\underset{\sim}{T} = \begin{bmatrix} \alpha_1 & \beta_1 & & \\ \beta_1 & \alpha_2 & \beta_2 & \\ & \beta_2 & \cdot & \cdot \\ & & \cdot & \cdot \end{bmatrix} \tag{6}$$

equations (3) expand to give

$$\begin{aligned} \underset{\sim}{K}^{-1}\underset{\sim}{M}\underset{\sim}{y}_1 &= \alpha_1\underset{\sim}{y}_1 + \beta_1\underset{\sim}{y}_2 \\ \underset{\sim}{K}^{-1}\underset{\sim}{M}\underset{\sim}{y}_2 &= \beta_1\underset{\sim}{y}_1 + \alpha_2\underset{\sim}{y}_2 + \beta_2\underset{\sim}{y}_3 \\ &\text{etc.} \end{aligned} \tag{7}$$

If $\underset{\sim}{y}_1$ is specified as the first trial vector (which has been normalized such that $\underset{\sim}{y}_1^T\underset{\sim}{M}\underset{\sim}{y}_1 = 1$), premultiplication of the first equation by $\underset{\sim}{y}_1^T\underset{\sim}{M}$ and use of the orthogonality conditions result in

$$\alpha_1 = \underset{\sim}{y}_1^T\underset{\sim}{M}\underset{\sim}{K}^{-1}\underset{\sim}{M}\underset{\sim}{y}_1 \tag{8}$$

A vector $\underset{\sim}{w}$ can be computed such that

$$\underset{\sim}{w}_1 = \underset{\sim}{K}^{-1}\underset{\sim}{M}\underset{\sim}{y}_1 - \alpha_1\underset{\sim}{y}_1 \tag{9}$$

Equation (9) from the first of equations (7) must equal $\beta_1\underset{\sim}{y}_2$. From the normalizing condition contained in equation (4)

$$\underset{\sim}{w}_1^T\underset{\sim}{M}\underset{\sim}{w}_1 = \beta_1^2 \tag{10}$$

from which β_1 can be computed. At this stage $\underset{\sim}{y}_2$ is available from

$$\underset{\sim}{y}_2 = (1/\beta_1)\underset{\sim}{w}_1 \tag{11}$$

Equation (7b) can be manipulated in a similar way to yield α_2, β_2, and $\underset{\sim}{y}_3$. Subsequent equations permit the process to continue in a recursive way; breakdown occurs only when a null $\underset{\sim}{y}$ vector is computed.

The operations can be organized so that only one vector must be multiplied by $\underset{\sim}{M}$ and only one vector by $\underset{\sim}{K}^{-1}$ within each recursive cycle. The second operation involves forward and back substitution operations; however, an LU, LDL^T, or Choleski factorization of the stiffness matrix must be carried out before the recursion is begun.

A slight variation on the above is to convert equations (1) into the symmetric eigenvalue problem

$$(\underset{\sim}{L}^{-1}\underset{\sim}{M}\underset{\sim}{L}^{-T})\underset{\sim}{y} = \lambda \underset{\sim}{y} \tag{12}$$

where $\underset{\sim}{y} = \underset{\sim}{L}^T\underset{\sim}{x}$ and $\lambda = 1/\omega^2$; a standard Lanczos process is then carried out on the matrix $\underset{\sim}{L}^{-1}\underset{\sim}{M}\underset{\sim}{L}^{-T}$ without explicitly forming it (see Newman and Pipano [12]).

Much research has been carried out on the Lanczos method. One concern is whether or not the vectors should be formally orthogonalized with respect to all previous vectors; the reason is that rounding errors tend to destroy the orthogonality if the recursive sequence is carried on for many steps. Paige [13] has found that reorthogonalization is unnecessary although without it multiple copies of eigenvalues can be obtained. Cullum and Willoughby [14] described a method without reorthogonalization to compute all the eigenvalues of large sparse symmetric matrices. Parlett and Scott developed a method with selective orthogonalization [15, 16]. With others Parlett has published a method of tracking convergence that can be used with or without selective reorthogonalization [17]. He has also examined the problem of computing the largest eigenvalue of a sparse matrix [18].

Convergence properties of the basic Lanczos method have also been discussed [19-21]. One important aspect is that the outer eigenvalues in the spectrum usually converge first; indeed, it is normal for the largest eigenvalues correspondong to the lowest frequencies to converge with less total computation than with the power method, Guyan reduction, or simultaneous iteration.

One feature of Lanczos implementations is that they require eigensolution of a tridiagonal matrix that is growing in size at each recursion [22]. Difficulties are encountered with the basic Lanczos method if there are multiple eigenvalues. In that case one of the eigenvalues must be accurately obtained before the vector set begins to contain significant components of the eigenvector associated with one of the others.

In practice, if coincident frequencies are possible and knowledge of them is required, it is necessary to carry on the recursion sequence sufficiently far to ensure that all such eigenvalues have been found. An alternative procedure is to use block or band Lanczos algorithms in which multiple eigenvalues can converge simultaneously in all cases in which the multiplicity of the eigenvalues is less than the block size or bandwidth employed [23, 24]. Lewis and Grimes [25] discussed implementation; Ramaswamy [26] suggested that Lanczos vectors are good starting vectors for simultaneous iteration.

FREQUENCY SEARCH METHODS

In contrast to vector iterative methods are various techniques that test different frequencies with the object of determining when the matrix $(\underset{\sim}{K} - \omega^2\underset{\sim}{M})$ is singular. Because the simplest way to determine this singularity is to factorize the matrix, these methods are most effective when the bandwidth of the matrix is narrow. For the standard eigenvalue problem

$$\underset{\sim}{A}\underset{\sim}{q} = \lambda \underset{\sim}{q} \tag{13}$$

the equivalent method involves determining when $(\underset{\sim}{A} - \lambda\underset{\sim}{I})$ is singular. For symmetric problems, a method of carrying out this search is the well known Sturm sequence method. In this method the number of agreements in sign in the sequence of principal minors -- which can be obtained during the factorization process -- is used to indicate the number of frequencies (or eigenvalues) below the trial frequency (or eigenvalue). The use of bisection with Sturm sequence evaluation for tridiagonal matrices [27] and matrices having a regular band structure [28] have been discussed. Sentance and Cliff [29] improved an earlier technique for quindiagonal matrices. Simpson [30] used a Newton-Raphson iteration procedure incorporating Sturm sequence evaluation.

For problems of larger bandwidth, when factorization times can be excessive, Iyer [31] used a Lagrange interpolation prediction for the characteristic polynomial to reduce the number of trial frequencies required. One difficulty with this method is that the matrix to be factorized is symmetric but not positive definite; therefore, pivoting is theoretically necessary to ensure stability of the process although, with a good computer word length, failure of the process would be unlikely. Iyer did not use pivoting and did not discuss word length.

Waldvogel [32], on the other hand, discussed how a stable pivoting strategy can be implemented in a variable bandwidth store after only slight modifications to that store. Mang and Walter [33] examined the use of the Sturm sequence property when the equations are subject to certain linear constraints.

VECTOR ITERATIVE METHODS WITH SHIFTING

The powerful vector iterative methods (including Lanczos) are more economical then frequency search methods for finding a limited number of the lowest frequencies and mode shapes of large order problems in which the bandwidths of the equations are not unusually small. However, considerable benefits might be obtained by uniting the two basic approaches; several techniques have been published in the last three years.

The advantages of frequency search methods that can be utilized are as follows:

- Sturm sequence evaluations provide an absolute check on the number of eigenvalues in an interval and can be used to ensure that vector methods have not omitted any eigenvalues. This is probably more important with the Lanczos method in which omission of multiple eigenvalues is a distinct possibility.

- Frequency search methods can be of use when the number of required frequencies is large. In this case the convergence of vector methods becomes slower.

- When only frequencies within a specified band are required, they can be determined with frequency search methods without the need to evaluate all the lower frequencies and mode shapes first.

The two techniques can be combined by applying an eigenvalue shift μ to the basic equations (1) to give

$$(\underset{\sim}{K} - \mu\underset{\sim}{M})\underset{\sim}{x} = (\omega^2 - \mu)\underset{\sim}{M}\underset{\sim}{x} \qquad (14)$$

and then proceeding roughly as before but with $(\underset{\sim}{K} - \mu\underset{\sim}{M})$ replacing $\underset{\sim}{K}$. A negative value of μ has previously been used to solve vibration problems in which the presence of body freedoms make the stiffness matrix singular [34]. However, with positive values of μ, rapid convergence is achieved to those frequencies for which ω^2 is close to μ.

A technique of progressive shifting with simultaneous iteration [35] is particularly advantageous when many frequencies are required; it also reduces the storage requirement from that required for basic simultaneous iteration. A comparable technique has been given for subspace iteration by Bathe and Ramaswamy [36]; the authors advocated using acceleration techniques and more trial vectors in the iteration process. Ericsson and Ruhe [37, 38] used a shift technique with the Lanczos method to determine eigenvalues within a specified interval. This technique was discussed by Parlett [39].

METHODS FOR AVOIDING STIFFNESS MATRIX FACTORIZATION

All the methods described thus far involve factorization of the stiffness matrix when applied to vibration equations in the conventional way. If the mass matrix is diagonal, either simultaneous iteration with shift or the Lanczos method can be used to determine the lower eigenvalues of the transformed equations

$$(\underset{\sim}{M}^{-1/2}\underset{\sim}{K}\underset{\sim}{M}^{-1/2})\underset{\sim}{\bar{x}} = \omega^2\underset{\sim}{\bar{x}} \qquad (15)$$

where $\bar{x} = M^{1/2}x$. These methods are likely, however, to lead to very bad convergence rates [21]. Alternative relaxation methods avoid factorization of the stiffness matrix even when M is not diagonal. The main method for vibration problems appears to be simultaneous coordinate overrelaxation [40]. The penalty for avoiding factorization is much slower convergence rates. Another problem can be ascertaining that convergence is to the lowest frequencies; the reason is that the basic coordinate relaxation method can converge to a frequency that is not the lowest. The Sturm sequence check cannot be applied without performing the factorization that the method is trying to avoid.

Several related methods have been published in the fields of physics and chemistry [41-46]. However, problems that occur in molecular orbit calculations, for which Davidson's and related algorithms are claimed to be particularly effective, have been reported by Parlett [39] as "being quite special in the sense that the eigenvector matrix is fairly close to the identity." Preconditioned iterative methods could prove a way of improving convergence rates without involving a factorization, but the methods of Evans and Shanehchi [47, 48] are limited to classical eigenvalue problems in which the matrix is explicitly formed. The method is therefore not applicable to equation (1) unless M is a diagonal matrix.

OTHER METHODS FOR UNDAMPED EQUATIONS

Apart from the quadratic eigenvalue formulations in association with Guyan reduction [4, 5], Gupta [49] has developed a dynamic formulation for plane triangular elements that gives rise to quadratic eigenvalue equations. Although the solution of the quadratic equations by a combined Sturm sequence and inverse iteration procedure costs about the same as the standard linear equations, improved accuracy must be weighed against the increased complexity of the finite element equations. Scott and Ward [50, 51] compared Rayleigh quotient iteration with a Lanczos formulation with shifts for solving quadratic eigenvalue problems with real roots arising from spinning structures and highly damped structures. The conclusion was that the Lanczos method is preferable for problems with large bandwidth.

Meirovitch and Baruh [52] developed what they call the Choleski method (really the LR method) for finding eigensolutions of band matrices by transformation methods. Their use of double iteration steps and shifting based on Sturm sequence or Gerschgorin bounds enables them to quote faster computing times than for the more usual QR method. This technique could be useful for problems that are not too large and in which the matrix requiring eigensolution can be explicitly obtained in sparse format (particularly when the mass matrix is diagonal). It could also be used for the eigensolution process for the reduced equations obtained by the Lanczos or block Lanczos methods. Howson [53] used the theoretically exact transcendental eigenvalue formation to solve plane frame problems.

DAMPED EQUATIONS AND THE UNSYMMETRIC EIGENVALUE PROBLEM

Dynamic equations including a damping matrix $\underset{\sim}{C}$ having the form

$$\underset{\sim}{M}\ddot{\underset{\sim}{x}} + \underset{\sim}{C}\dot{\underset{\sim}{x}} + \underset{\sim}{K}\underset{\sim}{x} = 0 \tag{16}$$

can be reduced to the standard matrix eigenvalue problem

$$\begin{bmatrix} -\underset{\sim}{M}^{-1}\underset{\sim}{C} & -\underset{\sim}{M}^{-1}\underset{\sim}{K} \\ \underset{\sim}{I} & \underset{\sim}{0} \end{bmatrix} \begin{bmatrix} \underset{\sim}{z} \\ \underset{\sim}{y} \end{bmatrix} = \lambda \begin{bmatrix} \underset{\sim}{z} \\ \underset{\sim}{y} \end{bmatrix} \tag{17}$$

by the substitutions $\underset{\sim}{x} = \underset{\sim}{y}e^{\lambda t}$ and $\underset{\sim}{z} = \lambda\underset{\sim}{y}$. This matrix is unsymmetric and -- because complex solutions are expected for λ -- cannot normally be transformed to a symmetric eigenvalue problem. If the dominant modes of vibration from an undamped analysis are used as the basic variables $\underset{\sim}{x}$ the eigenvalue problem will not be of very large order, and transformation methods can be used for solution. For low order unsymmetric eigenvalue problems modifications of Eberlein's Jacobi-like algorithm [54-57] are likely to show greater stability than methods based on the characteristic polynomial [58]. Dax and Kaniel [59] advocate a reduction to upper Hessenberg form followed by a reduction to tridiagonal form and then LR transformations. In some cases in which the tridiagonalization process is not stable they advocate reverting to the standard QR technique.

Powerful vector iterative methods that have been extended to solve unsymmetric eigenvalue problems could be useful if only some of the extreme eigenvalues are required, particularly if it is inconvenient to store the matrix requiring eigensolution explicitly -- as in equation (17) if M, C, and K are banded. It is likely that alternative transformations to equation (17) will be required to ensure that the required eigenvalues are obtained first [60]. One such vector iterative method is simultaneous iteration [61];

another is Arnoldi's method, which is a stable Lanczos type method [62, 63]. Saad discussed the acceleration of such methods [64].

Gupta [65] extended frequency search methods to eigenvalue search techniques for problems that include damping. A penalty is that factorizations might have to employ complex arithmetic to determine complex roots. Soni and Bogner [66] determined the spectrum of frequency response for structures with material damping.

OTHER PAPERS

Other papers of use are by Stavrinidis [67] on coupling dynamic equations, Williams [68] on the treatment of structural symmetry, Stetson and Harrison [69] on the redesign of vibration modes, Wallach [70] on symmetric eigensolution on parallel computers, Scott and Gruber [71, 72] on techniques of computer implementation, and Parlett [73] on a review of software availability.

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BOOK REVIEWS

INDUSTRIAL NOISE CONTROL

L.H. Bell
Marcel Dekker, Inc., New York, NY
1982, 600 pp, $75.00

I liked Bell's earlier book, Fundamentals of Industrial Noise Control, published by Harmony Publications in 1973; it contained basic noise control principles and examples in a well written and finely illustrated 8½ x 11 format. So I was greatly looking forward to reviewing this volume.

Happily, this book exceeded my expectations. It is one of the best basic books in noise control I have reviewed in many years. Not only is it well written and comprehensive but it also has a good layout, many example problems and case studies, numerous references, and excellent illustrations. Perhaps the only shortcoming is its price, which is far more than most texts. But, for individuals who need a single volume work either as an undergraduate text or as an engineering and research reference, this book is an especially good value.

Bell's book consists of almost 600 pages of small print; thus the size of the volume is not indicative of the large amount of information contained. It is divided into four parts: fundamentals of sound and its measurements, noise control techniques in general, noise sources and their control, and building and community noise. The part on noise control methods includes sections on acoustical materials, enclosures, silencers and mufflers, reverberation control, and vibration control. Bell treats each section thoroughly. The section on enclosures, for example, includes discussions of absorbing materials, transmission loss, and damping materials. Barriers are not mentioned as a noise control technique in this section; Bell calls them partial barriers and has included them in the section on fundamentals called sound propagation. The part concerned with sources of noise contains sections on fans, jets, gears and a single section on pumps, presses, electrical equipment, and vibration bowls.

Bell has written a volume that is easy to read. Clearly stated example problems (with answers) are included at the end of each chapter. The appendix contains a listing of SI units, a limited but sufficient table of conversion factors, listings of standards organizations and major acoustical standards, a list of recommended acoustical descriptors, a compilation of sound absorption coefficients of many materials (with a figure showing the old ASTM absorption mounting classification), a Noys table, and an old version of the OSHA noise regulation (29CFR1910.95). (The latter is useful except there is an addition, the 1983 Hearing Conservation Amendment.)

The index is long and reasonably complete. I believe it could have been expanded to cover more cases. For example if one were trying to find a barrier equation, looking up "barriers" would be fruitless because the equation is under "partial barriers".

In summary then, I think this book is excellent. An individual who needs a single book on industrial noise control or would like to have a volume with a reasonably rigorous treatment of the subject would certainly not be disappointed with Industrial Noise Control.

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15944 Shady Grove Road
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THEORY OF ELECTROACOUSTICS

J. Merhaut
McGraw-Hill Book Co., New York, NY
1982, 317 pp, $47.95

This book is a Richard Gerber translation from the latest Czech edition of the book with the same name and incorporates all the developments of the subject up to the present time. The electroacoustical theme is multidisciplinary in that it incorporates electrical, acoustic, and mechanical engineering. The author has an electrical engineering background; it is therefore not surprising that the electrical portion receives disproportionate emphasis. In particular, this reviewer found the consistent conversion of anything mechanical or acoustical into an equivalent electrical circuit somewhat overdone; e.g., "we solve the mechanical problem as if it were an electrical problem, by any known method: either graphically or by calculation, using a symbolic method, or, if transient effects are to be considered, using the appropriate operator method for the solution differential equations."

In the reviewer's opinion the problems addressed in the text can be solved if the governing field equations and associated variables for the mechanical and acoustical aspects of the problem retain their original identity throughout the solution process. The possibility of inadvertently introducing errors during the process of converting the problem into an equivalent circuit diagram and working with less familiar units would thus be avoided.

For those readers who do not object to the analogy approach, the material of electroacoustics is adequately covered. The book can serve as a university text as well as a theoretical treatise for research engineers and designers of electroacoustic instrumentation. Approximately half of the material provides a good introduction at the undergraduate level; the more advanced topics should be useful to postgraduates and professional engineers. However, one deficiency of the book as an undergraduate university text is the lack of a problem solving section at the end of each chapter.

Chapter 1 contains a complete derivation of lumped system analogies between mechanically vibrating and/or acoustical systems and electrical networks. The construction of laws of analogous networks is discussed in detail. The relevance of Thevenin's theorem regarding attaching additional impedance members to an existing system should be clarified. The second chapter deals with mechanically vibrating structural systems such as membranes, ribbons, bars, bending members, and distributed elements. In addition to the wave equations of these systems, analogous electrical networks are derived.

The third chapter is devoted to sound propagation, wave equations of sound in air, and the solution of typical cases in electroacoustical transducers. Chapter 4 introduces the general theory of sound transmitters of the nth order and derives radiation impedances for such typical transmitters as pulsating or vibrating spheres, vibrating pistons, and more complex structures. The fifth chapter deals with the theory of acoustical waveguides -- especially the exponential ones encountered in horns -- including their input acoustical impedances, calculation, and design.

Part of the material in Chapter 1 and practically all of the material in chapters 2 through 5 are treated equally well in other standard references on the same material. The following are particularly well done: Philip M. Morse's Vibration and Sound, which recently has been reissued, and Kinsler and Frey's Fundamentals of Acoustics.

Chapters 6 and 7, however, present an extensive treatment of passive reciprocal electromechanical and electroacoustical transducers and corresponding electrical network equivalents. Good coverage of the theory of acoustical receivers is provided, so that the author presents a solid basis for the inner workings of microphones and acoustical sensors. The last two chapters are the main contribution of the text.

In conclusion, the book is well written and contains a large number of clear illustrations and worked examples. It is recommended for those particularly interested in the theory of electromechanical and electroacoustical transducers and receivers. However, the material on acoustics and mechanical vibrations is treated in more depth in the other texts mentioned.

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EINFUHRUNG IN DIE BERECHNUNG PARAMETERERREGTER SCHWINGUNGEN

N. Eicher
Technische Universitat Berlin, Berlin, Germany
1981, Revised Edition, 413 pp, 17 DM (in German)

The book is concerned with the computation of parametric oscillations. It is organized as follows.

General properties of parametric oscillations are investigated in Chapters 1-5 with the aid of the Floquet theorem. Basic concepts, characteristics, and a classification of oscillations are presented in Chapter 1. Chapter 2 is concerned with the solution of linear homogeneous differential equations with periodic coefficients and the stability/instability of the solution; the Floquet theorem is presented and applied. Chapter 3 deals with the solution of the Hill equation and the stability/instability of the solution. The solution of the Mathieu equation and the stability/instability of the solution are covered in Chapter 4. Chapter 5 is concerned with the determination of regions of stability and instability.

Chapter 6 presents a numerical procedure for the successive approximation of solutions to nonlinear integrodifferential equations. It is applied in subsequent chapters.

Chapters 7-13 deal with various differential equations, various effects, and solution properties, such as nonlinear parametric excitations, regions of stability, stability criteria, and resonance.

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SHORT COURSES

FEBRUARY

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: February 6-10, 1984
Place: Santa Barbara, California
Dates: March 5-9, 1984
Place: Washington, DC
Dates: June 4-8, 1984
Place: Santa Barbara, California
Dates: August 27-31, 1984
Place: Santa Barbara, California
Dates: September, 1984
Place: Ottawa, Ontario

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 - (805) 682-7171.

MACHINERY VIBRATION ANALYSIS

Dates: February 21-24, 1984
Place: San Diego, California
Dates: May 15-18, 1984
Place: Nashville, Tennessee
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Chicago, Illinois

Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow-speed paper rolls.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MACHINERY VIBRATION ENGINEERING

Dates: February 21-24, 1984
Place: San Diego, California
Dates: May 15-18, 1984
Place: Nashville, Tennessee
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Chicago, Illinois

Objective: Techniques for the solution of machinery vibration problems will be discussed. These techniques are based on the knowledge of the dynamics of machinery; vibration measurement, computation, and analysis; and machinery characteristics. The techniques will be illustrated with case histories involving field and design problems. Familiarity with the methods will be gained by participants in the workshops. The course will include lectures on natural frequency, resonance, and critical speed determination for rotating and reciprocating equipment using test and computational techniques; equipment evaluation techniques including test equipment; vibration analysis of general equipment including bearings and gears using the time and frequency domains; vibratory forces in rotating and reciprocating equipment; torsional vibration measurement, analysis, and computation on systems involving engines, compressors, pumps, and motors; basic rotor dynamics including fluid film bearing characteristics, critical speeds, instabilities, and mass imbalance response; and vibration control including isolation and damping of equipment installation.

Contact: The Vibration Institute, 101 West 55th Street, Clarendon Hills, IL 60514 - (312) 654-2254.

DYNAMIC BALANCING SEMINAR/WORKSHOP

Dates: February 22-23, 1984
March 21-22, 1984
April 18-19, 1984
May 23-24, 1984
Place: Columbus, Ohio
Objective: Balancing experts will contribute a series of lectures on field balancing and balancing machines. Subjects include: field balancing methods; single, two and multi-plane balancing techniques; balancing tolerances and correction methods. The latest in-place balancing techniques will be demonstrated and used in the workshops. Balancing machines equipped with microprocessor instrumentation will also be demonstrated in the workshop sessions, where each student will be involved in hands-on problem-solving using actual armatures, pump impellers, turbine wheels, etc., with emphasis on reducing costs and improving quality in balancing operations.

Contact: R.E. Ellis, IRD Mechanalysis, Inc., 6150 Huntley Rd., Columbus, OH 43229 - (614) 885-5376.

VIBRATION DAMPING WORKSHOP

Dates: February 27-29, 1984
Place: Long Beach, California
Objective: The purpose of this workshop is to provide a forum for the latest state-of-the-art technology as well as selected tutorial information. Viscoelastic property measurement and representation, high-damped metals, friction damping, damping in composites, analysis and design, applications, experimental verification, controls-structure-interaction, and payoff/benefits are topics to be discussed. Also, the status of U.S. Air Force funded contracts on the Damping Design Guide, Passive and Active Control of Space Structure (PACOSS), and Reliability of Satellite Equipment in a Vibroacoustic Environment (RELSAT) contracts will be reviewed.

Contact: Mrs. Audrey G. Sachs, Administrative Chairman, University of Dayton, Research Institute, 300 College Park, Dayton, OH 45469 - (513) 229-2919.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 12-16, 1984
Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 19-23, 1984
Place: Phoenix, Arizona
Objective: Program emphasis is on how to increase productivity and cost-effectiveness for data acquisition groups in the field and in the laboratory. The program is intended for engineers, scientists and managers of industrial, governmental and educational organizations who are concerned with planning, executing, or interpreting experimental data and measurements. The emphasis is on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, Director, Stein Engineering Services, Inc., 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

APRIL

MODAL TESTING

Dates: April 3-6, 1984
Place: San Diego, California
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

ROTOR DYNAMICS

Dates: April 30 - May 4, 1984
Place: Syria, Virginia
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

FOURIER AND SPECTRAL ANALYSIS IN DYNAMIC SYSTEMS

Dates: April 30 - May 4, 1984
Place: Austin, Texas
Objective: This five day course will enable the participant to understand and apply the basic Fourier transform theory required to utilize the new digitally based Fourier and spectral analysis equipment. Lecture, demonstrations, discussions and lab will place emphasis upon a basic understanding of the digital processing of signals, including time and frequency domain characteristics, effects of sampling, windowing, statistical averaging, and some of the pitfalls present in collecting, processing, and interpreting data. Applications of the theory which will be discussed and/or demonstrated include dynamic system identification, signature analysis, random vibration, transfer function identification, experimental modal analysis, acoustics, and noise characterization and transmission.

Contact: Continuing Engineering Studies, College of Engineering, The University of Texas at Austin, Austin, TX 78712 - (512) 471-3506.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

Call for Papers

1985 ASME WINTER ANNUAL MEETING
November 17-21, 1985
Miami Beach, Florida

Symposium on Material Nonlinearity in Vibration Problems

Papers are invited by the Applied Mechanics Division on original theoretical, numerical, and experimental investigations concerning the effects of material nonlinearity on vibration problems dealing with structures, structural elernents such as beams, plates, shells, etc. It is proposed to have two technical sessions consisting of 12 papers selected by a peer-review process. The selected papers will be published in an ASME special bound volume. Authors can also submit their papers for subsequent publication in the ASME Transactions.

Authors are invited to submit a 500-word summary including title, name, work address, and phone. The summary should clearly indicate problems or questions addressed, work performed, and results and/or conclusions reached. Papers are screened solely on these summaries. Three copies of the summary should be sent by May 15, 1984 to M. Sathyamoorthy, Department of Mechanical and Industrial Engineering, Clarkson College of Technology, Potsdam, New York 13676 - (315) 268-2205. If accepted, three copies of the complete paper should be sent by October 15, 1984. Final acceptance is based on review of the full-length papers.

REVIEWS OF MEETINGS

54th SHOCK AND VIBRATION SYMPOSIUM

18 to 20 October, 1983
Huntington Sheraton Hotel
Pasadena, California

The 54th Shock and Vibration Symposium, sponsored by the Shock and Vibration Information Center (SVIC), was held in Pasadena in October. It was hosted by the Jet Propulsion Laboratory on behalf of NASA. The formal technical program consisted of more than 50 papers (see Vol. 15, No. 9 of the DIGEST for the complete program; paper summaries are available from the SVIC; papers will be published in the ***Shock and Vibration Bulletin***). Technical plenary sessions were conducted during the Symposium. Mr. Strether Smith delivered the fifth Elias Klein Memorial Lecture -- "Modal Testing -- A Critical Review." In the second plenary session Dr. George Morosow of Martin Marietta gave the Lecture -- "Solutions to Structural Dynamics Problems." The third plenary address on "Where is the Real Literature on Nonnuclear Airblast and Ground Shock?" was given by Dr. Wilfred Baker of Southwest Research Institute. A large and interesting session on short discussion topics covering many areas of mechanical vibration and shock was again held. Finally interesting panels sessions on MIL-STD-810D were conducted (see R. Volin report). Dr. J. Gordan Showalter, Acting Director of SVIC, the members of the SVIC staff, and the program committee are to be congratulated for the assembly of an outstanding program on shock and vibration technology. Among the 400 participants were representatives of the federal government, industry, academic institutions, and foreign nationals from NATO countries. The combination of formal and informal technical programs effected a meaningful transfer of shock and vibration technology.

The Opening Session

Dr. Ben Wada of the Jet Propulsion Laboratory, chairman of the opening session, introduced Mr. Robert J. Parks, Associate Director for Space Science and Exploration, Jet Propulsion Laboratory who gave the welcome address. Mr. Parks showed his appreciation for the importance of the activities of the meeting. He related the efforts of SVIC to the shock and vibration tests on Galileo and other satellites.

The keynote address on the past, current, and future problems related to structural dynamics was given by Bob Ryan of NASA Marshall Space Flight Center. Ryan expressed his favorable impressions on the record of the SVIC. He related the fact that training of the past has trapped us in linear thinking -- we need more lateral depth to get us out of that rut. A summary of where we have been with large launch vehicles usch as Saturn, satellites, and the shuttle program was given. Ryan reviewed where we are today with our utilization of space -- special missions, DoD facilities, space lab, and space telescope. He discussed where we are going and man's presence in space -- shuttle operations, space science, space applied technology, and aeronautics.

Ryan discussed the disciplines involved in space activities -- rotor dynamics, structural modeling, loads, response, criteria, testing, and reliability. A real funding challenge exists -- work goes up and real dollars go down. He described a generic problem area involving a high performance pump with all the technology areas. The solution of the problem involved iteration processes not commonly used. In the area of response analysis, the past (rigid body) and present (400 modes under 120 Hz) models of dynamic systems were discussed. The different dynamic test techniques were reviewed along with new design requirements where deformation oriented criteria must be used. In the area of structural dynamics the design load cycle must be improved -- conservatism is too great. Better models with finer resolution will be required.

The challenges of large space systems technology were set down: design for maintenance, refurbishment, and growth; design and verification from an integral test stand with all disciplines considered simultaneous; robust and forgiving designs; innovative development tools for large complex systems; use dynamic instead of quasistatic stress analysis; and extend the capabilities available in fluid and structural analyses.

In conclusion Ryan expressed the fact that it is time to reflect and go back to the basics, tools must be sharpened, alignments accelerated, high quality materials developed, and techniques hand polished and hone finished.

The first invited paper was given by Colonel Kovel of the Defense Nuclear Agency (DNA) on the DNA ICBM Technical R&D Program. Kovel gave a brief description of the DNA, its mission and operations, interactions with other agencies, and research activities. He showed DNA to be the focal point in the area of shock physics where the integration of research and testing efforts are managed. The DNA ICBM basing research and development program was reviewed. Its purpose being information for a national decision based on technology. Feasibility for silos and small mobile missiles is being explored to resolve uncertainties and establish maximum credible hardening levels. Kovel discussed a small generic missile with range, payload, and accuracy. The objectives in advanced silo hardening were reviewed including uncertainties on hardness levels, concepts, and test plans.

Colonel Kovel discussed the advanced silo hardening program scope – structural systems technology, environment definition, testing techniques, and field testing. He showed the historical trend in silo design including new design concepts. The Air Force analysis and test work on shock isolation systems was described including concepts – vertical active damping, barriers, crushable concrete. The hardened mobile missile basing concept was discussed -- hardened transporters, erectors, and launchers. Strategies for random moves on basing roads were described.

Nonideal airblast environments were summarized with respect to test technology development, air blast simulation, a large scale reusable airblast test facility, mobile basing hardening and validation, and transporter overturning.

In conclusion Kovel expressed the goal of incorporating existing technology into new needed concepts.

Dr. James R. Richardson of the U.S. Army Missile Laboratories discussed some dynamics problems in Army missile systems. Richardson discussed the varied sizes of missiles used and the fact that generic kinds of problems exist. The sources of dynamic loading on missile systems -- transportation, launch, and flight – were reviewed. Richardson discussed the problems involved in the concept, design, performance, and fielding along with the tools available for their solution. The present trend in design is for lighter, faster, cheaper, higher performing, and more versatile missiles. The role of composite materials in design was discussed. He noted that the more innovation needed can be done with dynamic design and better qualification testing. Richardson closed with some case histories on the VIPER, HELLFIRE, and HAWK missiles.

Colonel Frank J. Redd of the Air Force Space Technology Center spoke on the topic, "Space Technology Center -- Emphasis '84." Colonel Redd reviewed the mission and program of the new center (founded 1 October, 1982). He expressed the view that the formation of the Air Force Space Technology Center from Office of Space Plans and Operations was analogous to the formation of the Army Air Corp from the Army Signal Corp. The mission of the new center involves military space system technology, nonconventional and advanced weapons, geophysics, and coordination of non Air Force Space Technology labs.

Colonel Redd showed the organization, personnel, budget, and interfaces of the Center. The activities of the group including advanced space planning were discussed. Also noted was an emphasis on survivability instead of performance. He discussed the fact that satellites were not autonomous and were heavily dependent on vulnerable ground stations. The need for hardened ground facilities was expressed. The space nuclear reactor program development and goals were discussed. In summary Colonel Redd reviewed the opportunities for the center and the advanced technology required to achieve their goals.

Mr. Henry Pusey (former Director of SVIC) of NKF Engineering Associates spoke on the Navy's perspective on trends in dynamics. Pusey noted that today technology is advancing at a rapid pace -- contrasted with earlier slow development. These rapid changes have great impact on how warfare is conducted and places great demand on support. He traced the historical development of ship technology from the steamboat to current nuclear powered aircraft carriers. This evolution has placed many demands on supporting technologies -- one being dynamics. His presentation focused on the mechanical shock branch of dynamics as applied to ships -- air blast and underwater explosion. Pusey reviewed component shock tests, ship shock tests, shock design, shock spectra, shock measurement, shock isolation, progress in technology, and needs for the future.

In the area of shock tests he discussed the high impact shock machine -- tracing its development from WWI. He noted that it remains the preferred method of confirming shock resistance. He discussed research ship shock tests with the need to understand underwater explosions and gather design data and establish test criteria. Routine ship testing for certification was briefly reviewed. Pusey expressed the fact that reliability type test knowledge needs to be fed back into design work.

The evolution of shock design procedures from rules of thumb to static "g" method to the Dynamic Design Analysis Method (DDAM) was reviewed by Pusey. The role of shock spectra -- conceived by Biot and applied by Walsh -- in design was discussed.

In the area of measurement Pusey traced the development of instrumentation from the development of the quartz accelerometer in 1943 to on-line computers today. Shock isolation philosophy was briefly reviewed. Pusey noted that it presents a difficult design problem to use it and therefore should be used only when essential. Isolation hardware must not be a factor in amplifying other ship vibration environments.

Pusey cited the progress that has been made in improved shock resistance, firm hardware goals, test capabilities, advanced analysis capabilities, and improved design methods. Mr. Pusey closed with a discussion on needs for the future -- more diversified test capabilities including scale models, improved test fixtures, a data bank on test experiences, experimental work on dynamic yielding, research on and application of plastic design, analytical techniques on shock, whole ship analysis, application of modal testing to ships, and improved technical information activities.

The Plenary Sessions

The Elias Klein Memorial Lecture was given by Mr. Strether Smith of Lockheed Palo Alto Research Laboratory. The title of this interesting and comprehensive lecture was "Modal Testing -- A Critical Review." Smith talked about the art and science of modal testing including concepts, linearity, stiffness, damping, integration, and the frequency response function (FRF). He discussed the well developed tools available for these tasks. Smith reviewed some of the pitfalls in modal testing -- nonlinear materials and joints, noncoherent sources, and nonrepeatable tests.

The selection of the excitation for modal tests was discussed extensively. Single frequency versus multifrequency testing was reviewed. The excitation options including hammer and energy release (impact types) to steady state types such as electrodynamic and electrohydraulic. The advantages and disadvantages of impulse, sine sweep, chirp, random and multiple input random excitations were discussed by Smith.

Mr. Smith historically reviewed the field -- response tests in the 30's, tuned dwell in the 40's , single excitation sine sweep of Kennedy and Pancu, single excitation multiple frequency curve fit of Klosterman and Richardson, multiexciter curve fit of Smith, frequency domain analysis of Richardson and Potter, and time domain eigensolution technology. He also discussed modal test design including practical considerations and available equipment.

Smith went on to give interesting examples including the Galileo spacecraft test. He showed the next generation of modal testing equipment and reviewed the new challenges in modal testing including ground and space testing of large space structures.

The presentation in Plenary B was given by Dr. George Morosow of Martin Marietta Corporation on solutions to structural dynamics problems. Dr. Morosow gave a hypothetical interview which revealed future capabilities needed. He gave a history of computation for engineering beginning with the 1950's. The main theme of the talk involved modular versus fixed black box type programs. In the beginning engineers used a modular approach because modules were developed as the need occurred. Lately engineers are more prone to use black box programs because of high efficiency and ease of use. Of course the black box programs are difficult and time consuming to develop.

Morosow went on to compare the structure of computer programs to the structure of different types of languages. Languages like English use the modular approach in building up words whereas the Asian languages use the black box approach for word structure. He showed how a simple problem is solved by the two approaches. He noted in his conclusion that less skilled engineers could not tamper with fixed programs (black box) but in general better versatility and success can be obtained with the modular approach.

The Plenary C lecture was given by Dr. Wilfred E. Baker of Southwest Research Institute on the topic of the location of the real literature on nonnuclear airblast and ground shock. Dr. Baker identified the potential literature sources -- books, periodicals, technical reports and proceedings. He limited his lecture to unclassified, English language documents. He noted the sources of literature within the reports of DoD and its contractors, DOE, NASA, Bureau of Mines, and foreign agencies. Baker classified the literature into open and report literature. He surveyed the references according to number of books, reports and papers. He also related how authors referenced literature of others. Government authors referenced reports rather than open literature -- academics referenced the open literature. He suggested that both groups should have a look at the entire literature.

Technical Sessions

The technical sessions featured a varied number of papers on testing, computation, and hardware. Sessions on ship shock, shock, blast/ground shock, structural dynamics, machinery dynamics, space vibration, and vibration problems were conducted. An interesting short discussion topics session was held on Thursday afternoon.

In the ship shock session papers were given on human response, energy absorbing mounts and securing devices, and ship shock response -- test versus analysis. The shock session featured papers on verification of computational models with test data, shock test specification, vibroimpact experiments, models for shock induced damage, numerical simulation of acoustic fields, and the effect of mass loading on the shock environment. The session on blast/ground shock was devoted to papers on seismic survivability, dynamic response to underground arches, ground shock effect on soil field inclusions, airblast environments, design criteria, and computational procedures.

The structural dynamics session featured papers on viscoelastic elements, computational procedures, modal analysis of structural systems involving nonlinear coupling, cylindrical shells and ship hulls. Machinery dynamics papers were given on a gear case vibration isolation device, the effect of coupled torsional-flexural vibration of geared shaft systems, torsional oscillations induced by gear errors and analysis of blading using lumped parameter methods.

An interesting session on space vibration contained papers on space structures vibration control, system design for vibration control of space structures, transient vibration test criteria, and shuttle transient thermal problems. The session on vibration problems featured papers on container vibration, flow induced vibrations, off road vehicles, active vibration isolation, and random vibration testing and quantification.

The Fifty-fourth Shock and Vibration Symposium was both technically informative and interesting yielding a large number of excellent papers. Again the plenary sessions with their overviews and philosophical insights added incomprehensible value to the meeting for new and experienced engineers. The Shock and Vibration Symposium continues to be the major annual event in this field and the SVIC can be congratulated for their continued maintenance of the quality of the technical presentations and the organization of interesting update lectures, overviews, and philosophical discussions so necessary for a complete meeting. Papers presented at the Symposium will be reviewed for quality of technical content and published in the 54th **Shock and Vibration Bulletin** published by the SVIC.

The Symposium was concluded with a successful tour of the Jet Propulsion Laboratory.

R.L.E.

The MIL-STD-810D Sessions

If attendance is any measure of the success of sessions at technical meetings, then the two sessions on MIL-STD-810D must have been successful because both were well attended. Before briefly reviewing these sessions, I wish to thank all authors, the panelists, the cochairmen, and the chairmen for their contributions to these sessions. Special thanks are due to Dr. Sheldon Rubin for suggesting that this standard should be discussed at this symposium. Special thanks are also due to Mr. Eli Lesser of the Defense Materiel Specifications and Standards Office for his help in securing enough copies of MIL-STD-810D for distribution at the meeting. Their availability certainly helped generate interest in both of these sessions.

To summarize the content of these sessions, the morning session concerned the rationale behind MIL-STD-810D. Its chairman and cochairman were John Wafford of the Aeronautical Systems Division and Bob Hancock from the Vought Corporation. In that session Dr. Sheldon Rubin from the Aerospace Corporation described the changes in the shock testing procedures. A presentation coauthored by David Earls, Dr. Alan Burkhard and Scott Hall, all from the Wright Aeronautical Laboratories, described the overall impact of MIL-STD-810D on the environmental testing process; David Earls made this presentation. The session was concluded with a contributed paper by Henry Caruso and Edward Szymkowiak from the Westinghouse Electric Corporation on the response of Line Replaceable Units to bench handling shock; Edward Szymkowiak made the presentation.

I was capably assisted by Wallace Parmenter from the Naval Weapons Center in chairing the afternoon session. This session dealt with the implementation and the use of MIL-STD-810D, and it included formal presentation followed by a panel discussion. Howard Allen from the Rockwell International Corporation made the first presentation, and he described their experiences in developing vibration test criteria for Apollo and Space Shuttle Equipment. Harry Himelblau, also from the Rockwell International Corporation, and Marion Coody from the NASA Johnson Space Center were his coauthors. Dr. Allen Curtis from Hughes Aircraft Company discussed the impact of MIL-STD-810D on laboratory shock and vibration test procedures. Jack Robinson from the Army Test and Evaluation Command participated in the panel session along with the authors of the invited papers.

To conclude, space does not permit the discussion of the many changes to this version of MIL-STD-810. Overall, this document is more flexible because it provides for tailoring test conditions to specific platforms, and many of its test methods permit low level tests to be deleted if it is known that the equipment will be exposed to similar tests that are more severe. However, the increased flexibility in this standard is provided at the cost of requiring environmental engineering expertise to intelligently apply its provisions for developing realistic environmental test requirements.

R.H.V.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

Government Reports:	NTIS Springfield, VA 22151 (unless otherwise indicated)
Ph.D. Dissertations:	University Microfilms International 300 N. Zeeb Rd. Ann Arbor, MI 48106
U.S. Patents:	Commissioner of Patents Washington, DC 20231
Chinese Publications (CSTA):	International Information Service, Ltd. P.O. Box 24683 ABD Post Office Hong Kong (In Chinese or in English translation)

In all cases appropriate order numbers should be used (last line of citation).

When not available in local 'ibraries, copies of the majority of papers or articles may be obtained at Engineering Societies Center, 345 E. 47th St., New York, NY 10017, or Library of Congress, Washington, DC.

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

A list of periodicals scanned in published in issues 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

84-1

Unbalance Response of a Single Mass Rotor Mounted on Dissimilar Hydrodynamic Bearings

R. Subbiah, R.B. Bhat, and T.S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 113-125 (May 1983) 9 figs, 6 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Rotors, Bearings, Hydrodynamic bearings, Critical speeds, Unbalanced mass response

The critical speeds and unbalance response of a single mass rotor, mounted on dissimilar fluid-film bearings at the ends, are studied. The direct and cross-coupled coefficients of stiffness and damping at the bearings are included in the analysis, which are expressed as polynomials in Sommerfeld number. The equations of motion are obtained by Lagrangian approach. The resulting equations of motion are solved to obtain the unbalance response and critical speeds. Numerical results are obtained for a laboratory model of a single mass rotor and the effects of various parameters of the system on the response are investigated.

84-2

Prediction of Critical Speeds, Unbalance and Nonsynchronous Forced Response of Rotors

P. Berthier, G. Ferraris, and M. Lalanne

I.N.S.A., Laboratoire de Mecanique des Structures, E.R.A. C.N.R.S. 911 20, avenue Albert Einstein, 69621 Villeurbanne - France, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 103-111 (May 1983) 12 figs, 19 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Rotors, Critical speeds, Unbalanced mass response, Nonsynchronous vibration, Gas turbines, Turbines, Compressors

The dynamic behavior of rotors must be accurately predicted at the design stage of construction of rotating machinery. General equations of rotors consisting of symmetric shafts, rigid discs and nonsymmetric bearings are presented. These equations are obtained by using a finite element technique and solved with a modal method. Two industrial applications, a gas turbine and a centrifugal compressor, are presented for which the critical speeds, unbalance and nonsynchronous forced response are calculated.

84-3

Nonlinear Coupling Responses to Variable Frequency Excitations

F.H. Wolff and A.J. Molnar

Engineering-Analytical Dynamics Corp., Trafford, PA 15085, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 127-135 (May 1983) 15 figs, 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shafts, Torsional vibration, Couplings, Nonlinear systems, Tuning

Effects of a nonlinear coupling with a hardening torque-deflection characteristic on shaft torsional vibrations from a variable frequency excitation are calculated. Amplitudes for an accelerating excitation frequency are greater than amplitudes predicted by linear theory whereas amplitudes for a decelerating excitation frequency are less than amplitudes predicted by linear theory. With a nonlinear coupling both harmonic and subharmonic vibrations can occur when more than one vibration mode is involved.

84-4

Definition of Forces on Turbomachinery Rotors. Task B Report: Dynamic Analysis of Rotors

D.W. Childs

Texas A&M Univ., College, Station, TX, Rept. No. NASA-CR-170763, 105 pp (Mar 1, 1983)
N83-24507

Key Words: Rotors, Turbomachinery, Liquid propellant rocket engines

The rotordynamic characteristics of turbomachinery are known to depend on the forces developed due to relative motion between the rotor and the housing. For example, the critical speed locations generally depend on the bearing stiffnesses, seal damping influences rotor stability and bearing reaction amplitudes near critical speeds, etc. A systematic examination of the influence of changes in the forces acting on rotors is studied. More specifically, the sensitivity of the rotordynamic characteristics to changes in rotor forces is analyzed. Rotordynamic characteristics of the high pressure oxygen turbopump and high pressure fuel turbopump of the space shuttle main engine are investigated.

84-5

Rotationally-Sampled Flow-Field Measurements for Vertical-Axis Wind Turbines

R.E. Akins

Sandia Natl. Labs., Albuquerque, NM, Rept. No. SAND-82-2341C, CONF-830432-2, 6 pp (1983) DE83009550

Key Words: Turbines, Blades, Wind turbines, Turbulence

The effects a wind-turbine blade moving through a turbulent flow field have on the frequency content of the relative velocity seen by the blade are an important aspect of the aerodynamically induced loads and may also contribute to the fatigue loads. Recent work has emphasized these effects in large horizontal-axis turbines. Measurements of a rotationally-sampled flow field using the DOE/Sandia 17-m research turbine have been completed. These measurements show increased energy content at integer multiples of rotation rate and indicate why rotational sampling may be an important concept in rotor design.

84-6

Fans. Noise/Vibration Control: Now More Vital than Ever

J. Reason, Assoc. Editor

Power, 127 (9), pp 20-24 (Sept 1983) 11 figs

Key Words: Fan noise, Noise generation, Noise reduction

Three major sources of fan noise: blade passing frequency, air turbulence around the blades, and mechanical vibration of the fan housing and drive, resulting from inadequate design on maintenance are discussed, and means for controlling it are described. Fan wheel balancing is also critical. Use of silencers is recommended only as a last resort. Three case histories illustrate some problems and their solutions.

84-7

Forces on a Whirling Centrifugal Pump-Impeller

D.S. Chamieh

Ph.D. Thesis, California Inst. of Tech., 220 pp (1983) DA8315843

Key Words: Pumps, Centrifugal pumps, Impellers, Rotors, Turbomachinery, Fluid-induced excitation, Whirling

The present work is an experimental and theoretical investigation of the possible forces of fluid dynamic origin that can act on a turbomachine rotor particularly when it is situated off its normal center position. An experimental facility, the Rotor Force Test Facility, has been designed and constructed in order to measure these kinds of forces acting on a centrifugal pump impeller when the latter is made to whirl in a slightly eccentric circular orbit. The rotor speed, eccentric orbital radii and whirl speed could be varied independently. The scope of the present experimental work consists of measuring quasi-steady forces on the impeller as it whirls slowly about the axis of the pump rotation.

84-8

Noise from Small Heat Pumps

A. Jagenäs

Chalmers Univ. of Tech., Dept. of Bldg. Acoustics, S-412 96 Goteborg, Sweden, Noise Control Engrg., 21 (2), pp 56-65 (Sept/Oct 1983) 18 figs, 6 refs

Key Words: Compressors, Pumps, Noise generation

Small heat pumps, which are commonly used in one-family dwellings in Sweden, are investigated. Compressors are usually the main noise sources in heat pump systems. During the last ten years, manufacturers have succeeded in reducing A-weighted noise levels by 10 to 20 dB without modifying the compressors. Sound levels of some new heat pumps are still rather high and positioning in houses is critical.

RECIPROCATING MACHINES

(Also see No. 209)

84-9

Study of Dynamic Energy Equations for Stirling Cycle Analysis

V.H. Larson

Cleveland State Univ., Cleveland, OH, Rept. No. NASA-CR-168152, 44 pp (Apr 1983) N83-25043

Key Words: Stirling engines, Energy methods, Computer programs

An analytical and computer stuo,' of the dynamic energy equations that describe the physical phenomena that occurs in a Stirling cycle engine is presented. The basic problem is set up in terms of a set of hyperbolic partial differential equations. The characteristic lines are determined. The equations are then transformed to ordinary differential equations that are valid along characteristic lines. Computer programs to solve the differential equations and to plot pertinent factors are described.

METAL WORKING AND FORMING

84-10

Relative Assessment of the Dynamic Behavior and Cutting Performance of a Bonded and a Cast-Iron Horizontal Milling Machine

H.C. Chang, M.M. Sadek, and S.A. Tobias
Dept. of Mech. Engrg., Beijing Inst. of Post and Telecommunications, Peking, China, J. Engrg. Indus., Trans. ASME, 105 (3), pp 187-196 (Aug 1983) 13 figs, 2 tables, 12 refs

Key Words: Milling (machinery), Cutting, Machinery vibration, Chatter

The dynamic behavior and cutting performance of a horizontal milling machine, the structure of which was fabricated by bonding, are compared with those of a machine of nominally identical specification but containing cast structural components. Theoretical work predicted the chatter performance of these two machines from vibration tests, using dynamic cutting coefficients characterizing material behavior. The relative performance of the two machines is discussed with the aid of the predicted stability charts, relating to specific cutting conditions, and in a more general form, through merit charts.

84-11

Plane Strain Visioplasticity for Dynamic and Quasi-Static Deformation Processes

S.N. Dwivedi
Univ. of North Carolina at Charlotte, Charlotte, NC, J. Engrg. Indus., Trans. ASME, 105 (3), pp 197-202 (Aug 1983) 14 figs, 15 refs

Key Words: Machinery, Dynamic response

The visioplasticity approach is developed to enable the complete stress history of any steady or nonsteady, quasi-static or impact, plane strain plastic deformation process to be determined from a record of the deformation pattern. The velocity field is determined experimentally, and, for dynamic conditions, high-speed photographs are taken of grid patterns marked on the end surface of the specimen. Digitization of the instantaneous grid node positions allows the velocity fields to be obtained at predetermined time intervals throughout the transient deformation period. Hence, the strain-rate, equivalent strain rate, equivalent strain, and finally stress fields can all be obtained.

84-12

Development of a Prototype Retrofit Noise Control Treatment for Jumbo Drills

N.R. Dixon and M.N. Rubin
Bolt Beranek and Newman, Inc., Cambridge, MA, Rept. No. BUMINES-OFR-111-83, 107 pp (July 1982)
PB83-218800

Key Words: Drills, Rock drills, Noise reduction

The noise and vibration levels of four jumbo drills were characterized and a survey of percussive rock drill usage is reported. A Gardner-Denver DH 123 drill was chosen as a demonstration drill, and extensive noise diagnostic studies were performed. Noise control treatments were designed, developed, and evaluated in a reverberant drill test facility.

STRUCTURAL SYSTEMS

BRIDGES

84-13

Anchorage Plates for Cable-Stayed Bridges

C.P. Heins and K.-I. Kano
Civil Engrg. Dept., Univ. of Maryland, College Park, MD 20742, Computers Struc., 18 (1), pp 47-54 (1984) 16 figs, 7 refs

Key Words: Bridges, Cable-stayed bridges, Cables, Plates, Finite element technique

The design of cable-stayed bridges requires the engineer to examine in detail the local force distribution in the plates

which transfer the cable force to the main structure. The response of these plate elements, when subjected to the cable forces, is presented using the finite element method. The results are presented so that rapid evaluation of their strength can be determined.

84-14
Dynamic Response of Orthotropic Curved Bridge Decks Due to Moving Loads

S.S. Dey and N. Balasubramanian
Civil Engrg. Dept., Indian Inst. of Tech., Kharagpur - 721 302, India, Computers Struc., 18 (1), pp 27-32 (1984) 4 figs, 1 table, 16 refs

Key Words: Bridges, Moving loads

The dynamic response of horizontally curved bridge decks simply supported along the radial edges under the action of a moving vehicle is investigated. The bridge deck is idealized as a number of finite strips with orthotropic elastic properties. The stiffness and mass matrix of an individual element are derived using a homogeneous differential equation of an orthotropic plate in polar co-ordinates. The vehicle is idealized as a sprung mass moving at a constant speed in a circular path parallel to the central line of the bridge. Dynamic deflections and moments are presented for the mid-point of the bridge deck and values are compared with the available analytical solution.

BUILDINGS

84-15
Wind Response of Asymmetrical Buildings

S.M. Sharifan
Ph.D. Thesis, Polytechnic Inst. of New York, 158 pp (1983)
DA8316780

Key Words: Buildings, Wind-induced excitation, Torsional response

Uncertainties and shortcomings of current procedures for computing gust wind response of tall buildings, including bilateral translations and torsional displacements, are a main concern of structural engineers. Investigators who study the dynamic response of tall buildings under the action of gust wind usually consider the structure to be symmetrical and continuous. In this investigation, general equations of motion of a system are derived. The quasi-static representation of steady wind load and the random characteristics of the gust wind are utilized in determining the random response of the system. Random processes to describe the response of the discretized model under action of gust wind are developed. In order to derive the dynamic equations of motion for a tall building, the structure is idealized by a condensed system with fewer degrees of freedom while it includes the asymmetrical characteristics of the original system.

84-16
Analytical and Experimental Investigation of Structural Response - The Imperial County Services Building

G.C. Pardoen
Dept. of Civil Engrg., Univ. of California, Irvine, CA, Rept. No. NSF/CEE-83007, 222 pp (1983)
PB83-227579

Key Words: Buildings, Earthquake damage

Results are presented of a study undertaken to explain the failure of a building in California during the October 1979 earthquake. Ambient and forced vibration tests were conducted and elastic and inelastic response analyses were performed; the results of these investigations appear in the appendices. An analytical finite element model was developed that correlates the building's response due to low level forced vibration.

84-17
Vibration Testing of an Epoxy-Repaired Four-Story Reinforced Concrete Structure

R.E. Scholl and G.N. Owen
URS/John A. Blume and Associates, San Francisco, CA, Rept. No. CONF-830507-1, 12 pp (1983) (U.S./Japan Seminar on Repair and Retrofit of Structures, San Francisco, CA, May 13, 1983)
DE83003136

Key Words: Buildings, Multistory buildings, Reinforced concrete, Vibration tests

A full-scale, 4-story reinforced concrete structure, deliberately damaged by forced vibration, was repaired by the epoxy-injection method and again deliberately damaged by forced vibration. At low-amplitude motions, the epoxy-repaired structure was slightly less stiff than the original, undamaged structure. However, at large deflections associated with severe damage, the epoxy-repaired structure was stiffer than the original structure.

TOWERS

84-18

Local Vibration of Transmission Line Towers Due to Flood Flow

Central Power Res. Inst., Bangalore, India, Rept. No. TR-110, 24 pp (May 1982)
PB83-216960

Key Words: Towers, Transmission lines, Fluid-induced excitation, Vibration control

Local vibration of transmission line towers due to flood flow affects the slender lattices close to ground level. This is especially the case with broad based tangent towers for single conductor lines, since the stresses in the lattices are nominal and must be designed on the consideration of upper limit of slenderness ratio. Sustained flood flow can cause dynamic stresses resulting in yielding of the lattices, ultimately leading to failure of the tower itself.

84-19

Static and Dynamic Behavior of Mechanical Components Associated with Electrical Transmission Lines

P.G.S. Trainor, N. Popplewell, A.H. Shah, and R.B. Pinkney
Univ. of Manitoba, Winnipeg, Canada, Shock Vib. Dig., 15 (6), pp 27-38 (June 1983) 77 refs

Key Words: Transmission lines, Towers, Strings, Foundations, Reviews

This article describes the behavior of transmission towers, insulator strings, conductors, and foundations as determined from theoretical analyses, model testing, and full-scale tests. Line vibration is also briefly reviewed.

84-20

Nonlinear Dynamic Analysis of Guyed Tower Platforms

S. Y. Hanna, A. Mangiavacchi, and R. Suhendra
Brown and Root, Inc., Houston, TX 77001, J. Energy Resources Tech., Trans. ASME, 105 (2), pp 205-211 (June 1983) 7 figs, 1 table, 9 refs

Key Words: Towers, Guyed structures, Off-shore structures, Drilling platforms, Nonlinear response

A method of analysis is presented to predict the nonlinear dynamic behavior of compliant offshore structures, in particular guyed tower platforms. The structural model is analyzed in time domain using the normal mode superposition approach. Nonlinearities due to fluid-structure interaction are considered. The nonlinear stiffness of the mooring system is included by suitable modification of the forcing function. Secondary overturning effects due to large deflection are introduced by equivalent lateral forces at each mass point.

84-21

On the Efficiency of Some Recently Developed Integration Algorithms for Offshore Platforms

T.K. Datta and A.M. Sood
Dept. of Civil Engrg., Indian Inst. of Tech., Delhi, New Delhi, India, J. Energy Resources Tech., Trans. ASME, 105 (1), pp 73-77 (Mar 1983) 5 figs, 4 tables, 10 refs

Key Words: Towers, Off-shore structures, Time domain method, Integral equations, Equations of motion

The efficiency of some recently developed integration schemes is evaluated by applying them to the response analysis of an idealized offshore tower. The tower is fixed at the base, having an additional mass at the top. For the analysis the tower has been modeled as an assemblage of 2-D beam elements.

FOUNDATIONS

(Also see No. 19)

84-22

Seismic Analysis of Three-Dimensional Soil-Structure Interaction System with a Rectangular Base

S. Saylan
Ph.D. Thesis, The George Washington Univ., 140 pp (1982)
DA8310880

Key Words: Interaction: soil-structure, Foundations, Seismic analysis

An analytical procedure describing the three-dimensional soil-structure interaction effects is developed. The structure is modeled as an assembly of finite elements representing the three-dimensional superstructure which is attached to a rectangular base on a halfspace. Using the triple Fourier transform techniques, dynamic displacement equations of the three-dimensional elastic half-space are solved.

HARBORS AND DAMS

84-23

Vibration Test of Richard B. Russell Concrete Dam Before Reservoir Impoundment

V.P. Chiarito and P.F. Mlakar

Structures Lab., Army Engineer Waterways Experiment Station, Vicksburg, MS, Rept. No. WES/TR/SL-83-2, 89 pp (May 1983)

AD-A128 844

Key Words: Dams, Vibration tests, Natural frequencies, Mode shapes, Experimental test data

A forced vibration test of the Richard B. Russell Dam was conducted before an appreciable reservoir was impounded. Hence a rare opportunity was seized to experimentally measure the dynamic properties of a concrete gravity dam without hydrodynamic interaction. The structure was excited at three locations by a crest mounted 17,000-pound inertial mass which was driven by an electrohydraulic servo-controlled actuator.

CONSTRUCTION EQUIPMENT

(See Nos. 68, 69)

PRESSURE VESSELS

84-24

Corrosion Fatigue Crack Growth in Reactor Pressure Vessel Steels in PWR Primary Water

P.M. Scott and A.E. Truswell

Materals Dev. Div., AERE Harwell, Didcot, Oxon, Oxfordshire, UK, J. Pressure Vessel Tech., Trans. ASME, 105 (3), pp 245-254 (Aug 1983) 12 figs, 4 tables, 15 refs

Key Words: Pressure vessels, Nuclear reactors, Fretting corrsion, Fatigue life

Experimental results for corrosion fatigue crack growth in several different ferritic pressure vessel steels including A533-B and A508-III exposed to simulated PWR primary water at 288°C are described. Since relatively little influence of environment was detected in low-frequency tests on these materials, in contrast with data reported from another laboratory, specimens have been exchanged and tested in each laboratory. These results are described, and possible reasons for the observed differences when each tested the same material are discussed.

84-25

An Analysis of Dynamic Crack Propagation and Arrest in a Nuclear Pressure Vessel under Thermal Shock Conditions

J. Jung and M.F. Kanninen

Sandia Natl. Labs., Albuquerque, NM 87185, J. Pressure Vessel Tech., Trans. ASME, 105 (2), pp 111-116 (May 1983) 9 figs, 1 table, 15 refs

Key Words: Pressure vessels, Nuclear reactors, Crack propagation, Temperature effects

The inner wall of a nuclear pressure vessel can become embrittled during service due to irradiation effects. As a result, a small flow could become critical during the thermal shock that would accompany a loss-of-coolant-accident. To assess the consequences of this possibility, elastodynamic computations were performed on the subsequent rapid unstable crack run-arrest events. Using plausible estimates, computational results were obtained for comparison with conventional quasi-static analyses.

POWER PLANTS

(Also see Nos. 24, 89, 202, 210)

84-26

Seismically-Induced Sloshing Phenomena in LMFBR Reactor Tanks

D.C. Ma, W.K. Liu, J. Gvildys, and Y.W. Chang

Argonne Natl. Lab., Argonne, IL, Rept. No. CONF-820705-13, 34 pp (1982) (Joint ASME/ANS Nuclear Engrg. Conf., Portland, OR, July 25, 1982)

Portions are illegible in microfiche products.

DE83008932

Key Words: Interaction: structure-fluid, Nuclear reactors, Sloshing, Seismic excitation

A coupled fluid-structure interaction solution procedure for analyzing seismically-induced sloshing phenomena in fluid-tank systems is presented. Both rigid and flexible tanks are considered. Surface-wave effects are also included. Results demonstrate that tank flexibility could affect the free surface-wave amplitude and the sloshing pressure if the natural frequency of the fluid-structure system is below 5 Hz.

OFF-SHORE STRUCTURES

(Also see Nos. 20, 21, 126, 127, 191)

84-27

Hydrodynamic Loads on Flexible Marine Structures Due to Vortex Shedding

M.J. Every, R. King, and O.M. Griffin

BHRA Fluid Engrg., Cranfield, Bedford, UK, J. Energy Resources Tech., Trans. ASME, 104 (4), pp 330-336 (Dec 1982) 16 figs, 1 table, 19 refs

Key Words: Off-shore structures, Underwater structures, Pile structures, Vortex-induced vibration, Fluid-induced excitation

A comparison is made of experimental measurements and a recently developed methodology for the prediction of the increase in the steady drag of a cylinder undergoing vortex-induced vibrations. Experimental results obtained during the development of a means to reduce the flow-induced vibration of a cable-suspended pile of the COGNAC platform installation agree well with the predictions made in this paper.

84-28

The Significance of Dynamic Response in the Estimation of Fatigue Life

J.K. Vandiver

Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Energy Resources Tech., Trans. ASME, 104 (4), pp 369-372 (Dec 1982) 1 fig, 6 refs

Key Words: Off-shore structures, Fatigue life, Wave forces, Natural frequencies, Modal damping

The fatigue life of offshore structures is investigated under the conditions that dynamic response to waves is assumed to play a significant role. Under these conditions, the study emphasizes the significance of the placement of natural frequencies and the amount of modal damping. The results may be used to assess the confidence bounds on fatigue life estimates that result from uncertainties in design stage estimates of structural natural frequencies and damping.

84-29

Design Against Collision for Offshore Structures

Y. Mavrikios and J.G. deOliveira

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-83-7, NOAA-83052510, 180 pp (Apr 1983)

PB83-210468

Key Words: Off-shore structures, Collision research (ships)

The force deflection curve for a rigid-plastic circular cylinder subjected to transverse loading applied by a sharp wedge is derived following an energy approach. A local deformation field is assumed and global deformation of the cylinder acting as a beam is neglected. The concept of the moving hinge with no slope discontinuity is used. The effects of the global deformation of the cylinder are then taken into consideration, and the overall force-deflection curve of the member acting as a beam is calculated.

84-30

Noise Control for an Offshore Drilling Facility

S.P. Ying

Gilbert/Commonwealth, 209 E. Washington Ave., Jackson, MI 49201, Noise Control Engrg., 21 (2), pp 66-73 (Sept/Oct 1983) 10 figs, 7 refs

Key Words: Off-shore structures, Drilling platforms, Noise generation, Noise reduction

A comprehensive audible noise diagnosis on a large offshore oil rig was conducted using the coherence function technique to identify noise sources. Structure-borne noise, which was produced by engine generators and air conditioners, propagated into the control room, radio room, offices and the living quarters through steel structures. Noise control recommendations included the installation of vibration isolators and silencers for the noise sources. Acoustical treatment of a few special areas was suggested for further noise reduction.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 76, 78, 80, 189)

84-31

Document the Parameter Sensitivity Study -- Outline a Systems Analysis Approach and Perform a Sensitiv-

ity Study of the Passenger Air Cushion (PAC) Computer Model
M. Fitzpatrick
Fitzpatrick Engrg., Warsaw, IN, Rept. No. DOT-HS-806 292, 187 pp (Aug 26, 1982)
PB83-207290

Key Words: Collision research (automotive), Safety restraint systems, Inflatable structures, Air bags (safety restraint systems)

This report investigates the design and crash environment factors which influence the degree of protective capability offered by an inflatable restraint system to a three year old, forward-positioned child. Two separate restraint system designs are investigated.

84-32
Dynamic Testing of Child Occupant Protection Concepts
K. Weber and J.W. Melvin
Highway Safety Res. Inst., Univ. of Michigan, Ann Arbor, MI, Rept. No. UM-HSRI-82-19, DOT-HS-806 317, 55 pp (May 1982)
PB83-201483

Key Words: Collision research (automotive), Safety restraint systems

Alternatives to officially accepted restraint systems for children were tested to show the dangers of or potential value of these concepts. Results are given in terms relating to FMVSS 213. The discussion and conclusions highlight important points that will benefit public understanding and use of restraint systems.

84-33
Impact Tests of HBU-X Automatic Lap Belt Prototypes
J.W. Brinkley and D.E. Schimmel
Air Force Aerospace Medical Res. Lab., Wright-Patterson AFB, OH, Rept. No. AFAMRL-TR-82-66, 12 pp (Sept 1982)
AD-A128 182

Key Words: Collision research (automotive), Safety restraint systems, Seat belts, Impact tests

Impact tests were conducted to evaluate three preproduction HBU-X automatic lap belts of different designs developed by three competing contractors. Eight impact tests were performed as part of a program to select a lap belt to replace all HBU and MA-5/6 series lap belts currently in service.

84-34
Braking-Turning-Maneuvering Stability of Heavy Transporters
P. Woods
Martin Marietta Corp., Denver, CO, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 51-61 (May 1983) 11 figs, 4 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Ground vehicles, Dynamic stability, Braking effects, Cornering effects

Stable equilibrium is examined for heavy transporters executing maneuvers prescribed by several steering modes. Hydraulic suspension is modeled independently from the structural elements as a finite element fluid model. The fluid system is coupled to the structural system by Rayleigh-Ritz assumed modes which satisfy boundary conditions.

84-35
Vehicle Sound Level Reduction Due to Repair of Defective Exhaust Systems
M.A. Staiano
Staiano Engrg. Inc., 1923 Stanley Ave., Rockville, MD 20851, Noise Control Engrg., 21 (2), pp 49-55 (Sept/Oct 1983) 8 figs, 5 tables, 11 refs

Key Words: Exhaust systems, Ground vehicles, Motor vehicles, Noise reduction

The purpose of this study was to quantify the increased sound emissions from light vehicles with defective exhaust systems. Sound level measurements were performed on vehicles before and after repair at an exhaust system shop. Measurements were made on stationary vehicles at three engine speeds with microphones located near the tailpipe outlet and along the side of the vehicle. Measurements were performed on 61 defective vehicles, of which 45 were re-evaluated after repair.

84-36
Control of Wheel/Rail Noise and Vibration

P.J. Remington, N.R. Dixon, L.E. Wittig, L.G. Kurzweil, and C.W. Menge
Bolt Beranek and Newman, Inc., Cambridge, MA, Rept. No. DOT-TSC-UMTA-82-57, UMTA-MA-06-0099-82-5, 347 pp (Apr 1983)
PB83-218727

Key Words: Interaction: rail-wheel, Noise reduction

Results of a program to develop and evaluate techniques for the control of wheel/rail noise in urban rail transit systems are presented. A literature review and a cost-benefit analysis to select, for further study, the most cost-effective wheel/rail control treatments are included.

SHIPS

(Also see Nos. 29, 82, 197)

84-37

Preliminary Numerical Study of a New Slender-Ship Theory of Wave Resistance

C. Y. Chen and F. Noblesse
McDermott, Inc., New Orleans, LA, J. Ship Res., 27 (3), pp 172-186 (Sept 1983) 12 figs, 1 table, 21 refs

Key Words: Ships, Wave forces

Results of various numerical calculations of wave resistance designed to evaluate new slender-ship approximations are presented. Specifically, three main wave-resistance approximations are evaluated and studied.

84-38

Sway-Added Mass and Impact Load of a Large Tanker to a Jetty in Shallow Water

C.H. Kim
Davidson Lab., Stevens Inst. of Technology, Hoboken, NJ 07030, J. Energy Resources Tech., Trans. ASME, 105 (1), pp 78-82 (Mar 1983) 7 figs, 1 table, 14 refs

Key Words: Ships, Tanker ships, Impact response

A new simple technique is presented for evaluating sway-added mass and the impact energy absorbed by fenders and dolphins when maneuvering a tanker to a jetty in a shallow water environment. The technique is based on the law of energy conservation; i.e., that the kinetic energy of the berthing ship is totally absorbed by the fenders during the compression phase.

84-39

United States Fleet Survivability of U.S. Naval Combatant Ships

F.S. Hering
Naval Sea Systems Command, Washington, DC, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 39-49 (May 1983) 13 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Ships, Vulnerability

The state of naval ship survivability -- past, present, and future -- is discussed.

84-40

The Action of Irregular Waves on Ships Moored on Terminals

Yu-Cheng Li
Dalian Inst. of Tech., Dalian, People's Rep. of China, J. Energy Resources Tech., Trans. ASME, 104 (4), pp 363-368 (Dec 1982) 4 figs, 2 tables, 7 refs

Key Words: Ships, Moorings, Impact response

For the analysis of the dynamic characteristics of ships moored at the offshore terminals under the action of wind waves, the moored ship system may be simplified to be linear. It is shown that there is a significant relationship between the spectrum of the ocean waves and the impact energy of the ship.

84-41

Procedures for Shock Testing on Navy Class H.I. Shock Machines

E.W. Clements
Naval Res. Lab., Washington, DC, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt. 1, pp 183-185 (May 1983) 3 refs (53rd Symp. Shock Vib., Danvers,

MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Testing techniques, Shipboard equipment response

Combat worthiness of Navy shipboard systems and equipment is in large part due to tests conducted on Navy class high impact shock machines for lightweight and medium-weight equipment. Validity of tests performed on these machines depends on proper operation. This paper discusses the general rules to be followed and guidelines to be observed to achieve consistent valid tests.

AIRCRAFT

(Also see Nos. 79, 131, 206, 207, 231, 235, 239, 244)

84-42

Aircraft Survivability

D.B. Atkinson

Joint Technical Coordinating Group on Aircraft Survivability, Naval Air Systems Command, Washington, DC, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 33-38 (May 1983) 10 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft, Vulnerability

This paper gives an overview of the Naval Air Combat Survivability Program and selected activities of the Tri-Service Joint Technical Coordinating Group on Aircraft Survivability.

84-43

C-9A Interior Noise Evaluation

C.M. Jones

Air Force Occupational and Environmental Health Lab., Brooks AFB, TX, Rept. No. OEHL-83-101EH 174BNA, 25 pp (Feb 1983)

AD-A129 256

Key Words: Aircraft noise, Interior noise, Noise measurement, Experimental test data

Interior noise levels on the C-9A Nightingale aircraft were evaluated during aeromedical evacuation operations because of subjective opinion that the cabin has become more noisy in recent years. Measurements were made on 18 regular working flights.

84-44

Ai . t Interior Noise Models: Sidewall Trim, Stiffen. l 'tructures, and Cabin Acoustics with Floor Partition

L.D. Pope, E.G. Wilby, C.M. Willis, and W.H. Mayes

Bolt Beranek and Newman, Inc., Canoga Park, CA 91305, J. Sound Vib., 89 (3), pp 371-417 (Aug 8, 1983) 32 figs, 6 tables, 13 refs

Key Words: Aircraft noise, Interior noise, Noise prediction

As part of the continuing development of an aircraft interior noise prediction model, in which a discrete modal representation and power flow analysis are used, theoretical results are considered for inclusion of sidewall trim, stiffened structures, and cabin acoustics with floor partition. For validation purposes, predictions of the noise reductions for three test articles (a bare ring-stringer stiffened cylinder, an unstiffened cylinder with floor and insulation, and a ring-stringer stiffened cylinder with floor and sidewall trim) are compared with measurements.

84-45

Study of Noise Reduction Characteristics of Double-Wall Panels

R. Navaneethan, B. Qua/le, S. Stevenson, and M. Graham

Center for Research, Inc., Univ. of Kansas, Lawrence, KS, Rept. No. KU-FRL-417-21, NASA-CR-170308, 181 pp (May 1983)

N83-25497

Key Words: Aircraft noise, Interior noise, Noise reduction, Walls

The noise reduction characteristics of general aviation type, flat, double-wall structures were investigated. The experimental study was carried out on 20-by-20 inch panels with an exposed area of 18 by 18 inches. A frequency range from 20 to 5000 Hz was covered.

84-46

Investigation of the Acoustic Characteristics of Aircraft/Engines Operating in a Dry-Cooled Jet Engine Maintenance Test Facility

V.R. Miller, G.A. Plzak, J.M. Chinn, and R.J. Reilly

Air Force Wright Aeronautical Labs., Flight Dynamics Lab., Wright-Patterson AFB, OH, Shock Vib.

Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 105-114 (May 1983) 11 figs, 1 table, 12 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft engines, Acoustic properties, Noise measurement

A measurement program was undertaken to measure the acoustic environment in an Air Force hush house facility, during the operation of aircraft and uninstalled jet engines to ensure that structural sonic fatigue design limits were not exceeded. Data from external runway operations and other engine test facilities were also compared. The correspondence between noise levels at the hush house deflector ramp and the far-field was examined. The effect of axial distance between jet exhaust nozzle and the hush house exhaust muffler on acoustic levels inside the hanger was also investigated.

84-47

Separated Flow Noise of a Flat Plate at Large Attack Angles

Y. Maruta and S. Kotake

Res. Lab., EBARA Corp., Fujisawa-shi, Kanagawa, Japan, J. Sound Vib., 89 (3), pp 335-357 (Aug 8, 1983) 26 figs, 1 table, 6 refs

Key Words: Noise generation, Aircraft noise

Flow noise associated with separated flow of a flat plate with large attack angles was studied experimentally to obtain its acoustic characteristics and to understand its generation mechanism.

84-48

Unsteady Transonic Pressure Measurements on a Semi-Span Wind-Tunnel Model of a Transport-Type Supercritical Wing (LANN Model). Part 1. General Description, Aeordynamic Coefficients and Vibration Modes

J.J. Horsten, R.G. den Boer, and R.J. Zwaan

National Aerospace Lab., Amsterdam, The Netherlands, Rept. No. NLR-TR-82069-U-PT-1, AFWAL-TR-83-3039-PT-1, 261 pp (Mar 1983)

AD-A129 360

Key Words: Aircraft wings, Aerodynamic loads, Fluid-induced excitation, Vibration measurement, Wind tunnel testing

Unsteady transonic pressure measurements were performed on a semi-span wind-tunnel model of a transport type supercritical wing, oscillating in pitch. For each run, the vibration mode and detailed steady and unsteady pressure distributions were measured. Sectional as well as wing aerodynamic coefficients were obtained by integration of the pressure distributions.

84-49

Testing for Severe Aerodynamically Induced Vibration Environments

H.N. Roos and G.R. Waymon

McDonnell Aircraft Co., McDonnell Douglas Corp., St. Louis, MO, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 155-159 (May 1983) 14 figs, 1 ref (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Aircraft, Aerodynamic loads, Vibration tests, Wind tunnel testing, Flight tests, Experimental test data

Aircraft structural vibration caused by separated aerodynamic flow is a condition commonly seen on high performance aircraft. Low speed wind tunnel and flight testing were conducted to evaluate F-15 vertical tail vibration response to excitation from separated airflow at high angles of attack. Good correlation was obtained between wind tunnel and flight vibration data.

84-50

Calculation of Wing Response to Gusts and Blast Waves with Vortex Lift Effect

D.C. Chao and C.E. Lan

Ctr. for Research, Inc., Univ. of Kansas, Lawrence, KS, Rept. No. TR-CRINC-FRL-467-1, NASA-CR-170340, 67 pp (Apr 1983)

N83-24796

Key Words: Aircraft wings, Wind-induced excitation, Nuclear explosions, Shock waves

A numerical study of the response of aircraft wings to atmospheric gusts and to nuclear explosions when flying at subsonic speeds is presented. The method is based upon unsteady quasi-vortex lattice method, unsteady suction analogy and Pade approximant. The calculated results, showing vortex lag effect, yield reasonable agreement with experimental data.

84-51

Effects of Aerodynamic Interaction Between Main and Tail Rotors on Helicopter Hover Performance and Noise

R.P. Menger, T.L. Wood, and J.T. Brieger
Textron Bell Helicopter, Fort Worth, TX, Rept. No. NASA-CR-166477, 343 pp (Feb 1983)
N83-23275

Key Words: Helicopters, Rotors, Noise generation

A model test was conducted to determine the effects of aerodynamic interaction between main rotor, tail rotor, and vertical fin on helicopter performance and noise in hover out of ground effect. The experimental data were obtained from hover tests performed with a .151 scale Model 222 main rotor, tail rotor and vertical fin. Of primary interest was the effect of location of the tail rotor with respect to the main rotor.

84-52

Limits on the Prediction of Helicopter Rotor Noise Using Thickness and Loading Sources: Validation of Helicopter Noise Prediction Techniques

G.P. Succi
Bolt Beranek and Newman, Inc., Cambridge, MA, Rept. No. BBN-5114, NASA-CR-166097, 93 pp (Apr 1983)
N83-25498

Key Words: Helicopter noise, Noise prediction, Prediction techniques

The techniques of helicopter rotor noise prediction attempt to describe precisely the details of the noise field and remove the empiricisms and restrictions inherent in previous methods. These techniques require detailed inputs of the rotor geometry, operating conditions, and blade surface pressure distribution. The Farassat noise prediction techniques were studied, and high speed helicopter noise prediction using more detailed representations of the thickness and loading noise sources was investigated. These predictions were based on the measured blade surface pressures on an AH-1G rotor and compared to the measured sound field.

84-53

On Linear Acoustic Solutions of High Speed Helicopter Impulsive Noise Problems

C.K.W. Tam
Dept. of Mathematics, Florida State Univ., Tallahassee, FL 32306, J. Sound Vib., 89 (1), pp 119-134 (July 8, 1983) 6 figs, 17 refs

Key Words: Helicopters, Propeller blades, Noise prediction

The nature of linear acoustic solutions for a helicopter rotor blade with a blunt leading edge operating at high transonic tip Mach number is studied. As a part of this investigation a very efficient computation procedure for helicopter rotor blade thickness noise according to linear theory is developed. Numerical and analytical results reveal that as the blade tip Mach number approaches unity, the solution develops singularities and a radiating discontinuity.

84-54

Helicopter Noise Survey at Selected New York City Heliports

E.J. Rickley, M.J. Brien, and S.R. Albersheim
Office of Environment and Energy, Federal Aviation Admn., Washington, DC, Rept. No. FAA-EE-83-2, 78 pp (Mar 1983)
AD-A129 167

Key Words: Helicopter noise, Noise measurement

A noise measurement survey of helicopter operations was conducted at three principal heliports in New York City. The purpose was to gather needed information for defining noise problems with in-service helicopter operations within urban areas. These noise data will be used to further define the environmental problems associated with helicopter operations in urban areas.

84-55

AVRADCOM Research in Helicopter Vibrations. Keynote Address

S.C. Stevens
Commander, U.S. Army Aviation, Res. and Dev. Command, St. Louis, MO, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 3-20 (May 1983) 34 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Helicopter vibration, Vibration control, Reviews

Since the maiden flight in 1940 of the first Army helicopter, a multitude of vibration problems have decreased system productivity and increased life cycle costs. A progress report on reducing helicopter vibrations is presented.

84-56

Free Wake Aerodynamic Analysis of Helicopter Rotors

L. Morino, Z. Kaprielian, Jr., and S.R. Sipcic

Ctr. for Computational and Appl. Dynamics, Boston Univ., Boston, MA, Rept. No. CCAD-TR-83-01, 99 pp (May 26, 1983)

AD-A129 710

Key Words: Rotors, Helicopters, Aeordynamic loads

A formulation for the free wake analysis of helicopter rotors in incompressible potential flows is presented. The formulation encompasses both the theory and its numerical implementation. For the case of a single-bladed rotor in hover, the formulation is validated by numerical results.

MISSILES AND SPACECRAFT

(Also see Nos. 77, 204)

84-57

Acoustic Environments for JPL Shuttle Payloads Based on Early Flight Data

M.R. O'Connell and D.L. Kern

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 63-77 (May 1983) 10 figs, 2 tables, 6 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Space shuttles, Sound pressure levels

Shuttle payload acoustic environmental predictions for the Jet Propulsion Laboratory's Galileo and Wide Field/Planetary Camera projects have been developed from STS-2 and STS-3 flight data. This evaluation of actual STS flight data resulted in reduced predicted environments for the JPL shuttle payloads. Shuttle payload mean acoustic levels were enveloped.

84-58

Ice Impact Testing of Space Shuttle Thermal Protection System Materials

P.H. DeWolfe

Rockwell International, Downey, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 177-182 (May 1983) 10 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Space shuttles, Heat shields, Ice, Impact tests

An ice impact test program is currently in progress to evaluate the damage resistance of the various Space Shuttle thermal protection system materials when subjected to impact by ice projectiles shed from the external tank during ascent. This program required the development of a test method before material evaluation could begin. The development of the test method, as well as progress in material testing during 1982, are the subject of this paper. Descriptions of the impact, including ice source, velocity, incidence angle, and location are included. Five significant conclusions have been drawn to date and are reported.

84-59

Pyrotechnic Shock Test and Test Simulation

M.E. Hughes

Martin Marietta Corp., Orlando Aerospace, Orlando, FL, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 83-88 (May 1983) 11 figs, 2 tables, 1 ref (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spacecraft equipment response, Pyrotechnic shock environment, Shock tests, Testing techniques, Stage separation

Mechanical shock was measured at 18 locations during 5 ground tests of flight vehicle structures. The shock was generated by a linear shaped charge (LSC) cutting 0.063-in. aluminum skin to separate a reentry vehicle from a booster. A maximum shock response spectra of 32,000 g was measured 5 in. from the LSC cutting plane. The data were statistically treated to define the source environment and distance attenuation. A pyro shock simulation fixture was developed for equipment testing.

84-60

Strain Histories Associated with Stage Separation Systems Using Linear Shaped Charge

D.R. Powers

McDonnell Douglas Astronautics Co., Huntington Beach, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 89-96 (May 1983) 11 figs, 4 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982, Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spacecraft, Stage separation, Shock response spectra, Experimental test data

A series of design optimization tests were performed on subscale and full-scale vehicle interstage separation systems. Aluminum sheathed, 30 grains/foot, linear shaped charge was used to cut 1½ by 3 foot panels and 8-foot-diameter 6-foot-high cylindrical sections. Acceleration and strain histories and shock response spectra are presented from representative firings.

84-61

Dynamic Behaviour of a Satellite Antenna Structure in Random Vibration Environment

V.K. Jha, T.S. Sankar, and R.B. Bhat

SPAR Aerospace Limited, Ste-Anne-de-Bellevue, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 91-103 (May 1983) 9 figs, 3 tables, 5 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Antennas, Spacecraft antennas, Random excitation

Satellite antenna structures are often subjected to random excitations with power spectral densities varying in an arbitrary manner in the frequency domain. A mathematical model for effectively describing such excitations is proposed in order to compute the dynamic response of the antenna structure.

84-62

Computer Aided Synthesis of a Satellite Antenna Structure with Probabilistic Constraints

V.K. Jha, T.S. Sankar, and R.B. Bhat

SPAR Aerospace Limited, Ste-Anne-de-Bellevue, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 79-90 (May 1983) 6 figs, 9 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982, Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Antennas, Spacecraft antennas, Optimization, Environmental effects, Computer-aided techniques

A computer aided procedure is presented which involves synthesis of a finite element analysis program capable of analyzing complex structures and a state of the art optimization algorithm into one unified design system. This system is used for designing antenna structures subjected to random excitations and having design requirements specified in a probabilistic manner. An approach is presented to handle probabilistic design requirements. The design of a typical satellite antenna structure realized using the proposed design procedure is presented.

84-63

Electronic Damping of a Large Optical Bench

R.L. Forward, C.J. Swigert, and M. Obal

Hughes Res. Labs., Malibu, CA 90265, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 51-61 (May 1983) 14 figs, 5 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spacecraft components, Optical benches, Spacecraft equipment response, Active damping

Electronic damping was used to reduce the amplitude of response of two problem vibrational resonances in a large optical bench. A small 14-g piezoelectric ceramic strain transducer was used as a sensor, and ten others in parallel were used as a combined driver in a velocity-feedback damping loop operating on the bench. The data taken during this study shows that electronic damping using a single damping loop is sufficient to control both modes even when excited at the high levels of acoustic and vibrational noise experienced by the bench in its operational environment.

84-64

Eigenfrequencies of Inertial Oscillations in a Rotating Fluid via a Numerical Simulation

R. Sedney, N. Gerber, and J.M. Bartos

Ballistic Res. Lab., Army Armament Res. and Dev. Command, Aberdeen Proving Ground, MD, Rept. No. ARBRL-TR-02488, SBI-AD-F300 256, 47 pp (May 1983)

AD-A129 088

Key Words: Missiles, Fluid-filled containers, Rotating structures, Natural frequencies, Damping

An understanding of the instability of a spinning liquid-filled projectile requires a knowledge of the wave system in the rotating fluid. The axisymmetric wave system in a cylinder is studied by a numerical simulation; the particular case of perturbed solid body rotation is treated. Finite-difference solutions to the Navier-Stokes equations provide data from which wave frequencies and damping can be extracted using Fourier transform and digital filter techniques. The frequency and damping are compared with the values computed from a linearized eigenvalue analysis.

BIOLOGICAL SYSTEMS

HUMAN

84-65

Community Response to Blasting

S. Fidell, R. Horonjeff, T. Schultz, and S. Teffeteller

Bolt Beranek and Newman, Inc., P.O. Box 633, Canoga Park, CA 91305, J. Acoust. Soc. Amer., 74 (3), pp 888-893 (Sept 1983) 5 figs, 2 tables, 6 refs

Key Words: Blast loads, Mines (excavations), Noise generation, Human response

Annoyance due to chronic exposure to blast noise and vibration was assessed in residential areas near two surface mines and a quarry. It was found possible to base useful prediction of the prevalence of high annoyance on a metric of outdoor ground vibration related to high centiles of the long term distribution of exposure levels.

84-66

The Spectral Factor in Noise-Induced Hearing Loss: A Case for Retainng the A-Weighting

D.W. Robinson

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 90 (1), pp 103-127 (Sept 8, 1983) 6 figs, 9 tables, 18 refs

Key Words: Industrial facilities, Noise generation, Noise measurement, Human response

For the measurement of industrial noise in hearing conservation, majority usage including international standard practice favors the A-weighting. Any change would have important practical consequences and wide administrative repercussions, but direct validation of this frequency weighting through comparisons of persistent threshold shift is lacking. Data from a study of hearing and noise in industry are re-examined, paying particular attention to the age and noise exposure equivalence of groups of subjects classified by spectrum slope and shape.

84-67

The Fifteenth Sir Richard Fairey Memorial Lecture: The Quieter Airport

N.J. Payne

British Airports Authority, Gatwick Airport, Gatwick RH6 OHZ, UK, J. Sound Vib., 89 (4), pp 533-540 (Aug 22, 1983)

Key Words: Aircraft noise, Airports, Human response

Aircraft noise as a social problem has been a significant factor in airport planning and the development of air transport. This paper explains how the industry has responded, with the introduction of operating techniques, and how Governments have introduced controls, both designed to mitigate the effects of aircraft noise as far as possible, for people living near major airports.

84-68

A Stochastic Model for the Man-Machine-Soil-Environment System (MMSES) and the Influence of Vibrations

A. Massinas and P. Drakatos

Univ. of Patras, Greece, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 9-18 (May 1983) 10 figs, 5 tables, 10 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Earth handling equipment, Vibration excitation, Human response

The present work is concerned with the determination of a stochastic model which describes the interaction of different parameters involved in the man-machine-soil-environment system with respect to the efficiency of earth moving equipment. Experiments using six operators, five types of soil and three different machines under different environmental conditions were carried out and various results obtained. The effects of vibrational acceleration were also taken into consideration.

84-69
Researching the Man-Machine System as a Function of Soil-Environment System
A. Massinas and P. Drakatos
Univ. of Patras, Patras, Greece, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 1-7 (May 1983) 1 fig, 9 tables, 12 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Earth handling equipment, Vibration excitation, Human response

The present work is concerned with the determination of a stochastic model which describes the functional relationship between man-machine system and soil-environment system with respect to earth moving equipment. The Vashy-Buchingham theorem was applied and non-dimensional P_i terms resulted. This model has been validated by experiments.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

84-70
Vibration Isolation from Irregularity in a Nearly Periodic Structure: Theory and Measurements
C.H. Hodges and J. Woodhouse
Topexpress Ltd., 1 Portugal Place, Cambridge CB5 8AF, UK, J. Acoust. Soc. Amer., 74 (3), pp 894-905 (Sept 1983) 13 figs, 1 table, 13 refs

Key Words: Vibration isolation, Periodic structures

This article describes the theory and a simple experiment carried out to demonstrate the phenomenon of Anderson localization in an acoustical context. This is an effect whereby the propagation of vibration in a structure which is not entirely regular is impeded by the irregularities, giving rise on the average to an exponential decay of vibration level away from the driving point, even in the absence of any dissipation. The structure used in the experiment was a stretched string with masses attached to it. All measurements yielded satisfactory agreement with the theoretical predictions.

84-71
Damped Pneumatic Spring as Shock Isolator: Generalized Analysis and Design Procedure
M.S. Hundal
Univ. of Vermont, Burlington, VT 05405, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 73-83 (May 1983) 7 figs, 10 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock isolators, Springs, Pneumatic springs

Modeling, response and design procedure for a pneumatic shock isolator are presented. The isolator is a single-acting pneumatic spring with self-damping. The undamped pneumatic spring is also analyzed, the results of which can be readily used as the starting point in the design process. Parametric studies show the effect of non-dimensional parameters on system response. It is shown that a pneumatic spring and a linear spring isolator experience the same displacement for a short duration pulse.

84-72
Optimum Characteristics of Automotive Shock Absorbers under Various Driving Conditions and Road Surfaces
N. Fukushima, K. Hidaka, and K. Iwata
Vehicle Res. Lab., Central Engrg. Labs., Nissan Motor Co., Ltd., Yokosuka-shi, Japan, Intl. J. Vehicle Des., 4 (5), pp 463-472 (Sept 1983) 10 figs

Key Words: Shock absorbers, Automobiles

Shock absorbers have a significant influence on handling performance and riding comfort. However, no further reduction of vehicle vibration can be expected from using the velocity-dependent damping characteristics of the shock absorber. It is necessary to make modifications to improve the functions of the shock absorber. How input in the vertical direction affects the suspension under various driving conditions and road surfaces is examined. The study was performed while the steering wheel was being operated and the vehicle driven on smooth and rough roads.

84-73
The Centrifugal Pendulum as a Nonlinear Torsional Vibration Absorber
R. Dragani and M. Sarra
Istituto di Meccanica Razionale, Politecnico di Torino, Italy, Meccanica, 18 (2), pp 67-70 (June 1983) 8 figs, 15 refs

Key Words: Vibration absorption (equipment), Engine vibration, Torsional vibration, Pendulums, Viscous damping, Coulomb friction

The centrifugal pendulum as a torsional vibration absorber of an engine is studied. A non-autonomous two degrees of freedom mechanical system with viscous-Coulomb damping is considered. The motion equations are written and analyzed for small oscillations of the pendulum, the effect of the nonlinear damping on the response curves in amplitude.

84-74

Vibration Reduction over a Frequency Range

L. Kitis, B.P. Wang, and W.D. Pilkey
Dept. of Mech. Engrg., Worcester Polytechnic Inst., Worcester, MA 01609, J. Sound Vib., 89 (4), pp 559-569 (Aug 22, 1983) 4 figs, 2 tables, 30 refs

Key Words: Vibration absorption (equipment), Beams, Cantilever beams, Periodic excitation, Vibration control

An efficient optimal design algorithm for minimizing the vibratory response of a multi-degree of freedom system under sinusoidal loading over several excitation frequencies is presented. The method is applicable to large scale dynamic systems because it incorporates an effective time-saving reanalysis approach to compute cost function and cost function derivatives. In particular, the efficiency of the method is demonstrated by applying it to the problem of designing two dynamic vibration absorbers simultaneously applied to an undamped cantilever beam.

84-75

Application of Active and Passive Suspension Techniques to Improve High Speed Ground Vehicle Performance

J.K. Hedrick, D.N. Wormley, F. Buzan, L.C. Chen, and M. Partridge
Dept. of Mech. Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. DOT/RSPA/DMA-50/83/20, 210 pp (Oct 5, 1982)
PB83-224576

Key Words: Suspension systems (vehicles), Active vibration control, High speed transportation

Work completed during the second year of this research project is summarized. The goal of the project is to develop improved suspension designs for high speed ground vehicles, in particular in those applications where restricted operating envelopes limit the improvements that can be made by conventional means. The application area chosen for this project was the lateral ride quality of intercity passenger trains.

84-76

Active Controls in Ground Transportation - A Review of the State-of-the-Art and Future Potential

R.M. Goodall and W. Kortum
Loughborough Univ. of Tech., Leicestershire, UK, Vehicle Syst. Dynam., 12 (4-5), pp 225-257 (Aug 1983) 3 figs, 135 refs

Key Words: Suspension systems (vehicles), Active control, Active isolation, Transportation vehicles, Ground vehicles, Railroad trains, Reviews

Active control systems offer significant functional advantages over passive systems; their introduction into production-line vehicles, however, is cautious and slow. This survey describes the recent progress in the analysis, design and technology of active controls in vehicles. It includes the state-of-the-art of their introduction into operation as well as their future potential in view of recent advances in technology and computer aided design strategies. The survey is limited to suspensions for vehicles on roads and tracks.

84-77

A Free-Free Modal Survey Suspension System for Large Test Articles

R. Webb
Martin Marietta Corp., Denver, CO, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 171-179 (May 1983) 9 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Suspension systems (missiles), Modal tests, Missiles

The first assembly of a full-size, flight-weight MX missile was accomplished in February of 1982 for the purpose of conducting a modal survey test on a flight-configured test article. In order to approximate a free-free boundary condition simulating a missile in flight, a suspension system was required that would provide adequate separation ratios between lateral suspension frequencies and test article bending modes. A suspension system was developed that employed a large annular basering, to which the aft end of the first stage mounted, suspended vertically by three 200-inch long "pendulum" rods. The three-point suspension provided lateral stability even with a test article CG that was appreciably higher than the upper support point of the pendulum rods, while rod length was sufficient to allow rotational freedom of the missile base. A summary of the design and performance parameters is presented.

84-78

Frequency and Time Domain Analysis of Off-Road Motorcycle Suspension

M. van Vliet, S. Sankar, and C.N. Bapat

Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 35-49 (May 1983) 15 figs, 3 tables, 10 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Suspension systems (vehicles), Motorcycles, Frequency domain method, Time domain method

The objective of this investigation is to establish a systematic analytical procedure supported by suitable laboratory experiments to provide guidelines in the performance evaluation of motorcycle suspensions. The subject matter is developed by considering the front suspension as a nonlinear single degree of freedom system. The nonlinearities are introduced to obtain a physically accurate model. They include the effects of seal friction, entrapped gas, turbulent flow, and asymmetric damping.

84-79

Experimental and Analytical Investigation of Active Loads Control for Aircraft Landing Gear

D.L. Morris and J.R. McGehee

Air Force Wright Aeronautical Labs., Wright-Patterson Air Force Base, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 79-89 (May 1983) 11 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Active control, Computer programs, Aircraft, Landing gear

Experimental and analytical investigations of a series-hydraulic, active loads control main landing gear from a light, twin-engine civil aircraft were conducted. These tests included landing impact and traversal of simulated runway roughness. The results of these investigations show that the active gear is feasible and very effective in reducing the force transmitted to the airframe.

84-80

An Optimum Seat-Suspension for Off-Road Vehicles

S. Rakheja and S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 19-34 (May 1983) 17 figs, 13 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Suspension systems (vehicles), Off-highway vehicles

Low frequency terrain induced vibrations transmitted to off-road vehicle operators are quite severe and exceed ISO specified fatigue-decreased-proficiency limits. Design of an optimum seat-suspension to protect drivers from incoming injurious vibrations in bounce, longitudinal, lateral, roll, and pitch modes, is presented.

BLADES

84-81

Measurement and Analysis of Platform Damping in Advanced Turbine Blade Response

T.J. Lagnese and D.I.G. Jones

Air Force Wright Aeronautical Labs., AFWAL/MLLN, Wright-Patterson Air Force Base, OH 45433, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 19-27 (May 1983) 14 figs, 17 refs (53rd Symp. Shock Vib., Danvers, MA Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Blades, Turbine blades, Coulomb friction, Experimental test data

The measurement of dry friction damping is experimentally investigated by means of a digital signal data processing technique. The experimental technique identifies narrow frequency bandwidth linearity of the nonlinear response of a single turbine blade with dry friction damping. The nonlinear response data is compared with analytical results for a two-degree of freedom model of the blade.

84-82

Prediction of Steady and Unsteady Loads and Hydrodynamic Forces on Counterrotating Propellers

S. Tsakonas, W.R. Jacobs, and P. Liao

Stevens Inst. of Tech., Hoboken, NJ, J. Ship Res., 27 (3), pp 197-214 (Sept 1983) 2 figs, 12 tables, 20 refs

Key Words: Blades, Propeller blades, Propellers, Marine propellers, Hydrodynamic excitation

Linearized unsteady-lifting-surface theory has been applied in the study of counterrotating propeller systems with equal or unequal number of blades operating in uniform or nonuniform inflow fields when both units are rotating with the same rpm. The mathematical model takes into account as realistically as possible the geometry of the propulsive device, the mutual interaction of both units and the three-dimensional spatially varying inflow field.

84-83

Analytical and Experimental Investigation of Rotating Blade Response Due to Nozzle Passing Frequency Excitation

J.S. Rao, H.M. Jadvani, and P.V. Reddy

Indian Inst. of Tech., New Delhi, Indian, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 85-101 (May 1983) 22 figs, 1 table, 16 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982 Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Blades, Turbomachinery blades, Equations of motion, Forced vibration

The differential equations of motion of forced vibrations of a pre-twisted, staggered and rotating blade of uniform cross-section are derived using Lagrange's equations. The excitation of the blade is taken in the form of NPF (nozzle passing frequency) excitation. The effect of proportional damping is taken into consideration and the effects of rotary inertia and shear deformation are neglected. The forced vibration response is determined by using modal analysis. A test rig designed to study forced vibration response under NPF is described.

BEARINGS

84-84

Journal Bearings: Wear Characteristics and Lubrication. 1966 - July, 1983 (Citations from the Metals Abstracts Data Base)

NTIS, Springfield, VA, 121 pp (July 1983)

PB83-867606

Key Words: Bearings, Journal bearings, Wear, Lubrication, Bibliographies

This bibliography contains 157 citations concerning the hydrodynamics of the bearing-lubricant interface relative to bearing materials, additives in lubricants, applications of journal bearings, particulate contaminant in the lubricants, fluid film thickness, and durability of the lubricant. Thermal degradation, bearing designs, wear measurement and analysis, and external pressure effects are also considered.

84-85

Hypersonic Dynamic Testing of Ablating Models with Three-Degree-of-Freedom Gas Bearing

F.J. Regan and M.V. Krumins

Naval Surface Weapons Ctr., Silver Spring, MD, J. Spacecraft Rockets, 20 (5), pp 470-476 (Sept/Oct 1983) 9 figs, 7 refs

Key Words: Bearings, Gas bearings, Aerodynamic loads, Wind tunnel testing

A description of the design, construction, and operation of the Naval Surface Weapons Center three-degree-of-freedom gas bearing is presented. The data reduction techniques used to obtain the static and dynamic moment derivatives from angular measurements are discussed and applied to wind tunnel data.

GEARS

(See No. 211)

COUPLINGS

(See No. 3)

LINKAGES

84-86

The Fatigue Behavior of Large-Scale As-Welded and Stress-Relieved Tubular T Joints

C.D. Shinners and A. Abel

Esso Australia, Sydney, Australia, J. Energy Resources Tech., Trans. ASME, 105 (2), pp 170-176 (June 1983) 9 figs, 4 tables, 13 refs

Key Words: Joints (junctions), Welded joints, Tubes, Fatigue life

The changing strain distribution within large-scale tubular T joints, subjected to fully reversed axial brace fatigue loading, were measured in as-welded and stress-relieved conditions. Initial static loading enabled estimation of stress concentration factors and comparisons with the predictions of available published formulas. Dynamic load amplitudes were selected to give approximately equal hot-spot strains in all joints, thus facilitating direct comparison between specimens with different dimensions.

84-87

Fatigue Strength of Welded Tubular T Joints under Variable Amplitude Loading

M. Kawahara, A. Katoh, and T. Iwasaki

Technical Res. Ctr., Nippon Kokan K.K., Kawasaki, Japan, J. Energy Resources Tech., Trans. ASME, 105 (2), pp 184-188 (June 1983) 9 figs, 4 tables, 12 refs

Key Words: Joints (junctions), Welded joints, Tubes, Variable amplitude excitation, Fatigue tests

An experimental study on fatigue strength of welded tubular T joints, performed in small and large-scale models fabricated from mild steel tubes, is described. Fatigue tests were conducted under three kinds of loading patterns: constant amplitude loading, block programmed loading and random loading. The limits of validity of Miner's rule are discussed together with possible interpretations on the effects of the difference in load sequence patterns.

84-88

Fatigue Tests and Design of Offshore Tubular Joints

D. Dutta and F. Mang

Mannesmannroehren-Werke AG, Dusseldorf, W. Germany, J. Energy Resources Tech., Trans. ASME, 105 (2), pp 189-194 (June 1983) 11 figs, 3 tables, 16 refs

Key Words: Joints (junctions), Tubes, Off-shore structures, Fatigue tests

The AWS-X hotspot stress-load cycle curve used for designing tubular joints is based mainly on fillet-welded plate test data and data from small-scale tests on tubular joints. A review of recent tests leads to the conclusion that the influence of diameter and thickness of the tubes plays a significant role in joint fatigue behavior. Hence, they must be taken into consideration while designing tubular joints accurately and more economically. A modified design method is proposed with design curves for four diameter values.

VALVES

84-89

Computational Method for the Analysis of Valve Transients

T. Siikonen

Technical Res. Ctr. of Finland, Nuclear Engrg. Lab., Helsinki, Finland, J. Pressure Vessel Tech., Trans. ASME, 105 (3), pp 227-233 (Aug 1983) 15 figs, 6 refs

Key Words: Valves, Boiling water reactors, Nuclear reactors, Boundary condition effects, Method of characteristics

A computational method for valve dynamics is discussed. The method consists of a hydraulic part and the equations describing valve dynamics. These are coupled together using a boundary condition in the hydraulic model. Some important parameters for the boundary condition are determined experimentally. The hydraulic equations are solved using the method of characteristics. Some example calcualtions for a boiling water reactor are presented.

SEALS

84-90

Thermal and Elastohydrodynamic Analysis of Reciprocating Rod Seals in the Stirling Engine

Y. Yang

Ph.D. Thesis, Carnegie-Mellon Univ., 130 pp (1983) DA8315890

Key Words: Seals, Stirling engines, Elastohydrodynamic properties

The elastomeric Leningrader sliding seal and cap seal in the Stirling engine are analyzed both from an elastohydrodynamic and thermal view point. The analysis is implemented by a Runge-Kutta finite difference technique applied to the fluid equations in combination with a simple plane strain finite element calculation for the elastomeric solid to get the film thickness under an arbitrary initial clearance and preload condition.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

(Also see No. 19)

84-91

Vibrations of a Taut String and Torsional Vibration of a Gun Barrel under the Influence of a Moving Mass

B.R. Holmberg
Div. of Mechanics, Chalmers Univ. of Tech., 412 96 Gothenburg, Sweden, J. Sound Vib., 89 (3), pp 325-334 (Aug 8, 1983) 6 figs, 1 table, 10 refs

Key Words: Strings, Torsional vibration, Moving loads, Gun barrels

Vibration of a string under a moving mass is considered. Owing to the interplay between inertial forces and the string tension in this problem shows some differences from that of a traveling force. The torsional vibration of a gun barrel induced by the spin-up of a bullet is also examined.

CABLES

(Also see No. 13)

84-92

Dynamic Analysis of Mooring Cables

J. Lindahl and A. Sjoeberg
Institutionen foer Vattenbyggnad, Chalmers Univ. of Tech., Goeteborg, Sweden, Rept. No. SER-A-9, 46 pp (1983)
PB83-200782

Key Words: Cables, Moorings, Numerical analysis, Finite element technique

A finite element model for numerical analysis of the dynamic response of mooring cables is presented. The model takes into account the elasticity of the cable, inertia forces, drag forces and frictional forces between the sea bottom and the cable. The model is capable of handling both two- and three-dimensional problems.

BARS AND RODS

84-93

Dynamic Analysis of Slender Rods

D.L. Garrett
Shell Development Co., Houston, TX 77001, J. Energy Resources Tech., Trans. ASME, 104 (4), pp 302-306 (Dec 1982) 5 figs, 2 tables, 4 refs

Key Words: Rods, Finite element technique

A new three-dimensional finite element model of an inextensible elastic rod with equal principal stiffnesses is presented. The model permits large deflections and finite rotations and accounts for tension variation along its length. Its use in static analysis is described and a time integration method for dynamic analysis is developed. Accuracy of the spatial discretization and stability of the time integration method are demonstrated by comparison of numerical results with exact solutions for certain nonlinear problems.

BEAMS

(Also see No. 74)

84-94

Beam Vibrations with Time-Dependent Boundary Conditions

D.A. Grant
Dept. of Mech. Engrg., Univ. of Maine, Orono, ME 04469, J. Sound Vib., 89 (4), pp 519-522 (Aug 22, 1983) 7 refs

Key Words: Beams, Bernoulli-Euler method, Time-dependent parameters, Vibration analysis

A procedure is outlined for the solution of the vibration problem of a Bernoulli-Euler beam with time-dependent boundary conditions. The solution is greatly simplified if the dependent variable in the original partial differential equation can be changed to produce homogeneous boundary conditions and at the same time maintain a homogeneous differential equation. A method for making such a change is given and illustrated by solving a cantilever beam problem with a time-dependent tip displacement.

84-95
Free Vibration of Beams with Abrupt Changes of Cross-Section
H. Sato
Dept. of Mech. Engrg., Kanazawa Univ., Kanazawa, Japan, J. Sound Vib., 89 (1), pp 59-64 (July 8, 1983) 6 figs, 5 refs

Key Words: Beams, Variable cross-section, Natural frequencies

Free vibration of a beam with large and abrupt changes of cross-section is studied. Applying the simple beam theory to such a beam results in a noticeable error in certain cases, because of overestimation of the bending stiffness at the discontinuity of the cross-section. For this problem a combined type transfer matrix method in which the finite element method is partially used is presented. As a numerical example the first natural frequencies of free-free, square beams with a rectangular groove are calculated. The effects of the groove dimensions on the frequency are discussed and results are compared with those obtained by the simple beam theory.

84-96
Dynamic Behavior of Composite Layered Beams by the Finite Element Method
P. Trompette and R. Gaertner
Laboratoire de Mécanique des Structures, E.R.A. 911 - Bâtiment: 113 20, avenue Albert Einstein, 69621 Villeurbanne, France, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 151-157 (May 1983) 7 figs, 3 tables, 18 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Beams, Curved beams, Layered materials, Transverse shear deformation effects, Finite element technique

A new finite element especially adapted to the study of unsymmetrical laminated straight or curved beams is presented -- shear effects in all the laminates are included in the theory. Both the different stress and displacement continuity conditions at each laminate interface as the free stress conditions on the top and bottom surfaces of the beam are satisfied. This model has been applied to the determination of resonance frequencies of a ski with different boundary conditions. Good agreement between experiences and calculations has been observed.

84-97
Coupled Flexural-Longitudinal Wave Motion in a Periodic Beam
D.J. Mead and S. Markus
Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 90 (1), pp 1-24 (Sept 8, 1983) 16 figs, 7 refs

Key Words: Beams, Periodic structures, Flexural vibration, Longitudinal vibration, Coupled response

Periodic structure theory is used to study the interactions between flexural and longitudinal wave motion in a beam (representing a plate) to which offset spring-mounted masses (representing stiffeners) are attached at regular intervals. An equation for the propagation constants of the coupled waves is derived. The response of a semi-infinite periodic beam to a harmonic force or moment at the finite end is analyzed in terms of the characteristic free waves corresponding to these propagation constants. Computer results are presented which show how the propagation constants are affected by the coupling, and how the forced response varies with distance from the excitation point.

MEMBRANES, FILMS, AND WEBS

84-98
Vibration of a Parallelogram Membrane
H.F. Bauer
Fachbereich Luft- und Raumfahrttechnik, Hochschule der Bundeswehr Munchen, 8014 Neubiberg, Germany, J. Sound Vib., 89 (1), pp 17-30 (July 8, 1983) 3 figs, 2 tables, 13 refs

Key Words: Membranes (structural members), Natural frequencies

The approximate natural frequencies of oblique membranes are determined for arbitrary skew angles and side ratios. The response of such a membrane to a forcing function is then obtained in a similar fashion. The lower natural frequencies are presented for various side ratios of the membrane as a function of the skaw angle and vice versa.

PLATES

(Also see No. 13)

84-99
Large Amplitude Vibration of an Initially Stressed Moderately Thick Plate

L.-W. Chen and J.-L. Doong
Dept. of Mech. Engrg., National Cheng-Kung Univ., Tainan, Taiwan, Rep. of China, J. Sound Vib., 89 (4), pp 499-508 (Aug 22, 1983) 7 figs, 1 table, 16 refs

Key Words: Plates, Equations of motion, Transverse shear deformation effects, Rotatory inertia effects, Flexural vibration, Large amplitudes

Nonlinear equations of motion for a transversely isotropic moderately thick plate in a general state of nonuniform initial stress where the effects of transverse shear and rotary inertia are included are derived. The large amplitude flexural vibration of a simply supported rectangular moderately thick plate subjected to initial stress is investigated. The effects of various parameters on the nonlinear vibration frequencies are studied.

84-100
The Aerodynamic Loads on a Flat Plate Between Parallel Walls Due to Rotational Flow Disturbances
H.A.-R. Alnakeeb
Ph.D. Thesis, The Univ. of Western Ontario, Canada (1983)

Key Words: Plates, Aerodynamic loads, Turbulence

The effects of rotational flow disturbances on a body placed in an inviscid, incompressible fluid stream and, in particular, the case of a flat plate situated midway between two parallel planes, were studied. A single vortex approaching the flat plate was first considered and then expected to simulate the effects of pseudo-turbulence on the flat plate. The finite-element and finite-difference numerical methods were evaluated and arguments were made in support of using the finite-difference approach rather than the finite-element approach.

84-101
A Highly Accurate Analytical Solution for Free Vibration Analysis of Simply Supported Right Triangular Plates
D.J. Gorman
Dept. of Mech. Engrg., Univ. of Ottawa, Ottawa, Canada, J. Sound Vib., 89 (1), pp 107-118 (July 8, 1983) 9 figs, 1 table, 6 refs

Key Words: Plates, Triangular bodies, Eigenvalue problems, Free vibration, Vibration analysis

A new analytical technique is described for the free vibration analysis of simply supported right triangular plates. While it is seen that the basic mathematical approach is applicable to right triangular plates with various types of boundary conditions, the problem of the simply supported right triangular plate is resolved for illustrative purposes and eigenvalues are presented for the first four modes. The method employed is basically that of superposition. The governing differential equation is completely satisfied and by means of a judicious choice of building blocks the boundary conditions are satisfied to any desired degree of accuracy.

84-102
Vibration and Stability Analysis of Polar Orthotropic Uniform Discs Subjected to Peripheral Hydrostatic Loading
D.G. Gorman
Dept. of Mech. Engrg., Queen Mary College, London E1 4NS, UK, J. Sound Vib., 89 (4), pp 477-486 (Aug 22, 1983) 5 figs, 3 tables, 14 refs

Key Words: Disks, Hydrostatic excitation, Natural frequencies

An analysis based upon the annular finite element method is carried out of the transverse vibration and stability of uniform polar orthotropic discs subjected to peripheral hydrostatic loading. Both the axi- and anti-symmetrical modes are considered for both clamped and simply supported at the outer peripheral radius. By separation of the flexural and geometric (membrane) components, the effect on both with respect to the degree of orthotropy is plotted and subsequently both components can be easily combined to produce the natural frequencies of the loaded disc.

84-103
Vibrations of Polygonal Plates Due to Thermal Shock
S. Das
Dept. of Physics, Sonaulla H.S. School, Jalpaiguri 735101, India, J. Sound Vib., 89 (4), pp 471-476 (Aug 22, 1983) 2 figs, 2 tables, 7 refs

Key Words: Plates, Vibration response, Temperature effects

Vibrations of polygonal elastic plates due to thermal shock are investigated through use of complex variable theory. The numerical results are shown graphically for different polygonal plates and results for triangular, square and circular plates are compared with published results.

84-104

Vibration and Stability of a Circular Plate of Unidirectionally Varying Thickness

T. Irie, G. Yamada, and M. Kitayama
Dept. of Mech. Engrg., Hokkaido Univ., Sapporo, 060 Japan, J. Sound Vib., 90 (1), pp 81-90 (Sept 8, 1983) 9 figs, 2 tables, 18 refs

Key Words: Plates, Circular plates, Variable cross section, Stability, Vibration analysis

An analysis is presented for the vibration and stability of an elastically restrained circular plate of unidirectionally varying thickness subjected to an in-plane force. For this purpose, the transverse deflection of a circular plate of variable thickness is written in a series of the deflection functions of a uniform circular plate without the action of a force. The dynamical energies of the plate are evaluated analytically, and the frequency equation of the plate is derived by the Ritz method.

84-105

Sound Radiation from an Impact-Excited Clamped Circular Plate in an Infinite Baffle

A. Akay and M. Latcha
Mech. Engrg. Dept., Wayne State Univ., Detroit, MI 48202, J. Acoust. Soc. Amer., 74 (2), pp 640-648 (Aug 1983) 13 figs, 3 tables, 25 refs

Key Words: Sound waves, Wave propagation, Plates, Circular plates, Impact excitation

Transient sound radiation from impact-excited circular plates is studied both analytically and experimentally. The contact force developed during the inelastic collision of a ball with a flexible plate is obtained. The plate vibrations are then obtained using normal mode analysis. The sound radiation waveforms in the time domain are obtained by numerical integration of the Rayleigh integral.

84-106

Free Vibration of a Circular Plate Elastically Restrained Along Some Radial Segments

T. Irie, G. Yamada, and K. Tanaka
Dept. of Mech. Engrg., Hokkaido Univ., Sapporo 060, Japan, J. Sound Vib., 89 (3), pp 295-308 (Aug 8, 1983) 4 figs, 4 tables, 17 refs

Key Words: Plates, Circular plates, Free vibration

An analysis is presented for the free vibration of a circular plate restrained against deflection along radial segments. With the reaction forces acting on the segments regarded as unknown harmonic loads, the stationary response of the plate to these loads is expressed by use of the Green function. The force distributions along the segments are expanded into Fourier series with unknown coefficients, and the homogeneous equations for the coefficients are derived by restraint conditions on the supports.

84-107

Free Vibration of Annular Sector Plates by an Integral Equation Technique

R.S. Srinivasan and V. Thiruvenkatachari
Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras 600 036, India, J. Sound Vib., 89 (3), pp 425-432 (Aug 8, 1983) 4 figs, 3 tables, 13 refs

Key Words: Plates, Annular plates, Natural frequencies

A numerical method is presented for the free vibration analysis of polar orthotropic clamped annular sector plates. Results are compared with analytical and experimental values of other investigators. A parametric study is done by varying the sector angle and radii ratio. The frequencies for isotropic and orthotropic cases are presented in the form of graphs.

84-108

Nonlinear Vibrations of Plates – A Review

M. Sathyamoorthy
Dept. of Mech. and Industrial Engrg., Clarkson College of Tech., Potsdam, NY 13676, Shock Vib. Dig., 15 (6), pp 3-16 (June 1983) 194 refs

Key Words: Plates, Nonlinear vibration, Reviews

The survey of literature presented in this paper on nonlinear vibrations of plates is limited to papers published from 1979 to 1982. Geometric, material, and combinations of these nonlinearities are treated; complicating effects of anisotropy, attached masses, cutouts, elastic foundation, nonclassical boundary conditions, stiffeners, thermal stresses, variable thickness, transverse shear deformation, and rotatory inertia are also surveyed.

84-109
On the Face-Shear Vibrations of Contoured Crystal Plates
S. De
National Res. Inst., P.O. Bankisol, Bankura, W. Bengal, India, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 139-149 (May 1983) 4 figs, 25 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Plates, Variable cross-section, Shear vibration

The face-shear vibration characteristics of monoclinic crystal plates of varying thickness are generalized and the special features of the frequency spectrum are shown. Solution for a crystal plate with piece-wise continuous boundary is obtained. Results are compared with those obtained for a plate of uniform thickness.

84-110
Impact Damage of Composite Plates
K.M. Lal and G.L. Goglia
Old Dominion Univ., Norfolk, VA, Rept. No. NASA-CR-170309, 41 pp (Apr 1983)
N83-24558

Key Words: Plates, Composite structures, Impact response

A simple model to study low velocity transverse impact of thin plates made of fiber-reinforced composite material, in particular T300/5208 graphite-epoxy, is discussed. This model predicts the coefficient of restitution, which is a measure of the energy absorbed by the target during an impact event. Predictions are compared with test results of impacted circular and rectangular clamped plates.

84-111
Frequency Average Loss Factors of Plates and Shells
M.F. Ranky and B.L. Clarkson
Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 89 (3), pp 309-323 (Aug 8, 1983) 15 figs, 5 tables, 3 refs

Key Words: Plates, Shells, Loss factor, Vibration response, Statistical energy methods

This paper describes a thorough investigation of the measurement of frequency band average loss factors of structural components for use in the statistical energy analysis method of computation of vibration levels.

SHELLS
(Also see Nos. 111, 208)

84-112
Finite Element Analysis of 3-Ply Laminated Conical Shell for Flutter
P.J. Sunder, C.V. Ramakrishnan, and S. Sengupta
Dept. of Appl. Mechanics, Indian Inst. of Tech., New Delhi, India, Intl. J. Numer. Methods Engrg., 19 (8), pp 1183-1192 (Aug 1983) 6 figs, 2 tables, 8 refs

Key Words: Shells, Conical shells, Layered materials, Flutter, Finite element technique

The results of the finite element analysis of 3-ply laminated conical shells with light core for linear panel flutter are presented and certain advantages of such shells discussed.

84-113
Torsional Oscillations of a Finite Inhomogeneous Piezoelectric Cylindrical Shell
K.V. Sarma
Dept. of Mathematics, PSG College of Arts & Science, Colimbatore 641014, India, Intl. J. Engrg. Sci., 21 (12), pp 1483-1491 (1983) 5 refs

Key Words: Shells, Cylindrical shells, Torsional vibration, Piezoelectricity

Torsional wave motion of a finite right circular cylindrical shell of inhomogeneous piezoelectric material of (622) crystal class under time dependent electric potential on the boundary is investigated. The inhomogeneity is restricted to the variations of density and other physical constants of the medium. Two related problems are shown to be particular cases of the present problem.

84-114
Seismic Response of the Flexible Fluid-Tank Systems -- a Numerical Study
D.C. Ma, W.K. Liu, and Y.W. Chang

Argonne National Lab., Argonne, IL, Rept. No. CONF-820601-28, 28 pp (1982) (ASME Pressure Vessel and Piping Conf., Orlando, FL, June 27, 1982)
Portions are illegible in microfiche products.
DE83009028

Key Words: Storage tanks, Fluid-filled containers, Hydrodynamic excitation, Seismic design, Numerical analysis

Current practice in the seismic design of liquid storage tanks is reviewed. Significant numbers of failures in tanks designed under past practices suggest the need to examine more closely the assumptions made in the design and the resulting predicted behavior versus the actual, observed behavior. A coupled fluid-structure finite element method is presented for the seismic analysis of flexible fluid-tank systems. A detailed parametric study is then developed.

84-115

Normal Modes of the Modern English Church Bell

R. Perrin, T. Charnley, and J. DePont

Dept. of Physics, Loughborough Univ. of Tech., LE11 3TU, UK, J. Sound Vib., 90 (1), pp 29-49 (Sept 8, 1983) 12 figs, 3 tables, 9 refs

Key Words: Bells, Natural frequencies, Mode shapes, Experimental test data

Experimental measurements of the frequencies and nodal patterns of all the partials of a good quality 214 kg English church bell up to about 9 kHz are made. By matching these with the results of finite element calculations an understanding of the physical mechanisms generating the various partials is achieved. This has made possible the production, for the first time, of a classification scheme for the partials with a firm physical basis, and has given considerable new insight into church bell design.

PIPES AND TUBES

(Also see No. 240)

84-116

Instability of Circular Cylinder Arrays in Cross Flow

S.S. Chen

Components Tech. Div., Argonne National Lab., Argonne, IL, Shock Vib. Dig., 15 (7), pp 17-26 (July 1983) 2 figs, 47 refs

Key Words: Tube arrays, Fluid-induced excitation, Reviews

Developments in dynamic instability of circular cylinder arrays subjected to cross flow has been exciting in the past several years. This review presents a summary of progress since 1980; mathematical models, experimental data, stability criteria, design guidelines, and future research needs are discussed.

84-117

Experimental Validation of the Component Synthesis Method for Predicting Vibration of Liquid-Filled Piping

F.J. Hatfield, D.C. Wiggert, and L.C. Davidson

Michigan State Univ., East Lansing, MI, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 1-10 (May 1983) 4 figs, 18 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Pipelines, Fluid-filled containers, Fluid-induced excitation, Component mode synthesis, Vibration prediction, Prediction techniques

Vibration of piping can be caused by pulsation of contained liquid. Accurate prediction of such vibration requires consideration of the effect of pipe motion on fluid oscillation, as well as of acoustic pressure on pipe walls. Component synthesis is an analytic technique that approximates those interactions by synthesis of plane-wave acoustics of the liquid and normal modes analysis of the pipe structure. Results of analysis by component synthesis are compared to solutions of partial differential equations of motion and to experimental observations for two example pipe configurations.

84-118

Dynamics of the Water-Pipeline-Soil Interaction

K. Karal and S.A. Halvorsen

Norwegian Hydrodynamic Labs., Trondheim, Norway, J. Energy Resources Tech., Trans. ASME, 104 (4), pp 307-312 (Dec 1982) 5 figs, 4 tables, 9 refs

Key Words: Pipelines, Interaction: soil-structure, Fluid-filled containers, Fluid-induced excitation

A design engineer-oriented approach to determining the pipeline dynamic response to ocean forces accounting for complex environmental and pipeline conditions is presented. The described analysis yields time histories of pipeline motion and steel pipe stresses induced by water motion. Sinusoidal variation of normal water particle motion in time and along the pipeline, waves, flexural rigidity of pipe, damaged concrete coating, among other effects, are accounted for in the mathematical model.

84-119

Dynamic Behavior of Submarine Pipelines under Laying Operation

N. Suzuki and N. Jingu

Technical Res. Ctr., Nippon Kokan, K.K., Kawasaki, Japan, J. Energy Resources Tech., Trans. ASME, 104 (4), pp 313-318 (Dec 1982) 12 figs, 2 tables, 13 refs

Key Words: Pipelines, Underwater pipelines, Wave forces

Theoretical and experimental study on dynamic behavior of submarine pipelines under laying operation with articulated stingers is described. Wave response tests in regular waves and forced oscillation tests in still water were conducted using the 1/20 scale model of 406.4 mm o.d. (16 in. o.d.) pipeline laid in 150 m (500 ft) water depth.

84-120

Axial Stretching Oscillations of an 18,000-Ft Vertical Pipe in the Ocean

J.S. Chung and A.K. Whitney

Colorado School of Mines, Golden, CO 80401, J. Energy Resources Tech., Trans. ASME, 105 (2), pp 195-200 (June 1983) 9 figs, 5 refs

Key Words: Pipes (tubes), Underwater pipelines, Resonant response, Drilling platforms

For a long pipe in deep ocean with the equipment attached to its free bottom end, the bottom end oscillation can be amplified near resonance several times the top end oscillation amplitude. This can become a unique design and operation problem of the deepsea mining or drilling system equipment. Accounting for the added mass and damping of the bottom end equipment, the solution is obtained through numerical iteration for an 18,000-ft long vertical pipe with the bottom equipment, which is handled from a 300,000-t mining ship. It shows significantly large oscillatory pipe stretching near the resonance. The same trend of stretching is measured by the at-sea test with the Glomar Explorer test-mining operation. Near resonance, the bottom end motion is out of phase with the top end motion, thus increasing the net pipe stretching. The pipe response characteristics can be significantly altered by the pipe weight distribution, wall thickness, and length. These transfer functions, spectral analysis results and parametric analyses are presented.

84-121

Dynamic Elastic-Plastic Behavior of Circumferential Cracks in a Pipe Subject to Seismic Loading Conditions

T.J. Griesbach

Nuclear Safety Analysis Ctr., Palo Alto, CA, J. Pressure Vessel Tech., Trans. ASME, 105 (1), pp 63-72 (Feb 1983) 17 figs, 27 refs

Key Words: Pipelines, Cooling systems, Nuclear reactors, Cracked media, Seismic excitation

An analytic study is performed to investigate the structural stability, and inherent integrity, of a pressurized water reactor primary coolant loop cold leg pipe containing a through-wall circumferential crack. The purpose of this study is to gain a better understanding of the mechanisms and extent of crack opening behavior in a real piping system, and, thus, establish the basis for improved pipe break criteria.

84-122

Theoretical and Experimental Prediction of the Response of a Marine Riser Model Subjected to Sinusoid Excitation of Its Top End with Amplitude Equal to Two Diameters

C. Chryssostomidis, N.M. Patrikalakis, and E.A. Vrakas

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-83-2, NOAA-83052505, 90 pp (Mar 1983)

PB83-210575

Key Words: Marine risers, Pipes (tubes), Periodic excitation

The objective of this report is to provide an analysis of the experimental results obtained from a 3 m flexible riser model with its top end oscillated harmonically with an amplitude equal to two diameters, and a comparison of the experimental results from the flexible model with theoretical predictions of the response based on rigid and flexibly mounted rigid cylinder experimental results.

84-123

Theoretical and Experimental Prediction of the Response of a Marine Riser Model Subjected to Sinusoid Excitation of Its Top End with Amplitude of Two Diameters Parallel to a Uniform Stream of Speed Equal to 120 mm/s

C. Chryssostomidis and N.M. Patrikalakis

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-83-3, 69 pp (Mar 1983)

PB83-210328

Key Words: Marine risers, Pipes (tubes), Periodic excitation

The objective of this report is to provide an analysis of the experimental results obtained from a 3 m flexible riser model with its top end oscillated harmonically with an amplitude of two diameters parallel to a uniform stream which is constant with depth and of speed equal to 120 mm/s, and a comparison of the experimental results from the flexible model with theoretical predictions of the response based on rigid cylinder experimental results.

84-124

Theoretical and Experimental Prediction of the Response of a Marine Riser Model Subjected to Sinusoid Excitation of Its Top End with Amplitude of Two Diameters Parallel to a Uniform Stream of Speed Equal to 240 mm/s

C. Chryssostomidis and N.M. Patrikalakis

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-83-4, NOAA-83052507, 70 pp (Mar 1983)

PB83-210567

Key Words: Marine risers, Pipes (tubes), Periodic excitation

The objective of this report is to provide an analysis of the experimental results obtained from a 3 m flexible riser model with its top end oscillated harmonically with an amplitude of two diameters parallel to a uniform stream which is constant with depth and of speed equal to 240 mm/s, and a comparison of the experimental results from the flexible model with theoretical predictions of the response based on rigid cylinder experimental results.

84-125

Theoretical and Experimental Prediction of the Response of a Marine Riser Model Subjected to Sinusoid Excitation of Its Top End with Amplitude of Two Diameters Orthogonal to a Uniform Stream of Speed Equal to 120 mm/s

N.M. Patrikalakis and C. Chryssostomidis

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-83-5, NOAA-83052508, 89 pp (Mar 1983)

PB83-210559

Key Words: Marine risers, Pipes (tubes), Periodic excitation

The objective of this report is to provide an analysis of the experimental results obtained from a 3 m flexible riser model with its top end oscillated harmonically with an amplitude of two diameters orthogonal to a uniform stream which is constant with depth and of speed equal to 120 mm/s, and a comparison of the experimental results from the flexible model with theoretical predictions of the response based on rigid cylinder experimental results.

84-126

Theoretical and Experimental Prediction of the Response of a Marine Riser Model Subjected to Sinusoid Excitation of Its Top End with Amplitude of Two Diamters Orthogonal to a Uniform Stream of Speed Equal to 240 mm/s

N.M. Patrikalakis and C. Chryssostomidis

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. MITSG-83-6, NOAA-83052509, 89 pp (Mar 1983)

PB83-210583

Key Words: Pipes (tubes), Marine risers, Periodic excitation

The objective of this report is to provide an analysis of the experimental results obtained from a 3 m flexible riser model with its top end oscillated harmonically with an amplitude of two diameters orthogonal to a uniform stream which is constant with depth and of speed equal to 240 mm/s, and a comparison of the experimental results from the flexible model with theoretical predictions of the response based on rigid cylinder experimental results.

84-127

Flow-Induced Motions of Multiple Risers

T. Overvik, G. Moe, and E. Hjort-Hansen

Norwegian Inst. of Tech., Trondheim, Norway, J. Energy Resources Tech., Trans. ASME, 105 (1), pp 83-89 (Mar 1983) 16 figs, 6 refs

Key Words: Pipes (tubes), Marine risers, Fluid-induced excitation, Vortex-induced vibration, Galloping, Vibration tests

Vortex-induced and galloping vibrations of flexible risers in steady, uniform currents were investigated. The cross sections consisted of a bundle of pipes tied together to form a so-called multiple production riser. The tests were carried out in a wind tunnel at subcritical Reynolds numbers, using spring-mounted sectional models. The tests used the single tube case as a reference case, and the results indicated increased motions for all of the multiple configurations compared to the reference case.

84-128
Acoustical Modal Analysis of the Pressure Field in the Tailpipe of a Turbofan Engine
E.A. Krejsa and A.M. Karchmer
NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. E-1665, NASA-TM-83387, 32 pp (May 13, 1983) (Presented at 105th Meeting of Acoust. Soc. of Amer., Cincinnati, OH, May 9-13, 1983)
N83-25499

Key Words: Pipes (tubes), Tailpipes, Turbofan engines, Modal analysis

The results of a modal analysis of the pressure field in the tailpipe of a turbofan engine are presented. Modal amplitudes, at the tailpipe inlet and exit, are presented, as a function of frequency, for several operating conditions. The modal amplitudes were obtained using an optimization routine to obtain a best fit between measured cross spectra and an analytical expression for the cross spectra between pressures at circumferentially spaced locations.

84-129
Dynamic Crack Curving and Branching in Line-Pipe
M. Ramulu, A.S. Kobayashi, and B.S.-J. Kang
Dept. of Mech. Engrg., Univ. of Washington, Seattle, WA 98195, J. Pressure Vessel Tech., Trans. ASME, 104 (5), pp 317-322 (Nov 1982) 7 figs, 30 refs

Key Words: Pipes (tubes), Crack propagation

The newly derived dynamic crack curving and crack branching criteria are briefly reviewed. The two criteria are justified by a micro-mechanics model and are used to predict crack curving and crack branching of dynamic photoelastic experiments involving Homalite-100 fracture specimens.

DUCTS

84-130
Active Noise Control in Finite Length Ducts
M.C.J. Trinder and P.A. Nelson
Univ. of Essex, Wivenhoe Park, Colchester C04 3SQ, UK, J. Sound Vib., 89 (1), pp 95-105 (July 8, 1983) 8 figs, 10 refs

Key Words: Ducts, Active noise control

A simple technique for the active control of sound in ducts is investigated. A simple, virtual earth principle, feedback loop is used to drive the sound pressure to a minimum at a microphone placed close to a loudspeaker in the duct wall. This produces a reflection of downstream traveling plane waves. A detailed investigation of the loudspeaker near field has enabled the optimum position of the microphone to be identified. The system is shown to be especially effective at the frequencies of the longitudinal duct resonances, where the acoustic response of the duct produces a high loop gain.

84-131
Transonic Noise Generation by Duct and Profile Flow
G.E.A. Meier, R. Timm, and F. Becker
Max-Planck-Inst. fuer Stroemungsforschung, Goettingen, Fed. Rep. Germany, 45 pp (Apr 1983)
AD-A129 367

Key Words: Ducts, Noise generation, Helicopters, Rotors

To study the strong sound generation in the case of helicopter rotor vortex interaction, a vortex profile flow interaction experiment is performed in a transonic duct. Vortices are generated upstream of a NACA 0012 profile and the pressure and density fields are analyzed using digital signals processing methods and digital interferogram evaluation techniques.

84-132
Actuator Duct Representation of Turbomachinery Blade Rows
W.R. Hawthorne
Dept. of Engrg., Cambridge Univ., UK, Rept. No.

CUED/A-TURBO/TR-119, ISSN-0309-6521, 14 pp (1983)
N83-24859

Key Words: Ducts, Turbomachinery blades

The theory of the actuator for representing turbomachinery blade rows is developed starting from the actuator disk to include the effects of inlet shear and skew and the effects of compressibility.

BUILDING COMPONENTS

84-133

Maximum Response of Nonproportionally and Proportionally Damped Structural Systems under Multicomponent Earthquakes

M.P. Singh and M. Ghaford-Ashtiany
Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA,
Rept. No. VPI-E-83-13, 80 pp (Mar 1983)
PB83-216598

Key Words: Seismic response, Damped structures, Seismic design

Earthquake motions as felt by structures along three orthogonal directions are, in general, statistically correlated. The effect of this correlation on structural response is studied.

84-134

Modelling Hysteretic Behaviour of Coupled Walls for Dynamic Analysis

M. Saatcioglu, A.T. Derecho, and W.G. Corley
Dept. of Civil Engrg., Univ. of Toronto, Toronto, Ontario, Canada,
Earthquake Engrg. Struc. Dynam., 11 (5), pp 711-726 (Sept/Oct 1983) 17 figs, 4 tables, 8 refs

Key Words: Walls, Hysteretic damping, Computer programs, Multistory buildings, Buildings

Modeling techniques for dynamic inelastic response analysis of coupled wall structures are investigated. Emphasis is placed on effects of parameters defining the force-displacement hysteresis loop. Specifically, effects of axial force-moment interaction, strength reduction, shear yielding, pinching, reloading and unloading branches of hysteresis loops are considered. Effects of modeling parameters on selected response quantities are investigated and discusssed in detail.

ELECTRIC COMPONENTS

CONTROLS
(Switches, Circuit Breakers)

84-135

Vibration Challenges in Microelectronics Manufacturing

E.E. Ungar and C.G. Gordon
Bolt Beranek and Newman, Inc.,
Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 51-58 (May 1983) 7 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Optical methods, Vibration control, Microprocessors (computers)

The manufacture of smaller, more tightly packed, integrated circuits requires facilities designed to meet stringent vibration requirements. Vibration control is complicated by the need for extensive process support equipment and some service personnel in the vicinity of the sensitive machines. Facility criteria that have been developed on the basis of earlier facility experience have tended to be unrealistic and inadequately defined. The present paper delineates the shortcomings of these criteria and indicates how better criteria may be defined.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION
(Also see No. 105)

84-136

Response of Multiple Layered Media

G. Maidanik, L.J. Maga, and T.J. Eisler

David Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD 20084, J. Sound Vib., 89 (1), pp 31-57 (July 8, 1983) 13 figs, 15 refs

Key Words: Layered materials, Acoustic response

A recently developed method for estim·ting the response of multiple coupled one-dimensional dynamic systems can be adapted to deal with the response of multiple layered media. This paper discusses this adaptation. The purpose is to bring this method to bear on this important subject and to expand the range of applicability of the method.

84-137

Noise Analysis and Control in Fluid Power Systems

H.R. Martin

Dept. of Mech. Engrg., Univ. of Waterloo, Waterloo, Ontario, Canada, Hydraul. Pneumat., Pt 1: 35 (1), pp 296-301 (Jan 1982); Pt II: 35 (3), pp 91-94 (Mar 1983); Pt III: 35 (5), pp 118-120 (May 1982); Pt IV: 35 (9), pp 77-81 (Sept 1982); Pt V: 36 (6), pp 60-64 (June 1982)

Key Words: Noise measurement, Measuring instruments

In the first part of this article fundamentals, pressure and power level calculations, and measurements are discussed. Part two deals with basic instrumentation and octave band filters and part three, with sources of noise. In part four the series is closed with a discussion of impedances and estimating noise levels.

84-138

On the Application of Coherence Techniques for Source Identification in a Multiple Noise Source Environment

M.E. Wang and M.J. Crocker

Ray W. Herrick Labs., School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Acoust. Soc. Amer., 74 (3), pp 861-872 (Sept 1983) 16 figs, 17 refs

Key Words: Noise source identification, Coherence function technique

Two approaches for noise source identification based on theory for multiple-input systems are investigated. The concepts of the frequency response function and the coherent residual spectral density function are used to estimate the spectra of the noise sources accounted for in the multiple-input model.

84-139

Prony's Method Applied to Estimate Noise Source Locations and Their Sound Powers

K. Inomoto and S. Hattori

Dept. of Electrical Engrg., Mie Univ., 1515 Kamihama, Tsu City, 514 Japan, J. Sound Vib., 89 (4), pp 509-517 (Aug 22, 1983) 7 figs, 5 refs

Key Words: Noise source identification, Sound intensity, Prony's series analysis

An application of Prony's method for evaluating the acoustic power and location of sound sources from spatially sampled data is described. This paper deals with an estimation procedure to find the location and power of a noise source. The estimation is done by minimizing the sum of the squares of the errors between the model and measured data. The proposed method has general applicability to problems where the so-called inverse square law for intensity can be assumed to be valid.

84-140

A Restoration Procedure for (Non-Stationary) Signals from Moving Sources

H.P. Verhas

Welvaartstraat 98, B-9300 Aalst, Belgium, J. Sound Vib., 89 (4), pp 487-497 (Aug 22, 1983) 12 figs, 1 ref

Key Words: Power spectral density function, Coherence function technique, Moving loads

Moving sources, such as trains, cars and airplanes, provide nonstationary sound and vibration signals in situations where the receiver is not moving with the source. For nonstationary signals there are strong limitations on the use of computerized analysis techniques based on Fourier transformation. For instance, it is not possible to compute reliably either power spectral density functions or coherence functions. A procedure has been developed that restores nonstationary signals into stationary ones, thus enabling one to apply the analysis techniques mentioned above to moving source data with a reliable outcome.

84-141

Theoretical Foundations of Urban Noise Control

R. Makarewicz
Inst. of Acoustics, A. Mickiewicz Univ., 60-679 Poznan, Matejki 48/49 Poland, J. Acoust. Soc. Amer., 74 (2), pp 543-557 (Aug 1983) 21 figs, 9 refs

Key Words: Urban noise, Noise reduction, Sound propagation

Traffic noise propagating within an urban area of any configuration is considered. A street and a single building being a part of a loose urban area are examined closely. Final results allow one to determine any composite index of noise penetrating into a building; i.e., a room. These results are a synthesis of a study of such phenomena as propagation of noise over a flat surface, specular reflection and scattering by the walls of buildings, and transmission through a barrier; e.g., a window.

84-142

The Determination of a Typical Immission Parameter of Traffic Noise under Arbitrary Propagation Conditions (Bestimmung typischer Immissionsparameter bei Verkehrslärm in beliebigen Ausbreitungssituationen)

H.P. Quadt
Institute f. Technische Akustik, Rheinisch-Westfalische Technische Hochschule Aachen, Germany, Acustica, 53 (2), pp 61-71 (June 1983) 12 figs, 13 refs
(In German)

Key Words: Traffic noise, Noise measurement

Traffic noise is determined by traffic pattern and by noise radiation between the street and the point of observation. Radiation conditions are represented by the passing function (Vorbeifahrtfunction-MZT), defined as the time slope of noise intensity at an observation point while a vehicle is passing at a constant speed. From this passing function the time slope of the intensity of any traffic process, described by the distribution of vehicles on the street, can be calculated and from it the desired immission parameter can be derived. In this paper the passing functions for various situations are obtained (analytically, by mathematical modeling, test models, and by measurement on the street), and applied to various vehicle distributions. Analytical and measurement results are well within agreement.

84-143

Noise Source Identification for Three Small Engines

J.K. Thompson, L.E. Kung, and D.R. Tree
Dept. of Mech. Engrg., Louisiana State Univ., Baton Rouge, LA 70803, Noise Control Engrg., 21 (2), pp 74-80 (Sept/Oct 1983) 4 figs, 5 tables, 13 refs

Key Words: Engine noise, Noise source identification

Major noise sources were identified for three small engines using conventional measurement techniques consisting of reverberant room sound power measurements, selective source wrapping and selective source operation. The three internal combustion engines studied were all air-cooled, single cylinder engines of 2.2 or 6.0 kW (3 or 8 hp). Engine source sound power levels were obtained for rotational speeds ranging from 1600 to 3600 rpm and loads from 0 to 11 N-m (0 to 8 ft-lb) of torque. Forty-eight different operating conditions were studied.

84-144

The Field of a Spherical Wave Reflected from a Plane Absorbent Surface Expressed in Terms of an Infinite Series of Legendre Polynomials

A.D. Rawlins
Dept. of Mathematics, Brunel Univ., Uxbridge UB8 3PH, UK, J. Sound Vib., 89 (3), pp 359-363 (Aug 8, 1983) 12 refs

Key Words: Sound waves, Wave reflection

The acoustic field of a spherical sound wave reflected from a locally reacting plane surface is expressed as an asymptotic expansion whose terms consist of the product of Legendre polynomials and powers of the reciprocal of the distance from the image source.

84-145

Coefficient of Variation Spectral Analysis: An Application to Underwater Acoustics

P.D. Herstein and R.F. LaPlante
Naval Underwater Systems Ctr., New London, CT, Rept. No. NUSC-TD-6915, 18 pp (May 3, 1983) (Pres. at American Inst. of Aeronautics and Astronautics Conf. (8th), Atlanta, GA, Apr 11-13, 1983) AD-A128 191

Key Words: Underwater sound, Power spectral density

Acoustic noise in the ocean is often described in terms of its power spectral density. This noise consists of both narrowband and broadband frequency components. A major prob-

lem in the analysis of power spectral density measurements is distinguishing between narrowband spectral components of interest and contaminating narrowband components. In this paper the use of coefficient of variation spectrum is examined as an adjunct to the conventional power spectrum to distinguish narrowband components of interest from contaminating components.

84-146

The Group Velocity of Normal Modes

D.M.F. Chapman and D.D. Ellis

Defence Res. Establishment Atlantic, P.O. Box 1012, Dartmouth, Nova Scotia, B2Y 3Z7, Canada, J. Acoust. Soc. Amer., 74 (3), pp 973-979 (Sept 1983) 6 figs, 3 tables, 20 refs

Key Words: Underwater sound, Group velocity

A simple, general formula for normal mode group velocities provides an intuitive grasp of the factors influencing group velocity, especially for shallow water environments associated with strong seabed interaction. This is demonstrated using some hypothetical shallow water environments, and by comparing mode shapes at different frequencies. The formula is especially convenient to implement in normal mode computer codes which already perform similar calculations for mode normalization and attenuation coefficients.

84-147

Acoustic Wave Scattering by Elastic Cylindrical Shells in Water

T.A.K. Pillai, V.K. Varadan, and V.V. Varadan

Wave Propagation Group, Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 74 (2), pp 619-624 (Aug 1983) 5 figs, 1 table, 15 refs

Key Words: Acoustic scattering, Elastic waves, Sound waves, Shells, Cylindrical shells, Underwater sound

Frequency dependence of acoustic wave scattering by an infinite cylindrical shell of arbitrary cross section is analyzed using the T-matrix approach. Explicit expression for the T matrix of a two-layered cylinder is presented. Numerical results are obtained for plane wave incidence normal to the axis of the shell but arbitrary with respect to the noncircular cross section for a range of frequencies. Backscattering cross sections for various angles of incidence are presented for aluminum, steel, and plastic compliant tubes.

84-148

An Extended Unitary Approach for Acoustical Scattering from Elastic Shells Immersed in a Fluid

M.F. Werby and L.H. Green

Naval Coastal Systems Ctr., Panama City, FL 32407, J. Acoust. Soc. Amer., 74 (2), pp 625-630 (Aug 1983) 10 figs, 16 refs

Key Words: Acoustic scattering, Elastic waves, Shells, Submerged structures, Matrix methods

Equations are derived using the T-matrix approach for acoustical scattering from elastic shells immersed in a fluid. The equations contain unitary and symmetry constraints and afford a new procedure for the calculation of the T matrix. The technique, in addition to satisfying symmetry and unitary conditions, proves to be more numerically stable and less time consuming than the conventional method.

84-149

Wave Propagation through a Slender Curved Tube

Lu Ting and M.J. Miksis

Courant Inst. of Mathematical Sciences, New York Univ., New York, NY 10012, J. Acoust. Soc. Amer., 74 (2), pp 631-639 (Aug 1983) 1 fig, 9 refs

Key Words: Sound waves, Wave propagation, Tubes, Curved ducts

The transmission of an acoustic wave through a slender three-dimensional tubular region is investigated. The ratio of the reference length a of a cross section of the tube to the reference curvature of the center line of the tube is assumed to be small. The analysis is carried out for wavelengths ranging from the order of the reference curvature of the center line of the tube to wavelengths much smaller than the reference length of the cross-sectional area.

84-150

Concurrent Underwater Acoustic Wave-Front Fluctuations at Two Frequencies

H.W. Broek

Bell Labs., Whippany, NJ 07981, J. Acoust. Soc. Amer., 74 (2), pp 559-563 (Aug 1983) 15 figs, 13 refs

Key Words: Underwater sound

An experiment was performed to determine whether or not a relative phase fluctuation between two receivers of a signal transmitted over a long ocean path can be expressed as the angular frequency times a frequency-independent delay fluctuation.

84-151
Acoustic Coupling Between a Pulsating and an Oscillating Sphere

W. Thompson, Jr. and J.M. Reese
Appl. Res. Lab., P.O. Box 30, State College, PA 16801, J. Acoust. Soc. Amer., 74 (3), pp 1048-1050 (Sept 1983) 9 figs, 5 refs

Key Words: Acoustic coupling, Acoustic impedance, Radiation impedance

The modification of the radiation impedance load on each of two equal-sized spherical-shaped sources, one vibrating in the pulsating or n = 0 mode and the other in the oscillating or n = 1 mode has been calculated. Plots of the normalized resistive and reactive components of the modified radiation impedance are presented as a function of the wavelength size and separation of the two spheres.

84-152
On the Radiation Impedance of a Rectangular Piston

H. Levine
Dept. of Mathematics, Stanford Univ., CA 94305, J. Sound Vib., 89 (4), pp 447-455 (Aug 22, 1983) 6 refs

Key Words: Pistons, Radiation impedance

Single integral representations for the resistive and reactive components of the radiation impedance appropriate to a rectangular piston are established, thereby enabling a systematic refinement of estimates at both short and long wavelengths. Comparisons with previous analyses are made explicit as well as extensions and corrections thereto.

84-153
A New Rigorous Expansion for the Velocity Potential of a Circular Piston Source

T. Hasegawa, N. Inoue, and K. Matsuzawa
Dept. of Physics, Faculty of Science, Ehime Univ., Matsuyama, Ehime 790, Japan, J. Acoust. Soc. Amer., 74 (3), pp 1044-1047 (Sept 1983) 5 figs, 13 refs

Key Words: Pistons, Acoustic scattering

In the case of boundary value problems such as the sound scattering from a sphere placed in the nearfield of a plane piston source, it is sometimes essential to express the velocity potentials in terms of the orthogonal expansion. It is demonstrated that the Rayleigh surface integral, giving the velocity potential for a plane piston source surrounded by an infinite rigid flange, reduces to a rigorous expansion of the simplest form for a circular piston as series of spherical surface harmonics. The resulting equation is valid for any field points even on the piston surface.

84-154
Acoustic Radiation from Submerged Structures at Characteristic Frequencies

C.M. Piaszczyk
Ph.D. Thesis, Polytechnic Inst. of New York, 85 pp (1983)
DA8316777

Key Words: Submerged structures, Sound waves, Wave propagation

The application of the boundary integral methods to the problem of acoustic radiation encounters serious difficulties at the characteristic frequencies of the associated interior Dirichlet problem. Specifically, in the surface Helmholtz formulation, using the Green's surface integral formula in conjunction with the Newmann type of boundary conditions, the solution exists but is not unique. An iterative numerical overdetermination scheme is developed. This method is applied to the cylindrical transducer problem and proves to yield good results at characteristic frequencies. Next, using finite element discretization of the elastic structure, a problem of structure-fluid interaction is considered. An extension of the above exterior overdetermination method is developed for application. However, no characteristic frequencies for the sample considered have been found. Although nonexistence of such frequencies for the problems of this type is conjectured, no general proof is given.

84-155
Industrial Noise Control: The Past Three Years

R.J. Peppin
Bruel & Kjaer Instruments, Inc., 19544 Shady Grove

Rd., Gaithersburg, MD 20877, Shock Vib. Dig., 15 (7), pp 3-14 (July 1983) 184 refs

Key Words: Noise reduction, Industrial facilities, Reviews

This paper surveys literature concerning industrial noise control over the past three years. Broad categories are presented because of the encompassing nature of the areas.

SHOCK EXCITATION

(Also see Nos. 39, 42, 59, 60, 133, 201, 205, 207, 242, 243)

84-156

Dynamic Analysis of Dislocation Generation Due to Sudden Indentation

L.M. Brock

Dept. of Engrg. Mechanics, Univ. of Kentucky, Lexington, KY 40506, Intl. J. Engrg. Sci., 21 (12), pp 1437-1442 (1983) 2 figs, 11 refs

Key Words: Indentation, Dynamic analysis

The dynamic analysis of an edge dislocation generated under the edge of a rigid smooth indentor applied suddenly to an elastic half-plane is presented. The physical requirement that the indentor edge cannot induce a corner yields an equation relating the dislocation, indentor and half-plane parameters. Study of the equation allows several general observations on the dislocation motion.

84-157

Approximate Numerical Predictions of Impact-Induced Structural Responses

R.W. Wu

Lockheed Missiles and Space Co., Inc., Sunnyvale, CA 94086, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 131-138 (May 1983) 7 figs, 10 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Impact response, Numerical analysis

In the response prediction of a structural dynamic system impacting against a rigid object or with other flexural structural systems, the immediate consequence of the local impact interaction is often approximated by one of two means: the collision force method or the collision-imparted velocity method. In this paper the two methods are derived and evaluated. The limitations and advantages of the two methods are assessed via several numerical examples.

84-158

Dynamics of a Simple System Subjected to Random Impact

T.T. Soong

Dept. of Civil Engrg., State Univ. of New York at Buffalo, Amherst Campus, Buffalo, NY 14260, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 125-129 (May 1983) 6 figs, 8 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Impact response, Random excitation, Single degree of freedom systems

This paper is concerned with the impact characteristics of a simple mechanical system subjected to random collision or impact. The model analyzed is a simple one-degree-of-freedom mechanical system oscillating between two elastic reflectors when the supporting frame is subjected to a base motion modeled by a stationary random process.

84-159

Impulse Response of the Ocean Floor Nonlinear Techniques for Measurement Enhancement

T. Gabrielson

Naval Air Development Ctr., Warminster, PA, Rept. No. NADC-82253-30, 65 pp (Apr 1983). AD-A128 578

Key Words: Impulse response, Underwater explosions

This report describes a procedure for enhancement of impulse response measurements of the ocean floor. Special problems such as phase reconstruction and signal conditioning are discussed in the context of ocean floor measurements with explosives, and a computer code is presented that generates and checks the log-spectrum.

84-160

Materials Implications of Advanced Thermal and Kinetic Energy Threats

R. Fitzpatrick and J. Mescall

Army Materials and Mechanics Res. Ctr., Watertown, MA 02172, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 71-78 (May 1983) 15 figs, 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Protective shelters, Hardened installations, Vulnerability, Lasers

Directed energy threats; i.e., lasers, microwave systems, and particle beam devices, open a new frontier in the area of military research and technology and are capable, at least in theory, of depositing energy onto a target thereby causing damage. The damage is generally a result of very rapid and intense heating which results in structural failure, or failure of sensitive electronic materials due to thermal overload.

84-161

Aseismic Toughness of Structures

M. Como and G. Lanni

Istituto di Tecnica delle Costruzioni, Universita di Napoli, Meccanica, 18 (2), pp 107-114 (June 1983) 16 figs, 12 refs

Key Words: Seismic analysis, Dynamic structural analysis, Reinforced concrete

An approximate evaluation is given of the ductility and strength demand so that a structure can resist strong earthquakes of an assigned intensity level. It is shown, by means of a suitable energy balance equation, that the aseismic capacity of structures depends on a special coupling of strength and ductility defined as aseismic toughness. A broad evaluation of the toughness ratios that can be achieved in reinforced concrete structures is presented.

84-162

Equivalent Nuclear Yield and Pressure by the Response Spectrum Fit Method

J.R. Bruce and H.E. Lindberg

SRI International, Menlo Park, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 1[illegible]7-196 (May 1983) 6 figs, 8 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Nuclear weapons effects, Explosion effects, Prediction techniques

A new method for assigning an equivalent nuclear yield and range to the pressure-time history measured in simulating experiments is presented. The method is based on the linear response spectrum. Equivalent nuclear event parameters are selected so that the response spectrum of the nuclear event best fits that of the measured data over a preselected frequency range.

84-163

Fluid-Structure Interaction by the Method of Characteristics

F.D. Hains

Naval Surface Weapons Ctr., White Oak, Silver Spring, MD, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 23-27 (May 1983) 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Submerged structures, Underwater structures, Interaction: structure-fluid, Shock wave reflection, Method of characteristics

Linearized formulations for the pressure loading on submerged structures are inadequate when applied to impulsive loads from strong underwater shock waves. The limitations are discussed briefly, and a new approach based on the method of characteristics is presented.

84-164

A Solution to the Axisymmetric Bulk Cavitation Problem

F.A. Costanzo and J.D. Gordon

Underwater Explosions Res. Div., David Taylor Naval Ship Res. and Dev. Ctr., Portsmouth, VA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 33-51 (May 1983) 20 figs, 2 tables, 6 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Cavitation, Underwater explosions, Nuclear explosion effects, Explosion effects

Physical considerations are applied to the analysis of bulk cavitation in order to derive an existing method for determining the upper and lower cavitation boundaries. A closure model is developed which uses the upper and lower cavitation boundaries as input and computes the time and depth of bulk cavitation closure, as well as the magnitude of the pressure pulse generated by the water hammer.

84-165
A Solution to the One Dimensional Bulk Cavitation Problem

B.M. Stow and J.D. Gordo
Underwater Explosions ... David Taylor Naval Ship Res. and Dev. Ctr., Po..., VA, Shock Vib. Bull., U.S. Naval Res. Lab. ... 53, Pt 2, pp 53-61 (May 1983) 8 figs, 1 table, 2 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Cavitation, Underwater explosions, Nuclear explosion effects, Explosion effects

The bulk cavitation analysis method presented in this paper eliminates the need to segment water for the purpose of solving simple equations of motion between water elements. The one dimensional problem analyzed in detail demonstrates the ease of application of the method. Plots of cavitation closure, water pressure, and water particle velocity are provided from the analysis.

84-166
On the Behavior of Shock Waves in Deformable Dielectric Materials

B. Collet
Universite Pierre et Marie Curie (Paris VI), Laboratoire de Mecanique Theorique associe au C.N.R.S., Tour 66, 4 place Jussieu, 75230 Paris Cedex 05, France, Intl. J. Engrg. Sci., 21 (10), pp 1145-1155 (1983) 18 refs

Key Words: Shock wave propagation

The behavior of plane shock waves propagating in elastic dielectrics is examined. The differential equation governing the amplitude of wave and formulae concerning the polarization changes across the shock are deduced. Some particular situations are studied in detail.

84-167
Three-Dimensional Effects on the Focusing of Weak Shock Waves

M.S. Cramer
Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 90 (1), pp 25-28 (Sept 8, 1983) 1 fig, 6 refs

Key Words: Shock wave propagation

The focusing of weak three-dimensional shock waves at an arête is examined. By aligning the co-ordinate system with the principal directions on the initial shock surface, it is shown that the focusing of an arbitrary three-dimensional shock may be regarded as locally two-dimensional. In addition, the scaling relating the problems is given explicitly.

84-168
An Explosive Driven Shock Tube for Verifying the Survival of Radioisotope Heat Sources During Space Shuttle Launch Accident

F.H. Mathews
Sandia Natl. Labs., Albuquerque, NM, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 103-115 (May 1983) 11 figs, 6 tables, 5 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tube testing

Decay of radioactive isotopes provides a heat source for flights into deep space. Environmental concerns dictate that these heaters retain and immobilize their toxic contents in the event of a space shuttle detonation on the launch pad. This paper describes the planning, conduct, and analysis of experiments which employed explosive driven shock tubes to simulate such a blast.

84-169
Calculation of the Shock Wave from a Pentolite Tapered Charge

J.T. Gordon and D.K. Davison
Physics International Co., San Leandro, CA 94577, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 117-131 (May 1983) 17 figs, 1 table, 7 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock wave propagation, Underwater explosions, Nuclear explosion effects, Prediction techniques, Numerical analysis

Results are presented from two-dimensional computations simulating the shock wave produced by the underwater

detonation of a small-scale, 2.66 pound Pentolite tapered charge. These calculations were performed using the nonlinear explicit finite-difference computer code PISCES 2D ELK. Results presented include pressure contours, mesh plots, and pressure time histories.

84-170

Properties of Actual and Numerical Shock and Blast Wave Phenomena

I.I.Glass

Inst. for Aerospace Studies, Toronto Univ., Downsview, Ontario, Canada, Rept. No. ARO-16972.11-EG, 34 pp (Apr 1983)

AD-A129 483

Avail: Microfiche copies only

Key Words: Shock wave propagation

Application of the random-choice method to explosion and implosion dynamics (flows with changes in area and detonation) and weak spherical shock-wave transitions (flows with viscosity, heat condution, and vibrational excitation) is presented. Progress made in applying the fluid-in-cell technique to oblique-shock-wave reflections is also included.

84-171

Characteristic Frequencies of Transonic Diffuser Flow Oscillations

T.J. Bogar, M. Sajben, and J.C. Kroutil

McDonnell Douglas Corp., St. Louis, MO, AIAA J., 21 (9), pp 1232-1240 (Sept 1983) 13 figs, 2 tables, 20 refs

Key Words: Shock wave propagation

The time-mean and unsteady flow characteristics of a supercritical transonic diffuser are investigated as a function of shock Mach number and diffuser length. The flow is either attached or undergoes shock-induced separation, depending on shock strength.

VIBRATION EXCITATION

84-172

A Periodically Forced Piecewise Linear Oscillator

S.W. Shaw and P.J. Holmes

Dept. of Theore .ical and Applied Mechanics, Cornell Univ., Ithaca, NY 14853, J. Sound Vib., 90 (1), pp 129-155 (Sept 8, 1983) 17 figs, 29 refs

Key Words: Oscillators, Periodic excitation

A single-degree of freedom nonlinear oscillator is considered. The nonlinearity is in the restoring force and is piecewise linear with a single change in slope. Such oscillators provide models for mechanical systems in which components make intermittent contact. A limiting case in which one slope approaches infinity, an impact oscillator, is also considered.

84-173

Nonstationary Resonance Oscillations

B.N. Agrawal and R.M. Evan-Iwanowski

INTELSAT, 490 L'Enfant Plaza East S.W., Washington, DC 20024, Shock Vib. Dig., 15 (7), pp 27-33 (July 1983) 10 figs, 1 table, 37 refs

Key Words: Resonance pass through, Reviews

This article describes nonstationary oscillations in combination resonances, factors affecting nonstationary responses, and applications and unsolved problems of nonstationary responses.

84-174

Low Frequency Scattering by Local Inhomogeneities

G.A. Kriegsmann and E.L. Reiss

Northwestern Univ., Evanston, IL 60201, SIAM J. Appl. Math., 43 (4), pp 923-934 (Aug 1983) 15 refs

Key Words: Wave scattering, Low frequencies

An asymptotic expansion which is uniformly valid in space is obtained for the low frequency scattering of a plane wave incident on a localized inhomogeneity.

84-175

Criteria for Accelerated Random Vibration Tests with Non-Linear Damping

R.G. Lambert

Aircraft Equipment Div., General Electric Co., Utica, NY 13503, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 115-123 (May 1983) 7 figs, 4 tables, 8 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Random vibration, Vibration tests, Nonlinear damping

Closed form analytical expressions have been derived which relate the parameters for accelerating Gaussian random vibration tests such that the fatigue damage accumulated is the same for both the accelerated and non-accelerated cases. The same failures, only sooner, is the objective. Nonlinear structural damping, the significant parameter considered, was chosen for its practical importance. Numerical examples are included.

84-176

The Response of Single Degree of Freedom Systems with Quadratic and Cubic Non-Linearities to a Subharmonic Excitation

A.H. Nayfeh

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 89 (4), pp 457-470 (Aug 22, 1983) 4 figs, 16 refs

Key Words: Single degree of freedom systems, Subharmonic oscillations

The response of single degree of freedom systems with quadratic and cubic nonlinearities to a subharmonic excitation is investigated. The method of multiple scales is used to derive two first order ordinary differential equations that govern the evolution of the amplitude and phase of the subharmonic. These equations are used to obtain the steady state solutions and their stability.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 63, 73, 191, 192, 224)

84-177

Effect of an Impact Damper on a Multi-Degree of Freedom System

M.M. Nigm and A.A. Shabana

Dept. of Mech. Engrg., Ain Shams Univ., Abbasia, Cairo, Egypt, J. Sound Vib., 89 (4), pp 541-557 (Aug 22, 1983) 13 figs, 10 refs

Key Words: Shock absorbers, Multidegree of freedom systems

Theoretical analysis of the steady state vibrational motion of a multi-degree of freedom system equipped with an impact damper is presented. The analysis is based on the assumption that two generally distributed impacts occur in each cycle. The theory is applied to the special case of a single degree of freedom main system and the effects of various parameters are investigated. The theoretically possible modes of steady state motion with two impacts/cycle and with no impacts are predicted.

84-178

Experimental Investigation of Controlling Vibrations Using Multi-Unit Impact Dampers

C.N. Bapat, S. Sankar, and N. Popplewell

Concordia Univ., Montreal, Quebec, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 1-12 (May 1983) 14 figs, 11 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock absorbers, Vibration control

Free and forced vibrations of multi-unit impact dampers are investigated experimentally. In free vibrations the time rate of decrease of maximum displacement increased with number of units and was nearly constant only when initial deflection was greater than gap. In steady state motion with identical gaps, under sinusoidal load, impacts generally occurred only over a fraction of a cycle.

84-179

An Experimental Hybrid Model for a Bilinear Hysteretic System

K.R. McLachlan, N. Popplewell, W.J. McAllister, and C.S. Chang

Univ. of Manitoba, Winnipeg, Canada, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 13-17 (May 1983) 5 figs, 12 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Hysteretic damping

An experimental model, developed to simulate the nonlinear behavior of a complex hysteretic system, is described. Experimental data from the simplest form of this electro-mechanical model, the single degree-of-freedom system, is helpful in reconciling previously disparate theoretical results.

84-180

The Behavior of a Linear, Damped Modal System with a Non-Linear Spring-Mass-Dry Friction Damper System Attached

E.H. Dowell

Dept. of Mech. and Aerospace Engrg., Princeton Univ., Princeton, NJ 08544, J. Sound Vib., 89 (1), pp 65-84 (July 8, 1983) 11 figs, 43 refs

Key Words: Coulomb friction, Component mode analysis

A component mode analysis is carried out based upon the use of constraint conditions and Lagrange multipliers. It is used to generalize the well known results for a single-degree-of-freedom dry friction damper to a multi-mode linear system with a spring-mass-dry friction damper attached.

84-181

A Successive Transformation Method for the Dynamic Analysis of Damped Systems

L. Wu

Ph.D. Thesis, Tufts Univ., 246 pp (1983)

DA8316863

Key Words: Damped structures, Viscous damping, Successive transformation method, Transformation technique

A new approach, the Successive Transformation Method, is presented in this thesis to analyze linear dynamic systems with general viscous damping. The method features two successive transformations to the subsystem equations written in first order, state space form. The transformations are applied to each subsystem, making consecutive use of free interface undamped modes in the existing physical coordinates followed by fixed interface damped modes in the generalized coordinates. Numerical examples are carried out to test the applicability of the new method to eigenproblems, forced vibration problems and initial condition problems.

84-182

Damper Component Analysis and Integration with Rotor-Dynamics Program

J.A. Tecza, E.S. Zorzi, and W.H. Parker

Mechanical Technology, Inc., Latham, NY, Rept. No. MTI-82TR61, AFWAL-TR-82-2112, 126 pp (Nov 1982)

AD-A129 021

Key Words: Dampers, Squeeze-film dampers

Squeeze film dampers are widely used components in modern turbomachinery, but their behavior is not well understood. This program was initiated in order to extend the squeeze film damper analytical basis, confirm predictions by means of a test program, transfer the analytical technology to a gas turbine engine manufacturer, integrate it with existing rotordynamic tools, and develop and demonstrate a damper design system.

84-183

A Vibration Damping Treatment for High Temperature Gas Turbine Applications

A.D. Nashif, W.D. Brentnall, and D.I.G. Jones

Anatrol Corp., Cincinnati, OH, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 29-40 (May 1983) 27 figs, 3 tables, 20 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Temperature effects, Vibration damping, Gas turbine engines

An investigation of the behavior and properties of a family of vitreous enamels designed to give high damping properties when applied as coatings to high temperature static components in gas turbine engines is described. Complex modulus properties and effects of thermal aging are discussed.

FATIGUE

(Also see Nos. 24, 86, 87, 88)

84-184

Framework for Specifying the Fatigue Performance of Glass Fibre Reinforced Plastics

G.D. Sims and D.G. Gladman

Div. of Material Applications, National Physical Lab.,

Teddington, UK, Rept. No. NPL-DMA-A-59, 30 pp (1982)
PB83-212431

Key Words: Fatigue tests, Reinforced plastics

A procedure has been established for a low variability glass-fiber fabric/epoxy laminate that allows S-N data obtained under different test conditions to be normalized with respect to the ultimate strength, measured for identical specimens and at a loading rate equivalent to the fatigue loading rate, to yield a single S-N curve.

84-185
A Reliability Based Fatigue Damage Theory for Safe Design
C.D. Nash
Univ. of Rhode Island, Kingston, RI 02881, J. Energy Resources Tech., Trans. ASME, 105 (2), pp 212-216 (June 1983) 2 tables, 31 refs

Key Words: Fatigue life, Design techniques

A reasonably safe reliability approach to a fatigue damage theory can be based on the fact that, in most cases involving the public safety, the designer can accept only very low probabilities of failure by fatigue, and is almost exclusively concerned with the lower left-hand tails of the associated distribution functions. An approach to damage theory is presented based on this concept and its possible utility reviewed.

ELASTICITY AND PLASTICITY

(Also see Nos. 25, 129)

84-186
An Analysis of Dynamic Fracture in an Impact Test Specimen
T. Nishioka, M. Perl, and S.N. Atluri
Ctr. for the Advancement of Computational Mechanics, School of Civil Engrg., Georgia Inst. of Tech., Atlanta, GA 30332, J. Pressure Vessel Tech., Trans. ASME, 105 (2), pp 124-131 (May 1983) 20 figs, 11 refs

Key Words: Fracture properties, Finite element technique, Impact tests

Numerical simulations of fast fracture in four cases of dynamic tear test experiments on 4340 steel are performed using a moving singular finite element method. Results are discussed in the light of current controversies surrounding the dynamic fracture toughness properties governing crack propagation under impact loading.

84-187
The Emergence and Propagation of a Phase Boundary in an Elastic Bar
T.J. Pence
Ph.D. Thesis, California Inst. of Tech., 128 pp (1983)
DA8315856

Key Words: Bars, Phase effects

This dissertation is concerned with the dynamical analysis of an elastic bar whose stress-strain relation is not monotonic. Sufficiently large applied loads then require the strain to jump from one ascending branch of the stress-strain curve to another such branch. For a special class of these materials, a nonlinear initial-boundary value problem in one-dimensional elasticity is considered for a semi-infinite bar whose end is subjected to either a monotonically increasing prescribed traction or a monotonically increasing prescribed displacement.

WAVE PROPAGATION

(Also see Nos. 144, 163, 166, 170)

84-188
Scattering and Nonscattering Obstacles
V. Twersky
Univ. of Illinois, Chicago, IL 60680, SIAM J. Appl. Math., 43 (4), pp 711-725 (Aug 1983) 12 refs

Key Words: Wave scattering

Two problems of Helmholtz's equation for a wave incident on an obstacle are considered. For the first, the scattering problem, the obstacle's response satisfies Sommerfeld's outgoing wave radiation condition, and the net radiative response is positive; for the second, the response satisfies a standing wave condition (an appropriate combination of outgoing and incoming waves) such that the net radiative response is zero.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

84-189

Automated Vibration Schedule Development for Wheeled and Tracked Vehicles at Aberdeen Proving Ground

W.H. Connon, III

Materiel Testing Directorate, Aberdeen Proving Ground, MD, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 143-153 (May 1983) 11 figs, 5 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Vibrations tests, Testing techniques, Computer-aided techniques, Computer programs, Ground vehicles, Tracked vehicles, Military vehicles

An automated method of developing laboratory vibration schedules from field vibration data is described. Data are collected from a test vehicle negotiating a variety of test courses utilizing a pulse code modulation data acquisition system which allows on-vehicle digitization of approximately 60 channels of data simultaneously.

84-190

Dynamic Behaviour of Concrete: A Phenomenological Theory and Instrumented Impact Testing

W. Suaris

Ph.D. Thesis, Northwestern Univ., 174 pp (1983) DA8315970

Key Words: Impact tests, Concretes

A continuous damage theory is developed for the quasi-static and dynamic behavior of concrete. The continuous damage concept is compatible with the fact that concrete fails by the gradual accumulation of microcracks, rather than in an ideally brittle manner. A procedure is also developed for obtaining valid instrumented impact test results.

84-191

Measurement of Structural Damping Using the Random Decrement Technique

J.C.S. Yang, N.G. Dagalakis, G.C. Everstine, and Y.F. Wang

Univ. of Maryland, College Park, MD, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 63-71 (May 1983) 14 figs, 2 tables, 8 refs (53rd Symp. Shock Vib., Danvers, MA Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Random decrement technique, Damping coefficients, Off-shore structures, Drilling platforms

The use of the random decrement analysis technique was investigated for the determination of natural frequencies and damping ratios of different structural systems. The technique was applied to actual experimental response data recorded from transducers placed on off-shore platforms, bridges, and human bones.

84-192

Experimental Measurement of Material Damping Using Digital Test Equipment

P.W. Whaley and P.S. Chen

Univ. of Nebraska-Lincoln, Lincoln, Nebraska, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 41-50 (May 1983) 6 figs, 8 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spectrum analyzers, Material damping, Random vibration

A procedure for measuring loss factor under random vibration using two digital spectrum analyzers is described.

84-193

Interpolation Algorithms for Discrete Fourier Transforms of Weighted Signals

T. Grandke

Forschungslaboratorien der Diemens AG, D 8520, Erlangen, Germany, IEEE Trans., Instrum. Meas., IM-32 (2), pp 350-355 (June 1983) 3 figs, 2 tables, 10 refs

Key Words: Discrete Fourier transform, Algorithms

A new method is presented for determination of the parameters that characterize a multifrequency signal. The signal is weighted before the discrete Fourier transform is calculated from which the frequencies and complex amplitudes of the various components of the signal are obtained by interpolation.

84-194

Frequency Control Loop with Digital Integrator

J. Viennet, M. Jardino, R. Barillet, and M. Desaint-fuscien

Laboratorie de l'Horloge Atomique, Equipe de Recherche du CNRS associee a l'Universite Paris-Sud, 91405 Orsay, France, IEEE Trans., Instrum. Meas., IM-32 (2), pp 322-326 (June 1983) 7 figs, 12 refs

Key Words: Oscillators, Quartz crystals

A frequency control loop which locks the frequency of a 5-MHz quartz crystal oscillator to a value defined by the hyperfine transition of $^{199}Hg^{+}$ ions is described.

84-195

Harmonic Analyzer/Generator

J.C.M. Asquerino and R.A. Lopez

Centro de Edafologia y Biologia Aplicada del Cuarto, Apdo. 1052, Sevilla, Spain, IEEE Trans., Instrum. Meas., IM-32 (2), pp 312-315 (June 1983) 5 figs, 5 refs

Key Words: Wave analyzers, Harmonic analyzers, Phase data

A method of measuring the phase angle and magnitude of n harmonics corresponding to a periodic signal is described. The method includes the generation of sinusoidal bursts to reproduce significant components of distorted and complex signals; burst amplitude, burst initial phase, and burst frequency correspond, respectively, to harmonic amplitude, harmonic phase angle, and harmonic frequency.

84-196

Mechanical Signature Analysis

M.S. Hundal

Univ. of Vermont, Burlington, VT 05405, Shock Vib. Dig., 15 (6), pp 19-26 (June 1983) 77 refs

Key Words: Signature analysis, Reviews

Mechanical signature analysis encompasses the analysis of dynamic signals from machines and processes for the purposes of testing, monitoring, diagnostics, and system identification and modification. Literature in this field from 1980 through 1982 is reviewed in this paper.

84-197

The Evolution of Spectral Techniques in Navy Shock Design

G. Remmers

David Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 59-70 (May 1983) 21 figs, 21 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spectrum analysis, Shipboard equipment response, Biot theory

The purpose of this paper is to commemorate the 50th anniversary of Maurice A. Biot's initial development of spectral techniques to calculate stresses in structures which are subjected to dynamic loads from transient motion excitation. The evolution of this basic and very important work to U.S. Navy shock design applications is described in three parts.

84-198

Frequencies of Piezoelectrically Forced Vibrations of Electroded, Doubly Rotated, Quartz Plates

R.D. Mindlin

Ridgefield, CT, Rept. No. RDM/TR83/1, TR-2, 44 pp (May 30, 1983)

AD-A128 659

Key Words: Plates, Piezoelectricity, Forced vibration, Vibration analysis

Two-dimensional equations of motion of piezoelectric crystal plates, obtained from the three-dimensional equations of linear piezoelectricity by expansion in power series of the thickness coordinate of the plate, are solved for forced vibrations of electroded SC-cut quartz plates. Results of computations are given for frequencies of simple thickness modes of vibration, for the dispersion of straight-crested waves and for frequencies of vibration of a strip.

84-199

In-Plane Accelerations and Forces on Frequency Changes in Doubly-Rotated Quartz Plates

P.C.Y. Lee and Kuang-Ming Wu

Dept. of Civil Engrg., Princeton Univ., NJ, Rept. No. RR-83-SM-6, 57 pp (Apr 1983)

AD-A128 743

Key Words: Plates, Quartz crystals, Vibration analysis

Two-dimensional equations of motion of doubly-rotated quartz plates for the thickness-shear, flexure, and extensional vibrations under in-plane initial stresses are employed to predict changes in the fundamental thickness-shear frequencies due to initial stresses. Two types of initial stresses are considered: stresses due to a pair of diametral forces, and stresses due to steady accelerations for a three-point T shaped mount and a four-point + shaped mounted configurations.

84-200

Acoustic Emission Due to Nucleation of a Microcrack in the Proximity of a Macrocrack

J.D. Achenbach, K.-I. Hirashima, and K. Ohno

Dept. of Civil Engrg., Northwestern Univ., Evanston, IL 60201, J. Sound Vib., 89 (4), pp 523-532 (Aug 22, 1983) 3 figs, 1 table, 16 refs

Key Words: Acoustic emission, Cracked media

Acoustic emission generated by the nucleation of a microcrack in the proximity of a macrocrack is discussed. On the basis of some simple approximations the acoustic emission from a crack-opening event is directly related to its crack-opening volume as a function of time.

84-201

Efficient Algorithms for Calculating Shock Spectra on General Purpose Computers

F.W. Cox

Computer Sciences Corp., Houston, TX, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 143-161 (May 1983) 6 tables (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock response spectra, Time domain method, Algorithms

Standard shock spectral analysis is merely a problem in the time domain; thus, transform methods such as the FFT are both slow and superfluous on general purpose hardware. The solution to the differential equation is written in ways that are formally exact. Recursive algorithms can be devised that circumvent numerous evaluations of transcendental functions.

84-202

Fast Floor Response Spectra Generation Technique

M.J. Yan

Babcock & Wilcox, Nuclear Power Group, Nuclear Power Generation Div., Lynchburg, VA 24505, J. Pressure Vessel Tech., Trans. ASME, 105 (1), pp 35-41 (Feb 1983) 5 figs, 1 table, 6 refs

Key Words: Response spectra, Seismic response spectra, Floors, Nuclear power plants, Nuclear reactors, Interaction: equipment-structure

A consistent technique is derived for generating floor response spectra for equipment in nuclear reactor systems using response spectral analysis. The use of this technique eliminates the requirement for a time history analysis. The technique is based on the dynamic theory of coupling the supporting building with a very light spring-mass system representing the equipment.

84-203

Seismic Design Response by an Alternative SRSS (Square Root of the Sum of the Squares)

M.P. Singh and K.B. Mehta

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. VPI-E-83-12, 48 pp (Mar 1983)

PB83-216606

Key Words: Root mean squares, Seismic design

The square root of the sum of the squares (SRSS) procedures are often used to obtain seismic design response. The design inputs for such procedures are usually defined in terms of pseudo velocity or acceleration response spectra. Erroneous results have been obtained with these existing SRSS procedures, especially in the calculation of response where high frequency effects dominate. An alternative SRSS procedure is developed using the so-called mode acceleration approach of structural dynamics.

DYNAMIC TESTS

(Also see Nos. 41, 59, 60, 77, 85, 239)

84-204

Evaluation of Modal Testing Techniques for Spacecraft Structures

K. Shiraki and H. Mitsuma

National Space Dev. Agency of Japan, 2-4-1, Hamamatsu-cho, Minato-ku, Tokyo 105, Japan, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 161-170 (May 1983) 14 figs, 3 tables, 7 refs (53rd Symp. Shock Vib., Danvers, MA Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Modal tests, Testing techniques, Spacecraft

A comparative study of modal testing techniques with a base excitation which are applicable to the development of spacecraft structures is described. Classical sine sweeps and random test methods based upon digital analysis techniques are compared by measuring transfer functions of a simple beam specimen. For the random test data, modal analyses were performed using two kinds of analyzers, for two steps of input levels, respectively.

84-205

Evaluation and Control of Conservatism in Drop Table Shock Tests

T.J. Baca

Sandia National Labs., Albuquerque, NM 87185, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 163-175 (May 1983) 25 figs, 10 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock response spectra, Shock tests, Drop tests

A technique for evaluating and controlling the conservatism in drop table shock tests is presented. Alternative characterizations of shock transients are introduced which compensate for the limitations of absolute acceleration shock spectra in representing shock environments. A method of analyzing both field and laboratory shock environments is developed which can be used for any type of shock characterization to account for the variability in the description of the environments.

84-206

Vibration Test Environments for Electronics Mounted in a Remotely Piloted Vehicle

V.R. Beatty

Harris Corp., Melbourne, FL, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 125-134 (May 1983) 13 figs, 4 tables, 4 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Test facilities, Vibration tests, Airborne equipment response, Electronic instrumentation

The development of vibration test environments for an airborne data terminal which is mounted in a remotely piloted vehicle is described. Results of finite element analysis and mechanical model testing show that vibratory inputs to electronic components exceed expected fragility levels.

84-207

Effect of Measurement System Phase Response on Shock Spectrum Computation

P.L. Walter

Sandia National Labs., Albuquerque, NM, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 133-141 (May 1983) 7 figs, 6 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Test equipment and instrumentation, Phase effects, Shock response spectra, Spacecraft components

This article specifically investigates the effect of nonlinear phase response in systems measuring transient signals. The results of phase modification of input signals to measurement systems are illustrated. Distorted waveforms, erroneous signal amplitudes, and different pulse durations are shown to occur. The important role of measurement system phase response in shock spectrum computation is demonstrated and system design guidelines are provided to assure the generation of valid component shock test specifications.

SCALING AND MODELING

84-208

Experiments on the Determination of Immersed Shell Structure Mobilities via Scale Modeling

S.S. Sattinger

Westinghouse Res. and Dev. Ctr., Pittsburgh, PA 15235, J. Pressure Vessel Tech., Trans. ASME, 105 (3), pp 207-215 (Aug 1983) 10 figs, 3 tables, 9 refs

Key Words: Scaling, Frequency response function, Shells, Submerged structures

Experiments conducted to confirm scaling relations for structural frequency response functions as applied to immersed shell structures using same-material, same-liquid scale models are described. Accelerance (acceleration/force) frequency response magnitude data were acquired for full-scale and half-scale versions of a fixed-free open cylinder mounted in a rigid vessel. The data confirmed that corresponding frequencies in the model and prototype were in proportion to the inverse of the geometric scale.

DIAGNOSTICS

84-209

Objective Acoustic Quality Inspection of Complex Machines. Exemplary Investigation for a Combustion Engine

H.E. Meier and D. Frey

Inst. fuer Informations- und Datenverarbeitung, Rept. No. BMFT-FB-HA-82-046, ISSN-0171-7618, 84 pp (Nov 1982)

N83-23622

(In German)

Key Words: Diagnostic techniques, Failure detection, Signature analysis, Combustion engines, Camshafts

Acoustic quality inspection which recognizes damaged components and manufacturing defects by their characteristic noise and vibration is discussed. Partial automation reduces the effect of noise on the inspectors and at the same time increases the reliability of inspection. Partial automation was investigated for a combustion engine.

84-210

Understanding Pressure Phenomena in PWRs for Surveillance and Diagnostic Applications

J.A. Mullens and J.A. Thie

Oak Ridge National Lab., Oak Ridge, TN, Rept. No. CONF-830318-4, 31 pp (1983) (Power Plant Dynamics Control and Testing Symposium, Knoxville, TN, Mar 21, 1983)

Portions are illegible in microfiche products

DE83009834

Key Words: Diagnostic techniques, Nuclear reactors

New methods for detecting potential failures or degraded performance in reactors are being sought. A variety of ongoing research for the U.S. Nuclear Regulatory Commission aimed at bettering the understanding of pressure fluctuations and the associated pressure sensing system is discussed.

MONITORING

84-211

An Acoustic Method to Predict Tooth Surface Failure of Inservice Gears

K. Umezawa, T. Ajima, and H. Houjoh

Res. Lab. of Precision Machinery and Electronics, Tokyo Inst. of Tech., Nagatsuta, Midori-ku, Yokohama 227, Japan, NDT Intl., 16 (4), pp 201-204 (Aug 1983) 12 figs, 2 tables, 1 ref

Key Words: Monitoring techniques, Acoustic techniques, Computer-aided techniques, Failure analysis, Fatigue life, Gear teeth

A method is proposed for predicting tooth surface failure of gears in operation by automatic monitoring. It involves measuring frequency sideband variations around a dominant frequency component of the gear noise. The method is applicable to practical machinery.

84-212

Source Signature Recovery in Reverberant Structures

R.H. Lyon

Massachusetts Inst. of Tech., Cambridge, MA 02139, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 141-144 (May 1983) 4 figs, 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Monitoring techniques, Signature analysis, Phase effects

The use of vibration or acoustical signals to reveal operational parameters or developing faults of a machine is described.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

84-213

T-Matrix Approach to Study the Vibration Frequencies of Elastic Bodies in Fluids

B.A. Peterson, V.V. Varadan, and V.K. Varadan
Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 74 (3), pp 1051-1056 (Sept 1983) 2 figs, 2 tables, 34 refs

Key Words: Natural frequencies, Submerged structures

The T matrix or null field method is used as a computational scheme for analyzing the scattering frequencies of a homogeneous elastic body in a fluid. Lists and figures of the most important scattering frequencies for a sphere and a prolate spheroid are given.

84-214

A Simple Algorithm for the Nonlinear Dynamic Analysis of Networks

P.G. Papadopoulos
Faculty of Struc. Engrg., Univ. of Thessaloniki, Greece, Computers Struc., 18 (1), pp 1-8 (1984) 7 figs, 5 refs

Key Words: Network analysis theory

A simple and economical algorithm is presented for the nonlinear dynamic analysis of networks, with lumped masses on the nodes, bars obeying uniaxial stress-strain laws and no damping. The step-by-step algorithm of the trapezoidal rule is used, combined with the predictor-corrector technique, with only two corrections per step.

84-215

Seismic Analysis of Structures with Coulomb Friction

V.N. Shah and C.B. Gilmore
EG&G Idaho, Inc., Idaho Falls, ID 83415, J. Pressure Vessel Tech., Trans. ASME, 105 (2), pp 171-178 (May 1983) 13 figs, 14 refs

Key Words: Modal superposition method, Coulomb friction, Seismic analysis

A modal superposition method for the dynamic analysis of a structure with Coulomb friction is presented. The finite element method is used to derive the equations of motion, and the nonlinearities due to friction are represented by pseudo-force vector.

84-216

On the Static and Kinetic Methods of Conservative System Stability, and Rayleigh's Principle: A Reexamination

J.G. Papastavridis
School of Engrg. Science and Mechanics, Georgia Inst. of Tech., Atlanta, GA 30332, J. Sound Vib., 90 (1), pp 51-58 (Sept 8, 1983) 1 fig, 11 refs

Key Words: Variational methods, Rayleigh method, Stability

The relation between the static and kinetic variational methods of the stability of equilibrium analysis of conservative systems and the corresponding static and kinetic Rayleigh's principles is reexamined. Specifically made explicit are the connections between the virtual work principle (for the adjacent equilibrium configuration) and Rayleigh's principle of extremum critical loads and buckled modes, and Hamilton's principle (for the adjacent non-equilibrium configuration) and Rayleigh's principle of extremum frequencies and mode shapes, through simple familiar examples.

84-217

A Partitioned Finite Element Method for Dynamical Systems

A. Maher, P.G. Kessel, and R.D. Cook
Univ. of Wisconsin, Madison, WI 53706, Computers Struc., 18 (1), pp 81-91 (1984) 3 figs, 15 refs

Key Words: Dynamic structural analysis, Finite element technique, Rotor blades (turbomachinery)

A new analytical method is described for deriving the equations of motion of dynamical systems. The concept is to consider the displacements of the domain to be composed of rigid and elastic components. In contrast to other reduction methods, the domain modeled by finite number of degrees of freedom is discretized into two distinctive types of subdomains. Rigid and elastic subdomains are generated by consistent lumping of the domain properties under unique kinematic constraint relations.

84-218

Harmonic Acceleration Method for Dynamic Structural Analysis

I. Senjanovic
Faculty of Mech. Engrg. and Naval Architecture, Univ. of Zagreb, Yugoslavia, Computers Struc., 18 (1), pp 71-80 (1984) 4 figs, 2 tables, 16 refs

Key Words: Dynamic structural analysis, Integration methods

Harmonic acceleration is assumed in each time step of integration for the dynamic equilibrium equation of a structure and its modal transformation. Two different numerical integration methods are derived which are unconditionally stable and very accurate.

84-219

A Simplified Method for the Inelastic Analysis of Structures under Cyclic Loadings

J. Tribout, G. Inglebert, and J. Casier
Novatome, LePlessis-Robinson, France, J. Pressure Vessel Tech., Trans. ASME, 105 (3), pp 222-226 (Aug 1983) 8 figs, 6 refs

Key Words: Shakedown theorem, Cyclic loading

A simplified method to obtain a straightforward evaluation of the total inelastic strain which accumulates in a structure under cyclic loadings when shakedown occurs for a linear kinematic hardening material is discussed. The theoretical basis is recalled and an example of the application of the method is given which underlines its efficiency.

84-220

Eine kleine Eigenvalue Problem (A Simple but Informative Nonlinear Eigenvalue Problem)

B.A. Fleishman and P.W. Davis
Dept. of Mathematical Sciences, Rensselaer Polytechnic Inst., Troy, NY, 14 pp (Feb 1983)
AD-P001 019

Key Words: Eigenvalue problems

This paper exhibits a number of interesting properties of nonlinear problems, some established here by elementary arguments. For each eigenvalue the authors find all eigenfunctions (an infinite number of them) in explicit form. As lambda increases through O, there is an exchange of stability: the trivial solution, formerly stable, becomes unstable while the maximum and minimal eigenfunctions (lambda greater than O) are stable. The stability of non-extremal eigenfunctions is also discussed.

84-221

Changing Spectrum Estimation

G. Kitagawa
The Inst. of Statistical Mathematics, 4-6-7 Minami-Azabu, Minato-ku, Tokyo 106, Japan, J. Sound Vib., 89 (3), pp 433-445 (Aug 8, 1983) 9 figs, 16 refs

Key Words: Spectrum analysis, ARMA (autoregressive/moving average) models, Time-dependent parameters

An autoregressive (AR) model with time varying coefficients is used for the modeling of non-stationary covariance time series. A stochastically perturbed linear constraint model is presented as a model of time varying AR coefficients. The overall model for the time series is fitted by using the Kalman filter and Akaike's AIC criterion. An estimate of a changing spectrum is obtained by the fitted model and the fixed interval smoother. Examples are given to illustrate the procedure.

84-222

Dynamic Finite Element Analysis of Nonaxisymmetric Structures

A.R. Zak and A.D. Antartis
Dept. of Aeronautical and Astronautical Engrg., Univ. of Illinois, Urbana, IL 61803, Computers Struc., 18 (1), pp 33-39 (1984) 8 figs, 5 refs

Key Words: Finite element technique

A dynamic finite element method of analysis is developed for structural configurations which are derived from axisymmetric geometries but contain definite nonaxisymmetric features in the circumferential direction. The purpose of the analysis is to develop a method which will take into con-

sideration the fact that the stress and strain conditions in these geometries will be related to the corresponding axisymmetric solution.

84-223

Simple Approximate Models for a Class of Structures

A.J. Molnar and F.H. Wolff
Engineering-Analytical Dynamics Corp., Trafford, PA 15085, Shock Vib. Bull. U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 137-140 (May 1983) 5 figs, 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Approximation methods, Vibration analysis, Mathematical models

A two mass approximate model for investigating the interaction for a class of structures in a particular frequency range is developed. The method is applicable to both analytical finite element type models as well as physical structures where vibration response data are available.

84-224

Perturbation Methods for Slightly Damped Gyroscopic Systems

G. Ryland
Ph.D. Thesis, Virginia Polytechnic Inst. and State Univ., 141 pp (1982)
DA8313772

Key Words: Gyroscopes, Damped structures, Eigenvalue problems, Perturbation theory

This dissertation concerns the development of a perturbation theory applicable to the algebraic eigenvalue problem. The objective is to express the perturbed eigenvalues and eigenvectors in terms of the unperturbed eigenvalues and eigenvectors and the perturbing matrices, without solving a new eigenvalue problem. The perturbation theory was initially developed as an efficient means of solving the eigenvalue problem associated with linear gyroscopic systems for which the damping and/or circulatory effects are sufficiently small that they can be regarded as perturbations.

84-225

A Weighted Least Squares Method for Circle Fitting to Frequency Response Data

J.A. Brandon and A. Cowley
The Univ. of Manchester Inst. of Science and Tech., Manchester M60 1QD, UK, J. Sound Vib., 89 (3), pp 419-424 (Aug 8, 1983) 7 figs, 8 refs

Key Words: Curve fitting, Least squares method, Conformal mapping

A weighted least squares curves fitting method, based on a well known conformal mapping, is described. This method is shown to have important theoretical advantages over some established methods.

84-226

On the Variational Theory of Linear Configuration-Dependent Systems

J.G. Papastavridis
School of Engrg. Science and Mechanics, Georgia Inst. of Tech., Atlanta, GA 30332, J. Sound Vib., 89 (1), pp 85-94 (July 8, 1983) 15 refs

Key Words: Geometric effects, Variational methods

The stability of equilibrium of a linear, non-dissipative and non-gyroscopic, circulatory system is treated via Hamilton's action principle, thus showing how the well-known energetic theorems of the virial and work/energy for the adjacent states of motion follow by special choices of the virtual displacements (from these states).

84-227

A Variational Formulation for the Finite Element Analysis of the Vibratory and Acoustical Response of High Speed Machinery

B.S. Thompson
Dept. of Mech. Engrg., Michigan State Univ., East Lansing, MI 48824, J. Sound Vib., 89 (1), pp 7-15 (July 8, 1983) 1 fig, 21 refs

Key Words: Machinery noise, Machinery vibration, Finite element technique

The principle of virtual velocities is employed to develop a variational theorem for determining the vibratory and acoustical response of high speed mechanisms immersed in a perfect fluid (air). Both the solid and fluid media are modeled as continua and the basic functional expression is generalized by using Lagrange multipliers to incorporate field equations, boundary conditions and a kinematic constraint on the interface region between the two types of continua.

84-228

A New Approach to the Dynamic Analysis of Structures Using Fixed Frequency Dynamic Stiffness Matrices

A.J. Fricker

Central Electricity Res. Labs., Leatherhead, Surrey, UK, Intl. J. Numer. Methods Engrg., 19 (8), pp 1111-1129 (Aug 1983) 6 figs, 2 tables, 14 refs

Key Words: Dynamic structural analysis, Frequency dependent parameters, Dynamic stiffness, Matrix methods

The dynamic analysis of structures by the standard finite element method introduces additional inaccuracies into the solution which are not present when the method is used for static analyses. A new method of solution is proposed in which frequency-dependent terms are retained implicitly by using dynamic stiffness matrices defined at a number of fixed frequencies.

84-229

A Method for Solving High-Order Real Symmetric Eigenvalue Problems

A.J. Fricker

Central Electricity Res. Labs., Leatherhead, Surrey, UK, Intl. J. Numer. Methods Engrg., 19 (8), pp 1131-1138 (Aug 1983) 1 fig, 1 table, 7 refs

Key Words: Dynamic structural analysis, Eigenvalue problems, Algorithms

An algorithm for solving a high order real symmetric eigenvalue problem using simultaneous iteration is presented. Methods of accelerating the convergence and reducing the amount of computation are also described. A numerical example is given in which the algorithm is used to calculate the eigenvalues and eigenvectors of a framed structure.

84-230

Comparison of Statistical Energy Analysis and Finite Element Analysis Vibration Prediction with Experimental Results

L.K.H. Lu, W.J. Hawkins, D.F. Downard, and R.G. DeJong

Marine Div., Westinghouse Electric Corp., Sunnyvale, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 4, pp 145-152 (May 1983) 8 figs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Finite element technique, Statistical energy analysis, Experimental techniques, Framed structures, Computer programs

In order to further understand the practical application of the statistical energy analysis, a two section plate-like frame structure is analyzed by the finite element method, statistical energy analysis, and experimental techniques. Results are compared, discussed and also used as a benchmark for a newly developed in-house SEA computer program.

MODELING TECHNIQUES

84-231

Dynamic Simulation of Structural Systems with Isolated Nonlinear Components

L. Minnetyan, J.A. Lyons, and T.G. Gerardi

Clarkson College of Tech., Potsdam, NY, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 63-77 (May 1983) 5 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Simulation, Transient response, Dynamic structural analysis, Time domain method, Frequency domain method, Aircraft, Taxiing effects

A new hybrid method is formulated for the detailed dynamic analysis of complex structures. The new solution procedure incorporates a time-history analysis of the nonlinear response with a frequency domain analysis of the linear modes. The frequency domain analysis uses a larger number of modal coordinates to realistically simulate the details of structural response. The basic modal decoupling assumption of the hybrid method is studied by numerical application of the method to a simple elastic vehicle with nonlinear suspension properties taxiing over an irregular profile.

NONLINEAR ANALYSIS

84-232

Stability Criteria for a Class of Non-Linear Feedback Systems

S.B. Karmakar

Bell Labs., Piscataway, NJ 08854, J. Sound Vib., 89 (1), pp 1-5 (July 8, 1983) 2 figs, 10 refs

Key Words: Nonlinear systems, Stability

A numerical method is presented to determine the stability in the sense of bounded input bounded output (BIBO) of a class of nonlinear feedback systems. The output is expressed in the form of a functional series in terms of the input. Conditions for the boundedness of the series determine the BIBO stability criteria of the nonlinear system.

NUMERICAL METHODS

(See No. 21)

PARAMETER IDENTIFICATION

84-233

A Recursive Approach to Prony Parameter Estimation

P. Davies

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 89 (4), pp 571-583 (Aug 22, 1983) 5 figs, 4 tables, 8 refs

Key Words: Parameter identification technique, Prony series analysis, Recursive methods, Least squares method, Beams, Transient response

An algorithm that combines the Prony series method with the recursive least squares algorithm is described. This eliminates the need to invert any matrices and also requires only part of the data to be available at one particular time. The method is applied to analyze a simulated structure's response and also to analyze the response of a beam to transient excitation.

84-234

A Parameter Estimation Procedure for Mathematical Models of Dynamic Natural Systems with Sparse Data Sets

A.L.J.L. Blackwell

Ph.D. Thesis, The Univ. of Texas at Arlington, 282 pp (1982)
DA8314423

Key Words: Parameter identification technique

In an effort to resolve a class of important parameter estimation problems, a procedure was developed and demonstrated for three examples. This class of problems is typical of dynamic natural systems and is characterized by high state dimensionality, many process functions, numerous parameters, and calibration data so sparse that the data are insufficient for the calibration of the entire model. The objective of this research was to evaluate one strategy for estimating the values of the unknown parameters when data are insufficient for calibration and when certain other conditions prevail.

84-235

An Application of the Kinetic Energy Calculation as an Aid in Mode Identification

J.J. Brown and G.R. Parker

Hughes Helicopters, Inc., Culver City, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 111-123 (May 1983) 16 figs, 3 tables (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Parameter identification technique, Mode shapes, Helicopters

The ability to economically and efficiently solve large order finite element dynamic problems has become a reality; however, the task of modal identification has proportionately increased. By applying the kinetic energy calculation to the modal data, candidates for structural as well as local modes and possible modeling errors can be quickly isolated.

84-236

On the Modal Identification of Multiple Degree of Freedom Systems from Experimental Data

D.I.G. Jones and A. Muszynska

Materials Lab., AFWAL/MLLN, Wright-Patterson AFB, OH 45433, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 91-110 (May 1983) 29 figs, 9 tables, 24 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Parameter identification technique, Multidegree of freedom systems, Frequency domain method, Mode shapes

The relative merits of frequency domain modal identification procedures using receptance (response/excitation) and structural dynamic stiffness (excitation/response) representations of measured structural response data are discussed.

OPTIMIZATION TECHNIQUES

84-237

Computational Methods for Static and Dynamic Systems and Engineering Applications

A. Miele
Aero-Astronautics Group, Rice Univ., Houston, TX,
Rept. No. AAR-167, NSF/ECS-83006, 32 pp (1983)
PB83-227314

Key Words: Optimization

Research on computational methods of interest for static systems and dynamic systems, with particular regard to engineering applications, is summarized. The principal research topics discussed include optimality properties of the gradient phase of gradient-restoration algorithms; restoration algorithm for solving optimal control problems with nondifferential constraints and general boundary conditions; Chebyshev minimax problems of optimal control; and modified quasilinearization algorithm for optimal control problems with nondifferential constraints and general boundary conditions. Lists of research reports, journal articles, theses, presentations, and contributions to books are provided.

DESIGN TECHNIQUES

(See No. 62)

COMPUTER PROGRAMS

84-238

Acoustic Responses of Coupled Fluid-Structure System by Acoustic-Structural Analogy

Y.S. Shin and M.K. Chargin
Dept. of Mech. Engrg., Naval Postgraduate School, Monterey, CA,
Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 2, pp 11-21 (May 1983) 7 figs, 1 table, 8 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Interaction: structure-fluid, Acoustic response, Computer programs

The use of an analogy between structural mechanics and acoustics makes it possible to solve fluid-structural interaction (FSI) problems using an existing structural analysis computer program. This method was implemented in MSC/NASTRAN program and the FSI analysis was performed using 2-dimensional coupled fluid-beam model to assess and evaluate the adequacy of this approach. The coupled modal analysis of 3-D model is also briefly discussed. The normal mode, modal frequency response and transient response analysis of 2-D coupled fluid-beam system is presented.

84-239

Vibration Test Software for Electronics Mounted in a Remotely Piloted Vehicle

S.M. Landre
Harris Corporation Information Systems Div., Melbourne, FL,
Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 3, pp 135-141 (May 1983) 11 figs, 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Computer programs, Test facilities, Vibration tests, Airborne equipment response, Electronic instrumentation

A description of vibration test software that was developed for testing electronics mounted in a remotely piloted vehicle is presented. This software was developed because there was no known software that could simulate the required vibration environment on a shaker.

84-240

PAULA: A 3D Code for Analysis of Nonlinear Pipes

L. Lazzeri, M. Scala, and M. Agrone
Structural Dept., Ansaldo Impianti, Genoa, Italy,
J. Pressure Vessel Tech., Trans. ASME, 104 (5), pp 262-267 (Nov 1982) 10 figs, 31 refs

Key Words: Computer programs, Pipes (tubes), Pipe whip

The three-dimensional nonlinear code PAULA is described; its finite element library makes it particularly useful for analysis of pipes. The problem of pipe whip is dealt with in some detail. Comparisons are given with a 2D code named FRUSTRA.

84-241
NLS: A System Identification Package for Transient Signals. Description and User's Manual
D.M. Goodman
Lawrence Livermore National Lab., CA, Rept. No. UCID-19767, 50 pp (Mar 1983)
DE83009509

Key Words: Computer programs, System identification techniques, Transient response

NLS is a system identification package designed specifically for determining difference-equation models for systems whose inputs and outputs are transients. In its present form the code is available only for a VAX 11/780 using the VMS operating system, but transporting it to a different system should not be difficult. This document is a preliminary edition describing a preliminary version of NLS to show potential users how to run NLS intelligently. It is not intended to be a treatise on system identification.

84-242
Shock Spectral Analysis by Personal Computer, Using the IFT Algorithm
C.T. Morrow
Encinitas, CA, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 97-102 (May 1983) 9 figs, 3 refs (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Computer programs, Shock response spectra, Spectrum analysis, Indirect Fourier transform

Progress in the development of a program for personal computers, based on an algorithm that is comparable in practice to the FFT in computation time but much less demanding of computer memory, is reported. The current program is designed for 301 logarithmically spaced frequencies and deals with phase as well as magnitude in plottable form.

GENERAL TOPICS

TUTORIALS AND REVIEWS

(Also see Nos. 19, 108, 116, 173, 196)

84-243
Technical Information Support for Survivability
H.C. Pusey, R.H. Volin, and J.G. Showalter
Shock and Vib. Information Ctr., Naval Res. Lab., Washington, DC, Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 53, Pt 1, pp 21-31 (May 1983) 1 fig, 5 tables (53rd Symp. Shock Vib., Danvers, MA, Oct 26-28, 1982. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Vulnerability, Reviews

DoD policy requires that system survivability be a major consideration in the systems acquisition process. The need for an effective DoD survivability/vulnerability information service is established. The technology sources and the user community are examined and options are discussed for the organization of the information service. Recommendations are offered on the steps to take for the establishment of such a service.

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Airfoils: Drag, Turbulent Flow, and Vibration Reduction. 1973 - June 1983 (Citations from Information Services in Mechanical Engineering Data Base)
NTIS, Springfield, VA, 238 pp (June 1983)
PB83-867275

Key Words: Bibliographies, Airfoils, Vibration control, Fluid-induced excitation

This bibliography contains 287 citations concerning the design of airfoils for the minimization of drag and turbulent flow. Topics include parameters affecting the formation of vortices, excessive vibration, and fuel consumption.

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PROCEEDINGS SCANNED

INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL PROCEEDINGS
(IES, Proc.)
Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

INTERNATIONAL CONFERENCE, VIBRATIONS IN ROTATING MACHINERY
(Intl. Conf., Vib. Rotating Mach.)
The Institution of Mechanical Engineers
1 Birdcage Walk, Westminster
London SW1H 9JJ, UK

INTER-NOISE PROCEEDINGS, INTERNATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING
(Inter-Noise)
Noise Control Foundation
P.O. Box 3469, Arlington Branch
Poughkeepsie, NY 12603

MACHINERY VIBRATION MONITORING AND ANALYSIS MEETING, PROCEEDINGS
(Mach. Vib. Monit. Anal., Proc.)
The Vibration Institute
101 W. 55th St., Suite 206
Clarendon Hills, IL 60514

NOISE CONTROL PROCEEDINGS, NATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING
(Noise Control)
Noise Control Foundation
P.O. Box 3469, Arlington Branch
Poughkeepsie, NY 12603

THE SHOCK AND VIBRATION BULLETIN, UNITED STATES NAVAL RESEARCH LABORATORIES, ANNUAL PROCEEDINGS
(Shock Vib. Bull., U.S. Naval Res. Lab., Proc.)
Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, DC 20375

TURBOMACHINERY SYMPOSIUM
(Turbomachinery Symp.)
Gas Turbine Labs.,
Texas A&M University
College Station, TX 77843

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

Rotating Machines
Reciprocating Machines
Power Transmission Systems
Metal Working and Forming
Isolation and Absorption
Electromechanical Systems
Optical Systems
Materials Handling Equipment

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
Off-shore Structures

VEHICLE SYSTEMS

Ground Vehicles
Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

Absorbers and Isolators
Springs
Tires and Wheels
Blades
Bearings
Belts
Gears
Clutches
Couplings
Fasteners
Linkages
Valves
Seals
Cams

STRUCTURAL COMPONENTS

Strings and Ropes
Cables
Bars and Rods
Beams
Cylinders
Columns
Frames and Arches
Membranes, Films, and Webs
Panels
Plates
Shells
Rings
Pipes and Tubes
Ducts
Building Components

ELECTRIC COMPONENTS

Controls (Switches, Circuit Breakers)
Motors
Generators
Transformers
Relays
Electronic Components

DYNAMIC ENVIRONMENT

Acoustic Excitation
Shock Excitation
Vibration Excitation
Thermal Excitation

MECHANICAL PROPERTIES

Damping
Fatigue
Elasticity and Plasticity
Wave Propagation

EXPERIMENTATION

Measurement and Analysis
Dynamic Tests
Scaling and Modeling
Diagnostics
Balancing
Monitoring

ANALYSIS AND DESIGN

Analogs and Analog
Computation
Analytical Methods
Modeling Techniques
Nonlinear Analysis
Numerical Methods
Statistical Methods
Parameter Identification
Mobility/Impedance Methods
Optimization Techniques
Design Techniques
Computer Programs

GENERAL TOPICS

Conference Proceedings
Tutorials and Reviews
Criteria, Standards, and
Specifications
Bibliographies
Useful Applications

CALENDAR

FEBRUARY 1984

22-24 IAVD Congress on Vehicle Component Design [IAVD] Geneva, Switzerland *(Dr. M.A. Dorgham, International Association for Vehicle Design, The Open University, Walton Hall, Milton Keynes MK7 6AA - (0908) 653945*

27-Mar 2 International Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1984

13-15 12th Symposium on Explosives and Pyrotechnics [Applied Physics Lab. of Franklin Research Center] San Diego, CA *(E&P Affairs, Franklin Research Center, Philadelphia, PA 19103 - (215) 448-1236)*

20-23 Balancing of Rotating Machinery Symposium [Vibration Institute] Philadelphia, PA *(Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

APRIL 1984

9-12 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hqs.)*

9-13 2nd International Conference on Recent Advances in Structural Dynamics [Institute of Sound and Vibration Research] Southampton, England *(Dr. Maurice Petyt, Institute of Sound and Vibration Research, The University of Southampton, S09 5NH, England - (0703) 559122, Ext. 2297)*

30-May 3 Institute of Environmental Sciences' 30th Annual Technical Meeting [IES] Orlando, FL *(IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)*

MAY 1984

1-3 Mechanical Failures Prevention Group 38th Symposium [National Bureau of Standards, Washington, DC] Gaithersburg, MD *(Dr. J.G. Early, Metallurgy Div., Room A153, Bldg. 223, National Bureau of Standards, Washington, DC 20234)*

7-10 30th International Instrumentation Symposium [Instrument Society of America] Denver, CO *(Robert Jarvis, Grumman Aerospace Corp., Mail Stop T01-05, Bethpage, NY 11714)*

7-11 Acoustical Society of America, Spring Meeting [ASA] Norfolk, VA *(ASA Hqs.)*

10-11 12th Southeastern Conference on Theoretical and Applied Mechanics [Auburn University] Pine Mountain, GA *(J. Fred O'Brien, Director, Engineering Extension Service, Auburn University, AL 36849 - (205) 826-4370)*

JUNE 1984

26-28 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] New Orleans, LA *(Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

JULY 1984

21-28 8th World Conference on Earthquake Engineering [Earthquake Engineering Research Institute] San Francisco, CA *(EERI-8WCEE, 2620 Telegraph Avenue, Berkeley, CA 94704)*

AUGUST 1984

6-9 West Coast International Meeting [SAE] San Diego, CA *(SAE Hqs.)*

19-25 XVIth International Congress on Theoretical and Applied Mechanics [International Union of Theoretical and Applied Mechanics] Lyngby, Denmark *(Prof. Frithiof Niordson, President, or Dr. Niels Olhoff, Executive Secretary, ICTAM, Technical University of Denmark, Bldg. 404, Dk-2800 Lyngby, Denmark)*

SEPTEMBER 1984

9-11 Petroleum Workshop and Conference [ASME] San Antonio, TX *(ASME Hqs.)*

11-13 Third International Conference on Vibrations in Rotating Machinery [Institution of Mechanical Engineers] University of York, UK *(IMechE Hqs.)*

30-Oct 4 Power Generation Conference [ASME] Toronto, Ontario, Canada *(ASME Hqs.)*

OCTOBER 1984

8-12 Acoustical Society of America, Fall Meeting [ASA] Minneapolis, MN *(ASA Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE: American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME: American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF: International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE: Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
67 Alexander Dr.
Research Triangle Park, NC 27709

SAE: Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE: Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA: Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the **Shock and Vibration Digest.** Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
- titles of articles within quotations, titles of books underlined
- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).
5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).
7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

Articles for the DIGEST will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the DIGEST. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 3000 to 4000 words in length. For additional information on topics and editorial policies, please contact:

Milda Z. Tamulionis
Research Editor
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THE SHOCK AND VIBRATION DIGEST

Volume 16, No. 1 January 1984

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