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SVIC NOTES

PLAUDITS

I would like to take this opportunity to publicly thank all of the members of the shock and vibration community who reviewed the papers submitted for publication in the 54th Shock and Vibration Bulletin. In spite of heavy schedules and professional and personal commitments, those persons listed here have allowed us to maintain our publication schedule by promptly evaluating articles sent to them. Their comments have helped the authors to prepare a better paper, and we sincerely appreciate their efforts.

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EDITORS RATTLE SPACE

SEMINAR AND COURSE EFFECTIVENESS

Each month the Short Course section of the DIGEST contains a number of listings of courses and seminars given to the public. These courses have come to be an effective mechanism for the training and education of engineers. However, the queston of effectiveness always arises. What makes a seminar effective? In my opinion a seminar is effective if the technical material is well presented and the background and interests of the participants parallel those of the program. Two aspects of the seminar are important: first the general level and content of the technical material, second the audio-visual aids and text material. The first aspect requires good pre-seminar planning. The second to a large extent concerns execution.

In a two to five day seminar (short course) a finite amount of material can be presented and/or absorbed. This material can range from fundamental to sophisticated. One question that continues to plague me is the extent to which different levels of material can be mixed and have the participant come away with some valuable knowledge. Presentations must be planned to make a point and convey material in a short amount of time. The attention span of the audience is directly proportional to the effectiveness of the speaker. Visual aids have a definite bearing on speaker effectiveness. On the other hand, I have listened to speakers who needed no visual aids to keep the audience's attention. In my opinion no visual aids are better than poor ones; more than half the slides I've seen during presentations have been bad. Perhaps we should go back to that old fashioned medium of exchange: chalk and blackboard.

The often-stated purpose of the seminar is continuing education -- a means for an engineer to keep abreast of his field. It seems to me that short courses and seminars are also a way to introduce knowledge. A formidable problem for the seminar organizer with this sort of seminar, however, is the tendency of individuals to want to get right to the problem. The fact that this is not always possible presents a challenge in programming. Problem-oriented education is more interesting and yields more tangible results in the short run. The person interested only in solving problems may eventually find his effectiveness for dealing with intricate problems severely limited. The reason? He hasn't taken the time to grasp fundamentals. With this in mind the engineer should view the course as an introduction to an educational process -- carried out on his own under direction of material received in the course.

It is my view that the limitations are minor compared to the advantages of the training and experience that can be obtained from a short course.

R.L.E.

LITERATURE REVIEW OF TILTING PAD AND TURBULENT HYDROSTATIC JOURNAL BEARINGS FOR NUCLEAR MAIN COOLANT PUMPS

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

Abstract. *Research regarding tilting-pad and turbulent hydrostatic journal bearings is reviewed. Included are both theoretical and experimental work. Both static and dynamic characteristics are considered. The purpose of this paper is to enable a practicing engineer to apply presently available methods so that he can reliably predict load capacities and dynamic coefficients for the bearings.*

Fluid-film journal bearings are used in many modern turbomachines and have received considerable attention recently in the literature. They have long life expectancies and excellent damping characteristics if properly designed. The shafts in turbomachines are often very flexible, and a machine typically operates above the first or second critical speed of the rotor. Three important operating characteristics that must be considered when bearings are selected for a particular machine are load capacity, critical speed response, and instability threshold. Selection of the proper bearing geometry is of utmost importance because an improper bearing can cause a machine to destruct.

Analysis of a flexible rotor/bearing system requires development of two distinct methods: one for predicting the dynamical effect of the flexible rotor and another for the dynamic characteristics of the fluid-film bearings. Two bearings that receive considerable use in the nuclear power industry are tilting-pad bearings and hydrostatic bearings. The example in Figure 1 shows a main coolant pump with two tilting-pad journal bearings in the motor and a water-lubricated turbulent hydrostatic pump bearing. The purpose of this paper is to review the literature in which these two types of journal bearings are addressed. Literature in which load capacities or dynamic coefficients were experimentally measured or predicted are reviewed. Descriptions of applications of these types of bearings to particular machines are also included.

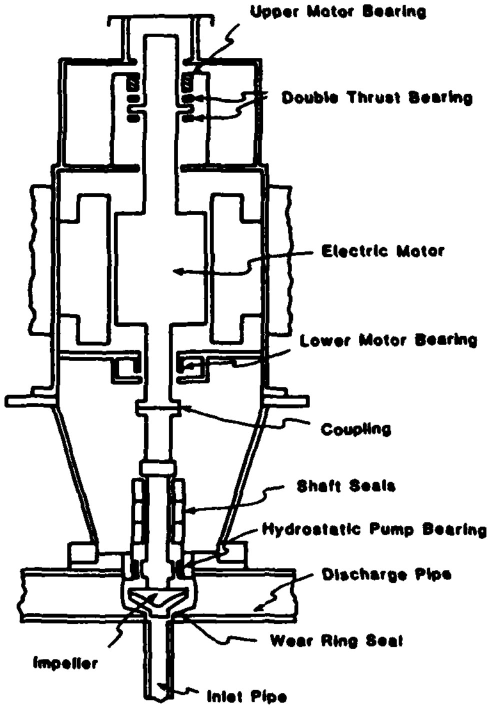

Figure 1. Journal Bearings in a Main Coolant Pump

TILTING-PAD BEARINGS

Figure 2 shows side views of an eight-pad and a six-pad tilting-pad bearing. They were the upper and lower motor bearings in the main coolant pump in Figure 1. Each pad has a radius of curvature R_p; the shaft has a radius R. The radius of the largest shaft

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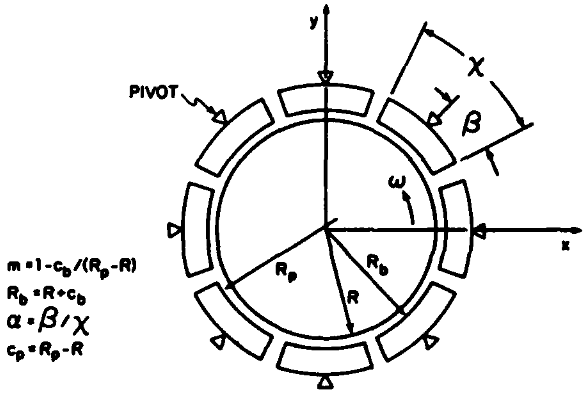
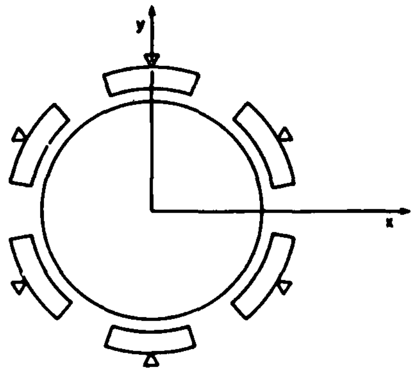
that can fit in a bearing is R_b; R_b is not necessarily equal to R_p. Thus, two different clearances can arise. The first is the bearing clearance c_b. The second is the pad clearance c_p. Two of the most important parameters are the preload factor m and the offset factor α. The preload factor is a measure of the difference between c_b and c_p. When c_p equals c_b, the preload factor is 0.0; i.e., the pad center is the same as the bearing center. The offset factor is a measure of the position of the pivot on the pad. When α equals 0.5, the pivot point is in the center of the pad. Parameters are defined in Figure 2.



a) Upper Motor Bearing



b) Lower Motor Bearing

Figure 2. Tilting Pad Motor Bearings

Boyd and Raimondi [1] were among the first to analyze tilting-pad bearings. They used a simple approximate analytical method to predict the static load capacity and power loss operating conditions for 4-, 6-, 8-, and 12-pad bearings with zero preload. They studied both off-pad and on-pad loading. Dynamic properties were not studied in this early paper. They later extended this method [2] to include pads with preload. They studied the static film thickness for four-pad bearings with different preloads. They also identified a pad instability called spragging. This condition occurs at high speeds or light loads and results from a dominant diverging film at the inlet to a pad. The authors discussed mechanical means for forcing convergent entrance regions.

Hagg and Sankey [3] experimentally measured stiffness and damping characteristics for a single four-pad bearing. They used a rig with known imbalances and measured the motion of the journal relative to the bearing. Writing the equations of motion for the shaft enabled them to determine the stiffness and damping for known journal mass, unbalanced force, and measured motions. For the bearing tested they found that the characteristics were independent of direction; this result implies that the bearing was operating nearly concentrically. Hagg and Sankey [4] extended the work to include six-pad bearings.

A finite difference method has been used to solve Reynolds equation for gas lubrication [5]. Individual static-pad characteristics (load capacity) were determined for pads of different preload. Individual pad data were assembled for multi-pad journal bearings so that the static characteristics for a complete tilting-pad journal bearing could be determined.

Castelli and McCabe [6] numerically integrated the transient equations of motion for a rigid rotor supported by tilting-pad bearings. They predicted the transient motion of the pads and a shaft as a function of shaft revolutions for two shafts. One shaft was originally displaced from the static operating point; the other shaft was unbalanced. Three-pad bearings were used; results compared to an experimentally measured response showed qualitative agreement.

Lund [7, 8] solved Reynolds equation numerically to determine non-dimensional stiffness and damping ratios for tilting-pad bearings. He varied the L/D ratios, preload factors, and load orientations of

4-, 5-, 6-, and 12-shoe bearings. The results are meant to be used as a design tool. General conclusions are not presented on operating characteristics, but an example is presented and comparisons are made with the test data of Hagg and Sankey [3]. Best agreement is found for small Sommerfeld numbers.

The results of Lund were used by Lund and Orcutt [9] to predict the unbalanced response of a flexible rotor representing a multistage compressor (up to four stages). The rotor was supported by two silicone-lubricated four-pad bearings. Different amounts of imbalance were added to an experimental rig, and results were compared to predictions. Good agreement was obtained overall, and differences were typically less than 25 percent.

Stability and critical speeds of rotor/bearing systems have also been predicted by Lund [10]. He used a lumped mass method to model the rotor; he linearized stiffness and damping coefficients for the bearings. He developed a general prediction algorithm that remains one of the most commonly used and demonstrated the method for a rotor in tilting-pad bearings.

Orcutt [11] extended the work of Lund [7, 8] so that stiffness and damping coefficients could be predicted when the bearing is operating with turbulent flow. He used a linearized turbulence model and considered four-pad bearings with two different preloads and Reynolds numbers up to 12000. Design charts are presented. He also compared static operating conditions (load capacity) to experimentally measured values. Results are typically within 25 percent for eccentricity ratios.

Reynolds equation was numerically solved by Elwell and Findlay [12] for three- and five-shoe bearings. They considered different L/D ratios, preload factors, offset factors, and load orientations. They presented load capacity curves and shear dissipation curves for these bearings. They results in this paper are primarily aimed for use in bearing design. The authors, however, interpreted the results and made several general recommendations.

Oil flow rates, film thicknesses, and power losses in large (16 and 20 in.) tilting-pad bearings have been measured [13]. The bearings had six pads and a central pivot. The authors derived empirical equations for the power loss and transition from laminar to turbulent flow. Gardner and Ulschmid [14] measured film thicknesses, oil and bearing temperatures, and power losses for a 17 in. tilting-pad bearing with five pads. They also determined the transition from laminar to turbulent flow and transition effects on the measured quantities.

A 13 in. five-pad bearing was tested at low Sommerfeld numbers by Gardner [15]. He examined the transition from boundary to hydrodynamic lubrication. Eccentricity ratios and power losses were measured for three weights of oil. He was able to determine the average film pressures at which babbitt wiping occurred.

Hohn [16] reviewed previous work for operating characteristics of fluid-film bearings, the basic concepts of hydrodynamic lubrication, and research being pursued at Brown Boveri on large tilting-pad bearings. He discussed the advantages of different types of bearings and the importance of seven bearing design features; i.e., type, speed, geometry, clearance, metal bond, metal, and oil.

Malcher [17] and Klumpp [18] used a previously developed rigid rotor test rig to measure stiffness and damping coefficients and film thicknesses of tilting-pad bearings. They studied three-pad bearings with the load directed on the pads and four-pad bearings with the load directed between pads. Three clearances were considered for the four-pad bearings; the data were nondimensionalized.

Leopard [19] discussed the limits of operation for tilting-pad bearings, babbitt material, pad designs, lubricants, alignment, clearances, and life. He considered hydrodynamics, design features, and environmental conditions and recommended minimum fluid-film thicknesses in figures. When possible, he made specific recommendations. The paper, which is based on a combination of theoretical predictions and practical experiences at Glacier, is a very good review of many of the practical considerations that must be addressed in tilting-pad bearing design. The author does not attempt to address the dynamic properties of the bearings.

Pollmann and Schwerdfeger [20] tested the rotor of an electric generator in four types of bearings the first three of which were variations of lemon-bore bearings. The last type was a five-pad tilting-pad bearing. The unbalanced response of the system was obtained, and the response of the system to a shock load was observed. The oil supply pressure did not affect the damping of the rotor in tilting-pad bearings. The tilting-pad bearings contributed the least damping of all bearings tested to the system.

The mobility method has been used to predict the dynamic motion of a shaft in a three-pad pivoted-pad bearing [21]. The lubricant film was analyzed for each pad. Experiments on a suddenly loaded shaft on a single pad showed reasonable agreement with theory. The method is, however, restricted because the authors conclude that the load on each pad must be known a priori.

A general method for solving the Reynolds equation using a finite element method has been developed [22]. The method yields load-capacity information as well as stiffness and damping coefficients for fixed- or tilting-pad bearings. The method has been used [23] to predict the static characteristics and dynamic coefficients for five-pad tilting-pad bearings. Various preload factors, offset factors, L/D ratios, and load directions were considered. Many design curves are presented for these bearings.

These predicted data [23] have been used to examine the unbalanced response of a 10-stage axial compressor [24] and the stability of an 11-stage compressor [25]. In one case [24] the authors were able to minimize the unbalanced response by judiciously choosing the optimum bearing coefficients. Similarly, in the other case [25] the authors demonstrated how a stability analysis could be completed for a rotor to maximize the rotor instability threshold. Thus, practical methods have been developed [24, 25] by which information obtained by a general method [22] can be used.

Varga [26] performed static tests on a large three-pad tilting-pad bearing. He measured pressures, temperatures, film thicknesses, flow rates, friction, and pad movements. He used film thickness and bearing temperature measurements to predict pad deformations. He did not attempt to compare his results to available theories or discuss dynamic data. The paper contains raw data for a large bearing used in turbo sets.

Yamauchi and Someya [27] developed a method whereby a flexible rotor mounted in tilting-pad bearings could be used to experimentally evaluate the bearing coefficients. They unbalanced the rotor, measured the response, and used the data to deduce the coefficients. Comparisons made to predictions were fair to poor, however. The primary problem with the method is that uncertainties in measurements significantly affect the calculated results when a matrix inversion is used. As a result, coefficients have very large uncertainties.

Bulanowski [28] developed a simplified stability analysis for flexible rotors in tilting-pad bearings. He used a single-mass two-tier (shaft-bearings) spring-damper model and derived the governing equations for stability. The equivalent damping of the system should be greater than approximately 0.055 based on previous experience. Examples are worked for five-pad bearings with different preload factors. This method is not as sophisticated as other available methods but is a simple method that can be used to establish guidelines quickly during a design.

Nilsson [29] studied the effect of pad bending on static and dynamic performance of tilting-pad bearings. He used a finite element analysis and allowed the pads to deform due to areas of high pressure. He found that the static characteristics and stiffness coefficients were not significantly affected. However, the dynamic coefficients were affected by pad bending.

Fitted tilting-pad bearings have been theoretically analyzed [30]. Fitted refers to bearings that have pad radii equal to the shaft radius; the bearings thus have a negative preload. Load capacity information, power loss, and dynamic coefficients are predicted. Because this type of bearing is little used due to the negative preload, the results of this paper must be considered somewhat academic.

Jones and Martin [31] used a finite difference method to analyze tilting-pad bearings. They varied clearance, preload factor, L/D ratio, number of pads, lubricant viscosity, and orientation of the bearing. Load capacity, power loss, temperature increase, and dynamic coefficients are presented as are specific examples. Variations of these examples show the dependence of the operating characteristics on the various parameters. Specific examples are worked in this well documented paper, but, the authors present several guidelines that should be of interest to design engineers.

Nicholas and Kirk [32, 33] theoretically and experimentally studied the response of rotors in four-pad tilting-pad bearings. They compared their results to those from three-axial groove, step, and five-pad tilting-pad bearings. In particular they examined the dynamic coefficients of the bearings, the unbalanced response of the rotor, and subsynchronous vibration. They found that the tilting-pad bearings did not split the first critical speed of the rotor as did the fixed-pad bearings. They also found that the four-pad bearings had the best damping characteristics and minimized the subsynchronous vibrations and response at the critical speed.

A porous, pivoted, slider bearing lubricated with a micro-polar fluid has been theoretically studied by Agrawal and Bhatt [34]. They found that the micropolar fluid supported more load than a Newtonian fluid. However, the porosity of the pad decreased the load capacity. The authors did not consider journal bearings. Thus, although the paper is interesting, it does not represent a contribution readily applicable to design.

Andritsos and Dimarogonas [35] experimentally measured the static operating characteristics of four different tilting-pad partial-arc bearings. They then used a pad assembly method to integrate the results for four identical pads around a journal bearing. They were able to predict, using experimental data, the static characteristics of four different journal bearings. They also predicted the dynamic stiffnesses on the basis of small perturbations from the static conditions. The stiffnesses compared to the experimental values of Hagg and Sankey; they obtained good agreement for low Sommerfeld numbers.

A Jeffcott type rotor has been tested in three types of bearings: axial groove, pressure dam, and five-pad tilting-pad [36]. The system went unstable due to whip with the fixed pad but did not do so with the tilting-pad bearings. No subsynchronous vibrations were observed with the tilting-pad bearings. The rotor had the largest unbalanced response with the tilting-pad bearings.

Flack and Rooke [37] predicted the unbalanced responses of the flexible rotor studied above [36]. They obtained very good agreement and predicted peak responses within 15 percent in amplitude and eight percent in speed. They showed that the peak response for the rotor in tilting-pad bearings was more than two times the responses of the other fixed-pad bearings.

The above two papers have been reviewed and combined with other results [38-41]. The authors summarized many of the advantages and disadvantages of tilting-pad bearings. A tilting-pad bearing will not produce whirl, is moderate in cost, has high horsepower losses, poor damping at critical speeds, and clearances that are difficult to measure.

Ettles [42] included thermal and elastic effects in his predictions of static and dynamic operating characteristics. He solved the Reynolds equation for the entire bearing (as opposed to a pad-assembly method) due to oil carry-over. Comparison of his data with the experimental data of Klumpp for four-pad bearings showed good agreement for the load-capacity and stiffness coefficients; however, fair to poor agreement was found for the damping coefficients. The author found cross-coupling characteristics due to elastic deformation of the pads. He also predicted the unbalanced response of a rotor studied previously [36]. He predicted the correct trends.

Adams and Makay [43] reviewed the basic operating characteristics of tilting-pad bearings. They indicated that orienting the load between pads will result in the smallest unbalanced response. They indicated that with more pads the load is shared by more than one pad but the load-capacity is decreased. It is for this reason that seven to nine pads are commonly used for vertical main coolant pumps of reactors. Other applications typically use five pads and moderate preload. This paper basically reviews known facts and does not present any new material.

Temperatures in a five-pad bearing have been experimentally measured by De Choudhury and Barth [44]. Temperature data for one point on one pad are presented. They found that the film temperatures were higher than the discharge temperatures. They also showed that the film temperature is much more dependent on load than the discharge oil temperature. The authors have supplemented these data in a more recent paper [45].

Rouch [46] developed a method to include pad translation (due to pivot flexibility) and pad rotation (mass and inertia effects). The method is used with a pad assembly. A five-pad bearing example is presented, and the effects of different pivot stiffnesses are shown. The method results in cross-coupled coefficients due to pivot stiffness and pad inertia.

A case study of a multi-stage steam turbine has been studied by Salamone [47]. The turbine originally was mounted in lemon-bore bearings. It had experienced critical speeds close to the operating range as well as subsynchronous instability frequencies. Salamone designed a set of five-pad tilting-pad bearings to eliminate the two problems. Details of the analysis are presented in the paper.

Adams and Payandeh [48] present a time transient nonlinear analysis for the motion of statically unloaded tilting pads. They found that unloaded pads could exhibit instabilities at approximately half the running speed and that pads with short arc lengths were less prone to such instabilities. Five-pad bearings are thus better than three- or four-pad bearings from this standpoint. Bearings with more pads have less load capacity, however.

A set of equations for evaluating the reduced dynamic coefficients for tilting-pad bearings has been derived [49, 50]. The equations were used to evaluate the effect of frequency ratio on the reduced dynamic coefficients for a rigid rotor at the instability threshold. For preloaded bearings the reduced coefficients did not change greatly with frequency. However, coefficients for bearings with zero preload did vary with frequency.

HYDROSTATIC BEARINGS

Figure 3 shows a side view of a typical hydrostatic bearing employed in main coolant pumps. Figure 4 shows an unrolled view of the bearing surface. The four pads are separated by axial grooves. Each pad contains two pockets that are separated by a land area. Figure 2 gives an unrolled view of the bearing; the two pockets in each pad are shown. Each pocket has an orifice restrictor in the center. The axial grooves mean that the design and analysis of these bearings differs from the hydrostatic bearings without grooves discussed in the literature to date.

Hydrostatic bearings operating with low viscosity lubricants have several applications. In main coolant pumps for nuclear applications [51] they have been used as guide bearings close to the impeller. They are lubricated with water and high stiffness properties that minimize shaft vibrations due to fluid forces acting on the impeller. Such pumps are used both in the U.S. and Canada [52]. Other water-lubricated hydrostatic bearings are used in steam-turbine helium-cooled reactors [53]. Sodium-lubricated bearings of similar type have been designed and tested for the Clinch River Breeder Reactor [54]. Similar bearings have been reported for other applications [55]. Hydrostatic bearings have also been considered for use in high-speed rocket turbopumps [56]. Both liquid oxygen and liquid hydrogen have been used as lubricants in the design and test of prototype bearings.

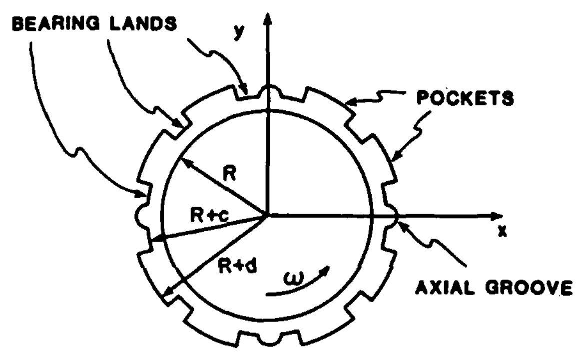


Figure 3. Side View of Hydrostatic Bearing Geometry

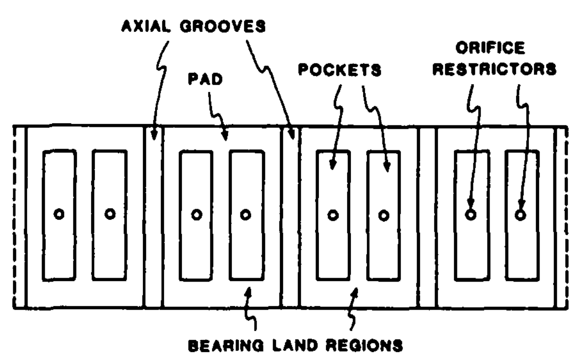


Figure 4. Unrolled Bearing Surface Geometry

Only a few papers on the analysis of turbulent hydrostatic bearings have appeared in the open literature [56-58]. Reddecliffe and Vohr [56] analyzed bearing designs for cryogenic rocket engine turbopumps with both liquid hydrogen and liquid oxygen as lubricants. A number of recesses were cut in the bearing surface, but there were no axial grooves. A finite difference analysis included turbulence, variable density and viscosity with pressure, and inertia forces. Pressure, flow rates, and bearing stiffness were calculated, but damping was not. An experimental program was conducted to measure bearing performance during steady-state and transient operation. The agreement between predicted and measured performance was good.

Heller [57] published other work related to hydrostatic bearings for turbopumps. His experimental work was, however, performed in water. The theoretical analysis assumed the fluid to be incompressible and included turbulence and entrance inertia effects. Finite differences were used to calculate steady-state load capacity, flows, friction loss, and dynamic stiffness and damping coefficients. An experimental program was carried out with a six-pocket water-lubricated bearing.

More recently, an analysis of hydrostatic journal bearings has been presented that includes turbulence in the film, inertia effects at recess boundaries, and hydrodynamic effects in the bearing [58]. A finite difference approach was combined with an iterative method between the Reynolds equation and a flow continuity equation taken over a control volume that included nine grid points at a time. The analysis was applied to liquid hydrogen and liquid oxygen lubricated bearings. The bearings considered in two papers [56, 58] have similar geometry and clearances such as might have been employed in rocket turbopumps. Both static and dynamic properties were calculated.

SUMMARY

Literature on the static and dynamic operating characteristics of tilting-pad and turbulent hydrostatic journal bearings has been reviewed. Experimental and theoretical work as well as applications in which these bearings were used in a dynamical analysis of the rotor/bearing system have been included.

Tilting-pad bearing literature can be divided into two time periods. Until approximately 1977 most authors were attempting to predict idealized characteristics; pivot stiffness, thermal effects, pad deformation, and pad inertia were ignored. The objectives were to develop methods for obtaining a reliable first approximation to the actual characteristics. Since that time more authors have been addressing the more complex phenomena using previous research as the starting point.

ACKNOWLEDGEMENTS

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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 an article about vibrations and stability of mechanical systems.

Dr. K. Huseyin of University of Waterloo, Waterloo, Ontario, Canada has written an article concerning general developments in the area of vibrations and stability of mechanical systems. Advances that have been made since 1980 are described. The review covers both linear and nonlinear theories as well as basic methodology developed for holonomic autonomous mechanical (discrete) systems.

VIBRATIONS AND STABILITY OF MECHANICAL SYSTEMS: III

K. Huseyin*

Abstract. This is the third review article concerning general developments in the area of vibrations and stability of mechanical systems. Advances that have been made since 1980 are described. The review covers both linear and nonlinear theories as well as basic methodology developed for holonomic autonomous mechanical (discrete) systems.

Earlier review articles [1, 2] provide an introduction to the present paper. The reader is referred to these articles for basic definitions and basic equations.

LINEAR THEORIES

Oscillations and stability of various mechanical systems have been the subject of many investigations. Attention has been particularly focused on nonconservative conditions, gyroscopic forces, and damping properties. Stable responses of damped linear systems have been reviewed separately [3, 4].

Although emphasis appears to have been placed on nonconservative systems, damped conservative systems -- associated with symmetric mass, damping, and stiffness matrices -- have also attracted attention. Definitions of critical damping and critical damping matrix have been given [5, 6] and a number of theorems concerning critical damping, over-damping, and under-damping have been developed [6]. Efficient methods for calculating the critical damping matrix have been developed [7, 8]. Calculation of eigenvectors is not required in the latter paper [8]; this is a significant advantage over other methods. A procedure for designing over-damped systems has been outlined [9], and an interactive design routine has also been described in a computer package for eigenvalue analysis and design of linear damped systems [10]. The algorithm developed in the latter paper [10] allows for interactive modifications of the physical structure of the system; the algorithm readily yields the matrix structure, latent roots, and latent vectors. Nicholson [11] has presented a necessary and sufficient condition for a system to be over-damped; the condition could prove useful in many applications.

Gyroscopic systems have been studied from various angles. The basic properties of stability regions and boundaries of rotating systems have been explored [12]; lower and upper bounds have been established for flutter as well as divergence boundaries of gyroscopic systems under combined internal and external damping. Flutter instability of rotating circular elastic shafts subjected to both a follower dead load and torque has been studied by Shieh [13]. He also analyzed an elliptic shaft subjected to axial compressive force; in both cases some instability and variational principles have been established. The results obtained concerning flutter boundary are in compliance with those discussed elsewhere [12]. Wauer [14] has also investigated the combined effect of gyroscopic forces and different damping mechanisms on the stability of rotating elastic shafts.

A simple, necessary, and sufficient condition concerning the stability of conservative gyroscopic systems has recently been derived [15] in terms of mass, gyroscopic, and stiffness matrices. The result, expressed as a theorem, covers, for example, all uniform rotating shafts. Hagedorn [16] has developed a perturbation analysis to obtain eigenvalues and eigenvectors for a general, slightly damped system (gyroscopic as well as non-gyroscopic) from those of the corresponding conservative system. Another stability condition concerning conservative gyroscopic systems is available [17]; this result, however, is for two-degree-of-freedom systems only.

General non-conservative systems with asymmetric damping and stiffness matrices have received further

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attention. Under certain symmetrizability conditions -- in analogy with pseudo-conservative systems -- a number of theorems concerning stability and asymptotic stability have been established [18]. The existence and use of classical normal modes in the modal analysis of general non-conservative systems have also been discussed [19].

Flutter and divergence instability of elastically restrained simple structures under non-conservative follower forces have been examined by Kounadis [20]. He explored the effect of the level of restraint on the nature of the instability. Conditions for the existence of classical normal modes in various classes of problems, the concept of Rayleigh damping, and computationally advantageous relations are discussed in an upcoming paper [21]. The nature of eigenvalues and oscillatory behavior, including conditions for critical damping, over-damping, and under-damping, have been explored [22]. Non-conservative systems receive extensive treatment in Leipholz's book [23].

BASIC METHODOLOGY

Considerable effort has gone into establishing more variational principles and conservation laws (invariants, constants of motion, first integrals) for non-conservative systems. Leipholz has discussed certain extensions of the classical energy method, Liapunov-like approaches, and certain time-invariant functionals together with the associated variational principles [24]. The use of the Hamiltonian for evaluating stability properties of non-conservative systems [25] and time-invariant functionals for certain mechanical systems subjected to follower forces [26] have also been discussed.

Simplified conditions for the derivability of the linearized equations of a network from a Lagrangian have been given by Bahar and Kwatny [27]. They also derived first integrals under a certain commutativity relation. An explicit time-dependent Lagrangian for damped harmonic oscillator and its relation to a time-invariant Lagrangian of the same problem have been presented [28]. Direct construction of first integrals for certain nonlinear dynamical systems has also been explored [29]; the simple approach reveals some interesting features when it is specialized to the case of linear equations. The methodology of this paper is also extended to systems described by second-order ordinary differential equations with time-varying coefficients [30].

The dynamic response characteristics of linear non-conservative systems has been explored through functions of matrices [31]. The application of this method is not contingent upon the symmetry properties of the matrix coefficients in the equations of motion; the method can, therefore, be used to predict the dynamic response of both gyroscopic and circulatory systems. A generalized Lagrange-Hamilton formulation for a broad class of electrical networks and association of the formulation to Brayton-Moser equations has been presented [32, 33]. Two methods developed for some dynamical systems have been used to construct first integrals that differ from the Hamiltonian [34]; certain conservation laws for some gyroscopic systems have been presented [35]. In the latter paper it is shown that, under separability property of a gyroscopic system and certain commutativity conditions, the equations of motion can be uncoupled.

The concepts and methodology of Hamiltonian mechanics have been applied to the stability analysis of discrete, holonomic, and scleronomic mechanical systems under both conservative and non-conservative forces [36, 37]. Critical conditions underlying divergence and flutter instability have been re-examined. Hamiltonian action has been used to establish variational principles characterizing kinetic stability [38]. The relation between static and kinetic variational methods for the stability of equilibrium of conservative systems and corresponding Rayleigh's principles has been re-examined [39]. Alternative proofs of the well-known convexity theorem concerning the loading-frequency relationship of conservative systems have also been presented [40].

A variational principle dependent on the Lagrangian and Rayleigh dissipation function has been presented [41]; it has been shown that the differential equations of motion are obtainable from the stationarity of a certain function. Approximate techniques based on Hamilton's principle for multi-degree-of-freedom and constrained systems have been discussed [42]. The stability of steady motions in free and restrained systems has been explored [43] with regard to ignorable coordinates.

An interesting book [44], devoted to fundamental theories in mechanics, presents the birkhoffian generalization of Hamilton mechanics. One of the objectives of the book, which has a mathematical orientation, is to provide a framework for analyzing systems with non-potential forces.

NONLINEAR THEORIES

An overall view of the instability behavior of autonomous systems, including linear and nonlinear theories, has been presented [45]; contrasts in the characteristics of potential and nonpotential systems were brought into sharp focus within the context of a linear formulation that yields the stability boundary in many practical cases. A nonlinear theory concerning bifurcations, instabilities, and catastrophes for all autonomous systems -- including pseudo-conservative, gyroscopic, and circulatory systems -- was then outlined from a unified point of view.

Several interesting books and articles concerning the instability behavior of conservative potential systems have appeared [46-51], but the most important developments have been in the area of nonpotential systems. As outlined in the previous review [2], a nonlinear, autonomous system can be described by the first order vector equation

$$\dot{x} = X(x, \eta)$$

where x is the state vector of n components, η is a scalar (or vector) parameter, and the dot denotes differentiation with respect to time t.

The salient features of this system include equilibria, limit cycles, and chaos. An initially stable equilibrium path (with η scalar) can lose its stability either by divergence (static bifurcation) or flutter (dynamic bifurcation). In the former case, explicit conditions of stability and instability concerning the initial equilibrium path and post-critical path(s) have been obtained through a perturbation approach [52]. It has been shown, for instance, that a symmetric point of bifurcation involves a post-critical equilibrium path that is totally stable (unstable) if the initial path is unstable (stable); this is an analogy with potential systems.

Coincident critical points and the associated interaction of modes have also been explored [53]. For the case in which η is a vector representing several parameters, the distinct forms of the equilibrium surface have been obtained analytically [54]. Structurally unstable forms (special critical points) have also been explored. Degenerate situations have been discussed [55].

Static bifurcations have also been analyzed in two recent books [56, 57] on bifurcation theory; the books contain valuable information about dynamic bifurcations as well. The latter phenomenon is associated with oscillatory instabilities and was first analyzed by Hopf; basic concepts and definitions have been summarized [2]. Developments in this area during the last three years have been extensive. Several volumes in addition to those mentioned above have appeared [58-61]; they contain various methods of analysis and a variety of applications [61].

In order to extend the methodology underlying static bifurcations [52-55] to the analysis of oscillatory instabilities and the associated family of limit cycles, an intrinsic method of harmonic balancing has been developed and applied to the ordinary Hopf bifurcation phenomenon [62-66]. The method is essentially a variation on the classical method of harmonic balancing and is designed to eliminate the drawbacks and shortcomings associated with the latter. Indeed, the new approach yields consistent approximations for nonlinear, dynamical bifurcation problems; the approach is based on a systematic perturbation procedure that parallels the analysis of static bifurcations. The new technique has contributed toward a desirable unification of methodology underlying both static and dynamic bifurcation phenomena. The new technique has also been used to obtain explicit formulas for the post-critical family of limit cycles, frequency of oscillations, and the path bifurcating from the critical point. These general results can be used directly in the analyses of specific problems falling within the scope of the formulation, but not much analysis need actually be performed [65]; this technique has been demonstrated [65, 66].

More recently the method has been employed in the analysis of generalized (or degenerate) Hopf bifurcations. These problems arise when the so-called Hopf condition(s) are violated. For example, the pair of complex conjugate eigenvalues does not cross the imaginary axis with nonzero velocity, in violation of the transversality condition, or some other key coefficient vanishes at the critical point. Under such conditions several distinct bifurcation phenomena can appear; they have been explored fully via the intrinsic method of harmonic balancing. If the pair of eigenvalues touches the imaginary axis tangentially without crossing it, the system can exhibit a symmetric bifurcation phenomenon [67] representing a family of limit cycles. Nevertheless, the existence of such a family is not guaranteed, and there might be no bifurcation at all, unlike the ordinary Hopf bifurcation.

Similarly, the circumstances giving rise to flat bifurcation [68], tangential bifurcation [69], cusp bifurcation [69], and double Hopf bifurcation [70] have been explored. Existence conditions as well as the asymptotic equations of bifurcating paths, families of limit cycles, and frequency-amplitude relationships have been derived in explicit terms for easy application in various fields.

The behavior of a system under the influence of two parameters has also been studied [71]. In this case a concept of behavior surface arises; the asymptotic equations of this surface, which describe the family of bifurcating limit cycles as well as topological properties, have been explored [71].

Other methods of analysis have been used to describe degenerate Hopf bifurcations [72, 73] and to classify these instabilities [73]. An example [53] has been used to demonstrate interactions of static and dynamic bifurcations [74]. The application of Ritz and Galerkin methods to bifurcations problems has been discussed [75]. Interesting applications of bifurcation theory to a tractor-semitrailer [76] and a number of other mechanical systems [77] have also been presented. Degenerate bifurcation at simple eigenvalues [78], sequence of bifurcations [79], and new methods of global bifurcation theory with regard to whirling strings [80] have been studied.

Studies of bifurcations involving periodic motions (or limit cycles) are inherently related to nonlinear oscillations, and a number of books in this area have appeared [81, 82]. Related volumes on methodology provide good background material as well as new directions [83-86]. New approaches can also be found in several recent papers: a time transformation method for the analysis of nonlinear oscillations [87], methods of differentiable dynamics to study the qualitative behavior of a nonlinear oscillator [88], methods for investigating stability in the large [89], an approach to tackle coupled linear-nonlinear non-conservative problems [90], and an efficient computational technique for determining the roots of functional lambda matrices [91].

Finally, in addition to equilibria and limit cycles, chaos has emerged as one of the salient features of autonomous systems. There are many unanswered questions concerning this phenomenon; a recent publication [92] could prove useful in clarifying some of these questions.

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BOOK REVIEWS

HANDBOOK FOR INDUSTRIAL NOISE CONTROL

W.G. Orr
National Technical Information Service
Springfield, VA, 1981, 139 pages

This handbook was prepared on contract for the NASA Langley Research Center and covers topics that are basic to understanding and applying noise control. There are seven chapters in the book. Chapter 1 is an introduction to the subject of noise and introduces various regulations that govern industrial occupational noise control. The basic physics of sound are covered in the second chapter. Important measurement techniques and procedures for conducting a noise survey are discussed in Chapter 3.

Chapter 4 covers different types of instrumentation needed to conduct sound measurement studies, including microphones, noise dosimeters, and frequency analyzers. Noise and vibration control materials are described as well as some of their physical characteristics and properties in Chapter 5. The proper implementation of noise control procedures is discussed in Chapter 6. The three basic types of noise control are detailed: those associated with the source of noise, those along the transmission path, and those at the receiver. A variety of techniques are introduced that can be applied to source, path, or receiver. The importance of cost, time needed for satisfactory noise control, availability of the noise control item, and the effects of noise control on operations are discussed. A detailed discussion of some common sources of noise problems and their solutions is given in Chapter 7. An appendix summarizes the Occupational Safety and Health Administration (OSHA) regulations and includes an assessment of hearing impairment. A glossary and bibliography are also provided. The bibliography contains a substantial list of additional general texts, journals and periodicals, conference proceedings, and manuals in addition to general policy and information documents and selected NASA technical papers.

This handbook will be useful to both the experienced and inexperienced engineer for understanding, measuring, and controlling noise. The low cost of this paperback – available through the National Technical Information Service (NTIS) -- also makes it extremely attractive, particularly as a supplemental text for an undergraduate course in noise and vibration control.

V.R. Miller
5331 Pathview Drive
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ACOUSTICAL MEASUREMENTS: METHODS AND INSTRUMENTATION

H.B. Miller, Editor
Hutchinson Ross Publishing, Stroudsburg, PA
1982, 409 pages, $53.00

This volume is the 16th in a series called "Benchmark Papers in Acoustics," developed, according to the series editor, R. Bruce Lindsay, because most of the important historical papers remain inaccessible to the average acoustical scientist and engineer. Each book contains a well researched collection of papers (usually presented in nearly chronological order) along with editorial comments that help explain some of the background and importance of each selection. Other volumes in this series that will be of interest to readers of the ***Digest*** include: ***Underwater Sound*** by Flanagan and Rabiner, ***Vibration: Beams, Plates, and Shells*** by Kalnins and Dym, ***Architectural Acoustics*** by Northwood, and ***Acoustic Transducers*** by Groves.

Miller has selected and commented upon an impressive collection of historically important papers; he has chosen papers that were printed in obscure, inaccessible, or now defunct publications. His reasoning is that other important papers are more readily obtained. The first part of the six-part book treats the nonelectronic detection of sound. The second part deals with electro-acoustic microphones; the third, visual observation of sound waves; the fourth, free-field calibrations and reciprocity; the fifth, sound absorption and acoustical impedance; and the last, phase and transient distortion. Miller also provides an author citation index and a subject index.

The papers date from the 1850s -- the Lissajous and Helmholtz's visual and analytical studies of acoustics -- to the late 1900s -- Nyquist and Brand's paper on phase distortion, Cook's work on absolute calibration of microphones, and Berman and Finchman's paper on the application of digital techniques to the measurement of loudspeakers. Some papers are complete or almost complete; others are only brief excerpts from longer papers. Illustrations and reproductions of plates help clarify ideas of the individual authors and editors. Comments, references, and an annotated bibliography concerning the papers precede each part. The editor provides notes after each paper to explain older nomenclature, the development of equations, or insight into concepts presented.

Miller has chosen an excellent collection of papers. I enjoyed the first-person, active writing styles of the more historical documents, especially in comparison with more contemporary works. I also appreciate the sense of history and the effort that went into developing devices in the field of acoustical measurements; such emphasis is lacking in many modern-day texts and courses of instruction. I particularly liked Wente's papers on condenser microphones; they were clearly written and a joy to read. Toepler's paper on Schlieren, translated by Lindsay, provides clear evidence of a brilliant and inventive experimenter. On the other hand, Sabine's paper on theater acoustics was severely edited. Fortunately, in the case of Sabine's paper, the full text is available through Dover Publications. With a limited space to present a large number of papers, the editor had the difficult problem of choosing the entries for this volume. I suspect it was not easy to make final decisions.

This volume will appeal strongly to those readers of the ***Digest*** who subscribe to and read the ***Journal of the Acoustical Society of America.*** I would expect ***Acoustical Measurements*** to appeal to all of us, however, who do, or desire to do, any type of experimentation. Reading the papers of people struggling to detect and measure quantities we take for granted is inspiring. I highly recommend the book.

R.J. Peppin
Bruel & Kjaer Instruments, Inc.
185 Forest Street
Marlborough, MA 01752

STOCHASTIC PROCESSES IN DYNAMICS

B. Skalmierski and A. Tylikowski
Nijhoff Publishing Co., Boston, MA
1982, 141 pages, $39.50

This is a broad ranging book that I would place in the advanced category. It is not suitable as a text because of the prerequisites it imposes. However, it contains material and engineering examples not available in other books on random vibrations. I recommend it to specialists with the caution that the prospective reader should be well versed in probability theory.

The Table of Contents includes:

1. Selected deterministic problems
2. Fundamentals of the theory of stochastic processes
3. Quasistatic methods
4. Correlation methods
5. Application of the method of kinetic equations
6. Stability of random systems

In Chapter 1 equations of motion (Lagrange's and Hamilton's) are given in a general setting (the reader should be familiar with co-variant and contravariant tensors and Christoffel symbols). Issues of stability, including the concept of technical stability, are described. The chapter ends with a thorough discussion of the process of linearization.

Chapter 2, which introduces probability theory and stochastic processes, is very technical in a mathematical sense. Treated are stationary and ergodic processes; spectral densities; the Wiener-Khinchin relations; and narrow-band, white noise, Markov, and Wiener processes. Stochastic differential equations are introduced and the associated Fokker-Planck-Kolmogorov (FPK) equations are derived; some solutions are given for special cases.

A major section of Chapter 3 is devoted to the determination of probability densities. Applications include harmonic vibrations with random phase, torsion of shafts, flow of a solid grain in a gas, and transverse vibrations of a beam with a random flexural rigidity. The physical motivation of the beam problem is not clear. The chapter concludes with a development of general recipes for the solution of the threshold crossing problem; more specific results are given for Poisson processes.

Chapter 4 opens with a discussion of the process of stochastic linearization. Linear systems are reviewed and circumstances are established under which the superposition integral exists. A detailed discussion is given of nonstationary excitation of a single-degree-of-freedom system by a sum of harmonics with random amplitudes and phases. A nonlinear problem involving a cubic spring is also examined. Finally, n-degree-of-freedom and continuous systems are treated; examples include stationary flexural excitation of a beam and nonstationary excitation of a thin-walled shell.

Chapter 5 would be more aptly entitled, "Applications of the FPK Equations." Examples focus on broadband excitation and include the three-dimensional motion of a rigid body. The asymptotic method of Krylov-Bogolubov-Mitropolski is generalized and used to study the transverse vibrations of a chain excited by random changes in tension and transverse load.

Chapter 6 is terse. It opens with a technical discussion of the various definitions of stochastic stability that are in common use. Ljapounov's direct method is generalized; the Ito and Stratonovich strategies for handling stochastic integrals are examined. One example is given; namely, the excitation of a set of linear constant coefficient differential equation excited by a white noise process. This is certainly a chapter for the specialist.

A strong feature of the book is the numerous references. They number 171 and provide a valuable guideline for more detailed study of individual topics.

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RESEARCH TECHNIQUES IN NONDESTRUCTIVE TESTING, VOL. VI

R.S. Sharpe, Editor
Academic Press, Inc., London
1983, 330 pages, $59.50

The authors have provided an excellent reference publication for some state-of-the-art techniques in nondestructive testing (NDT). The majority of the work is devoted to reviewing ultrasonic testing procedures. Thirteen authors have written the seven chapters that make up this volume.

Chapter 1 discusses ultrasonic synthetic-aperture focusing techniques in NDT; the techniques involve a flaw characterization method in which ultrasonic waves are used to form a high-quality image of a detected discontinuity. The emphasis throughout this chapter is on the physical principles that underlie the synthetic-aperture process. Impressive graphical displays accompany the text.

Chapter 2 reviews some electronic focusing techniques and acquaints the reader with their potential advantages. Practical problems of transducer design, array fabrication, and electronic control are discussed. Images from various techniques are shown.

Chapter 3 presents computer techniques for modeling ultrasonic waves in solids. Current methods for computer-based numerical modeling are reviewed, and present and possible future contributions that these techniques might make in the field of ultrasonic NDT are considered. Several examples of graphical representation of numerical calculations are given.

Chapter 4 contains a discussion of the measurement of residual stress using ultrasonic-based techniques. The theory of the propagation of ultrasound in deformed elastic solids is presented. Various experimental techniques to measure residual stress are reviewed. The effects of texture are extensively treated.

Chapter 5 is a review of photon attenuation techniques for monitoring the composition of materials. The value of photon attenuation is explored as an analytical tool in terms of minimum detectable quantities, resolution and dose. Many examples are given that relate to biological situations.

Chapter 6 provides a summary of applications of computerized tomography with X and gamma radiation. The principles and practical implementation of reconstructive tomography as well as the theory of tomographic image reconstruction are given. A survey of experimental photon tomography, including several pictorial examples, is included. The chapter ends with a review of current industrial applications of the technique and suggestions for future industrial use.

Chapter 7 is a review of screen/film combinations based on the recent upsurge of research connected with medical radiography interests. The theory of this subject is presented as well as sections on contrast, sharpness, noise, and visual performance.

The reviewer considers this volume an excellent review of some of the techniques of nondestructive testing. The chapters are well written, informative, and include extensive bibliographies. Scientists, engineers, technologists, and students should find this book valuable.

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REVIEWS OF MEETINGS

1984 ASME DESIGN ENGINEERING CONFERENCE AND NATIONAL DESIGN ENGINEERING SHOW

McCormick Place, Chicago, Illinois
March 26-29, 1984

The ASME Design Engineering Conference is an annual event that is held at the same time as the National Design Engineering Show. The technical sessions in this conference are largely sponsored by the Design Engineering Division of the ASME, and the individual sessions are arranged by the various technical committees within the division. Short courses are also offered as a part of this conference, and the topics of some of these short courses were computer aided engineering, finite element analysis, and the use of microprocessors and personal computers in mechanical design. This year, as in the past several years, multiple technical sessions were devoted to computer aided design, engineering or manufacturing; in fact, the unofficial theme of this conference might have been, "Remember the slide rule?"

A general, or a plenary, session was also held on each of the first two days of this conference. Dr. Eugene Rivin, from the Wayne State University, Detroit, MI, spoke on the subject of "Soviet R and D Benefits for U.S. Industry," in the plenary session on March 27. Dr. Rivin first described the Russian engineering research structure, and then he discussed the impressive nature of the Russian technical information collection and dissemination activities which are a part of the Russian engineering research structure. Finally, he pointed out the benefits of keeping up with their openly published technical literature.

The Technical Committee on Vibration and Sound of the ASME Design Engineering Division sponsored three sessions dealing with the use of small computers for solving vibration problems. The first session in this series concerned vibration monitoring. Dr. John Rollins discussed the importance of considering the dynamic behavior of systems with time varying dynamic characteristics, and the dynamic behavior of systems that exhibit sudden changes in mass in connection with vibration monitoring. The presence of time varying dynamic characteristics or conditions leading to sudden changes in mass may not be detected by vibration monitoring, therefore, systems with these characteristics are often prone to sudden and rapid increases in vibration to catastrophic levels.

Walter Taylor described how he used a microcomputer to help qualify piping inspectors to measure pipeline vibrations by using nothing more than their eyes. The qualification process involves measuring a set of distances, from the inspector to the vibrating object, at which the inspector is barely able to perceive the different amplitudes of the vibratory motion. The microcomputer is used to statistically analyze the measurements and plot a best fit curve for each inspector that shows the limit of their ability to detect vibration at different amplitudes as a function of the distance from the vibrating object.

Dr. John Carey presented a paper on monitoring the vibrations of rotating machinery to detect and diagnose the cause of mechanical faults at an early stage. He reviewed the various types of vibration measurements, e.g., third octave, broadband, etc., and the types of mechanical faults that could be detected from these measurements. He also discussed the characteristics of the instruments for machinery condition monitoring and the use of various signal processing techniques for extracting machinery condition data from low level vibration signals.

The second session, "Computer Aids for Design," contained three papers on the use of programmable calculators and microcomputers in solving vibration problems. Dr. Leonard Van Gulick discussed the use of programmable calculators to perform vibration calculations as part of a preliminary design effort, or to investigate the effects of changes in system parameters on natural frequencies or system response. To demonstrate the usefulness of programmable calculators in vibration analysis, his presentation included flow charts and program listings for predicting the forced response of single degree of freedom systems and the natural frequencies of a two degree of freedom spring-mass system.

Richard Wetzel described how microcomputers could be used to perform many different types of vibration analyses. His examples included modal testing and analysis, structural modification analyses and parameter sensitivity studies. Microcomputers can also be used in machinery condition monitoring to control data acquisition and manage machinery condition data bases; they can also be used to analyze time history data to construct alarm limits, trend data to predict when vibration will become excessive and diagnose the causes of excessive vibration.

Dr. Lola Boyce described a pilot project to develop an automated data acquisition and analysis system using a low cost microcomputer and microcomputer plug compatible data acquisition boards. Her presentation included a description of the functions and the performance characteristics of the data acquisition system. Dr. Boyce also discussed the role of the microcomputer in the overall data acquisition and analysis process, and she briefly discussed the characteristics of a Fast Fourier Transform algorithm which was optimized for use on microcomputers.

The last session dealt with analysis techniques for correcting vibration problems, or for eliminating vibration problems in the design stage. Two papers were presented in this session. The first paper, by Douglas Nickerson, described the analytical techniques that were used to solve two different pump vibration problems. Brij Seth presented the second paper in this session, and he described the design and analysis of a hardmount balancing machine for balancing automobile engines in a production environment.

PREVIEWS OF MEETINGS

AGARD/SMP SPECIALISTS' MEETING ON TRANSONIC UNSTEADY AERODYNAMICS AND ITS AEROELASTIC APPLICATIONS

Toulouse, France
September 3-6, 1984

Chairman: James J. Olsen, AFWAL, Wright-Patterson Air Force Base, OH 45433

Recorder: Walter J. Mykytow, 14 Old Stone Way, No. 9, Weymouth, MA 02189

SESSION I

Chairman: Richard Zwaan, National Aerospace Laboratory (NLR), Anthony Fokkerweg 2, Amsterdam 1059 CM, The Netherlands

Status and Prospects for Computational Fluid Dynamics for Viscous Unsteady Flows – P. Kutter, NASA Ames Research Center, Moffett Field, CA 94035; and W.J. McCroskey, U.S. Army Air Mobility R&T Laboratory, Moffett Field, CA 94035

Transonic Pressure Distributions on a Two Dimensional 0012 and a Supercritical MBB A-3 Profile Oscillating in Heave and Pitch -- H. Triebstein and R. Voss, DFVLR/AVA, Gottingen, W. Germany

Numerical Studies of Unsteady Transonic Flow over an Oscillating Airfoil -- W.J. Chyu and S.S. Davis, NASA Ames Research Center, Moffett Field, CA 94035

Analysis of Transonic Aerodynamic Characteristics for a Supercritical Airfoil Oscillating in Heave, Pitch and Flap Rotation -- R.G. den Boer, National Aerospace Laboratory (NLR), Amsterdam 1059 CM, The Netherlands

SESSION II

Chairman: H. Forsching, DFVLR/AVA, Göttingen, W. Germany

Experience with Transonic Unsteady Aerodynamic Calculations -- J.W. Edwards and S.R. Bland, NASA Langley Research Center, Hampton, VA 23665

Calculation of Harmonic Aerodynamic Forces on Aerofoils and Wings from the Euler Equations – D.J. Salmond, RAE, Farnborough, UK

Calcul d'Ecoulements Instationnaires Transsoniques avec Decollements par Interaction Visqueux - non Visqueux – P. Girodroux-Lavigne and J.C. Le Balleur, ONERA, Paris 92320 (Chatillon), France

A Semi-Empirical Unsteady Transonic Method with Supersonic Free Stream – M.J. Green and D. Lambert, British Aerospace, Manchester, UK

SESSION III

Chairman: J. Edwards, NASA Langley Research Center, Hampton, VA 23665

Trends in Computational Capabilities for Fluid Dynamics – V.L. Peterson, NASA Ames Research Center, Moffett Field, CA 94035

Improvement and Extension of a Numerical Procedure for the Three Dimensional Unsteady Transonic Flows – P. Mulak and J.J. Angélini, ONERA, Paris 92320 (Chatillon) France

Numerical Solution of Two Dimensional and Three Dimensional Unsteady Transonic Flows by Means of a Time-Linearized Method – M.H.L. Hounjet, National Aerospace Laboratory (NLR) Amsterdam 1059 CM, The Netherlands

Computation of Unsteady Transonic Flows about 2D and 3D AGARD Standard Configurations – J.B. Malone and S.Y. Ruo, Lockheed-Georgia Company, Marietta, GA 30063; and N.L. Sankar, Georgia Institute of Technology, Atlanta, GA

SESSION IV

Chairman: Brian Payne, British Aerospace, Weybridge-Bristol, UK KT13 OSF

A Study of Two-Degree-of-Freedom Transonic Flutter – N. Niedbal and R. Voss, DFVLR/AVA, Göttingen, W. Germany

Unsteady Transonic Aerodynamic and Aeroelastic Calculations about Airfoils and Wings -- D.M. Goorjian, NASA Ames Research Center, Moffett Field, CA 94035; and Guru P. Guruswamy, Informatics-General Corporation, Palo Alto, CA

The Application of Transonic Unsteady Methods for Calculation of Flutter Airloads – H. Zimmerman, MBB-UT, Bremen, W. Germany

Development of Unsteady Transonic 3D Full Potential Code and Its Aeroelastic Applications -- K. Isogai, National Aerospace Laboratory, 1880 Jindaiji-Machi Chofu, Tokyo, Japan

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SESSION V

Round Table Discussion

Chairman: W.J. Mykytow, Weymouth, MA 02189

Members: H. Garner, RAE (Ret.), Farnborough, UK

J.J. Angélini, ONERA, Paris, France

N. Lambourne, RAE (Ret.), Bedford, UK

J. Becker, MBB, Munich, W. Germany

Questions: How is transonic flutter clearance done today in the aircraft industry?

Will the emerging transonic CFD methods change those procedures?

How will transonic flutter clearance be done in 5 years?

How will transonic flutter clearance be done in 10 years?

What are the research needs for the next 5 years?

For further information contact: Dr. James J. Olsen, AFWAL/FIB, Wright-Patterson Air Force Base, OH 45433 - (513) 255-5723.

SHORT COURSES

AUGUST

MACHINERY INSTRUMENTATION AND DIAGNOSTICS

Dates: August 6-10, 1984
Place: Carson City, Nevada
Objective: To assist industry personnel in solving problems associated with machinery vibration programs. Topics include a review of transducers and monitoring systems, application of relative and seismic transducers to various types of rotating machinery, data acquisition and reduction instruments and techniques, and machinery malfunction diagnosis. The seminar includes a lab session with workshops on data acquisition instrumentation, balancing, oil whirl/whip and rubs, and monitor system calibration.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

MACHINERY VIBRATION ANALYSIS

Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Lisle, 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: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MACHINERY VIBRATION ENGINEERING

Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: October 9-12, 1984
Place: Houston, Texas
Dates: November 27-30, 1984
Place: Lisle, 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: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MODAL TESTING

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: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

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

Dates: August 27-31, 1984

Place: Santa Barbara, California

Dates: September 17-21, 1984

Place: Ottawa, Ontario

Dates: October 15-19, 1984

Place: New York, New York

Dates: November 5-9, 1984

Place: San Francisco, California

Dates: February 4-8, 1985

Place: Santa Barbara, California

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.

SEPTEMBER

MACHINERY INSTRUMENTATION

Dates: September 12-14, 1984

Place: Calgary, Alberta, Canada

Objective: To provide an in-depth examination of vibration measurement and machinery information systems as well as an introduction to diagnostic instrumentation. The seminar is designed for mechanical, instrumentation, and operations personnel who require a general knowledge of machinery information systems. It is a recommended prerequisite for the Machinery Instrumentation and Diagnostics Seminar.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

FIELD INSTRUMENTATION AND DIAGNOSTICS

Dates: September 18-21, 1984

Place: Edmonton, Alberta, Canada

Dates: December 3-6, 1984

Place: Houston, Texas

Objective: To provide a balanced introduction to diagnostic instrumentation and its applications for evaluating rotating machinery behavior. The seminar also covers fundamental rotating machinery behavior and some of the more common machinery malfunctions. It includes a lab session with workshops on data acquisition instrumentation, balancing, oil whirl/whip and rubs, and monitor system calibration.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

OCTOBER

ELECTROEXPLOSIVES DEVICES

Dates: October 16-19, 1984

Place: Philadelphia, Pennsylvania

Objective: Topics will include but not be limited to the following: history of explosives and definitions; types of pyrotechnics, explosives and propellants; types of EEDs, explosive trains and systems, fuzes, safe-arm devices; sensitivity and functioning mechanisms; output and applications; safety versus reliability; hazard sources; lightning, static electricity, electromagnetic energy (RF, EMP, light, etc.), heat, flame, impact, vibration, friction, shock, blast, ionizing radiation, hostile environments, human error; precautions, safe practices, standard operating procedures; grounding, shorting, shielding; inspection techniques, system check-out trouble shooting and problem solving; safety devices, packaging and transportation; specifications, documentation, information sources, record keeping; tagging, detection and identification of clandestine explosives; reaction mechanisms, solid state reactions; chemical deactivation, disposal methods and problem, toxic effects; laboratory analytical techniques and instrumentation; surface chemistry.

Contact: E&P Affairs, The Franklin Research Center, 20th and Race Streets, Philadelphia, PA 19103 - (215) 448-1000.

MECHANICAL ENGINEERING (POWER GENERATION)

Dates: October 22-26, 1984
Place: Carson City, Nevada
Objective: Emphasizes the mechanisms behind various machinery malfunctions. Problems associated with rotating equipment used for power generation are highlighted. The seminar is designed for mechanical, maintenance, and machinery engineers who are involved in the design, acceptance testing, and operation of rotating machinery. Other topics include data for identifying problems and suggested methods of correction. The seminar also includes a lab session.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

UNDERWATER ACOUSTICS AND SIGNAL PROCESSING

Dates: October 22-26, 1984
Place: State College, Pennsylvania
Objective: The course is designed to provide a broad, comprehensive introduction to important topics in underwater acoustics and signal processing. The primary goal is to give participants a practical understanding of fundamental concepts, along with an appreciation of current research and development activities. Included among the topics offered in this course are: an introduction to acoustic and sonar concepts, transducers and arrays, and turbulent and cavitation noise; an extensive overview of sound propagation modeling and measurement techniques; a physical description of the environment factors affecting deep and shallow water acoustics; a practical guide to sonar electronics; and a tutorial review of analog and digital signal processing techniques and active echo location developments.

Contact: Alan D. Stuart, Course Chairman, Applied Research Laboratory, The Pennsylvania State University, P.O. Box 30, State College, PA 16801 - (814) 863-4128.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

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

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

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U.S. patents and patent applications may be ordered by patent or patent application number from Commissioner of Patents, Washington, D.C. 20231.

Chinese publications, identified by a CSTA order number, are available in Chinese or English translation from International Information Service, Ltd., P.O. Box 24683, ABD Post Office, Hong Kong.

When ordering, the pertinent order number should always be included, not the DIGEST abstract number.

A List of Periodicals Scanned is published in issues, 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

84-1327

On the Shaft End Torque and the Forced Vibrations of an Asymmetrical Shaft Carrying an Asymmetrical Rotor

H. Ota, K. Mizutani, and Y. Nakatsugawa

Nagoya Univ., Chikusaku, Nagoya 464, Japan, Bull. JSME, 26 (222), pp 2178-2185 (Dec 1983) 8 figs, 10 refs

Key Words: Shafts, Unbalanced mass response

In a rotating asymmetrical shaft with an asymmetrical rotor, the increase rate of total energy and the torque applied to the shaft end change with the angular positions of the static and dynamic unbalances. The response curve also changes with the angular positions of the rotor unbalances. With a rotor mounted on the middle of an asymmetrical shaft, the parallel motion of the rotor is not connected with its conical motion, and the shaft end torque can be directly obtained from the equilibrium of forces and moments. The shaft end torque in an asymmetrical shaft and an asymmetrical rotor changes with the angular positions of rotor unbalances in a similar way to the response curve.

84-1328

Whirl Speeds and Unbalance Response of Multibearing Rotors Using Finite Elements

H.N. Özgüven and Z.L. Özkan

Middle East Technical Univ., Ankara, Turkey, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 72-79 (Jan 1984) 5 figs, 3 tables

Key Words: Rotors, Bearings, Disks, Unbalanced mass response, Whirling, Computer programs

This paper presents dynamic modeling of rotor bearing systems with rigid disks, distributed parameter finite rotor elements and flexible, discrete multibearings. A computer program is developed to calculate the forward and backward whirl speeds, the corresponding mode shapes, the dynamic unbalance response of multibearing rotor systems and to evaluate rotor stability. It utilizes the banded property of the system matrices to reduce the computational effort for the complex eigensolution.

84-1329

Probabilistic Design and Analysis of Foundation Forces for a Class of Unbalanced Rotating Machines

L. Boyce, T.J. Kozik, and E. Parzen

Univ. of Texas at San Antonio, San Antonio, TX 78285, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 90-99 (Jan 1984) 11 figs, 7 refs

Key Words: Rotors, Unbalanced mass response, Eccentricity, Base excitation

Rotors of rotating machinery inherently have mass eccentricities that transfer forces to the bearings, housing, and foundation of the machine. This paper considers, from a probabilistic viewpoint, ways to determine the foundation forces and their probabilities. A rotor-housing system is modeled with three degrees-of-freedom, a translation in the direction of the machine supports, a roll, and a pitch. Equations are presented for the motion of the model and the expression for maximum foundation force is developed.

84-1330

The Vibrational Behavior of a Multi-Shaft, Multi-Bearing System in the Presence of a Propagating Transverse Crack

W.G.R. Davies and I.W. Mayes

Central Electricity Generating Board, Nottingham NG11 OEE, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 146-153 (Jan 1984) 13 figs, 11 refs

Key Words: Shafts, Rotors, Coupled systems, Cracked media, Vibration response

The effects of a transverse crack on the dynamics of a multi-rotor, multi-bearing system are studied experimentally using a spin rig. It is concluded that except for very large cracks, the vibrational behavior is similar to that of a slotted shaft with additional excitation due to the crack opening and closing. The theory that it is possible to calculate the behavior of a cracked and/or slotted rotor for a realistic turbogenerator model for crack depths sufficient to give a measurable vibration vector change is confirmed.

84-1331

A Vibration Source in Refrigerant Compressors

K. Imaichi, N. Ishii, K. Imasu, S. Muramatsu, and M. Fukushima

Osaka Univ., Toyonaka, Osaka 560, Japan, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 122-128 (Jan 1984) 17 figs, 2 tables, 8 refs

Key Words: Shafts, Compressors, Vibration source identification

During a study of vibrations of a single-cylinder refrigerant compressor of the reciprocating type, which arise after the electric power of the motor is switched off, it was observed that higher frequency damped vibrations arose distinctly in the compressor frame vibrations. This paper shows that the higher frequency damped vibrations observed were caused by torsional and transverse elastic vibrations of the crankshaft which had a rotor of larger mass at one end of the comparatively long and slender shaft.

84-1332

Identification of Modal Parameters of an Elastic Rotor with Oil Film Bearings

R. Nordmann

Univ. of Kaiserslautern, Fed. Rep. Germany, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 107-112 (Jan 1984) 15 figs, 5 refs

Key Words: Rotors, Experimental modal analysis, Oil film bearings

Investigations of the dynamic behavior of structures have become increasingly important in the design process of mechanical systems. To have a better understanding of the dynamic behavior of a structure, the knowledge of the modal parameters is very important. This presentation shows improvements of the classical modal analysis for a successful application in rotating machinery with nonconservative effects. An example is given, investigating the modal parameters of an elastic rotor with oil film bearings.

84-1333

Finite Element and Modal Analyses of Rotor-Bearing Systems under Stochastic Loading Conditions

E. Hashish and T.S. Sankar

SPAR Aerospace Ltd., Montreal, Quebec, Canada, J. Vib., Acoust., Stres, Rel. Des., Trans. ASME, 106 (1), pp 80-89 (Jan 1984) 10 figs, 22 refs

Key Words: Rotors, Flexible rotors, Bearings, Stochastic processes, Finite element technique, Modal analysis

A flexible rotor bearing system is represented in detail utilizing the state of the art finite element technique. The mathematical model takes into account the gyroscopic moments, rotary inertia, shear deformation, internal viscous damping, hysteretic damping, linear as well as nonlinear stiffness, and damping for the finite bearing and the bearing support flexibility. Using a simple Timoshenko element and recognizing an analogy between the motion planes, a procedure is given that requires a construction of only three symmetric 4 x 4 matrices. As an application, the different effects of the bearing lining flexibility and the bearing support flexibility on the rotor stability behavior is studied and discussed.

84-1334

Study of Damped Critical Speeds and Damping Ratios of Flexible Rotors

S. Saito and T. Someya

Ishikawajima-Harima Heavy Industries Co., Ltd., 3-1-15, Toyosu, Kotoku, Tokyo, Japan, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 62-71 (Jan 1984) 14 figs, 7 refs

Key Words: Rotors, Flexible rotors, Critical speeds, Damping effects

Influences of bearing damping on critical speeds of flexible rotors are investigated. The damped critical speed and the damping ratio of a uniform shaft supported at both ends are examined. It is shown that there exists an *optimum* bearing damping that gives the maximum damping ratio for each order of critical speed, and that with increasing support stiffness the optimum damping increases but the maximum damping ratio decreases. The meaning of critical speed map is discussed on the basis of the attainable maximum damping ratio. The critical speed characteristics of a uniform shaft supported by three or four bearings are also examined.

84-1335

On the Critical Speed of Continuous Shaft-Disk Systems

H.N. Özgüven

Middle East Technical Univ., Ankara, Turkey, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 59-61 (Jan 1984) 5 figs, 4 refs

Key Words: Rotors, Shafts, Disks, Critical speeds, Error analysis

The critical speed of a shaft-disk system can be approximately determined from a single degree-of-freedom model. The errors in the critical speed predictions obtained from such a model are investigated. The percentage errors are plotted against disk to shaft mass ratio for different bearings and various disk locations.

84-1336

Flutter of Mistuned Turbomachinery Rotors

O.O. Bendiksen
Princeton Univ., Princeton, NJ 08540, J. Engrg. Gas Turbines Power, Trans. ASME, 106 (1), pp 25-33 (Jan 1984) 7 figs, 22 refs

Key Words: Rotors, Turbomachinery, Tuning, Flutter, Perturbation theory

An investigation of the fundamental aspects of flutter in mistuned turbomachinery rotors is presented. Perturbation methods are used to obtain asymptotic solutions to arbitrary order in the mistuning parameter. These solutions require only the knowledge of the eigensolution of the tuned system, and thus provide efficient formulas for calculating the effect of mistuning without solving a new eigenvalue problem. Numerical results are presented.

84-1337

Nonlinear Transient Finite Element Analysis of Rotor-Bearing-Stator Systems

J. Padovan, M. Adams, D. Fertis, I. Zeid, and P. Lam
Univ. of Akron, Akron, OH 44325, Computers Struc., 18 (4), pp 629-639 (1984) 24 figs, 18 refs

Key Words: Rotors, Finite element technique, Transient response

This paper extends the finite element scheme to handle the highly nonlinear interfacial fields generated in the fluid filled annulli of squeeze film and journal bearings so as to model the transient response of rotor-bearing-stator systems. Since such simulations are highly nonlinear, direct numerical integration schemes are employed to generate the overall response. Consideration is given to numerical efficiency/ stability and comparison of implicit and explicit schemes.

84-1338

Free Vibration Analysis of Beams and Shafts by Programmable Calculators

M.T. De Almeida and J.C. Dias
Escola Federal de Engenhaira de Itajuba, 37500-Itajuba, MG-Brazil, J. Sound Vib., 92 (1), pp 39-45 (Jan 8, 1984) 6 figs, 3 tables, 7 refs

Key Words: Beams, Shafts, Vibration analysis

The general problem of free vibration analysis of beams and shafts is presented in such a way that the necessary computations can be carried out by using tables, a programmable calculator, or a microcomputer. This approach is of interest to both the vibration specialist and the design engineer. Illustrative examples are given.

84-1339

A Study of Torsional Vibration Calculation Model and Rig Test Model for Crankshaft System of Automotive Engines

Li Ke Mai
CSICE, 1 (2), pp 57-66 (1983)
CSTA No. 621.43-83.38

Key Words: Crankshafts, Motor vehicle engines, Torsional vibration

The torsional vibration characteristics of an automotive engine shaft system are discussed. After analyzing test results, a torsional vibration calculation model and a rig test model for the crankshaft system of automotive engines are established, and a formula for calculating resonance amplitude is proposed.

84-1340

A Study on Passage through Resonances of a Rotor Supported by Vibration Isolation System with Many Degrees-of-Freedom

K. Matsuura
Mech. Engrg. Res. Lab., Hitachi Ltd., 502 Kandatsu-Machi, Tsuchiura-shi, Ibaraki-Ken, 300 Japan, Bull. JSME, 26 (222), pp 2216-2225 (Dec 1983) 12 figs, 12 refs

Key Words: Rotors, Resonance pass through, Modal analysis

A method for estimating the margins of energy source of a rotor passing through resonances is established for a rotor supported by a vibration isolation system with many degrees-of-freedom and an arbitrary number of unbalances. The equations of motion are introduced as a 7 degrees-of-freedom system consisting of a 6 degrees-of-freedom vibration system and a driving system of rotation. The actual analyses of motions are studied using a simplified system with axial symmetry. The relation between the center-of-gravity system and the center-of-mode system is made clear.

84-1341

Analysis of the Response of a Multi-Rotor-Bearing System Containing a Transverse Crack in a Rotor

I.W. Mayes and W.G.R. Davies

Central Electricity Generating Board, Scientific Services Dept., Nottingham NG11 OEE, UK, J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 106 (1), pp 139-145 (Jan 1984) 8 figs, 1 table, 15 refs

Key Words: Shafts, Rotors, Coupled systems, Cracked media, Flexural vibration

The paper describes work that has been carried out into the flexural vibrational behavior of a rotor mounted on several bearings and containing a transverse crack. A method of solving the equations of motion of a general system is presented. This method utilizes standard rotor dynamics computer programs and enables calculations on large systems to be made on a routine basis. An approximate method of estimating the reduction of a section diameter required to model a crack for use in beam theory based on finite elements is given which is simple to use and gives acceptable results in practice. The application of the methods to some large turbogenerators is described.

84-1342

Aeromechanical Stability of a Hingeless Rotor in Hover and Forward Flight: Analysis and Wind Tunnel Tests

W.T. Yeager, Jr., M-N.H. Hamouda, and W.R. Mantay

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-85683, USAAVRADCOM-TR-83-B-5, 21 pp (Aug 1983)

AD-A134 612

Key Words: Hingeless rotors, Wind tunnel testing

A research effort of analysis and testing has been conducted to investigate the ground resonance phenomenon of a soft in-plane hingeless rotor. Experimental data were obtained using a 9 ft. (2.74 m) diameter model rotor in hover and forward flight. Eight model rotor configurations were investigated. Configuration parameters included pitch-flap coupling, blade sweep and droop, and precone of the blade feathering axis. The paper presents an outline of the analysis, a description of the experimental model and procedures, and comparison of the analytical and experimental data.

84-1343

Vibration Control in Rotating or Translating Elastic Systems

A.G. Ulsoy

Univ. of Michigan, Ann Arbor, MI, ASME Paper No. 83-WA/DSC-9

Key Words: Rotating structures, Vibration control

The reduction of vibration in rotating or translating elastic systems (shafts, circular saws, belts, bandsaws) is an important engineering problem. This paper presents the characteristics of rotating or translating elastic system vibration problems that are significant for the design of active controllers.

84-1344

Lateral Forces on Pump Impellers: A Literature Review

R.D. Flack and P.E. Allaire

Univ. of Virginia, Charlottesville, VA, Shock Vib. Dig., 16 (1), pp 5-14 (Jan 1984) 58 refs

Key Words: Pumps, Impellers, Reviews

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.

84-1345

Substructuring and Wave Propagation: An Efficient Technique for Impeller Dynamic Analysis

R. Henry and G. Ferraris

Laboratoire de Mecanique des Structures, CNRS ERA 911, Institut National des Sciences Appliquees, 69621 Villeurbanne, France, J. Engrg. Gas Turbines

Power, Trans. ASME, 106 (1), pp 2-10 (Jan 1984) 9 figs, 4 tables, 28 refs

Key Words: Impellers, Centrifugal compressors, Compressors, Periodic structures, Mode shapes, Natural frequencies, Substructuring methods

This paper is of particular interest to gas turbine designers because it proposes an efficient method for dynamic analysis of rotationally periodic structures encountered in turbomachines. It combines the advantages of a substructure technique and that of wave propagation in periodic systems. The mode shapes and frequencies are obtained from the analysis of a single repetitive sector of the whole structure. The finite element method is the numerical method used. A detailed application of the method to a centrifugal compressor impeller is reported along with experimental verification of the computed results.

84-1346

Holographic Vibration Measurement of a Rotating Fluttering Fan

P.A. Storey

Rolls-Royce Ltd., Derby, UK, AIAA J., 22 (2), pp 234-241 (Feb 1984) 17 figs, 22 refs

Key Words: Fans, Flutter, Vibration measurement, Holographic techniques

The use of holograhic interferometry to determine the deflection shape of a rotating aero engine fan undergoing unstalled supersonic flutter is described. A mirror-Abbe image rotator was employed in a double pulse holographic system to compensate for the fan's rotational motion and thus maintain correlation between the two resultant holographic images.

84-1347

The Use of Sound Intensity Techniques for Obtaining Sound Power Ratings of Hydraulic Pumps

G.A. Clark and R.F. Ruhnow

International Harvester Co., SAE Paper No. 821116 (SP-523)

Key Words: Pumps, Hydraulic systems, Sound intensity, Measurement techniques

Sound intensity measurements have been proven as a valuable tool in the calculation of sound power. Measurements can be made directly on the vehicle, thus eliminating the need of external power supplies and loading devices. The sound intensity technique is quick, dependable and does not require the use of special acoustical rooms. This paper discusses an example of sound intensity for measurement of hydraulic pump noise. These measurements have been verified using conventional sound power measurements on the same pump.

84-1348

Considerations for Hydrostatic System Noise Control

J.W. Bolinger

Sundstrand Hydro-Transmission, SAE Paper No. 821119 (SP-523)

Key Words: Noise reduction, Pumps, Engines

To control hydrostatic system noise requires knowledge of its characteristics relative to design and operating parameters. Pump and motor noise have been characterized for normal operating ranges of axial-piston, mobile application. Using this data, combined with characteristics of other components, system design and operating parameters can be chosen so that the total response function minimizes the noise potential of each component.

84-1349

2000-hp Motor Support Structure Vibration Sensitivity: Tests, Finite Element Analysis, and Suggested Strategies for Prevention

R.B. Power and D.E. Wood

Union Carbide Corp., South Charleston, WV, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 113-121 (Jan 1984) 5 figs, 4 tables, 22 refs

Key Words: Compressors, Vibration control, Finite element technique

High vibration was detected during startup of three 2000-hp motors driving critical service compressors. A system natural frequency was close to the running speed. Extensive field tests were conducted; rotor dynamics were studied; and a simple finite element model was made to include the rotor, bearing oil film, motor frame, supporting steel structure, and concrete foundation. Results from the finite element model correlated well with field tests in the areas of natural frequencies, mode shapes, frequency shifts caused by changes in test conditions, transfer functions, and sensitivity to rotor unbalance. Design and procurement strategies to prevent or control future similar problems are proposed.

RECIPROCATING MACHINES

84-1350

A Nonlinear Acoustic Model of Inlet and Exhaust Flow in Multicylinder Internal Combustion Engines

M. Chapman, J.M. Noval, and R.A. Stein

Ford Motor Co., Dearborn, MI, ASME Paper No. 83-WA/DSC-14

Key Words: Internal combustion engines, Mathematical models

Presented is a model that bridges the gap between simple Helmholtz resonator models and more complex spatial models used to predict engine air flow. The validity of the model is demonstrated by means of a comparison of the predicted and experimentally determined volumetric efficiency and pressure time history in the inlet manifold of both a motored single-cylinder engine and a production four-cylinder engine.

84-1351

Piston "Stick Slip" Noise Generation Mechanism

J.M. Beardmore

General Motors Corp., G.M. Proving Ground, Milford, MI, SAE Paper No. 820753

Key Words: Diesel engines, Noise generation

An experimental approach was undertaken to investigate a low speed "diesel sounding" knock of an L-4, 1.6 litre, gasoline engine. Specific tests were devised to show the noise source to be associated with piston and ring friction. It was concluded that the noise was caused by a stick-slip action of the piston assembly as the piston reversed direction at the top and bottom of its stroke. Design parameters were optimized to provide a 10 dB(A) (A-weighted sound level) reduction of noise at idle.

POWER TRANSMISSION SYSTEMS

84-1352

Torsional Vibrations in a Mechanical Drive

G.R. Doyle, Jr. and L.L. Faulkner

Battelle Columbus Labs, SAE Paper No. 821029

Key Words: Driveline vibration, Torsional vibration

Torsional vibrations of an engine-powered hydraulic system were analyzed. The system consisted of a diesel engine, spline shaft with clearance, universal joints, propeller shaft, mechanical transmission with clutch engagement, hydraulic pump, and a load. Excessive torsional vibrations resulted in propeller, spline shaft, and U-joint failures. A nonlinear dynamic analysis was performed which included variations in system parameters.

84-1353

Measurement of Driveline Torsional Forces in Four Wheel Drive Agricultural Tractors

S. Jorissen

Steiger Tractor, Inc., Fargo, ND, SAE Paper No. 821094

Key Words: Driveline vibrations, Torsional response, Tractors

A procedure for investigating and analyzing driveline torsional characteristics during development of the Steiger Panther 1000 series four wheel drive tractor is described. This procedure is applicable to vehicle drives designed with transmissions remote mounted from reciprocating engines and driven by a jackshaft. The final design incorporating a torsional dampener was substantiated by dynamic measurements on the actual system.

METAL WORKING AND FORMING

84-1354

New Approaches to the Modal Analysis for Machine Tool Structure

Shinyi Wang, H. Sato, and M. O-Hori

Peking Inst. of Tech., Peking, China, J. Engrg. Indus., Trans. ASME, 106 (1), pp 40-47 (Feb 1984) 15 figs, 3 tables, 10 refs

Key Words: Modal analysis, Machine tools, Impulse testing, Curve fitting

Three new approaches to modal analysis using impulse response were developed to identify the vibration characteristics of machine tool structure. The methods are based on the principle of minimizing the sum of squares of the differences between the measured data and the analytical expression. One of the methods successfully simplified the algorithm of the curve fit procedure and the computation time was significantly economized, so that it could be carried out by a microcomputer with sufficient accuracy for the system having about 30-degrees-of-freedom.

84-1355

Assessments of the Kinetic and Dynamic Loads Sustained by Stationary Tools During High Rate Plastic Forming

J. Tirosh
Technion-Israel Inst. of Tech., Haifa 32000, Israel,
Intl. J. Mech. Sci., 26 (1), pp 73-82 (1984) 6 figs, 11 refs

Key Words: Machine tools

A systematic method for evaluating the kinetic and dynamic loads sustained by stationary tools during high rate plastic forming is examined and exemplified by examples. It is essentially based on the momentum theorem for continua for incompressible flow, utilizing kinematically admissible velocity fields.

84-1356

Investigation of Noise Reduction in Drop Force by Dual Film Hydrostatic Die Support

A. Daadbin, M.M. Sadek, and D.L. Taylor
Birmingham Univ., Birmingham, UK,
ASME Paper No. 83-WA/NCA-5

Key Words: Forging machinery, Noise reduction

Structural ringing has been identified as the major source responsible for the noise emission in forging hammers. To reduce the transmission of impact energy from the die to the anvil while retaining the deformation efficiency, a double pad oil film has been developed. The top oil pad, which replaces the springs used in previous studies, avoids the risk of noise emission from springs. The experimental results of the behavior of oil film for the particular designed conditions are obtained.

STRUCTURAL SYSTEMS

BRIDGES

84-1357

Equivalent Seismic Design of Curved Box Girder Bridges

C.P. Heins and I.C. Lin
Univ. of Maryland, College Park, MD,
Rept. No. NSF/CEE-82202, 179 pp (Feb 1982)
PB84-112697

Key Words: Bridges, Box girders, Seismic design

The seismic response of steel composite curved box girder bridges has been predicted by computing the natural frequency of the bridge and using a response spectrum curve for both translation and rotational accelerations. The natural frequencies have been predicted by simulation of the continuous curved bridge, restrained by equivalent springs. These natural frequencies are then utilized in conjunction with the response spectrum curves to evaluate the equivalent seismic force to be applied to the structure.

BUILDINGS

84-1358

Wind-Simulation Criteria for Wind-Effect Tests

J.E. Cermak
Colorado State Univ., Fort Collins, CO 80523,
ASCE J. Struc. Engrg., 110 (2), pp 328-339 (Feb 1984) 6 figs, 18 refs

Key Words: Buildings, Wind-induced excitation, Wind tunnel testing

Pressures, loads, dynamic responses and adverse pedestrian-level environments caused by wind action on buildings and structures are commonly determined by physical modeling in wind tunnels. Accurate quantitative evaluation of these effects for wind engineering requires that natural wind characteristics be simulated with reasonable fidelity. Features of boundary-layer wind tunnels that meet this requirement are presented and reviewed. Two general criteria are proposed as minimum performance requirements of wind tunnels used to test buildings and structures for wind effects.

84-1359
Charts for Seismic Design of Frame-Wall Systems
A.K. Basu, A.K. Nagpal, and S. Kaul
Indian Inst. of Tech., New Delhi, India, ASCE J. Struc. Engrg., 110 (1), pp 31-46 (Jan 1984) 12 figs, 5 tables, 5 refs

Key Words: Multistory buildings, Buildings, Seismic design

Charts are presented for the seismic design by the response spectrum method of fixed-base multistory buildings consisting of solid shear walls and frames, symmetrically arranged in plan and having constant properties along the height.

84-1360
Deterministic Design Procedures for Earthquake Resisting Ductile Reinforced Concrete Buildings
T. Paulay
J. Bldg. Structure, 4 (4), pp 12-23 (1983)
CSTA No. 624-83.65

Key Words: Buildings, Reinforced concrete, Seismic design

A brief review is given of a deterministic design philosophy with respect to earthquake resisting ductile structures for reinforced concrete buildings. In this approach a preferred hierarchy in the development of energy dissipating mechanisms is postulated. Some applications of capacity design procedures relevant to beams, columns, and shear walls are outlined.

84-1361
Building Acoustics. 1970 - November, 1983 (Citations from the Engineering Index Data Base)
NTIS, Springfield, VA, 174 pp (Nov 1983)
PB84-852615

Key Words: Buildings, Sound waves, Wave transmission, Bibliographies

This bibliography contains 269 citations concerning building acoustics and design innovations. Sound transmission through various composite wall panels; sound transmission classification system for rating building partitions; acoustic value of masonry, wood, and plastic compared and contrasted; and acoustic vibrational damage to structural components of buildings are among the topics included in this bibliography. Acoustic design regulations and codes are examined for public as well as residential buildings.

84-1362
Experimental and Analytical Predictions of the Mechanical Characteristics of a 1/5-Scale Model of a 7-Story R/C Frame-Wall Building Structure
A.E. Aktan, V.V. Bertero, A.A. Chowdhury, and T. Nagashima
Earthquake Engrg. Res. Ctr., Univ. of California, Richmond, CA, Rept. No. UCB/EERC-33/13, NSF/CEE-83017, 140 pp (Aug 1983)
PB84-119213

Key Words: Buildings, Multistory buildings, Dynamic tests, Fundamental frequency, Damping coefficients

This report documents the preliminary series of static and dynamic tests in Japan to measure the flexibility, frequency, and damping characteristics of a frame-wall structure and the associated analytical work conducted at U.C. Berkeley, as part of the U.S.-Japan Cooperative Research Program. The global flexibility, fundamental frequency and damping characteristics of the full-scale structure were simulated successfully. The bare model, prior to applying the auxiliary mass, which could be considered as a distorted model, had flexibility characteristics more than 100 percent different from those of the full-scale structure.

84-1363
Effect of Epicentral Direction on Seismic Response of Asymmetric Buildings
M. DiPaola and G. Muscolino
Istituto di Scienza delle Costruzioni, Facolta di Ingegneria, Universita di Palermo, Viale delle Scienze, 90128 Palermo, Italy, Earthquake Engrg. Struc. Dynam., 12 (1), pp 95-105 (Jan/Feb 1984) 5 figs, 4 tables, 9 refs

Key Words: Buildings, Multistory buildings, Seismic response

The influence of the epicentral direction on the displacement and stress response of multistory asymmetric buildings to earthquake horizontal ground motion is discussed. A method is given for computing for each plane frame of the complex structure a particular direction of the bidirectional stationary random input for which the horizontal floor displacement of the given frame is maximized. It is shown that this direction can be considered conservative for the corresponding nonstationary process.

TOWERS

84-1364

Self-Supporting Towers under Wind Loads

M.B. Ahmad, P.K. Pande, and P. Krishna

Z.H. Engrg. College, Aligarh Muslim Univ., India, ASCE J. Struc. Engrg., 110 (2), pp 370-384 (Feb 1984) 10 figs, 1 table, 23 refs

Key Words: Towers, Reinforced concrete, Wind-induced excitation

Alongwind and acrosswind response of self-supporting reinforced concrete and latticed steel towers is studied analytically as well as experimentally. The analytical approach utilizes existing methods of analysis with certain modifications, while the experimental study is carried out on aeroelastic models placed in uniform as well as shear flow fields generated in a medium size close-circuit wind tunnel. Results obtained are compared with measured prototype data and the comparison is found to be satisfactory.

84-1365

Fatigue in Crane Design

A.J. Karlsen

Det Norske Veritas, SAE Paper No. 821101

Key Words: Cranes (hoists), Off-shore structures, Fatigue life

Fatigue in cranes with particular reference to off-shore cranes is briefly discussed, and field measurement records illustrating types of vibration experienced in crane structures are shown. Design rules against fatigue in recognized crane standards are discussed. A modified procedure for evaluation of fatigue in offshore crane elements is described.

FOUNDATIONS

84-1366

Uncertainties in Dynamic Soil-Structure Interaction

F.S. Wong

Weidlinger Associates, 3000 Sand Hill Rd., 4-155, Menlo Park, CA 94025, ASCE J. Engrg. Mech., 110 (2), pp 308-324 (Feb 1984) 10 figs, 5 tables, 7 refs

Key Words: Interaction: soil-structure

Uncertainties in dynamic soil-structure interaction are divided into two groups: model and parameter uncertainties. Modeling uncertainties are associated with the differences between the real world phenomenon and the model, and parameter uncertainties are uncertainties in the parameters which appear in the model definition. A method to evaluate the effect of parameter uncertainties on the dynamic response of a soil-structure system is described and illustrated.

84-1367

Dynamic Interaction of Inclusion-Soil-Foundation System

D.P. Thambiratnam, T. Balendra, Chan Ghee Koh, and Seng-Lip Lee

National Univ. of Singapore, Kent Ridge, Singapore 0511, ASCE J. Engrg. Mech., 110 (2), pp 252-272 (Feb 1984) 12 figs, 12 refs

Key Words: Interaction: soil-foundation

The effects of an inclusion on the dynamic response of a shear wall foundation system subjected to plane harmonic SH-waves are investigated. The inclusion and foundation are modeled as having circular and semicircular cross sections, respectively. A closed form solution for the inclusion-soil-foundation interaction problem is obtained by the method of wave functions expansion. The image technique is employed to account for the reflection of waves at the ground surface.

84-1368

On the Effective Seismic Input for Non-Linear Soil-Structure Interaction Systems

J. Bielak and P. Christiano

Carnegie-Mellon Univ., Pittsburgh, PA 15213, Earthquake Engrg. Struc. Dynam., 12 (1), pp 107-119 (Jan/Feb 1984) 4 figs, 31 refs

Key Words: Interaction: soil-structure, Seismic excitation

Two equivalent semi-discrete formulations are presented for the problem of the transient response of soil-structure interaction systems to seismic excitation, considering linear behavior of the soil material and arbitrary nonlinear structural properties. One formulation results in a direct method of analysis in which the motion in the structure and the entire soil medium, rendered finite by an artificial absorbing boundary, is determined simultaneously. The other represents a substructuring technique in which the structure and the soil are analyzed separately.

84-1369
Active Control of Machinery Foundation
O. Vilnay
Dept. of Civil and Struc. Engrg., Univ. College, Cardiff, UK, ASCE J. Engrg. Mech., 110 (2), pp 273-281 (Feb 1984) 3 figs, 15 refs

Key Words: Machine foundations, Active vibration control

An open-loop active control mechanism is proposed to restrain the dynamical effect for machinery foundation. The active control mechanism is presented and the foundation reaction considering the active control mechanism is formulated. The design of the active control mechanism to eliminate the dynamical effect at the foundation is reviewed.

84-1370
Dynamic Response of 3-D Rigid Surface Foundations by Time Domain Boundary Element Method
D.L. Karabalis and D.E. Beskos
Ohio State Univ., Columbus, OH 43210, Earthquake Engrg. Struc. Dynam., 12 (1), pp 73-93 (Jan/Feb 1984) 7 figs, 76 refs

Key Words: Foundations, Dynamic response, Seismic excitation, Time domain method

The dynamic response of three-dimensional rigid surface foundations of arbitrary shape is numerically obtained. The foundations are placed on a linear elastic, isotropic and homogeneous half-space representing the soil medium and are subjected to either external dynamic forces or seismic waves of various kinds and directions, with a general transient time variation. The problem is formulated in the time domain by the boundary element method and the response is obtained by a time step-by-step integration. Two examples dealing with three-dimensional rectangular foundations are presented.

84-1371
Pore Pressure in Saturated Silty Sand under Cyclic Loading
Wei Ru Long, et al
China Civil Engrg. J., 16 (1), pp 22-32 (1983)
CSTA No. 624-83.37

Key Words: Sand, Cyclic loading

In order to study the liquefaction behavior of silty sand deposits saturated sand specimens are prepared in lab in the dry volumetric weight of the undisturbed samples and examined under cyclic loading for the cyclic shear resistance, pore pressure, and the residual shear strain developed. Tests are accomplished using a cyclic simple shear test apparatus.

ROADS AND TRACKS

84-1372
An Application of the Transfer Matrix Method to the Calculation of Dynamic Excitation of a Chain of Slabs Subject to Moving Loads (Eine Anwendung des Ubertragungsverfahrens auf die Berechnung der dynamischen Beanspruchung von Plattenketten durch Wanderlasten)
R. Mundl and W. Prochazka
Institut f. Maschinendynamik und Messtechnik, Technische Universitat Wien, Karlsplatz 13, A-1040 Wien, Austria, Z. angew. Math. Mech., 63 (11), pp 531-541 (1983) 6 figs, 12 refs
(In German)

Key Words: Roads (pavements), Moving loads, Transfer matrix method

The objective of this paper is the calculation of dynamic stresses of mainly one-dimensional structures under transient loading by means of the transfer matrix method. The example of a chain of slabs viscoelastically founded, elastically coupled at joints, and subjected to moving loads illustrates the proposed method.

POWER PLANTS

84-1373
Qualification of Active Mechanical Components for Nuclear Power Plants
R.D. Allen and F.J. Mollerus
Mollerus Engrg. Corp., Los Gatos, CA, ASME Paper No. 83-WA/NE-10

Key Words: Power plants (facilities), Nuclear power plants, Seismic response, Qualification test

EPRI has undertaken a study of active safety-related mechanical components in domestic nuclear plants to determine what qualification information exists and to establish a plan for qualification of those components. The overall objective of the study is to recommend appropriate methods and realistic criteria for the environmental, seismic, and dynamic qualification of active mechanical components.

OFF-SHORE STRUCTURES

(See No. 1365)

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 1524, 1525)

84-1374

Recent Developments in Vehicle Interior Noise Reduction

M. Asai and Y. Fujii

Toyota Motor Corp., SAE Paper No. 820963

Key Words: Ground vehicles, Motor vehicles, Interior noise, Noise reduction

In order to reduce the interior noise of a vehicle with a four-cylinder engine, investigations were made using finite element and vector methods, acoustic intensity testing and holography technique. The investigation resulted in inclination of the engine mounting, design changes to the front suspension member, a shock absorber engine mounting, structural modifications to reduce body panel vibration and a new engine mounting to insulate high frequency engine vibration.

84-1375

Damping Composite Sheet for Noise Control

K. Sakai, H. Fujiwara, and M. Sato

Kobe Steel Ltd., Kakogawa, Hyogo, Japan, SAE Paper No. 820752

Key Words: Automobile engines, Motor vehicle noise, Noise reduction, Vibration damping, Steel

To reduce the engine noise caused by a vibration damping composite steel sheet has been developed. This sheet is made of a layer of visco-elastic synthetic resin sandwiched by 2 sheets of steel. This paper describes the manufacturing process and some basic properties of this sheet followed by its applications.

84-1376

Noise Reduction by Engine Encapsulation

H. Danckert and W. Ebbinghaus

Volkswagenwerk, AG, Wolfsburg, W. Germany, SAE Paper No. 820754

Key Words: Motor vehicle noise, Automobile engines, Engine noise, Noise reduction

An engine-jacketing type capsule for a VW engine was built and tested. The entire drive unit, consisting of the engine, clutch, transmission and output shafts, was enclosed in a relative close-fitting sheet steel capsule. The radiator, carburetor, air-filter and muffler system are outside the capsule. A reduction in total vehicle drive-by noise of 7 dB(A) was achieved under ISO-test conditions.

84-1377

Acoustically Conspicuous Truck Trailers. Individual Noise-Generating Problem Areas – Part 1 (Auffällige Nutzfahrzeuganhänger Einzelprobleme ihrer Geräuschentwicklung – Teil 1)

S. Jäkel

Automobiltech. Z., 85 (7/8), pp 441-447 (July/Aug 1983) 7 figs, 8 refs

(In German)

Key Words: Noise generation, Trucks, Trailers, Traffic noise

This study classifies the noise conditions typical of acoustically conspicuous truck trailers in road traffic.

84-1378

Materials for Panel Damping in Motor Vehicles

R. Zimmerli

Interkeller AG, Consultant to Globe Industries, Inc., SAE Paper No. 820793

Key Words: Motor vehicles, Material damping

The application possibilities of materials for panel damping in modern motor vehicle construction are described. The basic parameters which govern damping are given; it is shown how they relate to motor vehicles. Two laboratory test methods are discussed for determining the damping performance of materials typically used in motor vehicles.

84-1379

Transient Dynamic Behaviour of a Vehicle by Mathematical Simulation

P. Beuzit, P. Fontanet, and J. Simon

Regie Nationale des Usines Renault, France, SAE Paper No. 820764

Key Words: Ground vehicles, Ride dynamics, Model analysis

In order to improve stability in riding, a complete linear mathematical model has been developed for a front wheel drive vehicle. All suspension and steering effects are taken into account.

84-1380

Simulation Methods for Evaluating Passenger Car Ride Comfort and the Fatigue Strength of Vehicle Components

A. Zomotor, K. Schwarz, and W. Weiler

Daimler-Benz AG, SAE Paper No. 820095

Key Words: Fatigue life, Ground vehicles, Ride dynamics, Simulation

A road simulation method has been developed to investigate ride comfort and fatigue strength in the laboratory. A short description is given of the road profile generation technique used.

84-1381

Three Wheeled Vehicle Dynamics

J.C. Huston, B.J. Graves, and D.B. Johnson

Iowa State Univ., Ames, IA, SAE Paper No. 820139 (SP-509)

Key Words: Ground vehicles, Dynamic stability

Comparisons are made between a three-wheeled vehicle with two wheels on the front axle, a three-wheeled vehicle with two wheels on the rear axle, and a standard four-wheeled vehicle. Each vehicle's lateral stability, rollover stability during lateral acceleration, rollover stability while braking in a turn, and rollover stability while accelerating in a turn are determined.

84-1382

Crosswind Response and Stability of Car Plus Utility Trailer Combinations

D.H. Weir, R.H. Klein, and J.W. Zellner

Dynamic Research Inc., Manhattan Beach, CA, SAE Paper No. 820137 (SP-509)

Key Words: Trailers, Ground vehicles, Aerodynamic loads

The results of a wind tunnel study and a computer simulation are used to determine the effects of aerodynamics on the lateral-directional stability and crosswind response of passenger car/utility trailer combinations. Single and tandem axle utility trailer configurations, with and without drag reducing add-on aerodynamic fairings, were considered with both sedan and station wagon tow cars.

84-1383

Interactive Computer Graphics for Vehicle Dynamic Analysis

D.L. Taylor

Sibley School of Mechanical and Aerospace Engrg., Cornell Univ., SAE Paper No. 820138 (SP-509)

Key Words: Ground vehicles, Transient response, Graphic methods, Computer graphics

An interactive computer graphics program has been developed to help in vehicle design. The most important aspect is the use of a highly interactive interface between the user and the underlying analytical model. This allows for a closed loop design process and enhanced communication in both directions, both to and from the program. The paper discusses how the program helps the user visualize the many facets of vehicle behavior, how the user can easily change the parameters of the vehicle, and how dynamic transient response is simulated.

84-1384

Optimization of a Light Truck Rough Road Durability Procedure Using Fatigue Analysis Methodology

J.E. Birchmeier and K.V. Smith

Ford Motor Co., Dearborn, MI, SAE Paper No. 820693 (P-109)

Key Words: Fatigue life, Trucks, Pavement roughness

A procedure using fatigue analysis methodology to interpret light truck rough road durability testing in terms of customer usage is described. The resulting correlation can be used in conjunction with optimization methods to provide a rough road durability procedure that insures adequate durability test objectives while decreasing the degree of over-test. The procedure can be adopted to any durability test where the relationship between durability test severity and customer severity can be quantified.

84-1385

Using Simulated Road Surface Inputs for Dynamic Analysis of Heavy Truck Combination Vehicles

P.R. Pierce

R&D Div., Fruehauf Corp., SAE Paper No. 820096

Key Words: Trucks, Articulated vehicles, Pavement roughness

A tractor/trailer combination vehicle is a complex nonlinear structural system exposed in normal road use to a wide range of operating environments. A method of analyzing the dynamic structural behavior of this system using simulated road surfaces as excitation is presented. Techniques for handling the nonlinearities and relating dynamic structural response (deflections and stresses) to road surface inputs are presented.

AIRCRAFT

84-1386

Cabin Noise Weight Penalty Requirements for a High-Speed Propfan-Powered Aircraft -- A Progress Report

J.D. Revell, F.J. Balena, and R.A. Prydz

Lockheed-California Co., SAE Paper No. 821360

Key Words: Aircraft noise, Interior noise

A non-dimensional parameter is developed and data provided to estimate the required mass penalty to achieve satisfactory interior cabin noise levels for advanced propfan powered aircraft. The cabin noise criterion is 80 dBA. Numerical results are given for an advanced narrow-body powered by two 10-bladed propfans, cruising at 0.70 and 0.80 Mach number, designated as the ATX-100.

84-1387

Interior Noise of General Aviation Aircraft

J.F. Wilby

Bolt Beranek and Newman, Inc., Canoga Park, CA, SAE Paper No. 820961

Key Words: Aircraft, Interior noise, Noise reduction

Interior sound levels of general aviation aircraft are reviewed and compared with corresponding levels in commercial aircraft, buses, automobiles and passenger trains. Noise sources are classified into three groups -- propulsion system, external flow and on-board equipment -- and their frequency characteristics are described. These characteristics include both broadband and discrete frequency components.

84-1388

Crash Tests of Three Identical Low-Wing Single-Engine Airplane

C.B. Castle and E. Alfaro-bou

NASA Langley Res. Ctr., Hampton, VA, Rept. No. L-15601, NASA-TP-2190, 39 pp (Sept 1983)

N83-34921

Key Words: Crash research (aircraft), Aircraft, Dynamic tests

Three identical four-place, low-wing single-engine airplane specimens with nominal masses of 1043 kg were crash tested under controlled free flight conditions. The tests were conducted at the same nominal velocity of 25 m/sec along the flight path. Two airplanes were crashed on a concrete surface and one was crashed on soil. The three tests revealed that the specimen in the test on soil sustained massive structural damage in the engine compartment and fire wall. Also, the highest longitudinal cabin floor accelerations occurred in this test.

84-1389

A Computer System for Aircraft Flyover Acoustic Data Acquisition and Analysis

D.W. Boston, E.E. Cashar, D.A. Cope, and B.M. Glover, Jr.

The Boeing Co., Seattle, WA, J. Aircraft, 21 (2), pp 155-158 (Feb 1984) 3 figs, 2 refs

Key Words: Aircraft noise, Noise measurement, Measurement techniques, Computer-aided techniques

A minicomputer-based system housed in a mobile trailer was designed for field measurements of aircraft flyover noise. The system was used to accomplish recent Federal Aviation Regulation Part 36 noise certification testing for the new Boeing Models 757 and 767 aircraft. The multiuser system performed acoustic and telemetered data acquisition, analysis, and data base storage. All data were available to on-line color monitors and on hardcopy. One-third octave band acoustic data were acquired and analyzed via microcomputer-controlled digital frequency analyzers. This computer system increased test efficiency by providing high-quality data to personnel for real-time decision making.

84-1390

Noise Levels and Data Analyses for Small Prop-Driven Aircraft

J.S. Newman, T.L. Bland, and S.A. Daboin

Office of Environment and Energy, Federal Aviation Admn., Washington, DC, Rept. No. FAA-EE-83-1, 191 pp (Aug 1983)
AD-A134 598

Key Words: Aircraft noise, Noise measurement

A noise measurement program was conducted to evaluate proposed revisions of international and US noise certification standards for light-weight propeller-driven aircraft. Tests were conducted using both single- and twin-engine propeller-driven light aircraft. Normally aspirated, turbo-charged, and turboprop engines were included, as were both fixed and variable pitch propellers. Takeoff noise measurements were made for eighteen aircraft. Additional measurments for nine of these aircraft (during level flight) provided sufficient data to examine the relationship of noise level versus helical tip Mach Number and engine power setting. This report presents noise measurements, aircraft position data, meteorological data, and cockpit instrument readings acquired during the test. Data analyses were also included.

84-1391

Deformation and Fatigue of Aircraft Structural Alloys

J.A. Wert, J.C. Chesnutt, and M.R. Mitchell

Rockwell International, Thousand Oaks, CA, Rept. No. AFOSR-TR-83-0745, 106 pp (July 1983)
AD-A133 947

Key Words: Aircraft, Fatigue life

This final report describes results obtained during the course of a two-part basic research program addressing problems of airframe structural materials. Both areas of investigation concentrated on deformation of alpha-Beta titanium alloys. In Part I, superplasticity of two-phase titanium alloys was investigated, with the goal of improving the superplastic forming capabilities through alloy modifications. Part II of this program concentrated on understanding the early stages of fatigue crack initiation and propagation in titanium alloys.

84-1392

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

D.C. Chao and C.E. Lan

Univ. of Kansas, Lawrence, KS, Rept. No. CRINC-FRL-467-1, NASA-CR-172232, 66 pp (Oct 1983)
N83-35997

Key Words: Aircraft wings, Wind-induced excitation, Nuclear explosion effects, Blast loads

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 approximate. The calculated results, showing vortex lag effect, yield reasonable agreement with experimental data for incremental lift on wings in gust penetration and due to nuclear blast waves.

84-1393

Noise Suppressor for Turbo Fan Jet Engines

D.Y. Cheng

NASA Ames Res. Ctr., Moffett Field, CA, Patent No. 4 372 110

Key Words: Jet engines, Turbofan engines, Noise reduction

A noise suppressor is disclosed for installation on the discharge or aft end of a turbo fan engine. Within the suppressor are fixed annular airfoils which are positioned to reduce the relative velocity between the high temperature fast moving jet exhaust and the low temperature slow moving air surrounding it. Within the suppressor nacelle is an exhaust jet nozzle which constrains the shape of the jet exhaust to a substantially uniform elongate shape irrespective of the power setting of the engine.

84-1394

Calculation of Subcritical Natural Frequencies and Damping Rates in a Flutter Investigation (Berechnung subkritischer Eigenfrequenzen und Dämpfungen bei einer Flatteruntersuchung)

H. Wittmeyer

Z. Flugwiss, 7 (5), pp 331-334 (Sept-Oct 1983) 2 tables, 9 refs
(In German)

Key Words: Aircraft, Flutter, Natural frequencies, Damping coefficients

The nonstationary aerodynamic coefficients are assumed given for discrete real values of the reduced frequency Ω. The natural circular frequency at the subcritical velocity V is denoted by ω. The damping rate associated with it is denoted D and the reference chord 2l. The flutter eigenvalue problem for the eigenvalue $\omega(1 + iD)$ is then solved in such a way that the (complex) reduced frequency Ω satisfies the required relationship $\Omega = \omega(1 + iD)l/V$; i.e., the flutter equations are satisfied using the aerodynamic coefficients for damped oscillations. As a comparison, the pk-method of Hassig only satisfies the approximate relationship $\Omega = \omega l/V$.

84-1395
Effect of Blade Structural Parameters on Helicopter Vibrational Characteristics
D.A. Peters
Dept. of Mech. Engrg., Washington Univ., St. Louis, MO, Rept. No. ARO-14585.4-EG, ARO-17067.8-EG, 87 pp (Oct 1983)
AD-A134 547

Key Words: Helicopter vibration, Propeller blades, Blades

This final report covers 6½ years of ARO-sponsored research into the fundamental mechanisms of rotor vibrations. This research effort has spanned several areas of vibration analysis including structural coupling, rotor-body interaction, dynamic stall, and the computational problems associated therewith (especially rotor trim). The main body of this report consists of reprints of some of the papers written during the reporting period.

84-1396
Rotor-Vortex Interaction Noise
R.H. Schlinker and R.K. Amiet
United Technologies Res. Ctr., East Hartford, CT, Rept. No. NASA-CR-3744, 130 pp (Oct 1983)
N84-10912

Key Words: Helicopter noise, Noise prediction, Vortex shedding

A theoretical and experimental study was conducted to develop a validated first principles analysis for predicting noise generated by helicopter main-rotor shed vortices interacting with the tail rotor. The generalized prediction procedure requires a knowledge of the incident vortex velocity field, rotor geometry, and rotor operating conditions. The analysis includes compressibility effects, chordwise and spanwise noncompactness, and treats oblique intersections with the blade planform.

MISSILES AND SPACECRAFT

84-1397
Spacecraft Model Verification Using Swept Sine Data Analysis
J.R. Fowler, W.F. Davis, and E. Dancy
Hughes Aircraft Co., El Segundo, CA, SAE Paper No. 821479 (SP-529)

Key Words: Spacecraft, Experimental data, Swept sine wave excitation, System identification techniques, Overlap processing method

Spacecraft sinusoidal vibration test data is analyzed, using overlap processing, to compute transfer functions and to determine frequencies, damping, and modal amplitudes. Results are compared with results obtained from random vibration test data and show excellent agreement. The overlap processing method, therefore, is acceptable for performing system identification computations from typical swept sine vibration test data. Use of alternative reference point for computation of transfer functions is discussed.

BIOLOGICAL SYSTEMS

HUMAN

84-1398
The Effect of Numbers of Noise Events on People's Reactions to Noise: An Analysis of Existing Survey Data
J.M. Fields
NASA Langley Res. Ctr., Hampton, VA 23665, J.

Acoust. Soc. Amer., 75 (2), pp 447-467 (Feb 1984) 15 figs, 12 tables, 26 refs

Key Words: Noise tolerance, Human response

The effect of the number of noise events on noise annoyance is examined in an analysis of data from large-scale social surveys. Although there are some surveys in which annoyance decreases as numbers of events increase above about 150 a day, the available evidence is not strong enough to reject the conventional assumption that reactions are related to the logarithm of the number of events. The conventional assumption that the effects of number and peak noise level are additive cannot be rejected with these data. It is concluded that significant improvements in the knowledge about the effects of numbers of noise events will only occur if surveys include large numbers of study areas, a requirement which can only be met if economical noise measurement techniques are developed which have known levels of precision.

84-1399

Effects of Traffic Noise on Quality of Sleep: Assessment by EEG, Subjective Report, or Performance the Next Day

R.T. Wilkinson and K.B. Campbell

Medical Res. Council, Applied Psychology Unit, Psychophysiology Section, 5 Shaftesbury Rd., Cambridge, UK CB2 2BW, J. Acoust. Soc. Amer., 75 (2), pp 468-475 (Feb 1984) 1 fig, 1 table, 42 refs

Key Words: Noise tolerance, Human response

Twelve people living in areas of high traffic noise were studied to assess its effect on their sleep. During 3 weeks, their sleep was monitored physiologically in the natural setting of their own bedrooms. Their performance and subjective report of sleep were recorded each day. For the middle week, the bedroom windows were double glazed to reduce the prevailing level of traffic noise at the bedside by an average of 5.8 dB(A). Most physiological measures were unaffected by the noise reduction, but stage 4 sleep and low-frequency, high-amplitude delta waves in the EEG, both thought to be signs of deep sleep, were increased.

84-1400

The Fallacy of Using NII in Analyzing Aircraft Operations

R.G. Melton and I.D. Jacobson

Pennsylvania State Univ., University Park, PA, J. Aircraft, 21 (2), pp 151-154 (Feb 1984) 7 figs, 2 tables, 7 refs

Key Words: Aircraft noise, Human response

Three measures of noise annoyance (noise impact index (NII), level-weighted population, and annoyed population number) are compared regarding their utility in assessing noise reduction schemes for aircraft operations. While NII is intended to measure the average annoyance per person in a community, it is found that the method of averaging can lead to erroneous conclusions, particularly if the population does not have uniform spatial distribution.

84-1401

Critical Issues in Finite Element Modeling of Head Impact

T.B. Khalil and D.C. Viano

Biomedical Science Dept., General Motors Res. Labs., Warren, MI, SAE Paper No. 821150 (P-113)

Key Words: Collision research (automotive), Human response, Head (anatomy), Finite element technique, Shells, Fluid-filled containers, Impact response

Current finite element models of head impact involve a geometrically simplified fluid-filled shell composed of homogeneous, linear and (visco) elastic materials as the primary surrogate of the human skull and brain. The numerical procedure, which solves the mechanical response to impact, requires and presumes continuity of stress and displacement between elements, a defined boundary condition simulating the neck attachment and a known forcing function. The critical review of the models discusses primarily the technical aspects of the approximations made to simulate the head and the limitations of the proposed analytical tools in predicting the response of biological tissue. Many critical features, identified as major factors which compromised the accuracy and objectivity of the models are discussed.

84-1402

Unrestrained, Front Seat, Child Surrogate Trajectories Produced by Hard Braking

R.L. Stalnaker, L.F. Klusmeyer, H.H. Peel, C.D. White, G.R. Smith, and H.J. Mertz

Southwest Res. Inst., San Antonio, TX, SAE Paper No. 821165 (P-113)

Key Words: Collision research (automotive), Human response

This paper describes a study to determine the influence of preimpact vehicle braking on the positions and postures of unrestrained children in the front seat at the time of collision. Anesthetized baboons were used as child surrogates.

84-1403

Predictions of Child Motion During Panic Braking and Impact

I. Kaleps and J.H. Marcus

Air Force Aerospace Medical Res. Lab., SAE Paper No. 821166 (P-113)

Key Words: Collision research (automotive), Human response

To study child motion during vehicle deceleration, 167 simulations were conducted using a large three-dimensional gross body motion model program in which seven initial body positions, 2.5-, 3- and 6-year-old body sizes, three levels of panic braking deceleration, cases of super-imposed crash decelerations and several seat sliding friction coefficients were considered. Predicted head impact times and velocities of impact are given and three-dimensional motion graphics presented for a number of the simulations which illustrate body and vehicle interaction and gross three-dimensional body motion. Also included are comprehensive data sets for body dimensions, inertial properties and initial three-dimensional position descriptions.

84-1404

Interaction of Car Passengers in Frontal, Side and Rear Collisions

E. Faerber

Traffic Safety and Accident Res., Dept. of the Federal Highway Res. Inst., (BASt), Cologne, SAE Paper No. 821167 (P-113)

Key Words: Collision research (automotive), Human response

The aim of this study is systematically to evaluate and quantify the influence of interaction of car passengers in impacts. Within this program 70 car tests were performed. Test cars were of subcompact type. Impacting vehicle was a rigid moving barrier. Each of the 14 configurations was repeated 5 times. The effects of interaction were studied on 50 percent male dummies.

84-1405

Comparison Between Frontal Impact Tests with Cadavers and Dummies in a Simulated True Car Restrained Environment

D. Kallieris, H. Mellander, G. Schmidt, J. Barz, and R. Mattern

Univ. of Heidelberg, W. Germany, SAE Paper No. 821170 (P-113)

Key Words: Collision research (automotive), Human response

A test series of 12 fresh cadavers and 5 Part 572 dummies is reported. The test configuration is frontal impact sled simulation at 30 mph and aims to simulate the restraint environment of a Volvo 240 car. The test occupants are restrained in a 3-point safety belt. Measured values are given and discussed together with the medical findings from the cadaver tests. The occurrence of submarining with cadavers and dummies is reported. A comparison is also made with earlier work where both field accidents and sled simulations of similar violence have been reported.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 1460, 1484, 1485)

84-1406

Experimental Study of Active Vibration Control

W.L. Hallauer

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, Rept. No. AFOSR-TR-83-0855, 11 pp (Apr 15, 1983)

AD-A133 818

Key Words: Active vibration control

Control system hardware, including velocity sensors, force actuators, and analog circuitry, has been designed, fabricated, calibrated, and tested in operation. Active vibration control in the forms of direct-velocity-feedback control and modal-space control has been implemented on a dynamically uncomplicated beam-cable structure, and theoretical simulations of the structure-control dynamics have been completed.

84-1407

Electro-Hydraulic Digital Control of Cone-Roller Toroidal Drive Automatic Power Transmission

H. Tanaka

Yokohama National Univ., Japan, ASME Paper No. 83-WA/DSC-33

Key Words: Active control, Power transmission systems

The paper presents design features of the electrohydraulic interface between microcomputer and cone roller toroidal type CVT, dynamic characteristics of cone roller motion, and test results of the practical computer control of CVT.

84-1408

Controller Implementation for a Pneumatic Active Suspension

G. de los Reyes, L.C. Chen, and J.K. Hedrick

Massachusetts Inst. of Tech., Cambridge, MA, ASME Paper No. 83-WA/DSC-34

Key Words: Active vibration control, Suspension systems (vehicles), Pneumatic isolators, Railroad trains

Analysis, design, and hardware realization of a pneumatic active suspension system are described. The system was designed to improve the lateral ride quality of an intercity passenger rail vehicle.

SPRINGS

84-1409

A Parabolic Spring with a Progressive Characteristic for Commercial Vehicles (Parabelfeder mit progressiver Kennung fur Nutzfahrzeuge)

W. Tautenhahn and P. Otto

Automobiltech. Z., 85 (7/8), pp 457-460 (July/Aug 1983) 6 figs

(In German)

Key Words: Springs, Leaf springs, Suspension systems (vehicles)

This paper describes a new leaf spring developed with a progressive characteristic for real axle suspensions. This spring, which can be used mainly for commercial vehicles between 4 and 10 t GVW, combines the advantages of a parabolic spring having a linear characteristic with those of a traditional rear axle spring having a progressive characteristic. Better comfort and more overload capacity result from the improved spring characteristic (ratio of final to initial spring rate).

TIRES AND WHEELS

84-1410

On the Acoustic/Dynamic Characteristics of the Resilient Wheel (Part 1: Comparison with Other Anti-Noise Wheels in the Running Test)

H. Arai

Railway Technical Research Inst., JNR, Kokubunji, Japan, Bull. JSME, 26 (222), pp 2200-2207 (Dec 1983) 16 figs, 1 table, 5 refs

Key Words: Wheels, Interaction: rail-wheel, Noise reduction

Various types of wheels were tested for the reduction of wheel/rail noise and the characteristics of wheel/rail noise were examined. It was verified that the contribution of noise generated by the vibration of the wheel to the wheel/rail noise (roar) is comparatively small in high speed operation on a straight track. A study is made on the dominant characteristics of a resilient wheel which controls the wheel/rail force.

84-1411

On the Acoustic/Dynamic Characteristics of the Resilient Wheel (Part 2: A Theoretical Analysis on the Radial Dynamic Characteristics)

H. Arai

Railway Technical Res. Inst., JNR, Kokubunji, Japan, Bull. JSME, 26 (222), pp 2208-2215 (Dec 1983) 10 figs, 8 refs

Key Words: Wheels, Interaction: rail-wheel, Noise reduction

To suppress the wheel/rail roar noise effectively by use of a resilient wheel, the detailed dynamic characteristics of the wheel must be clarified. In this paper the resilient wheel is regarded as a ring with T-section supported discretely on a rigid circular cylinder. A method of analysis on its radial dynamic characteristics is proposed and the accuracy of analysis is improved by consideration of shearing deformation and rotatory inertia.

84-1412

Dynamic Behavior of Nonuniform Tire/Wheel Assemblies

T.D. Gillespie

Transportation Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UMTRI-83-8, 57 pp (Nov 1983)
PB84-125541

Key Words: Interaction: tire-wheel

Nonuniformities in the rotating tire and wheel components of a motor vehicle may excite ride vibrations. Both the vehicle and the wheel assembly are dynamic systems that interact via the forces and motions produced. Measurement of the force variations inherent to a nonuniform tire/wheel assembly in a meaningful way therefore requires a basic understanding of the dynamic systems involved. Impedance methods are employed to formulate a dynamic model for a nonuniform tire/wheel assembly and a loading system that can represent either a test machine or a motor vehicle. The models are used to explain the potential error sources that may arise in tire uniformity tests on a machine that has dynamic response in the range of interest.

BLADES

84-1413

Analysis of an Axial Compressor Blade Vibration Based on Wave Reflection Theory

J.A. Owczarek

Lehigh Univ., Bethlehem, PA 18015, J. Engrg. Gas Turbines Power, Trans. ASME, 106 (1), pp 57-64 (Jan 1984) 5 figs, 3 refs

Key Words: Blades, Compressor blades, Flutter, Wave reflection

The paper describes application of the theory of wave reflection in turbomachines to rotor blade vibrations measured in an axial compressor stage. The blade vibrations analyzed could not be explained using various flutter prediction techniques. The wave reflection theory, first advanced in 1966, is expanded, and more general equations for the rotor blade excitation frequencies are derived. The results of the analysis indicate that all examined rotor blade vibrations can be explained by forced excitations caused by reflecting waves (pressure pulses).

84-1414

Transient Blade Response to Surge Induced Structural Loads

M.D. Rudy

Structural Analysis, Teledyne CAE, SAE Paper No. 821438

Key Words: Blades, Surges

Axial compressor blade durability is addressed from the standpoint of a surge induced structural load. The qualitative characteristics of the aerodynamic and structural dynamic phenomena of surge loads and deflections are considered. Pertinent technology from the available literature is surveyed and extended to specific aspects of the problem. Analytical models for predicting load magnitudes and distributions as a function of time are presented along with the corresponding transient structural dynamic model. Results are presented for an isolated airfoil response. Assumptions, limitations, and parametric studies of the various components of the analytical models are discussed and areas of future work identified.

84-1415

Effects of Structural Coupling on Mistuned Cascade Flutter and Response

R.E. Kielb and K.R.V. Kaza

NASA Lewis Res. Ctr., Cleveland, OH 43135, J. Engrg. Gas Turbines Power, Trans. ASME, 106 (1), pp 17-24 (Jan 1984) 15 figs, 22 refs

Key Words: Blades, Cascades, Disks, Flutter, Coupled systems, Tuning

The effects of structural coupling on mistuned cascade flutter and response are analytically investigated using an extended typical section model. Previous work using two degree of freedom per blade typical section models has included only aerodynamic coupling. The present work extends this model to include both structural and aerodynamic coupling between the blades. Results show that the addition of structural coupling can affect both the aeroelastic stability and frequency.

84-1416

Tone Generation by Rotor-Downstream Strut Interaction

R.P. Woodward and J.R. Balombin

NASA Lewis Res. Ctr., Cleveland, OH, J. Aircraft, 21 (2), pp 135-142 (Feb 1984) 15 figs, 13 refs

Key Words: Blades, Struts, Interaction: rotor-stator

A JT15D fan stage was acoustically tested in the NASA Lewis anechoic chamber as part of the joint Lewis/Langley

Research Center investigation of flight simulation techniques and flight effects using the JT15D engine as a common test vehicle. Suspected rotor-downstream support strut interaction was confirmed through the use of simulated support struts, which were tested at three axial rotor-strut spacings. Tests were also performed with the struts removed. Inlet boundary layer suction in conjunction with an inflow control device was also explored.

84-1417

Cascade Flutter Analysis of Cantilevered Blades

A.V. Srinivasan and J.A. Fabunmi

United Technologies Res. Ctr., East Hartford, CT 06108, J. Engrg. Gas Turbines Power, Trans. ASME, 106 (1), pp 34-43 (Jan 1984) 11 figs, 13 refs

Key Words: Blades, Cascades, Flutter

An analysis has been developed to treat the aeroelastic behavior of a cascade of cantilevered blades. The unique features of the formulation include consideration of coupling between bending and torsion in each of the blade modes, coupling among blade modes, spanwise variation of blade mode shapes, mechanical damping in each mode, aerodynamic coupling among all blades of the assembly, and mistuning.

BEARINGS

84-1418

An Adaptive Squeeze-Film Bearing

C.R. Burrows, M.N. Sahinkaya, and O.S. Turkay

Univ. of Strathclyde, Glasgow, UK, J. Tribology, Trans. ASME, 106 (1), pp 145-151 (Jan 1984) 12 figs, 14 refs

Key Words: Bearings, Squeeze film dampers, Squeeze film bearings, Shafts, Helicopters

This paper examines the effect of controlling the oil supply pressure to squeeze-film bearings in applications where these elements are used to provide damping for a light flexible transmission shaft having an arbitrary unbalance mass distribution. The shaft length and diameter selected for the study are typical of those used for helicopter tail rotor transmissions. A computer simulation is undertaken to study the effect of a squeeze-film damper located at the end supports, mid-span with undamped end supports, and mid-span with damped end supports.

GEARS

(See No. 1535)

COUPLINGS

84-1419

Selection of VULKAN Flexible Couplings with Linear and Non-Linear Stiffness Characteristics (Einsatz elastischer VULKAN-Kupplungen mit linearer und progressiver Drehfedercharakteristik)

J. Böhmer

MTZ Motortech. Z., 44 (5), pp 183-186 (May 1983) 7 figs

(In German)

Key Words: Couplings, Flexible couplings, Torsional vibration

Using the linear and nonlinear torsional stiffness characteristics of highly flexible couplings as references, differences in the torsional vibration response of a marine propulsion installation can be detected by calculating the undamped natural frequencies and the corresponding vibratory loads. The highly flexible EZR couplings with their nonlinear stiffness characteristic offer advantages in marine drive systems with fixed-pitch propellers (wide range of operating speeds), whereas the highly flexible RATO couplings with their linear stiffness characteristic offer advantages in variable-pitch propeller installations (constant speed, combinator operation).

84-1420

Theory and Guidelines to Proper Coupling Design for Rotor Dynamics Considerations

R.G. Kirk, R.E. Mondy, and R.C. Murphy

Ingersoll-Rand Co., Phillipsburg, NJ 08865, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 129-138 (Jan 1984) 16 figs, 1 table, 8 refs

Key Words: Couplings, Compressors, Turbomachinery, Pumps

The use of couplings for high-speed turbocompressors or pumps is essential to transmit power from the driver. Typical couplings are either of the lubricated gear or dry diaphragm type design. Recent test stand and field data on continuous lube gear type couplings have forced a closer examination of design tolerances and concepts to avoid operational instabilities. Two types of mechanical instabilities are reviewed in this paper: entrapped fluid and gear mesh instability resulting in spacer throw-out onset. Test and results of these types of instabilities and other directly related problems are presented together with criteria for proper coupling design to avoid these conditions.

FASTENERS

84-1421

Fatigue Behavior of Adhesively Bonded Joints

S. Mall

Univ. of Maine at Orono, Rept. No. NASA-CR-174458, 11 pp (Aug 1983)

N83-36509

Key Words: Joints (junctions), Adhesives, Fatigue life

The fatigue damage mechanism of composite to composite adhesively bonded joints was characterized. The mechanics of the possible modes of fatigue damage propagation in these joints when subjected to constant amplitude cyclic mechanical loading were investigated. The possible failure modes in composite bonded joints may be cyclic debonding, interlaminar damage, adherend fatigue, or a combination of these.

84-1422

Low-Cycle Fatigue of Stiffened Tubular Joints

S. Baba, K. Ninomiya, and T. Kajita

Nagoya Univ., Furo-cho, Chikusa, Nagoya, 464-Japan, ASCE J. Struc. Engrg., 110 (2), pp 301-315 (Feb 1984) 9 figs, 6 tables, 6 refs

Key Words: Joints (junctions), Tubes, Fatigue tests

Low-cycle fatigue tests were conducted for X-type welded tubular joint specimens with three types of stiffeners. The test data are arranged in the form of total plastic work, total strain, and the S-N curve; and the relationship between type of stiffener and scatter of strength is examined in connection with fatigue resistance.

84-1423

Fatigue Considerations in Welded Structure

D.V. Nelson

Stanford Univ., Stanford, CA, SAE Paper No. 820695 (P-109)

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

Primary factors which influence the fatigue behavior of welded structures are described. The status of methods for predicting the life to crack formation in weldments and subsequent life spent in crack propagation are reviewed, and their advantages and current limitations for use in fatigue design evaluations discussed. Manufacturing methods for improving weld fatigue strength are summarized. Future life prediction development needs are suggested.

84-1424

Rotary Flexure Testing of Hydraulic Tube Connections

D.L. Perkins and J.H. Van der Velden

Boeing Commercial Airplane Co., Seattle, WA, SAE Paper No. 821512

Key Words: Joints (junctions), Tubes, Qualification tests, Fatigue life

Flexure testing is used as a qualification test method for hydraulic tube fittings and as a development tool to evaluate the flexure fatigue performance of tube connections. The background of this test is described, and examples of test data for various tube to fitting connections and tube materials presented. The standardization status of this test method is discussed and suggestions for further standardization efforts added.

VALVES

84-1425

Coefficients and Factors Relating to the Aerodynamic Sound Level Generated by Throttling Valves

H.D. Baumann

H.D. Baumann Associates, Ltd., 35 Mirona Rd., Portsmouth, NH 03801, Noise Control Engrg. J., 22 (1), pp 6-11 (Jan/Feb 1984) 6 figs, 13 refs

Key Words: Valves, Noise generation

A method is introduced to estimate throttling valve noise. In this method the generated sound power is expressed as a function of the mechanical power converted in a valve multiplied by a "valve specific" acoustical efficiency factor.

This factor is shown to be dependent on the valve pressure ratio and a characteristic pressure recovery coefficient. A comparison of the proposed method with available test data and current empirical valve noise estimating techniques shows good agreement both in the subsonic and the supersonic flow regime.

84-1426

Dynamic Characteristics of a Single-State Relief Valve with Directional Damping

J. Watton

Univ. College of Cardiff, Wales, ASME Paper No. 83-WA/DSC-40

Key Words: Valves, Damping coefficients

The dynamic characteristics of a stable single-stage pressure relief valve is investigated using both linearization and exact simulation techniques. A special class of nonlinear damping, which depends upon the sign of velocity, is studied, and it is shown that this approach gives a satisfactory compromise for the dynamic response.

84-1427

Dynamic Analysis of Check Valve Performance

M.J. Sundquist and C.N. Papadakis

STS Consultants, Ltd., Ann Arbor, MI, ASME Paper No. 83-WA/FE-18

Key Words: Valves, Fluid-induced excitation

A mathematical model was developed to simulate the dynamic behavior of check valves. The model incorporates a simplified description of the fluid torque on the check valve based on a readily available valve characteristic, the steady-state loss coefficient across the valve.

84-1428

Self-Excited Vibration of Valves Operating at Small Openings

W. D'Netto and D.S. Weaver

McMaster Univ., Hamilton, Ontario, Canada, ASME Paper No. 83-WA/FE-17

Key Words: Valves, Self-excited vibrations

Experiments were conducted on a simple plug valve to examine its stability behavior at small openings. Valve initial opening, restraint stiffness and downstream pipelength (fluid inertia) were varied. Measurements were taken of dynamic pressure across the valve, instantaneous velocity in the downstream pipe, and valve displacement during limit cycle oscillations.

SEALS

84-1429

Hydrodynamic Lubrication in Seals with Cavitation (4th Report, Lubricating Film Between Tilted Flat Faces)

K. Ikeuchi and H. Mori

Kyoto Univ., Kyoto, 606, Japan, Bull. JSME, 26 (222), pp 2265-2271 (Dec 1983) 15 figs, 15 refs

Key Words: Seals, Hydrodynamic lubrication

Axial force and diagonal moment of a radial face seal with tilted flat faces under fixed average film thickness and tilt corresponding to the development of a cavity are calculated. A seal with three degrees of freedom operating under constant axial force and diagonal moment is theoretically analyzed as a practical model of a flexibly mounted mechanical seal, and the angular stiffness is found to be negative.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

84-1430

The Vibration of a Rotating Circular String Subject to a Fixed Elastic Restraint

G.S. Schajer

Weyerhaeuser Co., Tacoma, WA 98477, J. Sound Vib., 92 (1), pp 11-19 (Jan 8, 1984) 5 figs, 12 refs

Key Words: Strings, Rotating structures, Elastic restraints, Natural frequencies

The natural frequencies of a rotating circular string subject to a fixed elastic restraint are calculated. This simple system is important because its dynamic behavior has most of the characteristics of more complex rotating systems. The variation of the natural frequencies with change in rotation speed and spring constant is examined. The results show "avoided crossing," a characteristic of eigenvalue problems where there is coupling between modes.

BARS AND RODS

84-1431

Dynamic Torsion of an Orthotropic Conical Rod

M.R. Sitzer

Institut f. Werkstoffkunde (Lehrstuhl A), RWTH Aachen, Forsch. Ingenieurwesen, 49 (6), pp 178-181 (1983) 1 fig, 3 refs

Key Words: Rods, Torsional vibration

Dynamic torsion of a conical rod with spherical orthotropy is treated. The exact solution for the mixed problem of torsional vibrations of an orthotropic conical rod of finite length is presented. The solution is obtained under the condition that on one face the displacement is specified as an arbitrary function of the angular coordinate and time, while the other face is fixed.

BEAMS

(Also see Nos. 1338, 1482)

84-1432

Direct Shear Failure in Reinforced Concrete Beams under Impulsive Loading

T.J. Ross

Air Force Weapons Lab., Kirtland AFB, NM, Rept. No. AFWL-TR-83-84, 232 pp (Sept 1983)
AD-A133 666

Key Words: Beams, Reinforced concrete, Impulse response

An analytic procedure is developed, using classic elastic Timoshenko beam theory, to define conditions under which reinforced concrete beams and one-way slabs can fail in a direct shear mode when subjected to distributed impulsive loading. The procedure is based on the assumption that incipient failure occurs in direct shear when the beam support shear exceeds a strength threshold before the support bending moment attains its ultimate capacity. The Timoshenko theory is extended to include rotational beam-end restraint and to account for viscoelastic material response to assess qualitatively the influence of rate effects on shear and bending moment.

CYLINDERS

84-1433

Hydroelastic Instabilities of Square Cylinders

A.R. Bokaian and F. Geoola

London Centre for Marine Tech., Dept. of Civil Engrg., Univ. College London, London WC1E 6BT, UK, J. Sound Vib., 92 (1), pp 117-141 (Jan 8, 1984) 15 figs, 2 tables, 28 refs

Key Words: Cylinders, Vortex-induced vibration, Resonant frequencies, Galloping

Experiments were conducted to investigate the vortex resonance and galloping instabilities of a square cylinder, mounted elastically and with oscillations restricted to a plane normal to the incident water flow. The cylinders tested comprised sharp-edged sections and sections with corner radius ratios of 0·164 and 0·318. The still water added mass of a cylinder was found to be independent of the oscillation amplitudes, while the still fluid damping was observed to be viscous for amplitudes up to 30% of the cylinder width.

84-1434

Study on the Coupled Vibration of Square Cylinders in a Liquid (First Report, Comparison of Experimental and Analytical Results)

H. Kasai, M. Kaga, and T. Moriyama

Mech. Engrg. Res. Lab., Hitachi, Ltd., Kandatsu-machi, Tsuchiura-shi, Ibaraki, Bull. JSME, 26 (222), pp 2186-2192 (Dec 1983) 14 figs, 5 refs

Key Words: Cylinders, Coupled response, Tube arrays, Fluid-induced excitation

The vibrational response of square cylinders enclosed in a vessel of liquid and subjected to forced vibrations is analyzed. Inertia force acting on each cylinder and damping effects are clarified by solving Navier-Stokes equation of motion for fluid under the assumption of viscous flow and using the fluid field network theory, in which the non-steady flow in cylinder-to-cylinder clearance is assumed to be two-dimensional.

COLUMNS

84-1435

Short RC Columns under Bilateral Load Histories

K. Maruyama, H. Ramirez, and J.O. Jirsa

Technological Univ. of Nagaoka, Japan, ASCE J. Struc. Engrg., 110 (1), pp 120-137 (Jan 1984) 17 figs, 1 table, 15 refs

Key Words: Columns, Reinforced concrete, Cyclic loading, Dynamic tests, Earthquake resistant structures

An experimental study of the behavior of short columns subjected to different cyclic lateral loading (deformation) histories is described. The influence of loading history on the deterioration of shear strength and stiffness is examined. The results indicate the effect of sequence and magnitude of lateral deformation and axial load on the shear response of short columns.

84-1436

Influence of Reinforcement on RC Short Column Lateral Resistance

K.A. Woodward and J.O. Jirsa

National Bureau of Standards, Gaithersburg, MD, ASCE J. Struc. Engrg., 110 (1), pp 90-104 (Jan 1984) 11 figs, 3 tables, 18 refs

Key Words: Columns, Reinforced concrete, Earthquake response, Seismic response

The effect of varying amounts of transverse and longitudinal reinforcement on behavior of short reinforced concrete columns is studied. The short columns are cyclically deflected along their diagonals to produce bilateral deformations more representative of severe earthquake loadings. Bond degradation is found to be a serious problem in some columns. The rates of degradation of the hysteretic load-deflection loops are strongly influenced by the spacing of the transverse reinforcement. The importance of transverse reinforcement to shear resistance in the form of inclined crack width control is confirmed.

FRAMES AND ARCHES

84-1437

Optimal Design of Friction-Braced Frames under Seismic Loading

M.A. Austin and K.S. Pister

Earthquake Engrg. Res. Ctr., Univ. of California, Richmond, CA, Rept. No. UCB/EERC-83/10, NSF/CEE-83015, 106 pp (June 1983)
PB84-119288

Key Words: Frames, Multistory buildings, Seismic design

This report describes the results of a multi-objective investigation. Several optimal earthquake-resistant designs for a ten-story, single bay, friction-braced steel frame excited by a single scaled ground motion are calculated. The frame's performance is assessed on the basis of its response to three different loadings; gravity loads only, gravity loads plus moderate earthquake and gravity loads combined with a rare severe earthquake ground motion.

PANELS

84-1438

Nonlinear Oscillations of a Fluttering Panel in a Transonic Airstream

F.E. Eastep

Dayton Univ., OH, Rept. No. UDR-TR-83-43, AFOSR-TR-83-0858, 110 pp (Apr 1983)
AD-A133 918

Key Words: Panels, Flutter, Finite element technique

A flutter analysis has been conducted on a simply supported panel to demonstrate the successful combining of the panel (Von Karman) large deflection equations with a linear aerodynamic (Piston) theory for determining the panel response. The panel response was determined by coupling a Galerkin modal representation with a numerical time integration scheme. The time integration scheme was also successfully used to obtain the linear structural (small-deflection) response to a nonlinear aerodynamic pressure.

PLATES

(Also see No. 1507)

84-1439

A Higher Order Dynamic Theory for Viscoelastic Plates and Layered Composites

Y. Mengi and D. Turhan

Dept. of Civil Engrg., Cukurova Univ., Adana, Turkey, J. Sound Vib., 92 (3), pp 311-320 (Feb 8, 1984) 1 fig, 1 table, 9 refs

Key Words: Plates, Viscoelastic properties, Layered materials

By using a new technique approximate theories are developed for the dynamic response of viscoelastic plates and layered composites. The originality of the new technique lies in the fact that it permits the approximate theory to satisfy correctly the lateral boundary conditions of a plate, or the interface (continuity) conditions of a layered composite. This, in turn, enables the approximate theory to describe accurately the geometric dispersion of waves propagating in a plate or layered composite.

84-1440

Magnetoelastic Stability and Vibration of Ferromagnetic Thin Plates in a Transverse Magnetic Field

A. Dalamangas

Dept. of Mechanics, Univ. of Ioannina, Greece, Mech. Res. Comm., 10 (5), pp 279-286 (Sept/Oct 1983) 9 refs

Key Words: Plates, Magnetoelastic vibrations

The stability and vibration of a thin plate (rectangular, circular) of an elastic, soft ferromagnetic material in a transverse magnetic field is examined. For simplification the plate is assumed to be isotropic, it is kept under isothermal condition and the effect of Lorentz forces is neglected, since the equations are linearized and the magnetic field is normal to the median surface of the plate.

84-1441

Real-Time Vibration Control of Rotating Circular Plates by Temperature Control and System Identification

C.D. Mote and A. Rahimi

Univ. of California, Berkeley, CA, ASME Paper No. 83-WA/DSC-35

Key Words: Plates, Circular plates, Rotating structures, Vibration control, Mode modification method, Temperature effects

A system for real-time control of the transverse vibration of a rotating circular plate, based on a thermal stressing technique and dynamic system identification, is presented. In this method the plate natural frequency spectrum is modified through the introduction of thermal membrane stresses.

84-1442

Natural Frequencies of Completely Free Annular and Circular Plates Having Polar Orthotropy

Y. Narita

Hokkaido Inst. of Tech., Sapporo 061-24, Japan, J. Sound Vib., 92 (1), pp 33-38 (Jan 8, 1984) 2 figs, 3 tables, 11 refs

Key Words: Plates, Annular plates, Circular plates, Orthotropism, Natural frequencies

A simple approximate, yet quite accurate, Ritz method analysis is presented for dealing with vibration of completely free annular plates having polar orthotropic characteristics. It is shown that the method is readily applicable to the determination of approximate frequency values for solid circular plates. The natural frequencies of these plates are obtained for the various orthotropic parameters, and comparison is made with exact values for isotropic cases, showing excellent agreement.

SHELLS

(Also see Nos. 1401, 1447)

84-1443

The Axisymmetrical Response of a Circular Cylindrical Double-Shell System with Internal Damping

T. Irie, G. Yamada, and Y. Muramoto

Hokkaido Univ., Sapporo 060 Japan, J. Sound Vib., 92 (1), pp 107-115 (Jan 8, 1984) 5 figs, 1 table, 16 refs

Key Words: Shells, Cylindrical shells, Concentric structures, Internal damping, Time-dependent excitation, Natural frequencies

The axisymmetrical response of a circular cylindrical double-shell system with internal damping to a time-dependent surface load is determined by the matrix analysis method. For this purpose, the equations of vibration of the system based upon the Goldenveizer-Novozhilov theory are written as a coupled set of first order differential equations by the use of the state vector of the system. Once the vector has been determined by quadrature of the equations, the steady state response is calculated numerically together with the natural frequencies in terms of the elements of the transfer matrix of the system under any combination of boundary conditions. By the application of the method, the dynamic response and the resonant frequencies (the natural frequencies) are calculated numerically for a double-shell system simply supported at the edges.

84-1444

Asymmetric Vibrations of Thin Shells of Revolution

T. Kosawada, K. Suzuki, and S. Takahashi

Yamagata Univ., Yonezawa, Japan, Bull. JSME, 26 (222), pp 2165-2171 (Dec 1983) 10 figs, 2 tables, 15 refs

Key Words: Shells, Shells of revolution, Natural frequencies, Axisymmetric vibrations

The asymmetric vibrations of thin barrel-like shells of revolution are analyzed. The equations of vibration and the boundary conditions are determined from the stationary conditions of the Lagrangian of the shells of revolution. The equations of vibration are solved exactly by a series solution and then natural frequencies and mode shapes are obtained. Effects of various parameters upon natural frequencies are clarified in a discussion of numerical results.

84-1445

Numerical Calculation of the Translational Forced Oscillations of a Sloshing Liquid in Axially Symmetric Tanks

U. Schilling and J. Siekmann

Universitat Essen -- Gesamthochschule, Essen, Fed. Rep. Germany, Israel J. Tech., 20 (4/5), pp 201-205 (1982) 3 figs, 4 refs

Key Words: Tanks (containers), Sloshing, Fluid-induced excitation, Translational response

The irrotational motion of a homogeneous, ideal and incompressible liquid due to translational forced excitations of its containment has been investigated. The fluid partially fills a tank with rotational symmetry which is excited harmonically normal to its symmetry axis. The direction of the gravitational field is supposed to be parallel to the axis of the container. Under the assumptions made the potential flow of the liquid is governed by the Laplace equation, the impenetrability condition at the wetted tank wall and the conditions at the free liquid surface. In order to solve the problem under consideration numerically, a panel method has been applied.

RINGS

84-1446

Static and Dynamic Equilibrium of a Vaporous Vortex-Ring (Équilibre statique et dynamique d'un tore de vapeur tourbillonnaire)

P. Genoux and G.L. Chahine

Ingenieur de l'Armement, Direction Recherches, Etudes et Techniques, boulevard Victor, 75015 Paris, France, J. de Mecanique Theor. Appl., 2 (5), pp 829-857 (1983) 8 figs, 33 refs

(In French)

Key Words: Rings, Fluid-induced excitation

In an oscillating submerged jet, cavitation is concentrated in vaporous rotating rings located on the periphery of the jet and convected downstream. The self-induced velocity of the ring is derived and an inviscid and incompressible liquid is considered. The presence of gas inside the torus and of surface tension at the interface are taken into account. The stability of a torus of a circular section is shown. The evolution of the torus shape and its motion, when submitted to a finite duration pressure drop, is considered.

PIPES AND TUBES

(Also see Nos. 1424, 1434)

84-1447

Dynamic Response of Pipelines to Moving Loads

S.K. Datta, T. Chakraborty, and A.H. Shah

Univ. of Colorado, Boulder, CO 80309, Earthquake Engrg. Struc. Dynam., 12 (1), pp 59-72 (Jan/Feb 1984) 16 figs, 5 refs

Key Words: Pipelines, Underground structures, Moving loads, Shells

Vibration of buried pipelines induced by moving axial and radial loads is studied. A thin shell model is used for the pipeline, which is assumed to be lying in an infinite isotropic homogeneous elastic medium. In order to allow for possible motion of the pipe out of phase with the surrounding ground a very thin layer of viscoelastic material is assumed to separate the pipe from the ground. Calculations indicate the presence of the interfacial viscoelastic layer does not influence the pipe response in a significant manner.

84-1448

Pressure Pulsations in Turbo-Pump Piping Systems (1st Report, Experiments on the Natural Frequencies of the Liquid Columns in Centrifugal Pump Piping Systems)

M. Sano

Res. Lab., Ebara Corp., 4720 Fujisawa, Fujisawa City, Bull. JSME, 26 (222), pp 2129-2135 (Dec 1983) 18 figs, 13 refs

Key Words: Piping systems, Pumps, Centrifugal pumps, Natural frequencies

Experiments were made on the natural frequencies of liquid columns in piping systems with tanks at both ends and with a double suction volute pump between the tanks. The natural frequencies of the liquid columns in the pump piping systems depend on the dimensions of the suction and discharge pipes, and the size of the pump. By replacing the pump by an equivalent pipe, the natural frequencies of the liquid columns can be predicted precisely. The natural frequencies of the liquid columns are not affected substantially by the rate of discharge and the rotating speed of the pump.

84-1449

Analysis of Liquid Flow-Induced Motion of a Discrete Solid in a Partially Filled Pipe

B.M. Mahajan

National Bureau of Standards, Washington, DC, J. Res. National Bureau of Standards, 88 (4), pp 261-288 (July-Aug 1983)

PB84-115872

Key Words: Pipes (tubes), Fluid-induced excitation

An analysis is presented for the liquid flow-induced motion of a solid in partially filled pipes. A general equation of the flow-induced motion of a solid is developed. Two alternate force models, one based on free stream velocity and another based on free stream momentum flux, are formulated to simplify the general equation.

84-1450

General Quasi-Static Seismic Analysis of Buried Straight Piping Systems

L.R.L. Wang and A. Olabimtan

Univ. of Oklahoma, Norman, OK, Rept. No. FSEL/NSF-83-01, LEE-006, NSF/CEE-83213, 132 pp (Sept 1983)

PB84-125186

Key Words: Piping systems, Underground structures, Seismic analysis, Computer programs

To assist the seismic analysis and design of buried pipelines in a seismic environment, a comprehensive non-linear quasi-static analysis model was developed. The analysis includes non-linear elasto-plastic behavior of soil and joint springs. A general computer program was devised to accept most influential parameters. This program, capable of handling continuous as well as segmented pipelines, was tested with various physical, geological and seismological parameters.

DUCTS

84-1451

Analysis of Sound Attenuation in a Duct with a Solid or Porous Splitter

M. Namba, T. Notomi, and T. Fujimoto

Kyushu Univ., Hakozaki, Higashi-ku, Fukuoka 812, Japan, J. Sound Vib., 92 (1), pp 47-66 (Jan 8, 1984) 14 figs, 11 refs

Key Words: Ducts, Sound waves, Wave attenuation, Wave propagation

The equivalent singularity method is developed for the analysis of sound propagation in a duct with a thin solid or point-reacting porous splitter of a finite streamwise length. The method consists of representing the splitter by a singular plane of pressure dipoles and mass sources, distributions of which are determined so that the boundary condition at the splitter surfaces is satisfied. The boundary condition is expressed in terms of two admittance parameters giving relations between pressures and normal displacements of fluid particles at the upper and lower surfaces of the splitter. Computed results are presented to illustrate the dependence of the sound power transmitted through the splitter section on the acoustic properties, length and location of the splitter and the flow Mach number.

84-1452

Duct Acoustics – A Numerical Technique for the Higher Order Mode Solution of Three-Dimensional Problems with Rigid Walls and No Flow

A. Cabelli and I.C. Shepherd

Commonwealth Scientific and Industrial Res. Organization, Melbourne, Australia, J. Sound Vib., 92 (3), pp 419-426 (Feb 8, 1984) 4 figs, 10 refs

Key Words: Ducts, Rigid wall ducts, Sound waves, Finite difference technique

A three-dimensional, time dependent, finite difference technique is developed for the steady state solution of the acoustic wave equation in the absence of flow. The acoustic characteristics of a mitred bend are used to illustrate the use of the technique and numerical results are corroborated by experimental data.

84-1453
Power Requirements for Active Noise Control in Ducts
R.D. Ford
Dept. of Applied Acoustics, Univ. of Salford, Salford M5 4WT, UK, J. Sound Vib., 92 (3), pp 411-417 (Feb 8, 1984) 10 refs

Key Words: Ducts, Active attenuation, Wave attenuation, Sound waves

Active attenuation of noise in a duct generally requires either one or two rings of cancelling loudspeakers located around the duct perimeter. Consideration is given to the acoustic loading on the loudspeakers and it is shown that the use of a horn is likely to create more problems than it solves. Direct radiator operation, with the drive units attached directly to the duct walls, is preferable. The single ring (monopole) system reflects the noise giving rise to upstream standing waves, meaning that the loudspeakers and amplifiers must be able to handle correspondingly larger signals. The double ring (dipole) system absorbs the noise and is more efficient than the monopole system.

84-1454
A Finite Element Scheme for Acoustic Transmission through the Walls of Rectangular Ducts: Comparison with Experiment
R.J. Astley and A. Cummings
Univ. of Canterbury, Christchurch, New Zealand, J. Sound Vib., 92 (3), pp 387-409 (Feb 8, 1984) 15 figs, 15 refs

Key Words: Ducts, Rigid wall ducts, Sound waves, Wave transmission, Finite element technique

Previous work on modeling acoustic transmission through the walls of rectangular ducts has left some open questions about structural damping, radiation damping and the way in which the acoustical radiation should be treated. In an attempt to provide answers to these questions a new numerical theory for the problem is described. The results are in good agreement with measurements, both in detailed and in overall descriptions of the transmission phenomena.

BUILDING COMPONENTS

84-1455
Structural Serviceability: Floor Vibrations
B. Ellingwood and A. Tallin
National Bureau of Standards, Washington, DC 20234, ASCE J. Struc. Engrg., 110 (2), pp 401-418 (Feb 1984) 9 figs, 1 table, 35 refs

Key Words: Floors, Vibration control

Floor vibrations arising from normal human activity may affect the serviceability of modern building structures, which are becoming lighter and more flexible. Existing serviceability criteria for floors are reviewed in the light of research dealing with human perception of structural motion. The dynamic response of floors to realistic pedestrian movement excitation models is analyzed. Tentative serviceability criteria to minimize floor vibrations that are objectionable to building occupants are presented.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

84-1456
Response of Geometrically Nonlinear Elastic Structures to Acoustic Excitation - An Engineering Oriented Computational Procedure
G. Maymon
Lockheed International Res. Inst., Lockheed Georgia Co., Marietta, GA 30063, Computers Struc., 18 (4), pp 647-652 (1984) 1 fig, 8 refs

Key Words: Acoustic excitation, Random excitation, Normal modes

The response of a structure to acoustic, random excitation is calculated in a design-oriented computational procedure. The procedure is based on the normal-modes solution approach and introduces the concept of stress modes. This concept permits the use of static loadings to solve the linear dynamic problem, thus the user can use his engineering judgment to predict the points at which maximum stresses and strains will be encountered during the dynamic loading. A static loading approach is also used to include geometrically nonlinear effects in the analysis. A practical application of the procedure is described. This procedure is used now to analyze the response of isotropic and composite skin structures to acoustic noise fields.

84-1457
Sound Attenuation in Forests
F. Fricke

Univ. of Sydney, Sydney, New South Wales 2006, Australia, J. Sound Vib., 92 (1), pp 149-158 (Jan 8, 1984) 7 figs, 2 tables, 16 refs

Key Words: Trees (plants), Noise reduction, Sound waves, Wave attenuation

Many measurements of sound attenuation rates in forests have been made but there is little in common in the measuring procedures used or the results obtained. Consequently there is a considerable divergence of opinion on the effectiveness of vegetation as a noise control measure. In this paper the factors controlling the transmission of sound through vegetation are examined and the attenuation rates achieved in pine plantations are presented.

84-1458

Supersonic Maneuvers without Superbooms

H. Schilling

Rheinmetall GmbH, Ulmenstr. 125, D-4000 Düsseldorf, Fed. Rep. Germany, Israel J. Tech., 20 (4/5), pp 214-219 (1982) 8 figs, 6 refs

Key Words: Sonic boom

This paper deals with a new concept in studying the occurrence and intensities of sonic booms and focused sonic booms. It is based on a paper by Prandtl and uses the functional relations between the emission time of a signal from an airplane and the time an observer receives this signal.

84-1459

The Design of a Quiet, Efficient Industrial Air Jet and a Performance Evaluation Technique

P.M. Wilson

Lucas Industries Noise Centre; Lucas CAV Limited; Warple Way, Acton, London W37SS, UK, Noise Control Engrg. J., 22 (1), pp 25-30 (Jan/Feb 1984) 16 figs, 14 refs

Key Words: Noise reduction, Noise generation, Industrial facilities, Jet noise

Perennial problems for engineers involved with factory noise are the high noise levels produced by air jets used for component ejection, cooling, drying or swarf (metal particles) removal. Although a number of proprietary "quiet" nozzles are available, their acoustical performance is often not related to the efficiency of the jets as air movers. Moreover, there is no test technique available that can be used to compare the performance of different nozzles. The design of a quiet, efficient air jet for these applications is described in this paper in conjunction with the development of a nozzle performance evaluation technique.

84-1460

Acoustic Impedances Obtained Using a Spark and Steady State Tube – A Comparison

J. Mathew and R.J. Alfredson

Monash Univ., Clayton, Victoria, 3168 Australia, Noise Control Engrg. J., 22 (1), pp 12-17 (Jan/Feb 1984) 13 figs, 11 refs

Key Words: Acoustic impedance, Impulse testing

An impulse technique for measuring the acoustic impedance and absorption coefficient of materials is described. It involves the measurement of the input and reflected transient signals created by a spark source in a wave tube. The fourier transforms of the respective signals are used to calculate the transformed impedance. Experiments were conducted to determine the normal impedance and absorption coefficient of A.C.I. Fibreglass (48 kg/m^3 bulk density), Soundfoam and Meracell Foam 080. The samples were 50 mm thick. The results were compared with those obtained using the conventional standing wave tube method. The agreement was good for a frequency range of 0.6 to 10 kHz for the fibreglass specimen. The significant advantage offered by the spark tube method is that impedance and consequently absorption coefficients can be obtained in a fraction of the time required when using the conventional steady state technique.

84-1461

Diffraction Effects in Surface Acoustic Wave Harmonic Generation

F. Palma and G. Socino

Istituto di Acustica "O.M. Corbino," CNR, Via Cassia 1216, 00189 Rome, Italy and Dipartimento di Fisica, Universitá di Perugia, Perugia, Italy, J. Acoust. Soc. Amer., 75 (2), pp 376-381 (Feb 1984) 8 figs, 26 refs

Key Words: Sound waves, Wave diffraction, Fourier analysis

Fourier analysis method has been applied to model the diffraction integral of the second harmonic field nonlinearly generated by a surface acoustic wave beam. Cross-section profiles of the second harmonic field have been calculated at different longitudinal positions along an acoustic beam propagating on a yz-$LiNbO_3$ crystal. Theoretical curves are reported together with experimental results relative to the case of a fundamental wave emitted by a 24-wavelengths-wide transducer at the frequency of 35 MHz. A theoretical determination of the energy loss produced by diffraction effects in second harmonic generation is performed by evaluating the acoustic energy of the second harmonic wave over cross sections of the acoustic beam and by normalizing these quantities to the ones relative to plane wave propagation. Diffraction loss in isotropic and anisotropic materials has been calculated as a function of the longitudinal position along the beam axis for different directivities of the source. A generalized diffraction loss curve is reported, which takes different beam directivities and different anisotropy parameters into account for the case of isotropic media and of anisotropic media with parabolic velocity surfaces.

84-1462

Reflection of Impulses as a Method of Determining Acoustic Impedance

A.J. Cramond and C.G. Don

Chisholm Inst. of Tech., Caulfield East, 3145 Victoria, Australia, J. Acoust. Soc. Amer., 75 (2), pp 382-389 (Feb 1984) 13 figs, 9 refs

Key Words: Sound waves, Acoustic impedance, Acoustic pulses

An impulse technique has been developed which allows investigation of the reflection of acoustic transients at different angles from an impedance boundary. From measurements of the direct and reflected impulses, the complex surface impedance has been calculated from the ratio of the corresponding Fourier components. The surfaces were modeled as a locally reacting boundary between homogeneous media; this representation was found to be adequate for grassland and a carpet layer but unsatisfactory for a thick fiberglass layer. There was no need to include a ground wave term when reconstituting pulse shapes at different angles over grass or carpet for the range of frequencies and angles investigated in this paper.

84-1463

Arctic Ocean Background Noise Caused by Ridging of Sea Ice

R.S. Pritchard

Res. and Tech., Flow Industries, Inc., 21414 68th Ave. South, Kent, WA 98032, J. Acoust. Soc. Amer., 75 (2), pp 419-427 (Feb 1984) 6 figs, 2 tables, 24 refs

Key Words: Sound waves, Wave generation, Underwater sound, Ice

A new method is presented to explain how noise is generated under pack ice by ridging of the pack ice. The energy dissipated during the ridging process is assumed to be the proper measure of the noise source level. Noise source levels generated by ridging are simulated. Noise intensity at a specific site is calculated by summing signals from all these sources after accounting for propagation losses. Calculations are made to compare this simulated noise with observations for an experiment conducted during the winter of 1975-76 in the Beaufort Sea. During a 120-day period, 46% of the intensity of the noise signal is explained using this process, and over several 20-day periods, in excess of 64% is explained. In addition to explaining a significant amount of energy and ambient noise, the model is attractive on physical grounds and properly explains lack of noise when winds are high but ice is strong enough to resist ridging.

84-1464

Acoustic Propagation in a Shallow Sound Channel in the Northeast Pacific Ocean

S.E. Dosso and N.R. Chapman

Defence Res. Establishment Pacific, FMO, Victoria, B.C., Canada V0S 1B0, J. Acoust. Soc. Amer., 75 (2), pp 413-418 (Feb 1984) 10 figs, 10 refs

Key Words: Sound waves, Wave propagation, Underwater sound

An experiment was carried out off the west coast of Canada to investigate the effects of a shallow sound channel on propagation for the frequency range from 20-4000 Hz. Using small explosive charges deployed in the shallow channel, the propagation loss was measured at receivers located in both the shallow and deep sound channels. The shallow channel behaved like an acoustic waveguide with an optimum duct propagation frequency of 800 Hz. At the optimum frequency, the propagation loss closely approached that due to cylindrical spreading, while at frequencies lesser or greater than the optimum the loss increased by up to 20-30 dB. The sound channel propagation was strongly dependent on changes in the environment with range, therefore the parabolic equation was used to model the experimental results. The parabolic equation model correctly predicts the range and frequency-dependent trends observed in the measured data.

84-1465

Low-Frequency Sound Propagation in the South Fiji Basin

R.N. Denham, R.W. Bannister, K.M. Guthrie, and D.G. Browning

Defence Scientific Establishment, Ministry of Defence, Auckland Naval Base Post Office, Auckland, New Zealand, J. Acoust. Soc. Amer., 75 (2), pp 406-412 (Feb 1984) 10 figs, 21 refs

Key Words: Sound waves, Wave propagation, Underwater sound, Low frequencies

A joint experiment was carried out to investigate the characteristics of low-frequency (10-400 Hz) underwater sound propagation in the South Fiji Basin north of New Zealand using explosive sound sources. The source depth was 18 m and as a result propagation nearly everywhere within the basin was dominated by bottom-reflected modes. There were 5-dB level enhancements associated with the bathymetric features forming the southern, western, and eastern boundaries of the basin and 15-20-dB enhancements associated with the slope up to the Fiji Plateau to the north. The propagation loss across the abyssal plains is predicted well, while the level enhancements associated with all the features bounding the basin and the typically 15-dB shadowing losses associated with the ridges east and west of the basin can be approximately predicted with a model (ASTRAL) which allows for horizontal changes in the environment. However, it appears that more sophisticated models may be required to accurately predict the enhancement and shadowing.

84-1466

Underwater Acoustic Modeling Techniques

P.C. Etter

ODSI Defense Systems, Inc., 6110 Executive Blvd., Rockville, MD 20852, Shock Vib. Dig., 16 (1), pp 17-23 (Jan 1984) 71 refs

Key Words: Underwater sound, Mathematical models, Reviews

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.

SHOCK EXCITATION

84-1467

Reliability Analysis of Structures under Seismic Excitation (Part 1: Response Ratio of Structure Having Bi-Linear Spring Behavior)

T. Iwatsubo, T. Sugano, and R. Kawai

Kobe Univ., Rokko, Nada-ku, Kobe, Japan, Bull. JSME, 26 (222), pp 2226-2232 (Dec 1983) 14 figs, 7 refs

Key Words: Seismic response

This paper is the first report in a series of papers which concern the reliability analysis of mechanical component mounted on structures. In this paper, nonstationary random responses are obtained for one and two degrees of freedom systems with bi-linear hysteresis restoration force by using Fokker-Planck equation. The effects of the non-linear spring constant, eigenfrequency of the system, and predominant frequency of the seismic excitation on the response and magnification factor are investigated.

84-1468

Reliability Analysis of Structures under Seismic Excitation (Part II: Reliability by Cumulative Damage Failure Method)

T. Iwatsubo, T. Sugano, T. Nakagawa, and R. Kawai

Kobe Univ., Rokko, Nada-ku, Kobe, Japan, Bull. JSME, 26 (222), pp 2233-2238 (Dec 1983) 11 figs, 6 tables, 4 refs

Key Words: Seismic response, Fatigue life

In this paper the fracture reliability of structures due to cumulative damage fatigue is obtained by combining the seismic response which is obtained in Part I and the experimental data on the low frequency fatigue, in which the variation of material characteristics due to damage is considered. By using the method, the effect of eigenfrequency of the structures, one and two degrees of freedom systems, and magnitude of stress on the probability of cumulative damage fatigue failure are investigated.

84-1469

Reliability Analysis of Structures under Seismic Excitation (Part III: Comparison of Reliabilities Obtained by First Passage Failure Method and Cumulative Damage Failure Method)

T. Iwatsubo, T. Sugano, T. Nakagawa, and R. Kawai

Kobe Univ., Rokko, Nada-ku, Kobe, Japan, Bull.

JSME, 26 (222), pp 2239-2243 (Dec 1983) 5 figs, 1 table, 3 refs

Key Words: Seismic response, Fatigue life

There are two evaluating methods for reliability of structures subjected to seismic excitation, i.e., first passage failure and cumulative damage failure methods. By comparing the two methods, it is known that the first passage failure method evaluates the system as weaker than the other method does. This is due to a difference in the selection of failure reference value (usually static strength of material is taken as the reference value). It is made clear in the present paper that when the static strength and stress velocity are used as a function of the failure reference, the reliability of evaluation is very close to that of the cumulative damage failure.

84-1470

Intensity of Waves in a Randomly Non-Homogeneous Layered Medium

Z. Hryniewicz

Technical Univ. of Koszalin, Koszalin, Poland, Earthquake Engrg. Struc. Dynam., 12 (1), pp 1-8 (Jan/Feb 1984) 5 figs, 7 refs

Key Words: Wave propagation, Shear waves, Layered materials, Soils

The intensity of shear waves in the model of a multilayered stratum, the material properties of which are random functions, is considered. The solutions for displacements and stresses are obtained for one layer and then the formulation is extended to a multilayered stratum through transfer matrices. The solution for a random medium has been compared with the solution for the homogeneous medium. The analysis indicates that the stochastic imhomogeneities are likely to increase the damping in a significant way.

84-1471

Effect of Topography and Subsurface Inhomogeneity on Seismic Rayleigh Waves

A. Ohtsuki, H. Yamahara, and K. Harumi

Fukoku Seimei Bldg., 2-2-2 Uchisaiwai-cho, Chiyoda-ku, Tokyo, Japan, Earthquake Engrg. Struc. Dynam., 12 (1), pp 37-58 (Jan/Feb 1984) 25 figs, 3 tables, 35 refs

Key Words: Seismic waves, Wave propagation

The effect of topography and subsurface inhomogeneity on surface motion is investigated in the case of Rayleigh waves. The same effect has been investigated earlier in the case of SV waves. Several types of topography, such as cliffs both with and without a soft layer at the foot of the slope, are considered. Computations are made using a new hybrid method combining a particle model with a finite element method.

84-1472

Shock Wave Loading on a Two-Dimensional Generic Truck/Shelter Model

G. Bulmash

Technical Support Directorate, Army Armament Res. and Dev. Ctr., Dover, NJ, Rept. No. ARBRL-TR-02517, SBI-AD-F300 320, 114 pp (Aug 1983) AD-A133 683

Key Words: Shock tube testing, Trucks, Protective shelters

The BRL 57.5 cm shock tube was utilized to produce square and decaying waves. Pressure-time data were obtained for the diffraction and drag loading phases on a nonresponding two-dimensional model of a truck/shelter. Records were procured for the model, both with and without boundary conditions, at average input pressures of 34.3, 70.0, and 102.2 kPa. Comparisons with the NASA-AMES two-dimensional computer code are presented.

VIBRATION EXCITATION

84-1473

Random-Choice Solutions for Weak Spherical Shock-Wave Transitions of N-Waves in Air with Vibrational Excitation

H. Honma and I.I. Glass

Inst. for Aerospace Studies, Toronto Univ., Downsview, Ontario, Canada, Rept. No. UTIAS-253, ISSN-0082-5255, 112 pp (July 1983) N84-10502

Key Words: Vibration excitation

In order to clarify the effects of vibrational excitation on shock wave transitions of weak, spherical N-waves, which were generated by using sparks and exploding wires as sources, the compressible Navier-Stokes equations were solved numerically, including a one mode vibrational relaxation equation. A small pressurized air sphere explosion was used to simulate the N-waves generated from the actual sources. By employing the random choice method with an operator-splitting technique, the effects of artificial viscosity appearing in finite difference schemes were eliminated and accurate profiles of the shock transitions were obtained. It was found that, in addition to the vibrational relaxation time of oxygen, both the duration and the attenuation rate of a spherical N-wave are important factors controlling its rise time.

84-1474

Flutter Analysis Using Nonlinear Aerodynamic Forces

T. Ueda and E.H. Dowell
Princeton Univ., Princeton, NJ, J. Aircraft, 21 (2), pp 101-109 (Feb 1984) 9 figs, 1 table, 12 refs

Key Words: Airfoils, Flutter, Aerodynamic loads

The nonlinear effects of transonic aerodynamic forces on the flutter boundary of a typical section airfoil are studied. The flutter speed dependence on amplitude is obtained by utilizing a novel variation of the describing function method which takes into account the first fundamental harmonic of the nonlinear oscillatory motion. By using an aerodynamic describing function, traditional flutter analysis methods may still be used while including the effects of aerodynamic nonlinearities. Results from such a flutter analysis are compared with those of brute force time-marching solutions.

84-1475

Receptance Methods and the Dynamics of Disordered One-Dimensional Lattices

D.J. Mead and S.M. Lee
Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 92 (3), pp 427-445 (Feb 8, 1984) 9 figs, 2 tables, 19 refs

Key Words: Periodic structures, Mobility method, Natural frequencies, Mode shapes

The method of receptance analysis is used to set up a frequency equation for the free vibration modes of a one-dimensional periodic lattice (mass-spring system) containing a disorder which is itself a one-dimensional periodic lattice. The concepts of the propagation constant and wave-receptance function are used to determine the receptances of the component systems, and these are used to set up a simple frequency equation. An accurate root-searching computer program has been used to find the natural frequencies and corresponding modes of particle displacement. Some computed results are shown to demonstrate the capability of the method and program. Special attention is given to modes which occur in the frequency "forbidden" zone, and receptance methods are used to derive formulae for the frequencies of systems with a single-mass disorder. The wider usefulness of the method is briefly discussed.

84-1476

The Vibrational Response of the Rectangular Parallelepiped with Completely Stress-Free Boundaries

E.V.K. Hill
Morton Thiokol/Wasatch Div., P.O. Box 524, M/S 915, Brigham City, UT 84302, J. Acoust. Soc. Amer., 75 (2), pp 442-446 (Feb 1984) 2 figs, 1 table, 10 refs

Key Words: Parallelepiped, Free vibration, Forced vibration

Presented here are exact normal mode solutions for the free and forced vibration of the rectangular parallelepiped (block) with completely stress-free boundaries. Such solutions are meaningful in the field of quantitative nondestructive evaluation where the object is to deduce flaw growth mechanisms from perceived transducer outputs. In order to do this, it is necessary to know the frequency response of the specimen, the transducer, and the specimen-transducer interface, since each of these elements distorts the flaw growth signal. This presentation quantitatively describes the specimen response for the stress-free rectangular parallelepiped with both impulsive and step function inputs, two common forcing functions used to model acoustic emission source mechanisms.

84-1477

Vibrational Analysis of Fluids. 1970 - November, 1983 (Citations from the NTIS Data Base)

NTIS, Springfield, VA, 120 pp (Nov 1983)
PB84-854082

Key Words: Fluids, Fluid-induced excitation, Bibliographies

This bibliography contains citations concerning the vibrational responses of fluids. Fatigue, stress, and the mechanical responses of fluids are considered. Applications in mechanical engineering, hydrodynamics, hydraulics, aerodynamics and nuclear technology are presented. Mathematical modeling to aid computer simulation and analysis of fluid dynamics is discussed. (This updated bibliography contains 127 citations, 32 of which are new entries to the previous edition.)

84-1478

Vibrational Analysis of Fluids. 1970 - November, 1983 (Citations from the Engineering Index Data Base)

NTIS, Springfield, VA, 120 pp (Nov 1983)
PB84-853332

Key Words: Fluids, Fluid-induced excitation, Vibration analysis, Bibliographies

This bibliography contains citations concerning vibrational fatigue, stress, and mechanical responses of fluids through a range of applications. The report discusses general areas of shapes and mechanisms working within and/or in conjunction with fluids. The general information is experimental in nature and could transfer to numerous fields. Specific data and procedures include applications in mechanical engineering, hydrodynamics, hydraulics, and nuclear reactor technology. (This updated bibliography contains 166 citations, 14 of which are new entries to the previous edition.)

84-1479

Determination of the Viscoelastic Shear Modulus Using Forced Torsional Vibrations

E.B. Magrab
National Bureau of Standards, Washington, DC, Rept. No. NBSIR-83-2776, 63 pp (Sept 1983)
PB84-119700

Key Words: Vibration tests, Torsional vibration, Cylinders

A forced torsional vibration system has been developed to measure the shear storage and loss moduli on right circular cylindrical specimens whose diameter can vary to 9 cm and whose length can vary from 2 to 15 cm. The method and apparatus are usable over the frequency range 80 to 550 Hz and a temperature range of −20C to 80C.

84-1480

Quenching of Primary Resonance by a Superharmonic Resonance

A.H. Nayfeh
Yarmouk Univ., Irbid, Jordan, J. Sound Vib., 92 (3), pp 363-377 (Feb 8, 1984) 12 figs, 5 refs

Key Words: Harmonic excitation, Single degree of freedom systems, Frequency response, Multiple scale method

The method of multiple scales is used to determine a uniform second-order expansion for the response of a single-degree-of-freedom system to combined primary and superharmonic excitations. The resulting frequency response equation has the same form as the frequency response equation for the case of primary excitation only, except for an apparent shift in the linear natural frequency of the system. The amplitude of the primary is replaced by an effective amplitude that depends on the amplitudes and relative phases of the two components of the excitation. The expression for the effective amplitude is used to determine the amplitude and phase of a superharmonic excitation of order two or three needed to quench the primary response. The results are verified by numerically integrating the original equation.

84-1481

Combination Tones in the Response of Single Degree of Freedom Systems with Quadratic and Cubic Non-Linearities

A.H. Nayfeh
Yarmouk Univ., Irbid, Jordan, J. Sound Vib., 92 (3), pp 379-386 (Feb 8, 1984) 3 figs, 8 refs

Key Words: Single degree of freedom systems, Combination resonance, Multiple scale method

The method of multiple scales is used to analyze the response of a single-degree-of-freedom system to either the combination resonance of the additive type $\Omega_2 + \Omega_1 \approx \omega_0$ or the combination resonance of the difference type $\Omega_2 - \Omega_1 \approx \omega_0$, where Ω_1 and Ω_2 are the frequencies of the excitation and ω_0 is the linear undamped natural frequency of the system.

MECHANICAL PROPERTIES

DAMPING

84-1482

Vibration Control of Beams by Ball Screw Type Dampers (Case in Which Dampers Possess Viscous Damping)

K. Ohmata
Meiji Univ., 1-1-1 Higashimita, Tamaku, Kawasaki, Kanagawa, Japan, Bull. JSME, 26 (222), pp 2172-2177 (Dec 1983) 8 figs, 3 refs

Key Words: Dampers, Viscous damping, Beams

The effects of vibration isolation of a ball screw type damper applied to a simple beam, a clamped-clamped beam or a cantilever beam are discussed theoretically. Numerical examples are given for a simple beam with one or two ball screw type dampers. It is demonstrated that, when the locations of the dampers are chosen suitably, the first, second and third resonant frequencies can be lowered considerably and the amplitude response factors of the beam at the points of attachment of the dampers are about one except in a narrow range of resonant frequencies.

84-1483

Damping Materials, Finite Elements and Special Projects

M. Ruddell, P.A. Graf, M.F. Kluesener, D.M. Hopkins, and W. Goddard

Res. Inst., Dayton Univ., OH, Rept. No. UDR-TR-82-110, AFWAL-TR-82-4167, 222 pp (Dec 1982) AD-A135 409

Key Words: Material damping, Finite element technique

This report describes work under the subject contract in the area of polymeric and enamel material damping properties measurement, finite element analysis of damped components and some special projects, including state-of-the-art mobility measurement evaluations and development of a unique high temperature, high driving force electro-magnetic transducer.

84-1484

Response of Sliding Rigid Structures to Base Excitation

C.J. Younis and I.G. Tadjbakhsh

Rensselaer Polytechnic Inst., Troy, NY, ASCE J. Engrg. Mech., 110 (3), pp 417-432 (Mar 1984) 10 figs, 13 refs

Key Words: Coulomb friction, Base excitation, Base isolation

The rectilinear motion and the conditions of reattachment and separation of a rigid body, in friction contact with another body are considered. A graphical representation of the motion is indicated, and analytical expressions for the velocities and displacements are derived. The existence of limiting values of velocity and displacement is shown for a special class of periodic ground motions which include harmonic motions. Also, the equations of motion and the conditions of reattachment and separation of a two degrees of freedom model of a sliding structure and foundation are derived. Use of results of the parametric study, concerning amount of slippage, resonance frequency ratios, minimum allowable frequency for sticked mode, etc. in the design for structural base isolation is indicated.

84-1485

Active Damping in Road Vehicle Suspension Systems

D. Karnopp

Univ. of California, Davis, CA 95616, Vehicle Syst. Dynam., 12 (6), pp 291-316 (Dec 1983) 13 figs, 5 refs

Key Words: Damping, Active damping, Suspension systems (vehicles)

Low order, linearized dynamic models of road vehicle suspension systems are analyzed to provide insight into the benefits of suspensions incorporating generalized velocity feedback compared with conventional passive suspensions. Damping forces from passive dampers are supplemented by forces generated by an active element requiring a power supply. A simple criterion is developed which indicates whether or not the introduction of active damping forces will result in significant benefit for pneumatic tired vehicles.

84-1486

Wave Attenuation in Damped Periodic Structures

R. Plunkett and A.K. Roy

Dept. of Aerospace Engrg. and Mechanics, Minnesota Univ., Minneapolis, MN, 32 pp (July 12, 1983) AD-A133 736

Key Words: Periodic structures, Damped structures, Wave attenuation, Tuned dampers

It is known that periodic structures will act as filters for bending waves. The equations for an infinite ribbed bar have been published. The objective of this study is to get extensive quantitative results, both analytical and experimental, for a finite number of tuned ribs and to extend the work to plates and possibly shells. In the process, we intend also to investigate the differences between symmetric (two-sided) and asymmetric (one-sided) cantilever ribs. This first technical report gives analytical and experimental results for the uniform bar (unribbed) and for the same bar with fifteen pairs of tuned cantilevers which approximates the infinite ribbed bar.

84-1487

Vibrational Control of Large Linear Quadratic Symmetric Systems

G.J. Jeon

Houston Univ., TX, Rept. No. NASA-CR-174536, 104 pp (Oct 1983)
N84-10608

Key Words: Vibration damping, Vibration control

Some unique properties on a class of the second order lambda matrices were found and applied to determine a damping matrix of the decoupled subsystem in such a way that the damped system would have preassigned eigenvalues without disturbing the stiffness matrix. The resulting system was realized as a time invariant velocity only feedback control system with desired poles. Another approach using optimal control theory was also applied to the decoupled system in such a way that the mode spillover problem could be eliminated. The procedures were tested successfully by numerical examples.

FATIGUE

(Also see Nos. 1468, 1469)

84-1488

Fatigue Service Histories: Techniques for Data Collection and History Reconstruction

A. Conle and T.H. Topper

Ford Motor Co., SAE Paper No. 820093

Key Words: Fatigue life, Data presentation, Experimental data

A number of service fatigue history summarization statistics are examined for their suitability in regenerating the history in the laboratory. Evaluation criteria applied include: fatigue damage-per-level equivalence, implementation simplicity, waveform similarity, and fatigue life equivalence.

84-1489

Fatigue Considerations in Use of Aluminum Alloys

M.R. Mitchell, M.E. Meyer, and N.Q. Nguyen

Rockwell International Science Ctr., Thousand Oaks, CA, SAE Paper No. 820699 (P-109)

Key Words: Fatigue life, Alloys, Aluminum

The objective of this research was to predict the fatigue life of a member at 10 percentile levels for SAE-1045 (260HB) steel and 7075-T73 aluminum in aqueous and saline environments. Consideration of environmental effects as rate dependent phenomena promoted the usage of controlled strain rate testing on axial loaded, smooth specimens of each material. It was determined primarily that long-life fatigue resistance is more affected by aqueous and saline environments, and that a simple modification of the fatigue strength exponent adequately described strain-life behavior.

84-1490

A Servomechanical-Fatigue-Test Machine

L.J. Ceschini

Creep and Fatigue Lab., Westinghouse R&D Ctr., Pittsburgh, PA, Explt. Tech., 8 (2), pp 34-37 (Feb 1984) 6 figs

Key Words: Fatigue tests, Test equipment and instrumentation, Servomechanisms

It is shown that a servomechanical machine can execute complex fatigue oriented test programs. The machine performed with a high degree of accuracy and was stable in both the load and displacement control modes.

84-1491

A Discussion of Methods for Estimating Fatigue Life

N.E. Dowling

Westinghouse R&D Ctr., Pittsburgh, PA, SAE Paper No. 820691 (P-109)

Key Words: Fatigue life

Various methods for estimating fatigue life for machine or structural components are compared and discussed. Guidelines are offered to aid in choosing methods or combinations of methods for particular situations, such as different stages of design. The methods discussed include those based on local strain, nominal stress, component test data, and fracture mechanics.

84-1492

Theoretical Fatigue Life Prediction Using the Cumulative Damage Approach

E.B. Loverich

Northern Arizona Univ., Flagstaff, AZ, SAE Paper No. 820692 (P-109)

Key Words: Fatigue life, Crack propagation

A method is presented for conservatively estimating a total fatigue life through a prediction of crack initiation life using the cumulative damage approach. The procedure is based upon the use of Neuber's Rule, a cyclic stress-strain function, and a histogram of nominal *linearly elastic equivalent strain.* This provides for actual cyclic stress-strain definition and crack initiation life prediction at a particular point on a cyclically loaded body. Linear finite element stress analysis plays a major role in the solution. An outline for computer-aided implementation and a case history are included.

84-1493

Fatigue Considerations for FRP Composites

D.A. Riegner and J.C. Hsu

General Motors Corp., Warren, MI, SAE Paper No. 820698 (P-109)

Key Words: Fatigue life, Composite structures, Fiber composites

An introduction to the fatigue properties of Fiber Reinforced Plastic (FRP) composites is given. The implications of these properties in the design of composite structures are stressed. Topics covered include: an overview of FRP composites, a definition of fatigue and fatigue testing, a comparison of typical metal and FRP fatigue mechanisms, and a discussion of the major fatigue design considerations for FRP composites. Finally, a system's view is presented to illustrate the interdependence of material, design, and processing considerations in fatigue of FRP composites.

84-1494

Advanced Concepts of the Process

P.G. Feld and D.E. Johnson

Metal Improvement Co., SAE Paper No. 821455 (SP-528)

Key Words: Fatigue life, Impact excitation

New methods of measuring and controlling coverage and, in special situations, intensities, have been developed and are gaining recognition by concerned users of shot peening. For coverage control a fluorescent material accurately reflects degree of coverage attained. Techniques for the peening of very small holes to achieve a uniform beneficial compressive stress is shown as well as a method of measuring intensity in holes too small to be checked by conventional Almen strips. Shot peen precondition of autofrettage for improved fatigue life are combined to show significantly increased fatigue life in parts treated solely by either of these two processes alone.

84-1495

Fatigue Life Estimation by Portable Data Acquisition and Damage Analysis Microcomputer System

R.A. Schaefer

Ford Motor Co., SAE Paper No. 820780

Key Words: Fatigue life, Measuring instruments, Data processing

A portable microcomputer system with the capability of acquiring strain data and estimating fatigue life to crack initiation has been developed. This briefcase sized equipment performs rainflow cycle counting of the input strain signal and a cumulative damage analysis which fully accounts for both plastic and elastic region effects and includes the effects of a strain concentration factor using Neuber's rule. The system also provides a range of fatigue life estimates to suggest the sensitivity of the analysis to uncertainties in material properties.

84-1496

Computation of Influence of Defects on Static and Fatigue Strength of Composites

R.C. Tennyson, J.S. Hansen, G.R. Heppler, G. Mabson, and G. Wharram

Inst. for Aerospace Studies, Toronto Univ., Downsview, Ontario, Canada, Characterization, Analysis and Significance of Defects in Composite Materials, Conf. Proc., Lond, pp 14-1 - 14-17 (Apr 1983) (AD-A134 058)

AD-P001 921

Key Words: Fatigue life, Composite materials, Beams, Sandwich structures

A combined analytical and experimental investigation has been undertaken to determine the effects of flaws on the static strength and fatigue life of graphite/epoxy (AS1/3501-6) laminates. Both bond-line defects in sandwich beam construction and interlaminar disbond flaws were studied.

84-1497

Entropy Production During Fatigue as a Criterion for Failure. The Critical Entropy Threshold: A Mathematical Model for Fatigue

P.W. Whaley

College of Engrg. and Tech., Nebraska Univ., Lincoln, NB, 106 pp (Aug 15, 1983)
AD-A134 767

Key Words: Fatigue life, Mathematical models

A mathematical model of fatigue crack nucleation is described using the irreversible thermodynamics to quantify the damage caused by plastic straining. The model is based on the hypothesis that the entropy gain which results from dynamic irreversible plastic straining is a material constant. A random model of internal friction is used to calculate the irreversible part of the hysteresis energy dissipation rate, enabling the quantification of uncertainty through the variance of the dynamic plastic strain.

84-1498

Effect of Overstress on the Fatigue Behavior of a Heat-Treated 0.54% C Steel under the Stress of Fatigue Limit

H. Nisitani and M. Goto
Kyushu Univ., Hakozaki, Higashi-ku, Fukuoka, 812, Bull. JSME, 26 (222), pp 2033-2038 (Dec 1983) 11 figs, 5 tables, 5 refs

Key Words: Fatigue life, Steel

The effect of definite cycles of overstress which was applied periodically during the repetitions of the stress of fatigue limit was investigated through the behavior of a micro-crack.

84-1499

Growth of Delaminations under Fatigue Loading

R. Prinz
Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt e.V., Brunswick, Fed. Rep. Germany, Characterization, Analysis and Significance of Defects in Composite Materials, Conf. Proc., London, pp 12-14 (Apr 1983)
AD-P001 912

Key Words: Fatigue life, Layered materials

In order to determine the nature of failure mechanisms a number of fatigue tests were performed. The test specimens partly have artificial delaminations between different layers of the multidirectional laminates.

ELASTICITY AND PLASTICITY

84-1500

Methods of Elastodynamics of Mechanical, Structural and Industrial Robotic Systems Using Finite Line Elements

C. Bagci
Tennessee Technological Univ., Cookeville, TN, ASME Paper No. 83-WA/DSC-7

Key Words: Elastodynamic response, Finite element technique, Mechanisms

Using 2- and 3-D finite line elements coupled with the matrix exponential method, width mode uncoupling, and incremental forcing methods, techniques for the elastodynamic study of 2- and 3-D mechanical systems, mechanisms, structural systems, and industrial robots subjected to nonlinear forcing and damping are developed.

WAVE PROPAGATION

(See No. 1470)

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see No. 1354)

84-1501

MSA – Mechanical Signature Analysis

S. Braun
Technion-Israel Inst. of Tech., Haifa, Israel, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 1-3 (Jan 1984) 3 figs, 1 table, 2 refs

Key Words: Signature analysis, Monitoring techniques

Various aspects of Mechanical Signature Analysis (MSA) are presented, including a classification and application scheme. Described are general principles, common to applications of different character. These include data reduction, processing techniques, as well as the identification of some major existing problems.

84-1502

Some Error Bounds and Numerical Experiments in Modal Methods for Dynamics of Systems

I. Gladwell and P.M. Hanson
Univ. of Manchester, Manchester M13 9PL, UK,
Earthquake Engrg. Struc. Dynam., 12 (1), pp 9-36 (Jan/Feb 1984) 14 figs, 4 tables, 10 refs

Key Words: Modal analysis, Error analysis, Viscous damping

Some error expressions for approximate modal solutions of viscously damped linear structural vibration equations are presented. These approximations are calculated by a variety of modal techniques. Motivated by numerical experience, the equivalence of some different modal solutions in the presence of classical damping are shown.

84-1503

Interactive Design Using Eigenvalue Modification, a Comparison of Experimental and Theoretical Modal Analysis

V.W. Snyder, G.L. Meeuwsen, and W.R. Shapton
Michigan Technological University, SAE Paper No. 820191

Key Words: Modal analysis, Experimental modal analysis, Local eigenvalue modification procedure

This paper examines the feasibility of using eigenvalue modification as the effective algorithm for interactive modal analysis. The dynamic characteristics of a cantilever beam are determined experimentally and compared to the results of an analytical study. The model is then modified with the addition of mass and stiffness. The results predicted using eigenvalue modification theory on the analytical model compare very favorably with experimentally determined results.

84-1504

Multi-Channel Modal Testing

J.C. Deel and D.J. Durham
Zonic Corp., Milford, OH, SAE Paper No. 820192

Key Words: Modal analysis, Experimental modal analysis, Test equipment and instrumentation, Measuring instruments, Fast Fourier transform

The rapidly expanding use of modal analysis techniques creates a need for testing systems which can make the required measurements more efficiently and more accurately than in the past. This paper discusses the design criteria and architecture for a multi-channel FFT processor, and shows how processing up to sixteen parallel input signals can reduce measurement time by an order of magnitude. An example is given which shows the practical value of this increased efficiency.

84-1505

Dual Input Estimation of Frequency Response Functions for Automotive Structures

R.J. Allemang, R.W. Rost, and D.L. Brown
Univ. of Cincinnati, Cincinnati, OH, SAE Paper No. 820193

Key Words: Experimental modal analysis, Frequency response function, Multipoint excitation technique, Motor vehicles

The accurate measurement of the frequency response function is vital to the estimation of the system modal parameters. The use of the single input/output theory to formulate the equations for the frequency response function can be replaced by an equivalent theory involving multiple inputs. The results of this approach provide frequency response functions that are comparable to the single input/output case but with a reduction in the time required per measurement and an increase in the consistency of modal frequency and damping values estimated from different frequency response functions. Examples are included for representative automotive structures.

84-1506

Modal Decomposition Method for Stationary Response of Non-Classically Damped Systems

T. Igusa, A. Der Kiureghian, and J.L. Sackman
Univ. of California, Berkeley, CA, Earthquake Engrg. Struc. Dynam., 12 (1), pp 121-136 (Jan/Feb 1984) 5 figs, 23 refs

Key Words: Damped systems, Component mode analysis

The stationary response of multi-degree-of-freedom non-classically damped linear systems subjected to stationary input excitation is studied. A modal decomposition procedure based on the complex eigenvectors and eigenvalues of the system is used to derive general expressions for the spectral moments of response. These expressions are in terms of cross-modal spectral moments and explicitly account for the correlation between modal responses; thus,

they are applicable to structures characterized with significant non-classical damping as well as structures with closely spaced frequencies. Closed form solutions are presented for the important case of response to white-noise input. Various quantities of response of general engineering interest can be obtained in terms of these spectral moments. These include mean zero-crossing rate and mean, variance and distribution of peak response over a specified duration. Examples point out several instances where non-classical damping effects become significant and illustrate the marked improvement of the results of this study over conventional analysis based on classical damping approximations.

84-1507

Detection of a Misaligned Disk Coupling Using Spectrum Analysis

D.L. Dewell and L.D. Mitchell

Allied Corp., Chesterfield, VA, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 9-16 (Jan 1984) 10 figs, 15 refs

Key Words: Spectrum analysis, Couplings, Disks, Alignment

This paper contains the development of the expected vibration frequencies for a misaligned metallic-disk flexible coupling based on the analysis of the structural vibrations produced by misalignment. Further, experimental results obtained through real-time spectrum analysis showing that all the theoretically predicted vibration frequencies are produced by a misaligned metallic-disk flexible coupling, but the 2x and 4x running speed components show the largest changes as misalignment increases.

84-1508

A Comparison of Traditional Fourier and Maximum Entropy Spectral Methods for Vibration Analysis

T.M. Romberg, A.G. Cassar, and R.W. Harris

CSIRO Div. of Mineral Physics, Lucas Heights Res. Labs., Sutherland, NSW, Australia, J. Vib., Acoust., Stress Rel. Des., Trans. ASME, 106 (1), pp 36-39 (Jan 1984) 9 figs, 8 refs

Key Words: Spectrum analysis, Discrete Fourier transform

The structural vibrations monitored on a process plant often contain burst phenomena where several discrete frequencies are present. Spectral analysis of these vibration signals by Fourier transform methods is generally considered incapable of resolving discrete frequencies close together in a short time slice. The power spectral density estimates computed by traditional Fourier transform methods are compared with those computed by more recent maximum entropy spectral analysis methods for both data from a test system where the outputs of two tuned filters, excited by pseudo-random binary noise, are summed, and the vibration signals from an accelerometer mounted on a die in an extrusion process.

84-1509

A Multi-Input Modal Estimation Algorithm for Mini-Computers

H. Vold, J. Kundrat, G.T. Rocklin, and R. Russell

Structural Dynamics Res. Corp., SAE Paper No. 820194

Key Words: Experimental modal analysis, Parameter identification technique, Frequency response function

This paper describes a modal parameter estimation algorithm that uses frequency response functions relative to several exciter locations in a simultaneous manner. Phase information between the exciter locations is used to separate close or multiple roots, and consistent estimates are given for modal parameters and eigenvectors. An experimental investigation of a structure with repeated roots is described. In the single exciter location case, this method reduces to the least squares complex exponential technique.

84-1510

A Filter Technique for Parameter Identification

H.I. Weber and W.O. Schiehlen

Institut B für Mechanik, Universität Stuttgart, Fed. Rep. Germany, Mech. Res. Comm., 10 (5), pp 259-265 (Sept/Oct 1983) 3 figs, 4 refs

Key Words: Parameter identification technique

This paper presents a method using second moments of the response processes as well as the responses of linear filters added to the system's measurement devices. A complete identification of mechanical systems including gyroscopic and nonconservative stiffness forces is obtained without any measurement of the excitation processes. The presented method has been checked intensively by simulation and it will be applied in rotational dynamics of large hydraulic power stations subject to stochastic excitations by turbulent flow.

84-1511

System Identification Using Sinusoidal Test Data

K.D. Blakely and M.W. Dobbs

ANCO Engineers, Inc., Culver City, CA, SAE Paper No. 821460 (SP-529)

Key Words: System identification techniques, Periodic excitation, Experimental data, Shakers

System identification -- the refinement of an analytical model to match test data -- is presented as it pertains to dynamic testing via sinusoidal shakers. Each phase of the system identification process is illustrated: pretest model formulation, sinusoidal testing, eigen-parameter identification, and post-test model refinement. Examples are shown from full-scale sinusoidal tests on actual structures.

84-1512

Identification of the Frequency Spectrum Signal Modeling

A. Rahimi and C.D. Mote, Jr.

Shugart Corp., Sunnyvale, CA, ASME Paper No. 83-WA/DSC-36

Key Words: Parameter identification technique, Power spectra

A signal-modeling method for estimating the power spectrum of a signal is proposed. A prediction model of the observed time series is "fit" to the data by least squares estimation and the spectrum is estimated from the model coefficients.

84-1513

A Comparison of Fourier and Parametric Methods for Structural System Identification

P. Davies and J.K. Hammond

Inst. of Sound and Vib. Res., Univ. of Southampton, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 40-48 (Jan 1984) 11 figs, 4 tables, 22 refs

Key Words: System identification techniques, Parameter identification technique, Fourier analysis

The aim of the paper is to compare Fourier methods and three parametric methods as techniques for the analysis of data acquired from a vibrating structure. The parametric methods include the prony series, recursive least squares, and instrumental variable analysis. The methods are used to analyze simulated data as well as acceleration and force measurements obtained from a simple vibrating structure. The paper highlights the advantages and disadvantages of each method and shows that in certain circumstances the parametric methods provide useful alternatives to standard Fourier methods. The effect of noise on signal measurements for each method is also addressed, along with the problem of model order selection for the parametric approaches.

84-1514

Substructure Synthesis and Its Iterative Improvement for Large Nonconservative Vibratory Systems

A.L. Hale

Univ. of Illinois at Urbana-Champaign, Urbana, IL, AIAA J., 22 (2), pp 265-272 (Feb 1984) 2 figs, 3 tables, 21 refs

Key Words: Substructuring methods, Structural synthesis

A general synthesis method is developed for the dynamic analysis of nonconservative vibratory systems composed of substructures. The idea of the synthesis is to represent each substructure by a reduced-order model and to couple the substructure models together to act as the whole system. For general nonconservative systems, a state space formulation is adopted for each substructure. Reduced-order substructure models are obtained by approximating each state vector as a linear combination of a small number of real trial vectors. The accuracy with which the synthesized model represents the whole system depends on the choices of trial vectors and the number of vectors used. A procedure is developed for increasing the accuracy by iteratively generating improved substructure trial state vectors.

84-1515

The Reduction of Bias Error in Transfer Function Estimates Using FFT-Based Analyzers

P. Cawley

Imperial College of Science and Tech., London, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 29-35 (Jan 1984) 9 figs, 5 refs

Key Words: Fast Fourier transform, Frequency response function, Error analysis

The susceptibility to bias error of two methods for computing transfer (frequency response) functions from spectra produced by FFT-based analyzers using random excitation has been investigated. Results from tests with an FFT analyzer on a single degree-of-freedom system set upon an analog computer show good agreement with the theoretical predictions.

84-1516

Portable Dynamic Pressure Generator for Static and Dynamic Calibration of in Situ Pressure Transducers

P.A. Bolt, R.W. Hess, and W.T. Davis

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-85687, 15 pp (Aug 1983)

N84-10538

Key Words: Transducers, Calibrating

A portable dynamic pressure generator was developed to meet the requirements of determining the dynamic sensitivities of in situ pressure transducers at low frequencies.

84-1517

Transducer for Measuring the Internal Forces in the Columns of a Frame-Wall Reinforced Concrete Structure

R. Sause and V.V. Bertero

Earthquake Engrg. Res. Ctr., California Univ., Richmond, CA, Rept. No. UCB/EERC-83/05, 112 pp (May 1983)

PB84-119494

Key Words: Transducers, Internal forces, Columns, Multistory buildings, Reinforced concrete

An internal force transducer capable of accurately measuring the internal forces of the first-story columns of a 1/5 scale model of a seven-story frame-wall reinforced concrete structure has been designed, developed, and applied in this structure under static and dynamic loading conditions.

84-1518

New Transducers for High-Resolution Ultrasonic Testing

J.P. Weight

The City Univ., London EC1V OHB, UK, NDT Intl., 17 (1), pp 3-8 (Feb 1984) 8 figs, 13 refs

Key Words: Transducers, Nondestructive tests, Ultrasonic techniques

High resolution NDT requires ultrasonic transducers which can produce very short pulses with well-defined constant shape through the field. The theory, construction and applications of such transducers are discussed.

84-1519

An Economical System for the Determination of Acoustic Machine Characteristics (Kostengünstiges System zur Ermittlung von akustischen Maschinenkenngrössen)

P. Grund and R. Humpert

Rechnerunterstutzte Gerätemesstechnick, VDI-Berichte No. 468, pp 47-50 (1983) 7 figs

(In German)

Key Words: Measuring instruments, Noise measurement

An inexpensive multipurpose measurement and analysis system for highly fluctuating acoustic measurement tasks is described. It consists of a receiver (a manual sound pressure level meter, structure-borne noise receiver), a transformer, and a conventional desk-top calculator. The design of the transformer and its mode of operation are explained. Several examples for the application of the measurement system, using current computer programs, are presented.

84-1520

Techniques and Instrumentation for the Measurement of Transient Sound Energy Flux

P.S. Watkins and F.J. Fahy

Institute of Sound and Vibration Research, The University, Southampton S09 5NH, England, ISVR Tech. Rept. No. 122 (Dec 1983)

Key Words: Sound intensity, Measurement techniques, Measuring instruments, Two microphone technique, Time domain method, Frequency domain method

The purpose of this work is to extend the already well established two-microphone technique of sound intensity measurement to encompass applications on transient noise sources.

84-1521

Multichannel Structural Inverse Filtering

R.E. Powell and W. Seering

Cambridge Collaborative, Inc., Cambridge, MA, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 22-28 (Jan 1984) 15 figs, 11 refs

Key Words: Machinery components, Frequency response function, Frequency filters

A technique has been implemented for predicting the multiple input force time histories acting on a machinery component through the use of multiple vibration measurements and a stored matrix of mechanical frequency response functions. A least squares pseudo-inverse of this transfer matrix is computed in the frequency domain using the singular value decomposition. This decomposition is used to condition the pseudo-inverse against potential singularities caused by uncertainties in the data. The constructed inverse filter is capable of separating multiple input force signals even when the vibration signals contain reverberated information from the inputs in overlapping frequency ranges. The technique has been successfully applied to a flat plate system with two inputs and up to four vibration measurements. Guidelines are suggested for reducing the effects of measurement inaccuracies on the force predictions.

84-1522

Application of Back-Back Accelerometers to Precision Vibration Measurements

B.F. Payne

National Bureau of Standards, Washington, DC, J. Res. National Bureau of Standards, 88 (3), pp 171-174 (May/June 1983)

Key Words: Accelerometers, Calibrating, Vibration measurement, Measuring instruments

Precision vibration measurements depend on accurate and repeatable calibration methods. Standardization of calibration test equipment and measurement techniques ensures more accurate and repeatable measurements. The use of the back-to-back accelerometer as a laboratory standard has become widespread. However, this use has been somewhat limited because of inadequate calibration methods. Recent developments in improved calibration methods have given the back-to-back accelerometer a greater potential as an accurate, repeatable, and stable vibration standard. As a vibration standard, the back-to-back accelerometer should prove to be a valuable asset for laboratories involved in vibration measurements and vibration transducer calibrations. By adapting existing techniques of laser interferometric calibration to the special geometry of the back-to-back accelerometer, improved accuracy (over existing methods) can be obtained over the range of 2 - 15,000 Hz and extension to 20,000 Hz is a good possibility. Recent work at NBS in this area is presented along with a description of a sample back-to-back transducer calibration.

84-1523

Measuring Sound Intensity

G. Rasmussen

Bruel & Kjaer, Denmark, SAE Paper No. 820962

Key Words: Sound intensity, Measuring instruments

The development of techniques and new tools for the direct measurement of the flow of acoustic energy offer new ways for determination of source location, source ranking, energy flow path and absorption measurements. Optimum microphone probe configurations for different applications, digital processing and data presentation will be discussed. The use of true real time data processing in collection of energy flow data in mechanical structures is suggested as a new tool for the mechanical design engineer.

DYNAMIC TESTS

84-1524

Replication of Revenue Track Input Using a Vibration Test Unit for Freight Car Structure and Lading Damage Evaluation

B.R. Rajkumar, F.D. Irani, and C.L. Orth

Assn. of American Railroads, Transportation Test Ctr., Pueblo, CO 81001, J. Engrg. Indus., Trans. ASME, 106 (1), pp 1-10 (Feb 1984) 32 figs, 4 refs

Key Words: Vibration tests, Test facilities, Railroad cars, Freight cars

The vibration test unit of the Rail Dynamics Laboratory at Pueblo, Colorado, can be used for vibration testing of railroad vehicles with revenue track input. Until recently, the usual source of track geometry input consisted of Plasser car digital tape recordings of track displacements as a function of distance along the track. A second track geometry input was developed based on the locomotive track hazard dector concept, which produced displacement history data obtained by processing the time histories of special axle-mounted accelerometers. Tests were conducted at the Transportation Test Center, Pueblo, Colorado, to validate a suitable form of input to the vibration test unit which closely duplicates the actual revenue track input.

84-1525

Roll Dynamics Unit (RDU) Truck Hunting Demonstration

S.K. Punwani and A.V. Arslan

Assn. of American Railroads, Chicago, IL 60616, J. Engrg. Indus., Trans. ASME, 106 (1), pp 11-15 (Feb 1984) 12 figs, 1 table, 14 refs

Key Words: Vibration tests, Test facilities, Testing techniques, Railroad cars, Freight cars

The paper describes a test program conducted in order to demonstrate the capabilities of a Roll Dynamics Unit built at the Transportation Test Center, Pueblo, Colorado. A detailed description of the test program, the RDU and Test Track results, and correlation with a 25 deg-of-freedom analytical truck hunting model is provided. The stability characteristics of conventional 89-ft (27.1-m) lateral flat car, which was borrowed from TOFC service and was equipped with convention three-piece freight car trucks, were defined. During the test the car was equipped with two different sets of wheel profiles, one of which was service-worn. It clearly demonstrated the usefulness of the Roll Dynamics Unit for lateral dynamics testing.

84-1526

Developing a Small Sample Facility for Testing Automotive Acoustical Materials at Low Frequencies

P. Saha and C.W. Davis

Chemical Engrg. Dept., C.F. Braun & Co., Alhambra, CA, SAE Paper No. 820755

Key Words: Test facilities, Noise reduction, Ground vehicles

This paper discusses the development of a small sample test facility for properly evaluating the low frequency noise control performances of various automotive acoustical materials.

84-1527

A Method for Recognizing Structural Nonlinearities in Steady-State Harmonic Testing

J. Kirshenboim and D.J. Ewins

Imperial College of Science and Tech., London, UK, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 49-52 (Jan 1984) 11 figs

Key Words: Dynamic tests, Harmonic excitation, Nonlinear systems

A method for recognizing the extent of the nonlinearity of data acquired by the steady-state harmonic excitation methods is developed. The level of the nonlinearity is defined by a single parameter -- the J factor -- in the range 1-0 (1 for perfect linearity). An example of the application of the J factor is given.

84-1528

Nondestructive Testing: Acoustic Emission Techniques and Equipment. May, 1982 - November, 1983 (Citations from the Metals Abstracts Data Base)

NTIS, Springfield, VA, 57 pp (Nov 1983)

PB84-853498

Key Words: Nondestructive tests, Testing techniques, Test equipment and instrumentation, Bibliographies

This bibliography contains citations concerning acoustic emission techniques and equipment for the nondestructive inspection and evaluation of a wide variety on non-nuclear materials, objects, and structures. Ultrasonic techniques are excluded. (This updated bibliography contains 71 citations, all of which are new entries to the previous edition.)

84-1529

Nondestructive Testing: Acoustic Emission Techniques and Equipment. 1966 - April, 1982 (Citations from the Metals Abstracts Data Base)

NTIS, Springfield, VA, 192 pp (Nov 1983)

PB84-853480

Key Words: Nondestructive tests, Acoustic emission, Bibliographies

This bibliography contains citations concerning acoustic emission techniques and equipment for the nondestructive inspection and evaluation of a wide variety on non-nuclear materials, objects, and structures. Ultrasonic techniques are excluded. (This updated bibliography contains 337 citations, none of which are new entries to the previous edition.)

84-1530

Background for Impulse Testing of Hydraulic Medium and High Pressure Components

J.H. Van der Velden

Boeing Commercial Airplane Co., Seattle, WA, SAE Paper No. 821511

Key Words: Hydraulic systems, Impulse testing, Qualification tests

Hydraulic impulse testing is used for development and qualification testing and for development of hydraulic system components, in particular for standard and standard-like items such as hose and fitting assemblies. Testing for aerospace applications requires pressure peaking above the nominal operating pressure. Background and details of the test method are described to support a proposal for acceptance of this test as an international (ISO) standard.

84-1531

A Random Vibration Control System for Testing a Single Test Item with Multiple Inputs

D.O. Smallwood

Sandia National Labs., SAE Paper No. 821482 (SP-529)

Key Words: Test equipment and instrumentation, Shakers

This paper describes a multiple shaker control system developed at Sandia National Laboratories for driving a single test item with random excitation. The system allows for cross-coupled mechanical systems with partially coherent control points. The system uses time-domain randomization to generate the continuous Gaussian drive signals.

84-1532

Use of Digital Signal Processing, Modal Testing, and Finite Element Techniques in Equipment Qualification and Acceptance Testing

J.B. Steedman and A. Edelstein

National Technical Systems, Structural Dynamics Lab., SAE Paper No. 821477 (SP-529)

Key Words: Instrumentation response, Seismic response, Hydrodynamic response, Experimental modal analysis, Finite element technique

A systematic procedure in which digital signal processing, modal testing and finite element techniques can be used in equipment qualification and acceptance testing is presented. A new method was also developed, in which measured transmissibility functions and Fourier transformation techniques were combined to compute instrument response spectra.

84-1533

Pulse Excitation Techniques

F.B. Safford

Agbabian Associates, El Segundo, CA, SAE Paper No. 821459 (SP-529)

Key Words: Pulse excitation, Testing techniques

A series of rectangular or other simple pulses can be convolved with the impulse functions of a structure to induce motions closely approximating those caused by natural and manmade events. Control of the excitation; portability to the site; ease of attachment to the structure; multiaxial excitation; low cost of excitation equipment; and the ability to excite structures from simple harmonic motion to expected multifrequency response-time histories are possible by the development of pulse techniques. Recent investigations have also disclosed the utility of pulse techniques to oppose structural motions as in earthquakes or in large antenna arrays in space.

84-1534

Experimental Error Propagation in Pseudodynamic Testing

P.B. Shing and S.A. Mahin

Earthquake Engrg. Res. Ctr., Univ. of California, Richmond, CA, Rept. No. UCB/EERC-83/12, NSF/CEE-83016, 187 pp (June 1983)

PB84-119270

Key Words: Seismic response, Testing techniques, Error analysis

The pseudodynamic method is a relatively new experimental technique which can simulate quasi-statically the seismic response of large scale structural models using a computer-controlled actuator system and a numerical integration algorithm. Because of the large number of integration steps involved in a single test, the cumulative errors can be significant even though the actual experimental feedback errors within each step are relatively small. This study looks into the possible sources and the characteristics of experimental feedback errors in pseudodynamic testing, and presents a general analytical technique to study the error-propagation behavior of step-by-step integration algorithms.

DIAGNOSTICS

(Also see Nos. 1330, 1341)

84-1535

Design of a High-Level Diagnostic System

R.H. Lyon and R.G. DeJong

Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 17-21 (Jan 1984) 10 figs, 13 refs

Key Words: Diagnostic instrumentation, Gears

The use of vibration signals produced by the operation of a machine to control its operations and detect developing faults is appealing because of the ruggedness of vibration sensors and their ease of placement. A diagnostic system that employs a few sensors, remotely located from a number of vibration generating mechanisms, to analyze the performance of these mechanisms is termed a "high-level" diagnostic system. The goal of such a diagnostic system is to infer from the remote vibration sensors the characteristics of the internal sources (such as forces and pressures) which could not be easily measured directly. The use of multiple sensors and advanced signal processing methods is necessary for such a system to be viable. A series of studies on vibration excitation, propagation, sensing, and signal processing that demonstrate the basic feasibility of such a diagnostic system are described. The design of a high-level diagnostic system for detecting the combustion and gear mesh excitations in a diesel engine analysis is presented, along with the results of a preliminary application of the system.

84-1536

A Sound Method of Testing

Compressed Air, pp 14-17 (Sept 1983) 5 figs

Key Words: Diagnostic techniques, Acoustic emission, Failure detection

Various uses of acoustic emission devices are described. Among such applications are steam trap monitoring and tube truck testing.

84-1537

Noise and Vibration Measurements of 50 kW Vertical Axis Wind Turbine Gear Box

G. Krishnappa

Engine Lab., National Res. Council, Ottawa, Ontario, Canada K1A OR6, Noise Control Engrg. J., 22 (1), pp 18-24 (Jan/Feb 1984) 11 figs, 6 refs

Key Words: Diagnostic techniques, Gear boxes, Wind turbines

An analysis of noise and vibration measurements was carried out for the gear box and the power house panels of the 50 kW Vertical Axis Wind Turbine operating at Christopher Point on Vancouver Island, B.C. The spectra of noise and vibration signals show strong peaks at the gear mesh frequency and its harmonics even under light load conditions. The sound power radiated from the power house panels is significantly higher than that radiated by the gear box casing. The analysis also indicates misalignment of the pinion shaft or eccentricity of the pinion and errors in the gear tooth profiles.

84-1538

Diagnostic Systems for Agricultural Equipment

P. Wright

Central Electronics Group, Massey-Ferguson Industries Ltd., SAE Paper No. 820924 (P-111)

Key Words: Diagnostic instrumentation, Agricultural machinery

Several factors (changing operator skills, changing legislation, and changing technology among others) are creating the need for improved vehicle diagnostic systems. There are many difficulties in designing good diagnostic systems that incorporate the optimum compromise between effectiveness in locating a fault, and test hardware overhead. Before such a compromise can be arrived at, it is necessary to move away from the add-on approach to diagnostic hardware, and treat failure detection, isolation, and repair as a total system that pulls together vehicle, dealer, and factory capabilities.

84-1539

Acoustic Emission Techniques for Locating Internal Leakage of Redundant Components

H. Wichmann and D. Phillips

The Marquardt Co., Van Nuys, CA, J. Spacecraft Rockets, 21 (1), pp 36-40 (Jan/Feb 1984) 10 figs, 2 tables, 2 refs

Key Words: Acoustic emission, Spacecraft, Crack detection, Failure detection

Acoustic emission techniques have been used for over a decade to locate leaks in petrochemical operations. This approach was refined for locating low-level peaks in spacecraft liquid rocket propellant and pressurant feed systems. This paper presents the principles of acoustic emission leak detection, describes the sensors and signal conditioning, discusses acoustic signal transmission and isolation techniques, as well as experimental data, and shows how these data can be applied to identify internally leaking parallel redundant components in all-welded feed systems.

84-1540
Dynamic Effects During Vibrothermographic NDE of Composites
S.S. Russell and E.G. Henneke, II
General Motors Res. Labs., Warren, MI, NDT Intl., 17 (1), pp 19-25 (Feb 1984) 12 figs, 7 refs

Key Words: Vibrothermographic techniques, Diagnostic techniques, Composite materials

Vibrothermography is an NDE technique whereby a structure is excited with mechanical vibrations and the temperature profile on the surface is mapped by real-time video thermography. Damage in the structure is frequently more efficient at converting the input mechanical energy to heat than are undamaged regions of the structure. Hence damage appears on the thermal map as warmer regions. While using this technique to investigate manufacturing defects in tensile coupons made from sheet moulding compound and panels of graphite epoxy damaged by impact loadings, a dependence of the temperature patterns upon the frequency of the mechanical excitation was observed. This paper attempts to model this frequency dependent behavior and to verify the model by experiment.

BALANCING

84-1541
Heuristic Optimization in the Balancing of High-Speed Rotors
J.L. Yang, R.H. Chu, and T.W. Lee
Astro-Electronics, Princeton, NJ, ASME Paper No. 83-WA/DSC-32

Key Words: Rotors, Flexible rotors, Balancing techniques, Dynamic balancing

This paper presents a new approach to the dynamic balancing of flexible rotors. The unbalance of a rotor is treated as a combination of a number of discrete unbalancing components, which are identified and subsequently removed using an effective heuristic optimization technique.

84-1542
The Use of Signal Analysis and Identification Methods for Correction of Unbalance Computations
S. Braun and D. Shulman
Technion, Israel Inst. of Tech., Haifa, Israel, J. Vib., Acoust., Stress, Rel. Des., Trans. ASME, 106 (1), pp 53-58 (Jan 1984) 5 figs, 3 tables, 8 refs

Key Words: Balancing techniques

This paper describes a scheme for the correction of mass unbalance computations for the effect of torque disturbances. A general approach is dealt with, showing how to assess the disturbance of variables in monitoring schemes. Also described is a method to rank the disturbances according to their importance. The scheme makes use of conditioned signals, and mainly the multiple coherence function. An example dealing with a combustion engine test stand is given.

MONITORING

84-1543
An Investigation of Grinding and Wheel Loading Using Acoustic Emission
D. Dornfeld and He Gao Cai
Univ. of California, Berkeley, CA 94720, J. Engrg. Indus., Trans. ASME, 106 (1), pp 28-33 (Feb 1984) 11 figs, 17 refs

Key Words: Acoustic emission, Monitoring techniques, Machining, Machine tools

This paper investigates the potential for using acoustic emission signal analysis for a monitoring technique for process automation as well as a sensitive tool for investigation of grinding fundamentals. The acoustic emission generated during the grinding process is analyzed to determine its sensitivity to process efficiency and the condition of the grinding wheel. Acoustic emission from surface grinding is used to measure wear-related loading of the grinding wheel and sparkout (or loss of contact) between the wheel and the work surface. A discussion of energy dissipation in grinding and the generation of acoustic emission is included. This investigation showed that the acoustic emission energy, $(RMS)^2$, increases with the combined effects of wheel wear and loading, the signal energy, $(RMS)^2$, is a function of the undeformed chip thickness and that the signal accurately detects work-wheel contact and sparkout with a higher sensitivity than force measurements.

84-1544
Monitoring of Defect Progression by Acoustic Emission
J. Block

Deutsche Forschungs- und Versuchsanstalt fuer Luftund Raumfahrt e.v., Brunswick, Fed. Rep. Germany, Characterization, Analysis and Significance of Defects in Composite Materials, Conf. Proc., London, pp 3-1 - 3-11, Apr 12-14, 1983

Key Words: Monitoring techniques, Acoustic emission

Acoustic emission is a suited technique for the characterization of damage in composite materials, as also in metallic structures. A lot of tests with different CFRP specimens make sure that there are correlations between certain AE parameters, respectively their variation, and characteristics of defects, which are typical for composites. The damage history of the test specimens can be analyzed with a very good chronological resolution. This includes an exact correlation between acoustic and mechanical parameters, such as load, cycle number, etc. The present results demonstrate a potential for distinguishing between some dominant failure mechanisms, as fiber failure and matrix cracking, and noise generated by internal friction. Locating existing defects and tracking spatial damage progression is another field of application.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see No. 1513)

84-1545

Solution of Plane Transient Elastodynamic Problems by Finite Elements and LaPlace Transform

D.E. Beskos and A.Y. Michael

Univ. of Patras, Patras, Greece, Computers Struc., 18 (4), pp 695-701 (1984) 5 figs, 24 refs

Key Words: Elastodynamic response, Finite element technique, Laplace transformation

The general transient linear elastodynamic problem under conditions of plane stress or plane strain is numerically solved by a special finite element method combined with numerical Laplace transform. A rectangular finite element with eight degrees of freedom is constructed on the basis of the governing equations of motion in the Laplace transformed domain. Thus the problem is formulated and numerically solved in the transformed domain and the time domain response is obtained by a numerical inversion of the transformed solution. Viscoelastic material behavior is easily taken into account by invoking the correspondence principle. The method appears to have certain advantages over conventional finite element techniques.

84-1546

Absorbing Boundary Conditions for the Finite-Difference Approximation of the Elastodynamic-Field Equation

Y. Eskin

Technische Hogeschool, Delft, The Netherlands, Rept. No. R-1983-10, 45 pp (June 1983)
PB84-116029

Key Words: Boundary condition effects, Time domain method, Finite difference technique

When time-domain elastodynamic-field equations are solved using finite-difference techniques, there must be a method limiting the domain in which the field is computed. This is achieved by truncating the mesh and using absorbing boundary conditions at its artificial boundaries to simulate the unbounded surroundings. In this report a new type of absorbing boundary condition is studied. Numerical results are given that exhibit the usefulness of this condition.

84-1547

Application of the Integral Equation Method to the Elastodynamic Boundary-Value Problems

M. Shibahara and Y. Taniguchi

Kanazawa Univ., 2-40-20, Kodatsuno, Kanazawa, Ishikawa Prefecture, 920, Japan, Bull. JSME, 26 (222), pp 2054-2059 (Dec 1983) 9 figs, 7 refs

Key Words: Boundary value problems, Elastodynamic response

In this paper, the integral equation method is applied to plane-strain boundary-value problems of an elastic body. That is, by solving Fredholm integral equations derived from equilibrium equations, static stresses under uniform tensile field and dynamic stresses due to time-harmonic plane P and SV waves, around various cross-sectional cavities in an infinite elastic medium, were analyzed and numerical calculations were carried out.

84-1548

Eigenvalue Methods for Vibration Analysis II

A. Jennings

Queens Univ. of Belfast, Northern Ireland, Shock Vib. Dig., 16 (1), pp 25-33 (Jan 1984) 73 refs

Key Words: Eigenvalue problems, Reviews

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.

84-1549

Transient Response of an Elastic Solid to a Moving Torsional Load in a Cylindrical Bore

K. Watanabe

Technical College, Yamagata Univ., Yonezawa, Yamagata 992, Japan, Intl. J. Engrg. Sci., 22 (3), pp 277-284 (1984) 6 figs, 4 refs

Key Words: Transient response, Drilling, Elastic media, Torsional excitation

This paper is an attempt to apply Cagniard's technique to a transient problem of a dispersive medium. The transient response of an elastic solid to a moving torsional ring load in a cylindrical bore is considered. By making an approximation to the modified Bessel function, Cagniard's technique is applied. An approximate solution, which has explicit expressions for the wave front geometry and has a more suitable form for numerical computations, is obtained. The applicability of the solution is also discussed.

84-1550

Bifurcations of a Particular Forced Van der Pol Oscillator

D.K. Arrowsmith and K.I. Taha

Univ. of London, Hampstead, London NW3 7ST, Meccanica, 18 (4), pp 195-204 (Dec 1983) 8 figs, 14 refs

Key Words: Oscillators

The averaged equations of a forced non-linear oscillator, with both non-linear frictional and restoring forces, are considered as a two parameter system. The local and global bifurcations of the averaged two-parameter system are investigated. The local bifurcations are of Hopf and saddle-node type and are located in the parameter plane. The exceptional parameter points on the local bifurcation curves are investigated and the resulting global bifurcations are catalogued. Saddle connections, coalescence of limit cycles and saddle node creations on limit cycles are shown to occur using normal forms for vector fields and cycles without contact techniques. The behavior shows the dramatic increase in complexity obtained by adding a nonlinear restoring force to the standard forced Van der Pol oscillator.

84-1551

A Sequential Linearization Procedure for Nonlinear System Simulation

G.M. Lance and C.-G. Liang

Univ. of Iowa, Iowa City, IA, ASME Paper No. 83-WA/DSC-24

Key Words: Linearization methods

A sequential linearization procedure for simulation of nonlinear systems is presented. Computation of the system response is based on the known forms associated with the system eigenvalues and the use of the state equation in canonical form.

84-1552

Dynamic Analysis of Elastic Mechanism Systems, Part 1: Generalized Equations of Motion

D.A. Turcic and A. Midha

Penn State Univ., University Park, PA, ASME Paper No. 83-WA/DSC-43

Key Words: Mechanisms, Equations of motion, Finite element technique

This paper develops the generalized equations of motion for elastic mechanism systems by using finite element theory. The derivation and final form of the equations of motion provide the capability to model a general 2- or 3-D complex elastic mechanism, to include the nonlinear rigid-body and elastic motion coupling terms in a general representation, and to allow any finite element type to be used in the model.

84-1553

Dynamic Analysis of Elastic Mechanism Systems, Part II: Applications and Experimental Results

D.A. Turcic, A. Midha, and J.R. Bosnik

Penn State Univ., University Park, PA, ASME Paper No. 83-WA/DSC-38

Key Words: Mechanisms, Equations of motion, Experimental data

This paper presents an application of the analysis and solution methods devised for general elastic mechanism systems.

MODELING TECHNIQUES

84-1554

Mathematical Modeling of Complex Structures for Dynamic Analysis

C. Meyer and J.M. McCormick

Columbia Univ., New York, NY 10027, Computers Struc., 18 (4), pp 673-688 (1984) 21 figs, 8 refs

Key Words: Mathematical models, Dynamic response

The development of mathematical models of structural analysis requires not only knowledge of the principles of structural theory, but also practical experience. This is particularly true if the response to dynamic loads is to be analyzed. This paper summarizes a number of techniques which the authors have found useful for the purpose of developing and verifying mathematical models for complex structures encountered in engineering practice. Examples chosen from the dynamic analysis of machinery equipment of a modern ship are included to illustrate some of the techniques.

84-1555

The Prefiltering of an ARMA Series for a Linear System

Xie Zhong-jie

Acta Electronica Sinica, 11 (4), pp 93-101 (1983) CSTA No. 621.382-83.25

Key Words: Autoregressive-moving-average models, Frequency response function

This paper reports on the specific optimum solution of a formula for a linear system under the conditions of an autoregressive-moving-average model series and a rational frequency response function. The correction efficiency for the intersymbol interference of the prefiltering in a communication system is given as an example.

84-1556

A Simulation of Negative-Resistance Surge

M.P. Kissane and R.F. Boucher

Univ. of Sheffield, UK, ASME Paper No. 83-WA/DSC-11

Key Words: Surges, Fluid-induced excitation, Mathematical models

The modeling of negative-resistance surge in a simple fluid system is approached via the so-called method of lumping. The techniques developed are applied to a simple vortex amplifier circuit for which dynamic behavior is computed.

COMPUTER PROGRAMS

84-1557

Extreme Dynamic Loading Effects on Steel and Concrete Shell Structures

Y. Crutzen

Control Data Italia, Applications & Professional Services, Segrate (Mi), Italy, Interaction of Non-Nuclear Munitions with Structures, Proc. Symp. U.S. Air Force Acad., CO, May 10-13, 1983, Vol. 1, pp 141-145, 6 figs, 8 refs

Key Words: Computer programs, Shells, Steel, Concretes, Shock waves, Wave propagation

Using the modern computerized analysis, the special purpose computer program SLOOFSAN can be successfully applied for the evaluation of thin structure strength limits in presence of extreme dynamic loading phenomena. This program correctly solves wave-propagation-type of problems involving short transient (very rapid loading-time sequence) and including shock-wave response from impulsive loading (explosion or blast wave) and impact loading (missile impact). SLOOFSAN program is based on a finite element shell formulation using the Semiloof element and has been developed for transient dynamic non-linear analysis applying an efficient explicit direct time integration technique. SLOOFSAN 3-D capabilities in the fields of structural safety assessment and anti-missile design are illustrated in the paper.

84-1558

Dynsim, a Software Package for Computer-Aided Railroad Equipment Design Projects

G.F. List and H.A. List

Media, PA, ASME Paper No. 83-WA/RT-3

Key Words: Computer programs, Railroad trains, Suspension systems (vehicles)

Dynsim has been developed for railroad applications. It is targeted at car and locomotive truck and suspension systems that involve wheels, axles, motor mounts, bolsters, side-frames, and primary and secondary suspension elements. This paper describes Dynsim's principal features and presents examples of its use in one simple and one complex situation.

84-1559

SPAR Improved Structure/Fluid Dynamic Analysis Capability

J.T. Oden and M.L. Pearson

Lockheed Missiles and Space Co., Inc., Huntsville, AL, Rept. No. LMSC-HREC-TR-D867285, NASA-CR-170875, 112 pp (Aug 1983)
N83-36402

Key Words: Computer programs, Interaction: structure-fluid

The capability of analyzing a coupled dynamic system of flowing fluid and elastic structure was added to the SPAR computer code. A method, developed and adopted for use in SPAR utilizes the existing assumed stress hybrid plan element in SPAR. An operational mode was incorporated in SPAR which provides the capability for analyzing the flow of a two dimensional, incompressible, viscous fluid within rigid boundaries. Equations were developed to provide for the eventual analysis of the interaction of such fluids with an elastic solid.

84-1560

Frazer-Nash -- Predictors of Probability

Indus. Lubric. Trib., 35 (6), pp 204-206 (Nov/Dec 1983) 7 figs

Key Words: Computer programs, Impact response, Cranes (hoists), Gear drives

Three computer programs TROJAN, GENDYN and PROTEUS are described, which enable the designers to predict the probability of impact occurring in the rotating and slewing mechanisms of cranes manipulator arms and other gear driven machinery.

84-1561

A Computer-Aided System for Interactive Geometric Modeling, Structural/Dynamics Analysis and N/C Manufacturing/Inspection of Radial Flow Compressors

R. Culverhouse

Avco Lycoming Div., Stratford, CT, SAE Paper No. 821440

Key Words: Computer programs, Compressors, Design techniques, Dynamic structural analysis

The technological advances which have been made in the computer hardware industry, from interaction computer graphics systems to numerically controlled manufacturing and inspection machines, has resulted in major changes in the impeller design process. The contents of this paper describes an interactive CAD/CAM Geometric Modeling System for Impellers developed to integrate aerodynamic design, mechanical design, structural and dynamics analysis, manufacturing and quality assurance into an integrated CAD/CAM impeller system.

84-1562

Accuracy and Sensitivity of CRASH

R.A. Smith and J.T. Noga

U.S. Dept. of Transportation, National Highway Traffic Safety Admn., SAE Paper No. 821169 (P-113)

Key Words: CRASH (computer program), Computer programs, Collision research (automotive)

The accuracy and sensitivity of the CRASH computer program are examined. Accuracy is related to how well CRASH performs in comparison to results from 53 vehicles in 27 independent staged collisions. Sensitivity is related to how estimated field errors or imprecision affect the precision of computer delta-V. The sensitivity to error in the coefficients of the force-deflection relationship is examined.

84-1563

Interactive Computer Program for Analysis of Ultrasonic Modulus Data on Anisotropic Materials

A. Woolf

Div. of Material Applications, National Physical Lab., Teddington, UK, Rept. No. NPL-DMA-A-68, 35 pp (1983)
PB84-112820

Key Words: Computer programs, Stiffness coefficients, Elastic properties, Composite materials

The program computes stiffness components, compliances and engineering elastic constants for composite materials, using velocity measurements taken from the ultrasonic immersion method. The method is applicable to transversely isotropic, tetragonal and orthotropic materials. A fully worked example is included.

AUTHOR INDEX

CALENDAR

AUGUST 1984

5-9 3rd International Conference on Solid Lubrication [ASLE] Denver, CO *(ASLE Hqs.)*

6-9 West Coast International Meeting [SAE] San Diego, CA *(SAE Hqs.)*

12-16 International Computers in Engineering Conference and Exhibit [ASME] Las Vegas, NV *(ASME 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

3-6 AGARD Specialists' Meeting on "Transonic Unsteady Aerodynamics and Its Aeroelastic Applications" [AGARD/SMP] Toulouse, France *(Dr. James Olsen, AFWAL/FIB, Wright-Patterson Air Force Base, OH 45433 - (513) 255-5723)*

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

1-3 Army Symposium on Solid Mechanics [Army Materials and Mechanics Research Center] Newport, RI *(Army Materials and Mechanics Research Center, Arsenal Street, DRXMR-SM, Watertown, MA 02172 - (617) 923-5259)*

7-11 10th Design Automation Conference and 18th Mechanisms Conference [ASME] Cambridge, MA *(Prof. Panos Papalambros, Mechanical Engineering and Applied Mechanics, The University of Michigan, Ann Arbor, MI 48109 - (313) 763-1046)*

8-12 Acoustical Society of America, Fall Meeting [ASA] Minneapolis, MN *(ASA Hqs.)*

9-11 13th Space Simulation Conference [IES, AIAA, ASTM, and NASA] Orlando, FL *(Institute of Environmental Sciences, 940 E. Northwest Hwy., Mt. Prospect, IL 60056 - (312) 255-1561)*

15-18 Aerospace Congress and Exposition [SAE] Long Beach, CA *(SAE Hqs.)*

17-19 Stapp Car Crash Conference [SAE] Chicago, IL *(SAE Hqs.)*

22-24 ASME/ASLE Lubrication Conference [ASME/ASLE] San Diego, CA *(ASLE Hqs.)*

23-25 55th Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, DC] Dayton, OH *(Dr. J. Gordan Showalter, Acting Director, SVIC, Naval Res. Lab., Code 5804, Washington, DC 20375 - (202) 767-2220)*

DECEMBER 1984

3-5 International Conference on Noise Control Engineering [International Institute of Noise Control Engineering] Honolulu, Hawaii *(William W. Lang, Chairman, INTER-NOISE 84, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603)*

3-6 Truck and Bus Meeting and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

9-13 ASME Winter Annual Meeting [ASME] New Orleans, LA *(ASME Hqs.)*

FEBRUARY 1985

25-Mar 1 International Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1985

18-21 30th ASME International Gas Turbine Conference and Exhibit [Gas Turbine Division of ASME] Houston, TX *(International Gas Turbine Center, Gas Turbine Division, ASME, 4250 Perimeter Park South, Suite 108, Atlanta, GA 30341 - (404) 451-1905)*

APRIL 1985

8-12 Acoustical Society of America, Spring Meeting [ASA] Austin, TX *(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

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