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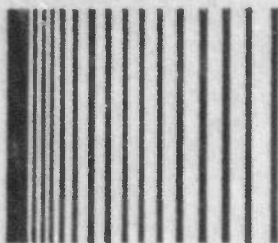
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SVIC NOTES

WHERE DID THAT NUMBER COME FROM?

Dynamic test requirements for equipment in vehicles often include numerical values and many users ask the question, "where did that number come from?" Interest in this subject is continuous but current efforts to revise MIL-STD-810, and requirements for test tailorability and for the disclosure of the rationale behind the numbers in test documents, have increased the awareness of this subject. Many methods have been used to set dynamic test requirements for vehicle equipment; it might be useful to briefly mention some of the more common of these.

First, if equipment is to be installed in an existing vehicle the establishment of test requirements might be simplified provided inputs from the vehicle to the item are available or can be measured.

If equipment is being developed for new vehicles it is only possible to establish preliminary test requirements at first because the equipment is usually developed before the vehicle exists. A typical orderly procedure includes the prediction of the expected dynamic environment followed by verification during field or laboratory tests once the prototype vehicle has become available. Many believe that preliminary test requirements should be slightly conservative to avoid the need to redesign the equipment and possible contractual difficulties if the operating environments turn out to be more severe than expected. Further details of this process have appeared in many of the previous *Shock and Vibration Bulletins* and papers on establishing qualification test requirements for airborne equipment will be published in the proceedings of the 53rd Meeting of the Advisory Group for Aerospace Research & Development (AGARD) Structures and Materials Panel which was recently held in the Netherlands.

Another method for setting dynamic test requirements for equipment in new vehicles is to use standards documents that contain guidelines that may be used to either derive test requirements or to establish the actual values of the dynamic test levels. Many prefer to use standards because they are convenient and often no other guidance is available. However, care must be taken in their use to avoid misinterpretation and this can only be done if the rationale behind the standard is known and understood. Many examples of the use of standards for establishing suitable dynamic test requirements for equipment in new vehicles are also available in the literature.

The foregoing are some of the more common methods for setting dynamic test requirements and other methods are available; some involve a combination of two or more of the methods that were previously mentioned, some are based on known physical limitations and still others are arbitrary. The most important requirements for any method for setting dynamic test requirements are that they must be as realistic as possible and that the rationale behind their numbers should be thoroughly documented.

R.H.V.

EDITORS RATTLE SPACE

DISTILLATION OF THE LITERATURE

Each year the twelfth issue of the *DIGEST* gives an indication of the volume of literature published in the shock and vibration area: there were almost 2700 abstracts published in the *DIGEST* in 1981. This represents a 40 percent increase in publications since 1978. At this rate of growth one wonders when the publishing system will go unstable and self destruct!

The increasing number of abstracts means that more and more information is being written in the shock and vibration field. More technology is thus available to the engineer trying to solve problems. Unfortunately, more is not always better. The large volume of literature means that the engineer will have to use valuable time attempting to identify pertinent articles and information. It is true that the abstract of an article or report can be retrieved as part of a subject or problem area, but this is only the beginning of the process of identifying what literature may be helpful in solving a problem or advancing a research and development project. The articles must be studied and analyzed to determine the available pertinent information. As the volume of literature increases, so does the time required to distill it. This brings us to the point of this editorial: the effort expended on literature reviews and distillation should increase in proportion to the growing volume of literature.

In past years the literature was distilled in textbooks and specialized technical books. This was and is a slow process. Today the distillation of the literature in book form is not keeping up with the growing volume of literature. The literature review section of the *DIGEST* is devoted to distillation of the literature – and is meant to provide an objective analysis of the literature. Many literature review articles are published in the *DIGEST* and in other journals, but other specific technical areas should also be reviewed. I feel that more effort should go into the writing of review articles. If you are interested in writing a review article, please contact the editors of the *DIGEST*.

R.L.E.

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FINITE-ELEMENT MODELING OF LAYERED, ANISOTROPIC COMPOSITE PLATES AND SHELLS: A REVIEW OF RECENT RESEARCH

J.N. Reddy*

Abstract. *This paper reviews finite element papers published in the open literature on the static bending and free vibration of layered, anisotropic, and composite plates and shells. The paper also contains a literature review of large-deflection bending and large-amplitude free oscillations of layered composite plates and shells. Non-finite element literature is also cited for continuity of the discussion.*

In recent years composites, especially fiber-reinforced laminates, have found increasing application in many engineering structures. This is mainly due to two desirable features of fiber-reinforced composites: a high stiffness-to-weight ratio and the anisotropic material property that can be tailored through variation of the fiber orientation and stacking sequence of lamina – a feature that gives the designer flexibility. The increased use of fiber-reinforced composites as structural elements has generated considerable interest in the analysis of laminated (anisotropic) composite plates and shells.

Recent developments in the analysis of plates and shells laminated of fiber-reinforced materials indicate that thickness has a more pronounced effect on the behavior of composite laminates than on isotropic laminates. Classical thin-plate and thin-shell theories assume that normals to the midsurface before deformation remain straight and normal to the midsurface after deformation; the implication is that thickness shear deformation effects are negligible. As a result, natural frequencies calculated using the thin-plate theory are higher than those obtained by including transverse shear deformation effects. In addition, the transverse deflections predicted by thin-plate theory are lower than those predicted by shear deformable theory (SDT). Due to the low transverse shear modulus relative to the in-plane Young's moduli, transverse shear deformation effects are even

more pronounced in composite laminates. Reliable prediction of the small deflection response characteristics of high modulus composite plates and shells therefore requires the use of shear deformable theories.

When the transverse deflections experienced by plates and shells are not small compared to laminate thickness, the interaction between membrane stresses and the curvatures – bending and shear – of the laminate must be considered. The interaction results in midplane stretching, which leads to nonlinear terms in the equations of motion. Thus, a more accurate prediction of deflections, stresses, and frequencies requires a solution of the laminate equations that can account for large deflections and thickness shear deformation.

LITERATURE REVIEW OF PLATES

Small-deflection theory of plates. A number of shear deformable theories for laminated plates have been proposed to date. The first theory for laminated isotropic plates is that of Stavsky [1]. The theory has been generalized to laminated anisotropic plates by Yang, Norris, and Stavsky [2]. Their work, called the Yang-Norris-Stavsky (YNS) theory, represents a generalization of Reissner-Mindlin plate theory for homogeneous isotropic plates to arbitrarily laminated anisotropic plates and includes shear deformation and rotatory inertia effects. A review of other theories, for example, the effective stiffness theory of Sun and Whitney [3], the higher-order theory of Whitney and Sun [4], and the three-dimensional elasticity theory of Srinivas et al [5-7], has been reviewed in [8]. It has been shown [3, 5, 9-13] that the YNS theory is adequate for predicting such overall behavior as transverse deflections and natural frequencies (first few modes) of laminated anisotropic plates.

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The first application of the YNS theory is apparently due to Whitney and Pagano [14], who presented closed-form solutions for symmetric and antisymmetric cross-ply and angle-ply rectangular plates under sinusoidal load distribution and for free vibration of antisymmetric angle-ply rectangular plates. Fortier and Rosettos [15] analyzed the free vibration of thick rectangular plates of unsymmetric cross-ply construction; Sinha and Rath [16] considered both vibration and buckling for the same type of plates. Following Whitney and Pagano [14], Bert and Chen [17] presented a closed-form solution for the free vibration of simply supported rectangular plates of antisymmetric angle-ply laminates.

Finite-element analysis of layered composite plates began with Pryor and Barker [18] and Barker, Lin, and Dana [19], who employed an element with seven degrees of freedom (three displacements, two rotations, and two shear slopes) per node to analyze thick laminated plates. Mau, Tong, and Pian [20] and Mau, Pian, and Tong [21] used the so-called hybrid-stress finite-element method to analyze thick composite plates. Noor and Mathers [22, 24] used finite element models based on a form of Reissner's plate theory -- i.e., mixed formulation -- to study the effects of shear deformation and anisotropy on the response of laminated anisotropic plates. One of the elements used had 80 degrees of freedom per element and thus required enormous computational resources. Hinton [24] used the so-called finite strip method to study the free vibration of layered cross-ply laminated plates. Mawanya and Davies [26] and Panda and Natarajan [27] used the quadratic shell element of Ahmad, Irons, and Zienkiewicz [28] to analyze the bending of thick multi-layer plates. Spilker, Chou, and Orringer [29] used two hybrid-stress elements to study the static bending of layered composite plates. The number of degrees of freedom in one of the two elements is proportional to the number of layers; therefore, the core storage and execution time requirements for the element increase rapidly with the number of layers in the plate. Reddy [30] recently developed a simple and efficient finite element based on the YNS theory. The element contains three displacements and two bending slopes as degrees of freedom per node. The accuracy and convergence characteristics of the element have been investigated [31]. The element has been used successfully in the free vibration and

thermoelastic analysis of ordinary and bimodulus (i.e., different elastic properties in tension and compression) layered composite plates [30-34].

Large-deflection theory of plates. Much of the research in the analysis of composite plates is limited to linear problems. This is perhaps due to the complexity of the nonlinear partial differential equation associated with the large-deflection theory of composite plates. Approximate solutions to the large-deflection theory (in the von Karman sense) of laminated composite plates have been attempted [35-43]. Chandra and Raju [38, 39] and Chia and Prabhakara [41, 42] employed the Galerkin method to reduce the governing nonlinear partial differential equations to an ordinary differential equation in time for the mode shape; the perturbation technique was used to solve the resulting equation. Zaghloul and Kennedy [40] used a finite-difference successive iterative technique in their analysis. In all of these studies with one exception [43], the transverse shear effects were neglected. The finite element employed by Noor and Hartley [43] includes the effect of transverse shear strains; however, it is algebraically complex and involves a large number of degrees of freedom per element. The use of such elements can thus be precluded in the nonlinear analysis of composite plates. Reddy and Chao [44, 45] recently adapted a shear deformable finite element [30] to the nonlinear bending of composite plates.

Analysis of nonlinear vibration of single-layer orthotropic plates has been done [46, 47]. Nowinski [48, 49] analyzed rectilinearly orthotropic plates of circular and triangular planforms using the Galerkin method; the effects of transverse shear deformation and rotatory inertia were not considered. Wu and Vinson [50] presented the dynamic analogue of Berger's equation of motion for an orthotropic plate, including the effect of transverse shear deformation and rotatory inertia; however, the solutions were restricted to transverse shear deformation. Mayberry and Bert [51] presented experimental as well as theoretical work on nonlinear vibration of laminated plates; the theoretical investigation was limited to a single-layer specially orthotropic rectangular plate with all four edges clamped and did not include the effect of transverse shear deformation and rotatory inertia. Nowinski [52] and others [53] used an assumed mode shape and Galerkin method to present a general equation for the nonlinear

analysis (i.e., large deflection and large amplitude free vibration) of orthotropic plates. Prabhakara and Chia [54] presented an analytical investigation of the nonlinear vibration of a rectangular orthotropic plate with all simply supported and all clamped edges. The effect of transverse shear and rotatory inertia on large amplitude vibration of composite plates was reported recently by Sathyamoorthy and Chia [55-57]. They used the Galerkin method and the Runge-Kutta numerical procedure.

In general, layered composite plates exhibit coupling between the in-plane displacements and the transverse displacement and shear rotations. For plates having layers stacked symmetrically with respect to the midplane, the bending-stretching coupling terms vanish and the problem is relatively simpler. Wu and Vinson [58] extended their earlier work [50] to deal with the nonlinear vibration of symmetrically stacked laminated composite plates. The first nonlinear vibration analysis of unsymmetrically laminated plates is that of Bennett [36], who considered simply supported (with immovable edges) angle-ply plates. Bert [37] used the thin plate theory of layered composite plates and the Galerkin method to investigate the nonlinear vibration of a rectangular plate arbitrarily laminated of anisotropic material. A multimode (two-term) solution for nonlinear vibration of unsymmetric all-clamped and all-simply supported angle-ply and cross-ply laminated plates was reported by Chandra and Basava Raju [38, 39, 59]. Chandra [39] used a one-term Galerkin approximation for the dynamic von Karman plate equations and the perturbation technique for the resulting ordinary equation in time to investigate the large-amplitude vibration of a cross-ply plate that is simply supported at two opposite edges and clamped at the other two edges. Prabhakara and Chia [54] presented an analytical investigation of the nonlinear free flexural vibrations of unsymmetric cross-ply and angle-ply plates with all-clamped and all-simply supported edges. The normal and tangential boundary forces in the plane of the plate were assumed to be zero. Reddy [60, 61] and Reddy and Chao [62] recently investigated the large-amplitude free vibration of layered composite plates using the finite-element method; they considered transverse shear and rotatory inertia effects. The finite-element studies [60, 62] are apparently the first to consider the nonlinear vibrations of layered anisotropic composite plates including transverse shear deformation.

Additional references, especially those before 1980, can be found in survey articles [63-67].

LITERATURE REVIEW OF SHELLS

Small-deflection theory of shells. The first analysis that incorporated the bending-stretching coupling (due to unsymmetric lamination) in shells is that of Ambartsumyan [68, 69]. He assumed that the individual orthotropic layers were oriented so that the principal axes of material symmetry coincided with the principal coordinates of the shell reference surface. Thus, Ambartsumyan's work dealt with what is now known as laminated orthotropic shells rather than with laminated anisotropic shells. In laminated anisotropic shells the individual layers are generally anisotropic; in addition, the principal axes of material symmetry of the individual layers do not coincide with the principal coordinates of the shell.

In 1962 Dong, Pister, and Taylor [70] formulated a theory of thin shells laminated of anisotropic material. The theory is an extension of that developed by Stavsky [71] for laminated anisotropic plates to Donnell's shallow shell theory [78] of shells. Cheng and Ho [73] analyzed laminated anisotropic cylindrical shells using Flugge's shell theory [74]. Bert [75] combined Vlasov's shell theory [76] with the most general anisotropic constitutive equations of Stavsky [71] to obtain an arbitrary shell geometry. A first-approximation theory for the unsymmetric deformation of nonhomogeneous, anisotropic, elastic cylindrical shells was derived by Widerra and Chung [77]; they used the asymptotic integration of the elasticity equations. For a homogeneous, isotropic material the theory reduces to the Donnell equations [78]. An exposition of various shell theories is available [79].

All of the theories discussed above are based on Kirchhoff-Love's hypotheses [72], in which transverse shear deformation is neglected. The effect of transverse shear deformation and transverse isotropy, as well as thermal expansion through the shell thickness have been considered by Zukas and Vinson [80] and Dong and Tso [81]. The theory used by Dong and Tso [81] is applicable only to layered, orthotropic, cylindrical shells; i.e., the orthotropic axes of each layer coincide with the coordinate axes of the shell. Whitney and Sun [82] developed a shear deformable

theory for laminated cylindrical shells that includes transverse shear deformation and transverse normal strain as well as expansional strains. Widera and Logan [83, 84] recently presented refined theories for nonhomogeneous anisotropic cylindrical shells.

As far as the finite-element analysis of shells is concerned, layered composite shells have not received the attention given to ordinary shells. The works of Dong [85] on statically-loaded orthotropic shell of revolution, Dong and Selna [86] on free vibration of the same, Wilson and Parsons [87] on static axisymmetric loading of arbitrarily thick orthotropic shells of revolution, and Schmit and Monforton [88] on laminated anisotropic cylindrical shells are the only ones that considered the finite-element method before 1970. The last reference is the only one that considered laminated anisotropic shells. During the 1970s there was increased interest in the finite-element analysis of bending and vibration of laminated anisotropic shells. A finite-element application in laminated anisotropic shells of arbitrary geometry is due to Thompson [89], who presented free vibration of general laminated anisotropic thin shells. Other finite-element analyses of layered anisotropic composite shells are available [90-100]; the effect of shear deformation was included in two papers [93, 100].

Large-deflection theory of shells. Despite the importance of nonlinear analyses of layered anisotropic shells, there is apparently no literature on the subject with the exception of the mixed finite-element analysis of Noor and Hartley [101] and recent work by Chang and Sawamiphakdi [102] and Reddy [103]. The work [102] utilizes a degenerated three-dimensional isoparametric element based on an updated Lagrangian description. In [103] a shear flexible finite element was developed based on a shell theory that combines various first-approximation shell theories [72, 78, 104-106]. The theory also accounts for large rotations.

CONCLUDING REMARKS

The bending and vibration analysis of layered anisotropic composite plates and shells is more complicated – due to bending-stretching coupling – than is the classical, isotropic, homogeneous analysis of

plates and shells. Because of these complexities, the available literature is sparse, especially in the area of nonlinear analysis of shells, compared to that of ordinary plates and shells.

Although the first-order shear deformable theories of layered composite plates yield acceptable solutions for global response of plates and shells, the theories do not accurately predict stress singularities and higher-order frequencies. The questions relating to interlaminar stresses, edge effects, and delamination in composites [107-116] can be addressed only when higher-order, three-dimensional theories are employed [82, 117-120].

As the use of composites for high performance design applications increases, the need for more realistic theoretical and experimental prediction of the response characteristics of composite-material structures will become increasingly important.

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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 vortex shedding from cylinders and the resulting unsteady forces and flow phenomena.

Ms. S.T. Fleischmann and Professor D.W. Sallet of the University of Maryland, College Park, Maryland have written the second part of a two-part paper that presents an extensive review of the unsteady flow phenomena that occur on and near cylinders in cross flow and that are related to vortex shedding. Part II introduces vortex shedding from non-circular cylinders and the topic of cylinders undergoing flow-induced vibration.

VORTEX SHEDDING FROM CYLINDERS AND THE RESULTING UNSTEADY FORCES AND FLOW PHENOMENA

PART II

S.T. Fleischmann and D.W. Sallet*

Abstract. *This two-part paper presents an extensive review of the unsteady flow phenomena that occur on and near cylinders in cross flow and that are related to vortex shedding. Part II introduces vortex shedding from non-circular cylinders and the topic of cylinders undergoing flow-induced vibration. Experimental values of the unsteady lift and drag coefficients and experimental values of the Strouhal number for circular cylinders over a wide range of Reynolds numbers obtained from numerous investigators are presented.*

VORTEX SHEDDING FROM NON-CIRCULAR CYLINDERS

The preceding section treated only vortex shedding from circular cylinders. Most measurements have been made using circular cylinders, but considerable data for cylinders of non-circular cross section (that is, of other basic shapes used in structures) also exist. Attempts have been made to correlate data from other shapes with that from circular cylinders through the development of a universal Strouhal number. So that it will be applicable to all bluff bodies from which vortex shedding occurs, this universal Strouhal number is based on wake parameters rather than free-stream velocity and cylinder dimensions. Various studies of vortex shedding from cylinders of non-circular cross sections are considered and the universal Strouhal number developed by three investigators are discussed below.

Knauss, John, and Marks [51] studied vortex shedding from elliptical cylinders having small eccentricity and from square cylinders at various angles of attack in the low Reynolds number range ($300 \leq Re \leq 1200$). It should be noted that the results from

elliptical cylinders should correspond most closely with those of circular cylinders because, as Knauss noted, the absence of a sharp edge allows the separation line to vary. For cylinders with sharp edges separation usually occurs along those edges. It was found [51] that, for elliptical cylinders with an eccentricity between 0.6 and 0.8 at zero angle of incidence, the data for $Re \leq 500$ are well represented by Roshko's relation for circular cylinders: $F = 0.212 (Re) - 2.7$. Above $Re = 500$, the best fit equation was a power law relationship $F = 0.27 (Re_{do})^{0.98}$ similar to Roshko's relation. For square cylinders there is a sudden drop in the Strouhal number as the angle of incidence increases beyond about 30° for various Reynolds numbers; this drop has been attributed to a detachment of the flow from the cylinder [51]. Huthloff [52] recently presented extensive measurements of the Strouhal number and the alternating lift coefficient for various cross sections, including circular cross sections, in the Reynolds numbers range of 10^4 to 10^5 . For non-circular cylinders he gave the lift coefficient and the Strouhal number as a function of angle of attack for various Reynolds numbers. He found that cylinders having square, rectangular, semicircular, or hexagonal cross sections experienced periodic forces that are considerably higher than those of circular cylinders. This is perhaps not surprising because all of the non-circular cylinders had sharp edges that would tend to define the separation line and therefore correlate the flow along the span of the cylinder. Highly correlated flow would then result in higher periodic forces. Representative results for C_L presented by Hothloff [52] are shown in Figure 11.

Lee [53] studied the effect of free-stream turbulence on vortex shedding and drag on square cylinders. He also presented a study of the effects of varying

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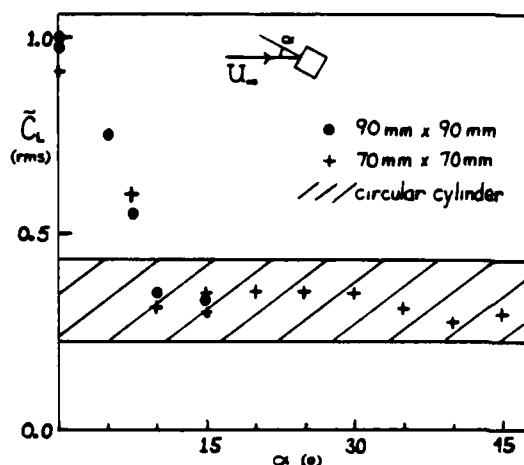


Figure 11. Representative Results [52] Showing Increased Lift Coefficient for Square Cylinders at Small Angles of Attack as Compared to Similar Results for Circular Cylinders ($4.2 \times 10^4 < Re < 1.8 \times 10^5$).

the angle of attack of square cylinders that included careful measurements of the pressure distribution on the faces of the square made with multiple, equally-spaced pressure sensors. Rockwell [32] also studied vortex shedding from square cylinders at various angles of attack and found that the low frequency modulation of the lift coefficient was due to unstable reattachment of the flow near the end of the cylinder wall

Twigg-Molecey and Baines [54] measured the Strouhal number as a function of Reynolds number for triangular cylinders in the range $9 \times 10^3 < Re < 4 \times 10^4$. They used pressure measurements on the cylinder face to obtain the periodic coefficients of lift and moment. These studies are presented as typical examples and to illustrate the general problem of vortex shedding from non-circular cylinders. The papers by Knauss [51] and Huthloff [52] contain numerous references to other work in this area.

In all of the studies mentioned (with the exception of the elliptical cross section at low Reynolds numbers) the $S = S(Re)$ relationship was found to be different from that for circular cylinders. Figure 12, which shows Roshko's data for a circular cylinder, a

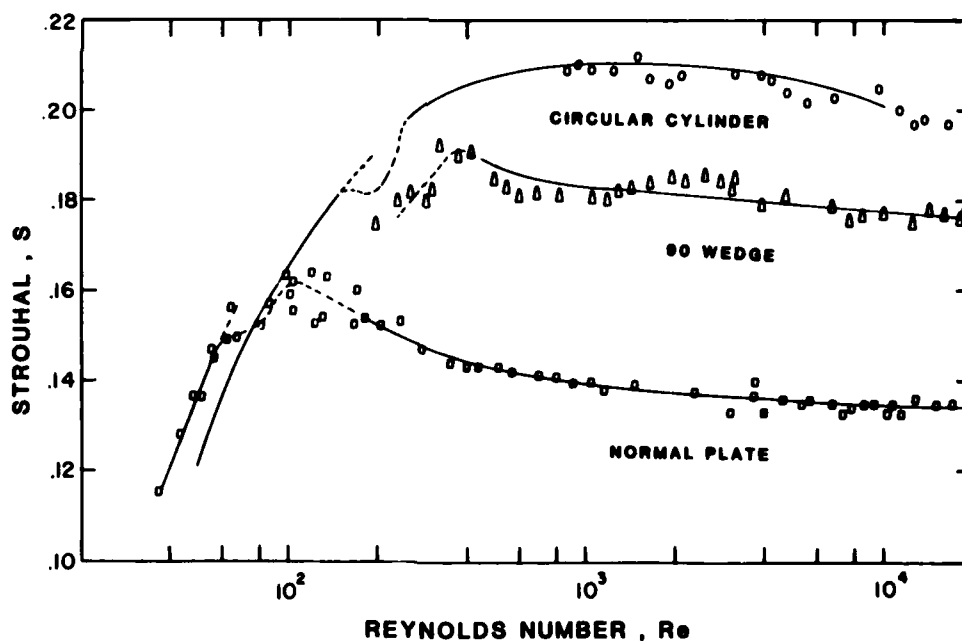


Figure 12. Roshko's Measurement of $S = S(Re)$ for Various Geometries [55].

at that point is not equal to the shear layer separation obtained from notched hodograph theory. Bearman then defined a new universal Strouhal number based on the distance h'' between the shear layer at the commencement of vortex shedding. This distance h'' is equal to the lateral spacing h in the vortex street. Bearman's universal Strouhal number is defined as:

$$S_B = \frac{fh}{U_b} = \frac{Sh}{d} \frac{U_\infty}{U_b}$$

The ratio $\frac{h}{d}$ can be found using the stability criterion proposed by either von Karman ($h/\ell = .281$) or Kronauer

$$\left. \frac{\partial C_D}{\partial (h/\ell)} \right|_{\frac{U_S}{U_\infty}} = 0$$

C_D is Karman's analytical expression. Bearman found the best correlation by using the Kronauer stability criterion to determine $\frac{h}{\ell}$; the shedding frequency and base pressure coefficient were experimentally obtained.

Both Roshko's and Bearman's formulations apply to stationary cylinders. Griffin [57] recently extended the concept of the universal Strouhal number to the case of freely vibrating cylinders. In his formulation the length parameter h' was the measured distance between the shear layers at the end of the vortex formation region. His results using his own data and the data of other investigators are given in Figure 13; there is good agreement with results for stationary cylinders of various cross sections.

VIBRATING CYLINDERS

The periodic forces due to vortex shedding from a cylinder in cross flow and the various flow regimes for a rigidly supported circular cylinder – that is, a cylinder for which the flow-cylinder interaction is restrained – have been described. The question now arises: what happens when flow-cylinder interaction is allowed and the cylinder vibrates. The question is relevant to all disciplines of engineering because costly structural damage can occur due to vortex-induced resonant motions of elastically-supported structural members; more knowledge in this area is needed.

Berger and Willie [37] reviewed the work in vibrating cylinders up to 1972 and Mair and Maull [40] reported on results presented at Euromech 17. Brief introductory reviews of more recent work are available [58, 59]. A scheme for the classification and analysis of flow-induced vibration problems has been given [60]. Numerous conferences concerning flow-induced vibrations in the past 10 years attest to the continued research interest in this problem [61-65]. This section considers flow-induced cylinder vibration; emphasis is on the physical processes involved.

It should be noted that the flow-cylinder interaction is extremely complex and highly nonlinear. The motion of the cylinder changes the geometry of the vortex wake and the periodic fluid forces on the cylinder. In turn, the changes in the periodic forces change the cylinder motion. Because the flow-cylinder interaction is so complex, results obtained from experiments in which the frequency and amplitude of vibration are externally controlled are often applied to the case of flow-induced vibration. Such applications must be done very carefully. Griffin [66] has shown that the near wake and the phase relation between the flow field and the cylinder motion are essentially the same for cylinders under forced and flow-induced vibrations if the Reynold's number and the frequency and amplitude of vibration are matched.

For small amplitude vibrations increased span-wise correlation in flow has been reported [24, 37, 67]. The increased span-wise correlation makes the flow more strongly two-dimensional and therefore increases the lift force on the cylinder. In experiments on forced vibrating cylinders Griffin and Ramberg [30] noted that when the ratio of vibration amplitude to cylinder diameter, a/d , is less than 50% (within the range of observed resonant response to flow-induced vibrations) the circulation of the vortices increases and the length of formation decreases. Bearman [56] found a nearly inverse relation between the base pressure coefficient (and therefore the drag) and the length of formation. Increased steady drag for a vibrating cylinder has been observed.

When the vortex shedding frequency is sufficiently close to the natural frequency of an elastically mounted cylinder or structural member, the vortex

shedding frequency, f , and the natural frequency become synchronized; that is, the Strouhal frequency, f_s , is suppressed and for a range of Reynold's numbers the shedding frequency is equal to the natural frequency of the cylinder system. This phenomenon is known as lock-in or wake capture. It is under conditions of lock-in that large amplitude resonant vibrations are observed.

Umemura, Yamaguchi, and Shiraki [68] used a spring mounted circular cylinder to investigate the amplitude response and the limits of lock-in as a function of external damping. They presented the amplitude response and the frequency of vortex shedding for the same cylinder under three different conditions of damping. For the highly damped system they found that almost no lock-in occurred. When damping was decreased by about an order of magnitude, lock-in occurred when the Strouhal frequency reached the system's natural frequency and persisted over a short range of higher Reynold's numbers, after which the shedding frequency abruptly returned to the Strouhal frequency. When the damping was decreased by yet another order of magnitude, lock-in occurred over the entire range of Reynold's numbers tested, both below and above V^* , the free-stream velocity for which the Strouhal and natural frequencies are equal. The maximum amplitude of vibration increased by roughly an order of magnitude each time the damping was decreased by about an order of magnitude. Furthermore the flow speed at which the maximum amplitude occurred increased with decreased external damping.

Although the flow speed, V_{max} , for which the maximum amplitude occurred was different for the three cases quoted, and the maximum amplitude was different, the flow speed range over which pronounced resonant vibration occurred relative to V_{max} seemed to be about the same (± 1 m/sec) in all cases. For cases of high and medium damping the vibration built up and died down outside the region of lock-in, but the maximum amplitude of vibration occurred in the region of lock-in.

Feng and Parkinson [69], in experiments with spring mounted cylinders of circular and D-section, observed similar behavior in their investigation of lock-in for the case of the circular cylinder. They also found that the free-stream velocity for which the maximum amplitude was attained was lower

when the velocity was gradually decreased than when it was gradually increased through the lock-in region. Feng and Parkinson [69] also observed that, while lock-in occurred mostly above V^* for circular cylinders, it occurred mostly below V^* for the D-section cylinders.

All cylinders experience fluid damping in addition to external mechanical damping. Griffin and Koopmann [59] reported a rapid decrease in fluid damping just before lock-in and a rapid increase immediately thereafter. Skop, Ramberg, and Ferer [70] have discussed the measurement and evaluation of fluid damping and added mass.

The amplitude and frequency response of spring mounted and externally damped cylinders that were free to vibrate perpendicular to the flow direction in water have been studied by Meier-Windhorst [71]. Similar results for spring mounted cylinders in air have been obtained by Glass [72] and others [58, 59]. Toebes and Eagleston [73] showed experimentally that the amplitude response of non-circular bluff bodies depends in general on the trailing edge geometry.

Throughout the lock-in region (with the exception of possibly one point) the shedding frequency is different from the Strouhal frequency observed for stationary cylinders. Because the shedding frequency is different, the longitudinal spacing of the wake vortices will also be different from that in the wake of stationary cylinders. In an extension of the two-dimensional Karman model to cylinders under small amplitude vibrations Sallet [14] noted that, for constant lateral spacing, an increase in longitudinal spacing leads to an increase in lift and vice versa. The Karman model also shows that, at constant longitudinal spacing (shedding frequency), changes in lateral spacing change the lift. In observations of cylinders under forced vibration Griffin and Ramberg [30] confirmed earlier observations [28] that, at constant vibration frequency, an increase in cylinder amplitude results in a decrease in lateral vortex spacing and that, at constant amplitude, the longitudinal spacing varies inversely with vibration frequency. The lateral spacing for a cylinder forced to vibrate at 85% of the Strouhal frequency approached zero as a/d approached 0.5 [30]. Further increases in the amplitude caused serious distortions of the wake. For vibration frequencies closer to the Strou-

hal frequency the critical vibration amplitude for which serious disorders in the wake first appeared also increased. It is possible that the approach to zero lateral spacing poses a limit to the amplitude of flow-induced vibration.

In accord with the observed resonant amplitude response of an elastically-supported cylinder under conditions of lock-in, Griffin and Koopmann [59] showed that the coefficient of lift increases to a maximum of $C_L^* = 0.5$ to 0.6 and then gradually decreases as the Reynolds number is slowly increased through the region of lock-in. Bishop and Hassan [74] showed that C_L^* for a vibrating cylinder is greater than C_L for a stationary cylinder before the maximum amplitude is reached and that C_L^* was less than C_L afterward.

Griffin, Skop, and Koopmann [58] noted that the energy transfer from the fluid to the cylinder is positive when the lift force has a component in phase with the cylinder motion. They used measurements to show that maximum energy transfer occurs when the maximum amplitude is obtained. It has been reported [58, 59, 74, 75] that a phase shift of about 90° occurs as the lock-in region is traversed; i.e., a phase shift of cylinder motion relative to the lift force.

The amplitude response of a cylinder in cross flow is evidently complex. The most successful model of cylinder motion has been the wake oscillator model, which was introduced by Hartlan and Currie [76] and further developed by Skop and Griffin [77]. An introduction to the model and further references are available [2, 3, 58, 59].

The focus of this paper has been the periodic forces on a cylinder in cross flow. Not only do the periodic forces due to cylinder vibration change but the steady drag force is also increased. Sallet [14] in his extension of the Karman model to vibrating cylinders noted a general trend to increased steady drag as cylinder amplitude increases. Tanida, Okajima, and Watanabe [78] have measured the increased drag experienced by a forced vibrating circular cylinder that was towed through water. Griffin, Skop, and Koopmann [58] measured an increased steady drag for freely vibrating cylinders. Griffin and Ramberg [30] found an inverse relation between the length of formation and the steady drag and reported

increased steady drag when the cylinder vibrates. Additional information is available [3].

Both the periodic forces and the steady forces change radically as a cylinder vibrates; flow-cylinder interaction is extremely complex. The topic of flow-induced vibrations is a topic of current research and much work remains in this area.

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BOOK REVIEWS

STATISTICAL ENERGY ANALYSIS OF DYNAMIC SYSTEMS

R.H. Lyons
MIT Press, Cambridge, MA

Large and lightweight aircraft and other structures, including houses have focused interest on higher modal analysis for predicting structural fatigue, equipment failure, and noise production. Traditional analyses of mechanical system vibration of machines and structures were concerned with lower resonant modes. Statistical energy analysis (SEA), which is expressed in terms of random parameters, is now being utilized by mechanical and structural engineers.

The prime advantage of SEA is that a large number of modes can be compressed into a few coherent features of the modal pattern (direct field and a few early reflections), and the incoherent pattern (reverberant field) can be compressed into a few frequency bands. In addition, SEA allows for a simple description of a system; modes or waves are used to describe the field.

The 15 chapters of the book are contained in two parts; the numerous references are annotated.

Part I on basic theory consists of four chapters. The history and development of SEA, and single- and multi-degree-of-freedom systems are described. The storage of kinetic and potential energy by modes in free and forced vibration plus the decay or rate of energy removed by damping are considered.

Chapter III introduces the concept of average power flow - average in both ensemble and temporal sense between simple single- and more complicated multi-degree of freedom-systems. The idea of blocked systems, similar to that used in electrical systems, is introduced. Power flow in terms of both blocked and coupled system energies are considered; the idea of enlarged modal interactions as a white noise source is presented.

Chapter IV considers the problems of estimating response using average energy distribution. The estimation of displacement and stresses leads to the development of intervals of estimating and confidence coefficients. This is important when statistical analysis of variance shows that the standard deviation is an appreciable fraction of the mean.

Part II centers upon engineering applications of SEA in predicting vibration. Four chapters discuss response estimation during the early stages in the design of a high-speed flight vehicle; dynamic response of a system in terms of stress, acceleration, and pressure; estimations of the average system energy from the SEA model and knowledge of its parameters. The use of such SEA parameters as loss factor, power transfer parameters, and modal density of a system plus the important input power prediction are described. The ratio of the convection speed of pressure waves to the bending wave speed in a turbulent boundary layer is given.

The next three chapters show how the system can be modeled and define subsystems; included are the identification and evaluation of coupling between systems. Parameter evaluation, which is the engineering basis for SEA, is illustrated by measuring damping in both simple and built-up structures, including constraint layer structures.

The author illustrates the evaluation of coupling loss factors by applying them to aerospace structures, acoustical spaces, cylinders, and coupling between structural subsystems. An example is given of the use of SEA in the response estimation of a re-entry vehicle; information on modal density, high-frequency modal coupling loss factors, and the experimental procedures required to determine the parameters are described.

The reviewer has noticed that the most important uses to date have been in noise control problems, noise propagation in ships, and vibrations in nuclear reactors and enclosed space structures. SEA has a major stumbling block: the determination of param-

eters from experimental tests. The reviewer does recommend this book to engineers involved in this subject. However, more work must be done.

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DYNAMICS OF MECHANICAL SYSTEMS

J.M. Prentis
Halsted Press, New York, NY
1980, 486 pages, 2nd Edition

This undergraduate text contains material that would typically be found in separate books on machine dynamics, vibrations, and automatic control theory. The entire text would be suitable for a two-semester senior level course; a one semester course could be based on selected chapters. The chapter by chapter contents are as follows:

Chapter 1 - Simple Mechanisms I. This short introductory chapter to the first one-third of the book is devoted to the classification of plane and spatial mechanisms.

Chapter 2 - Simple Mechanisms II. The practical kinematics of planar mechanisms such as cams, gears, gear trains, and linkages are illustrated. The mathematical presentation is based on elementary calculus, without reference to vectors or complex numbers.

Chapter 3 - Force Relationships in Mechanisms I Transmitted Forces and Friction. The first part of this brief chapter considers frictionless mechanisms. The virtual work concept applied to friction is introduced. The chapter concludes with a study of the effects of friction on cams, four-bar, and slider-crank mechanisms.

Chapter 4 - Velocities and Accelerations. The vector kinematic relations for moving spatial reference frames are derived at the beginning of the chapter. The relations are then applied mainly to such planar mechanisms as cams and linkages; the concept of equivalent mechanisms is introduced.

Chapter 5 - Force Relations in Mechanisms II Inertia Forces. This 60-page chapter covers D'Alembert's principle, balancing concepts, gyroscopic effects, angular momentum, plane motion inertia, transmission of inertia forces, and inertial stresses. Analytical and graphical methods are emphasized.

Chapter 6 - I First Order Systems. The automatic control third of the book is introduced with this chapter on lumped parameter modeling. Proportional elements, integrating elements, transfer relations, response, lag, and superposition are described mathematically and physically using differential equations and complex numbers.

Chapter 7 - II Second Order Systems. Chapter 7 is a continuation of the previous chapter. The concepts of amplitude, phase, and frequency are described mathematically and illustrated using spring-mass systems and servo-mechanisms.

Chapter 8 - Automatic Control. This very long chapter deals with the standard topics of open and closed loop systems, derivative control and integral control, position and speed control, stability criteria, Bode diagrams, and system design. The presentation is mainly theoretical; there are illustrations of the application of the theory to practical systems.

Chapter 9 constitutes almost one third of the book. It follows logically the modeling techniques introduced in the chapter on automatic control. The classical spring-mass system, isolation techniques, seismic excitation, and phase plane analysis are considered. Simple multi-degree-of-freedom systems are analyzed. Energy concepts and the Rayleigh method are applied to lumped and distributed systems. Elementary rotor dynamics are also considered.

A section containing practice problems keyed to the chapters follows the last chapter; the answers are given. An index concludes the book.

There is always the danger that a textbook purporting to cover such a wide range of topics will do none of them, or its readers, justice. For the most part the author has successfully avoided this trap. To my personal taste chapters 5 and 9 which deal with dynamics and chapter 8 on automatic control are a bit lean. I would have preferred a stronger treatment and more applications. Another reviewer might say the same about other sections.

Considering the intended usage, and the latitude given the instructor to introduce additional material, the author has produced a reasonable compromise.

The text is well illustrated with clearly marked line drawings. The typeset and organization are pleasing to the eye. The style and exposition are easy to read. Students will probably be pleased with the quantity of well-written descriptive material, which is generally more voluminous than is found in American technical books.

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DYNAMICS IN CIVIL ENGINEERING: ANALYSIS AND DESIGN

A. Major
Akadémiai Könyvkiadó, Budapest, Hungary
Vol. I-IV, 1981, 1212 pages, \$96.00

Vibration problems caused by time-dependent loads arise in many structures. This comprehensive reference book deals with the theoretical and practical aspects of solving such dynamic problems, which are often very complex. This book is a completely revised and considerably enlarged edition of the internationally known author's 1961 work, *Vibration Analysis and Design of Foundations for Machines and Turbines*, which is a standard reference book for many engineers.

The extended scope of this second edition includes more detailed treatment of the fundamentals of structural dynamics and their practical applications. To assure convenient handling of this increased material, the book has been divided into four volumes. The fourth volume is devoted to wind and earthquake effects on tall buildings and various industrial structures and the dynamics of bridges.

The first volume (320 pp) contains a condensed but up-to-date introduction to structural and soil dynamics. In addition, the reader is exposed to the fundamental principles governing the design of machine foundations. The second volume (302 pp) deals with the vibratory characteristics of such machines as hammers and reciprocating engines and with the design of their foundations, including vibration isolation and mechanical methods for mitigating undesirable vibration effects.

The third volume (291 pp), a continuation of the subject matter of volume two, deals with high-speed machinery and steam and nuclear power plants. Again, such general considerations as design criteria are followed by descriptions of various computational methods and useful structural details of machine foundations.

The last volume (306 pp) is devoted mostly to vibrations of tall buildings and industrial structures subjected to wind, earthquake, and blast loads. One chapter deals with the dynamics of hydraulic structures. Finally, the reader is introduced to various types of bridge vibration.

The reviewer believes that the four volumes contain a most comprehensive treatment of dynamic problems in civil engineering from a wide variety of fields. Clear presentation of basic theories is followed by practical applications. In addition, a vast amount of pertinent information is given in tables and graphs; such information is not otherwise easily available to the practicing engineer. Application of the various computational methods are illustrated by numerical examples, and the work of the designer is facilitated by numerous figures showing structural details. The author also provides an extensive bibliography, citing 1377 references. The book is well produced, edited, and indexed. The reviewer believes that these volumes represent a significant contribution to the literature of structural dynamics and will become a standard reference book for anyone interested in the dynamic analysis and design of structures.

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BOOK REVIEWS: 1981

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SHORT COURSES

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 11-15, 1982

Place: Tucson, Arizona

Objective: The objective of this short course and workshop is to review the elements of probability and statistics and the recent theoretical and practical developments in the application of probability theory and statistics to engineering design. Special emphasis will be given to fatigue and fracture reliability.

Contact: Special Professional Education, Harvill Building No. 76, Room 237, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3054.

MACHINERY VIBRATION ANALYSIS

Dates: January 26-29, 1982

Place: Tampa, Florida

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

FEBRUARY

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

Dates: February 1-5, 1982

Place: Santa Barbara, California

Dates: March 1-5, 1982

Place: College Park, Maryland

Dates: April 12-16, 1982

Place: Dayton, Ohio

Dates: July 19-23, 1982

Place: England

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 St., Santa Barbara, CA 93105 - (815) 682-7171.

VIBRATION TESTING AND SIGNAL ANALYSIS

Dates: February 16-18, 1982

Place: Southampton, England

Objective: Topics include: types of testing; introduction to the various types of signal-linear system theory, etc. (i) testing with applied excitation - techniques - steady state, slow sweep, transient, random, (ii) response analysis (only) - system in motion due to natural excitation; instrumentation and signal conditioning - effects of attachments on system characteristics; instrumentation system characteristics; limitations, e.g. bandwidth, integration, analogue filtering, etc; signal processing; and specification testing.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, SO9 5NH - (0703) 559122, Ext. 2310.

BALANCING OF ROTATING MACHINERY

Dates: February 23-26, 1982

Place: Galveston, Texas

Objective: The seminar will emphasize the practical aspects of balancing in the shop and in the field. The instrumentation, techniques, and equipment pertinent to balancing will be elaborated with case histories. Demonstrations of techniques with appropriate instrumentation and equipment are scheduled. Specific topics include: basic balancing techniques (one- and two-plane), field balancing, balancing without phase measurement, balancing machines, use of programmable calculators, balancing sensitivity, flexible rotor balancing, and effect of residual shaft bow on unbalance.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 1-5, 1982

Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 8-12, 1982

Place: Phoenix, Arizona

Objective: Program emphasis is on how to increase productivity, cost-effectiveness of data acquisition systems and groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

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

SHOCK AND VIBRATION CONTROL

Dates: March 16-18, 1982

Place: Southampton, England

Objective: Topics include: introduction - structural parameters and their role in vibration control; dynam-

ic properties of structural materials - damping materials and their properties, application of damping treatments to structures, fibre reinforced plastics, fatigue; mobility methods - concepts, system coupling, application to the isolation problem, approximate methods; vibration transmission through structures - path identification - classical, cross correlation, etc., power flow - mechanisms, use of statistical energy methods, acoustic radiation, radiation efficiency; shock - impacts in machines - effects of structural parameters on acoustic radiation, isolation - machinery installations, the transient environment - packaging and packaging materials.

Contact: Mrs. G. Hyde, ISVR Conference Secretary, The University, Southampton, SO9 5NH - (0703) 559122, Ext. 2310.

APRIL

DESIGN OF FIXED OFFSHORE PLATFORMS

Dates: April 5-16, 1982

Place: Austin, Texas

Objective: This course is dedicated to the professional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas at Austin, Austin, TX 78712 - (512) 471-3506.

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

COMPILATION OF DAMPING DESIGN GUIDE

The Flight Dynamics Laboratory, one of the Air Force Wright Aeronautical Laboratories located at Wright-Patterson Air Force Base Ohio, awarded a three-year contract in September 1981 to Lockheed-California Company, Burbank, California and University of Dayton Research Institute, Dayton, Ohio, to develop an aerospace structures technology damping design guide. The objective of this effort is to collect and summarize available design methods and data on acoustic and vibration control using damping materials/methodology and compile this information into a damping design guide which may be readily applied for use in controlling structure and equipment vibration problems on board aircraft, spacecraft, and other aerospace systems. The design guide will be written for aerospace systems designers and provide to the designer the methods of damping design, limits of application, sources of derivation, and examples illustrating the use of each method.

The scientific/engineering community is invited to offer examples of successful application of damping methods/technology and detailed background information for these examples for inclusion in the damping design guide. Data on available damping material adhesives and compounds are also of interest and will be included in the guide, as will a list of vendors active in this field.

Anyone interested in participating or offering information is urged to contact: J. Soovere, Lockheed-California Company, Dept 63G, Plant A-1, Burbank, California 91520 - (213) 847-2225; M. Drake, University of Dayton Research Institute, Dayton, Ohio 45469 - (513) 229-2644; or V. Miller, Flight Dynamics Laboratory, AFWAL/FIBED, Wright-Patterson Air Force Base Ohio 45433 - (513) 255-5229/5753.

ERRATA

The following errors were noted in the article *Linear Dynamic Thermoelasticity - A Survey*, published in the September issue of the Digest.

"The head conduction equation," page 4, should read "The heat conduction equation."

"The functions ρ, λ, \dots ," page 4, should read "The parameters ρ, λ, \dots ."

"The function θ_0 in equation (3) . . .", page 5, should read "The parameter θ_0 in equation (3) . . ."

INFORMATION RESOURCES

THE METAL MATRIX COMPOSITES INFORMATION ANALYSIS CENTER

MISSION

The MMCIAC, established in October 1980, is one of the newest of the DoD information analysis centers (IACs) administered and funded by the Defense Logistics Agency (DLA) and the Defense Technical Information Center (DTIC). As with the other IACs, the MMCIAC receives its technical sponsorship and guidance from a DoD laboratory, in this case the U.S. Naval Surface Weapons Center at Silver Spring, Maryland. Kaman Temp (a division of Kaman Sciences Corporation) located in Santa Barbara, California, operates and manages the MMCIAC.

The broad mission of the MMCIAC is to provide scientific and technical information analysis service to the DoD, other government agencies, government contractors, and the private sector in the area of metal matrix composite materials.

MMC TECHNOLOGY PROGRAM

Throughout the past decade the DoD has manifested a strong interest in developing Metal Matrix Composite (MMC) materials and has invested an estimated 70 million dollars in this technology over the past ten years. In the late 1970s a MMC "thrust" was implemented to further accelerate the developmental pace. The results of recent efforts directed by the Army, Navy, Air Force, and Defense Advanced Research Projects Agency (DARPA) has advanced the MMC community rapidly toward systems applications. Present efforts focus on making this new technology more cost effective.

The MMC technology program, over the past 12 years, however, has resulted in a growing, but fragmented data base. Current programs are producing a large amount of technical data and information that, within a short time, will equal and possibly surpass all the data previously generated. Therefore,

a need exists to centrally accumulate, evaluate, analyze, and disseminate this technical data and information through a well developed and dedicated technology transfer program. The DoD Metal Matrix Composites Information Analysis Center was established as the basic element of such a program.

TECHNICAL SCOPE

The subject matter coverage of the MMCIAC is the technology related to metal matrix composite materials. The materials are understood to be those composites that perform acceptably under severe conditions, both environmental and operational. The materials are those characterized as having high specific properties, proven environmental fatigue capability, reduced requirement for critical metals, improved creep and wear resistance, high design flexibility, high damage tolerance, and unique combinations of properties including mechanical, electrical, and thermal. The scope of this coverage embraces:

- Continuous fibers, wires, discontinuous whiskers with L/D 10, directionally solidified eutectics
- Fibers -- boron, graphite, silicon carbide, borsic, nitride, alumina, boron carbide, titanium diboride
- Wires -- stainless steel, tungsten, molybdenum, beryllium, titanium, niobium alloys and compounds
- Whiskers -- alumina, silicon carbide, silicon nitride
- MMC Systems -- alumina/magnesium, beryllium/titanium, boron/stainless steel/aluminum, boron/titanium/aluminum, borsic/aluminum, borsic/titanium, copper/graphite, graphite/lead, graphite/aluminum, tungsten/nickel.

Technical areas of interest for the MMCIAC include: manufacturing, fabrication process development,

defense systems applications, performance computations, cost, test and evaluation techniques and methods, properties data, operational serviceability and repair, environmental protection, sources, suppliers, and other MMC-related areas.

MMC PROPERTIES DATA BASE

A special function of the Center is to establish and maintain an MMC properties data base from which to develop information useful to designers concerned with MMC applications. Documents acquired by the Center may contain or reference MMC test data that substantiate derived conclusions and/or analytical results. In these instances, supporting test data are examined and screened for potential MMCIAC data base incorporation. Properties and test data selected for incorporation are evaluated, formatted and placed into an MMC data base organized for selective retrieval and analysis. The data summaries or data books produced from the MMC data base will be disseminated periodically to the Center's users.

INFORMATION OPERATIONS

The MMCIAC provides the facilities and capabilities to: (1) identify, collect, process, store, and disseminate authoritative MMC information; (2) prepare or sponsor the preparation of the necessary products and services to communicate this information to researchers, practicing specialists, manufacturers, and other users with interests and concerns in metal matrix composites; and (3) coordinate and augment existing information activities to improve the transmittal of this information to interested organizations and individuals in the government, military, and private sector.

Center activities include the collection, review, evaluation, analysis, dissemination of the literature related to MMC materials, and assisting visitors in using data files. Emphasis is placed on screening, filtering, and selective reduction to maintain a data base that truly reflects the current state-of-knowledge. MMCIAC personnel continuously review, analyze, refine, and pool worldwide published and unpublished scientific and technical information acquired from the DoD and NTIS and recognized professionals in Government and contractor organizations. They also moni-

tor publications of other IACs and data centers and actively participate in MMC technical conferences and symposia such as the MMC Technology Conference.

The Center's information sources include: Technical reports from DoD, other Government agencies, industry, and academic institutions, etc; open literature including foreign sources; unpublished papers; meetings; technical journals; conferences; workshops; and consultations with key scientists in the MMC community.

PRODUCTS AND SERVICES

The MMCIAC provides a central, authoritative, and easily accessible body of information consistent with MMC materials development and applications. Specifically, it is designed to provide:

- Continuous and comprehensive information acquisition and compilation
- On call, specialized user services for answering technical and bibliographic inquiries from qualified individuals and organizations
- State-of-the-art studies of MMC technology with usefulness extending from the bench level to all levels of RDT&E management
- Scientific and engineering reference works such as handbooks, design manuals and periodic MMC materials properties data summaries
- Critical reviews and assessments of MMC technology and related subjects of significant interest to the Defense RDT&E community
- Current awareness and other user-oriented publications in a quarterly newsletter, notices and proceedings of MMC and related conferences, and announcements with bibliographical accounts of newly acquired information. The quarterly newsletter is available without charge to any interested individual or company engaged in materials research, development, testing, fabrication, and/or applications.

ORGANIZATION AND STAFF

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ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

- Rotating Machines
- Reciprocating Machines
- Power Transmission Systems
- Metal Working and Forming
- Isolation and Absorption
- Electromechanical Systems
- Optical Systems
- Materials Handling Equipment

- Blades
- Bearings
- Belts
- Gears
- Clutches
- Couplings
- Fasteners
- Linkages
- Valves
- Seals
- Cams

- Vibration Excitation
- Thermal Excitation

MECHANICAL PROPERTIES

- Damping
- Fatigue
- Elasticity and Plasticity

STRUCTURAL SYSTEMS

- Bridges
- Buildings
- Towers
- Foundations
- Underground Structures
- Harbors and Dams
- Roads and Tracks
- Construction Equipment
- Pressure Vessels
- Power Plants
- Off-shore Structures

STRUCTURAL COMPONENTS

- Strings and Ropes
- Cables
- Bars and Rods
- Beams
- Cylinders
- Columns
- Frames and Arches
- Membranes, Films, and Webs
- Panels
- Plates
- Shells
- Rings
- Pipes and Tubes
- Ducts
- Building Components

EXPERIMENTATION

- Measurement and Analysis
- Dynamic Tests
- Scaling and Modeling
- Diagnostics
- Balancing
- Monitoring

VEHICLE SYSTEMS

- Ground Vehicles
- Ships
- Aircraft
- Missiles and Spacecraft

ANALYSIS AND DESIGN

- Analogs and Analog Computation
- Analytical Methods
- Modeling Techniques
- Nonlinear Analysis
- Numerical Methods
- Statistical Methods
- Parameter Identification
- Mobility/Impedance Methods
- Optimization Techniques
- Design Techniques
- Computer Programs

BIOLOGICAL SYSTEMS

- Human
- Animal

ELECTRIC COMPONENTS

- Controls (Switches, Circuit Breakers)
- Motors
- Generators
- Transformers
- Relays
- Electronic Components

GENERAL TOPICS

- Conference Proceedings
- Tutorials and Reviews
- Criteria, Standards, and Specifications
- Bibliographies
- Useful Applications

MECHANICAL COMPONENTS

- Absorbers and Isolators
- Springs
- Tires and Wheels

DYNAMIC ENVIRONMENT

- Acoustic Excitation
- Shock Excitation

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

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MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2585, 2593, 2655, 2660, 2661, 2663, 2665, 2666, 2667, 2668, 2669, 2676, 2688)

81-2505

Recognition of the Causes of Rotor Vibration in Turbomachinery

D.M. Smith

Turbine Generator Div., Associated Electrical Industries, Ltd., UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 1-4, 11 refs

Key Words: Rotors, Turbomachinery, Oil film bearings, Journal bearings, Vibration source identification

This paper discusses actions which influence rotor vibration and means of recognizing vibration set up by these actions. Attention is given primarily to rotors carried in oil-film journal bearings, as widely used in land and marine turbine plants. Stator vibration which contributes to rotor vibration is taken into account.

81-2506

Double-Frequency Accelerations in Turbogenerator Rotors Resulting from Anisotropy in the Bearings

W. Kellenberger

Brown Boveri, Birr, Switzerland, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 415-420, 5 figs, 3 tables

Key Words: Rotors, Turbogenerators, Acceleration effects, Bearings, Anisotropy

The motion of a turbogenerator rotor in any plane normal to the rotation axis is known to be elliptical. This results in alternating accelerations of all points of the shaft at double-rotation frequency. This paper is concerned with the calculation of these accelerations and the resulting alternating forces which act (at constant speed) on every rotor component (in addition to the steady centrifugal forces) and must be conveyed, over the component's attachment, to the main body of the rotor. Examples of attached

components are: slot-wedges, balancing masses, ventilator fan blades and end-rings.

81-2507

Further Investigations into Load Dependent Low Frequency Vibration of the High Pressure Rotor on Large Turbo-Generators

S.H. Greathead and M.D. Slocombe

N.E. Region Scientific Services Dept., MIMechE, Otley Rd., Harrogate, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 401-413, 15 figs, 2 tables, 6 refs

Key Words: Rotors, Turbogenerators, Nonsynchronous vibration, Low frequencies

This paper presents results from a gland rig which has been built to measure unbalanced steam forces arising in multi-cell shaft labyrinth glands with different geometries and flow conditions. Further operational evidence from observations and measurements on this type of machine obtained during investigations into this load dependent vibration instability is also presented. The gland rig results indicate that large unbalanced steam forces can be generated from steam flow in shaft glands. The operational evidence supports this and also indicates that such forces make an important contribution to the load dependent h.p. rotor instability problems experienced.

81-2508

On the Influence of Casing Stiffness in Turbomachinery Vibration Analysis

S.S. Stecco and M. Pinzauti

Dept. of Energetics, Univ. of Florence, Italy, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 139-144, 8 figs, 3 refs

Key Words: Turbomachinery, Critical speeds, Interaction: rotor-casing

Critical frequencies of turbomachines are often highly affected by the interaction effects between casing and rotor. A method, original under various aspects, is presented in order to predict from theoretical values (or, in some cases, from experimental data) the vibrational behavior of the machine. A practical application is also given showing the numerical results.

81-2509

Modal Dynamic Simulation of Flexible Shafts in Hydrodynamic Bearings

H.F. Black and R.D. Brown

Heriot-Watt Univ., Edinburgh, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 109-113, 6 figs, 13 refs

Key Words: Rotors, Flexible shafts, Modal analysis, Non-linear theories

The major sources of non-linearity in flexible rotors are the forces originating from hydrodynamic bearings. When large excitation forces occur, journal motion may be so great that nonlinearity must be considered. The calculation time for nonlinear simulation depends on the number of modes used and the lubricant film force model. An existing Rayleigh-Ritz linear program was adapted for numerical integration. Bearing oil films forces were obtained as time dependent functions using an approximate method. The results presented demonstrate that nonlinear effects can be significant for peak response levels.

81-2510

The Transient Response of Turbo-Alternator Rotor Systems under Short-Circuiting Conditions

J.S. Rao, D.K. Rao, and K.V. Bhaskara Sarma

Indian Inst. of Technology, New Delhi, India, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 271-275, 4 figs, 1 table, 7 refs

Key Words: Rotors, Torsional vibration, Natural shapes, Transfer matrix method, Computer programs

Sudden short-circuiting conditions at the alternator end generate predominant transient torsional oscillations in a turbo-alternator rotor inducing severe dynamic stresses. To evaluate these stresses, a continuous transfer matrix model was developed to determine torsional frequencies and modes. A discrete dynamic system of specified number of rotors is extracted from continuous system and its modes are evaluated by Jacobian method. Transient response is evaluated by modal expansion method. A computer program was developed and the results for a 6MW turbo-alternator system are presented.

81-2511

An Approximate Formula for the Fundamental Fre-

quency of a Uniform Rotating Beam Clamped off the Axis of Rotation

D.H. Hodges

Aeromechanics Lab., U.S. Army Research and Technology Labs. (AVRADCOM), Ames Res. Ctr., Moffett Field, CA, J. Sound Vib., 77 (1), pp 11-18 (July 8, 1981) 5 tables, 8 refs

Key Words: Rotors, Blades, Beams, Rotating structures, Fundamental frequency

A semi-empirical method involving asymptotic expansions is used to obtain an approximate formula for the fundamental frequency of a uniform rotating beam clamped off the axis of rotation. Results from the formula are shown to be of the order of 0.1% different from the exact results for a wide range of rotor speeds and hub radii up to the order of blade length. Thus, the designer is provided with a rapid, very accurate estimate of the frequency, without having to interpolate results from a chart or run a digital computer program.

81-2512

Finite Element Analysis of Rotating Disks

G.L. Nigh and M.D. Olson

Dept. of Civil Engrg., Univ. of British Columbia, Vancouver, British Columbia, Canada, J. Sound Vib., 77 (1), pp 61-78 (July 8, 1981) 8 figs, 1 table, 16 refs

Key Words: Disks (shapes), Rotating structures, Finite element technique, Critical speeds, Viscous damping

A finite element formulation is presented for the analysis of rotating disks in either a body-fixed or a space-fixed co-ordinate system. The in-plane stress distribution resulting from the in-plane body force due to rotation is determined first by a plane stress finite element analysis. This stress distribution is then used in calculating the out-of-plane geometric stiffness which in turn is added to the linear bending stiffness. In the space-fixed co-ordinate system, inertia and a viscous type damping also contribute to the out-of-plane stiffness, even in the steady state case. The formulation presented here places no restrictions on the disk geometry if the problem is solved in a body-fixed co-ordinate system, although only disks of axisymmetric geometry may be considered in the space-fixed co-ordinate system. A direct method of determining the critical speeds through an eigenvalue analysis in space-fixed co-ordinates is presented. The undamped steady state response to a space-fixed transverse point load is then examined. The effects of a viscous type damping are also presented.

81-2513

Reduction of Twice per Revolution Vibration Levels Due to Weight Effect in Large Turbogenerators

N. Bachschmid and G. Diana

Milan Polytechnic, Italy, *Vibrations in Rotating Machinery*, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 203-208, 11 figs, 2 tables, 10 refs

Key Words: Rotors, Turbogenerators, Vibration control, Stiffness coefficients, Asymmetry

A method is presented for determining the rotating stiffness inequality from the statical deflection as well as from the twice per revolution vibration measurements. In this way it is possible to verify if, and how strong, dynamical effects due to rotating speed may change the statical stiffness inequality distribution. It is further possible to detect where corrections must be applied in order to reduce the twice per revolution vibration levels. This method was applied to a 600 MW generator and proved to be reliable and a successful tool "twice per revolution balancing."

81-2514

Relative Energy Concepts in Rotating System Dynamics

G.T.S. Done

The City Univ., London, UK, *Vibrations in Rotating Machinery*, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 283-287, 5 figs, 4 refs

Key Words: Rotors, Work and energy balance

The concept of relative work and energy; i.e., work and energy expressed relative to nonfixed axes, is not a commonly used one, but it is nevertheless just as valid as that of relative displacement, velocity and acceleration. The basic mechanics are presented in the paper, and it is shown how problems that have arisen in classifying certain types of rotating systems as conservative or nonconservative are resolved. Both absolute and relative energy balances are formulated for two models that exhibit mechanical instability; namely, an unsymmetric cross-section rotating shaft and the lag-plane ("ground resonance") model of a helicopter rotor.

81-2515

Instabilities of Parametric Rotor Support Systems
J. Krodziewski, K. Marynowski, and Z. Parszewski

Politechnika Łódzka, Łódź, Poland, *Vibrations in Rotating Machinery*, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 289-296, 15 figs, 5 refs

Key Words: Rotors, Supports, Parametric response, Stiffener effects

Analysis of instability regions and forced vibrations of parametric discrete/machine/subsystems, interacting with real/supporting/structures is given and applied to model machines with rotors of unequal principal stiffnesses. Laboratory test results are cited and compared with computed ones, regarding instability regions and types of instability, forced vibrations amplitudes and journal center loci. First four harmonics content was computed and plotted for full experimental speed range.

81-2516

A Physical Explanation of Parametric Instabilities in Unsymmetric Rotors

D.A. Peters and I. Zvolanek

Washington Univ., St. Louis, MO, *Vibrations in Rotating Machinery*, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 77-82, 8 figs, 16 refs

Key Words: Rotors, Whirling, Flutter, Parametric excitation

Past work on instabilities in unsymmetric rotors has shown that instabilities can conceivably occur whenever the sum or difference of two natural frequencies equals an integer multiple of the rotor speed. It is also known that some of these potential instabilities are realized neither analytically nor experimentally. In this paper, rules are developed that predict which potential instabilities will occur in the presence of zero damping.

81-2517

Instability Threshold of an Unbalanced, Rigid Rotor in Short Journal Bearings

J.W. Lund and H.B. Nielsen

Dept. of Machine Elements, The Technical Univ. of Denmark, Denmark, *Vibrations in Rotating Machinery*, Proc. 2nd Intl. Conf., Churchill College, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 91-95, 3 figs, 4 refs

Key Words: Rotors, Rigid rotors, Unbalanced mass response, Parametric excitation

The unbalance response of a rigid rotor in short journal bearings is considered. The whirl orbits are assumed to be elliptical at synchronous frequency and are determined from the method of averaging. The stability of the orbital motion is investigated on the basis of the variational equations which include the effect of parametric excitation. The calculated zones of instability are obtained as functions of the Sommerfeld number and a rotor mass parameter for several values of the mass unbalance. The results are shown in a diagram.

81-2518

Acceleration of Unbalanced Rotor through the Resonance of Supporting Structure

F. Victor and F. Ellyin

Dept. of Civil Engrg., Univ. of Sherbrooke, Sherbrooke, Quebec, Canada, J. Appl. Mechanics, Trans. ASME, 48 (2), pp 419-424 (June 1981) 11 figs, 10 refs

Key Words: Rotors, Unbalanced mass response, Resonance pass through, Transverse shear deformation effects, Rotatory inertia effects, Internal damping, Viscous damping

The dynamic response of a simple beam excited at its mid-span by the action of a turbomachine secured to it, is investigated in detail. The forcing function includes transients at startup or shutdown. Effects of the shear deformation, rotatory inertia, and the internal viscous damping, which may depend on the frequency, are considered individually as well as in combined forms. The results indicate that the maximum amplitude of vibration is highly dependent on the acceleration rate through the critical frequency. There is also an apparent shift in its position as compared to the classical resonance frequency. Influences of shear deformation and rotatory inertia are significant when the supporting structure (or foundation) is relatively massive.

81-2519

Fatigue and Fracture Analysis of Two Turbine Shafts

B.N. Leis, K. Dufrane, R. Rungta, R.D. Buchheit, M. Tuttle, P. Skulte, and S. Collard
Battelle Columbus Lab., Columbus, OH, ASME Paper No. 81-PVP-27

Key Words: Shafts, Fatigue life, Crack propagation

A coupled fractographic and mechanics based analysis of radical cracking problems in two low pressure steam turbine

shafts is presented. Cracks occurred at circumferential notches cut in the shaft near shrunk-on discs. Fractography showed fatigue cracks initiated at these notches from pits developed under the action of cyclic bending in a wet stream/condensate environment. Favorable comparison between predicted growth rates and observed growth rates suggest that for this study, fracture mechanics represents a viable tool for turbine shaft design and failure analysis, at least during the crack growth stage. Results also indicate that once the crack is initiated, failure will occur in a matter of days so that corrosion fatigue crack nucleation and the growth of very small cracks dominates the failure process.

81-2520

A Method of Calculating the Vibrational Behaviour of Coupled Rotating Shafts Containing a Transverse Crack

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

Central Electricity Generating Board, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 17-27, 9 figs, 9 refs

Key Words: Shafts, Cracked media

A method of calculating the vibrational response of a coupled rotor system to a transverse crack using standard finite-element computer programs is briefly described. The method employs the technique of successive approximations and utilizes the fact that the fractional change in stiffness of a rotor is small even for large cracks and that for speeds away from critical speeds of the shaft, the crack opening and closing is dominated by self-weight bending. The method has been validated by comparing calculations with the experimental results from a four-bearing, two-shaft spin rig, one of whose shafts has a propagating transverse crack. The application of the method to two suspect turbo-generators is described.

81-2521

On the Occurrence of Unstable Vibrations of a Shaft Having Either Asymmetrical Stiffness or Asymmetrical Rotor, Supported by Asymmetrically Flexible Pedestals

H. Ota and K. Mizutani

Dept. of Mech. Engrg., Faculty of Engrg., Nagoya Univ., Japan, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge,

UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 181-186, 6 figs, 1 table, 8 refs

Key Words: Shafts, Rotors, Variable material properties, Vibration response

In a rotating shaft with unequal stiffness or with an asymmetrical rotor, two kinds of unstable vibrations occur. In this paper, the mechanisms which cause the occurrence of unstable vibrations are clearly explained. Conditions under which unstable vibrations occur are derived and ascertained by use of an analog computer.

81-2522

Vibration of a Rotating Shaft Passing through Two Critical Speeds

S. Yanabe and A. Tamura

Tokyo Inst. of Technology, Tokyo, Japan, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 19-35, 6 figs, 2 tables, 11 refs

Key Words: Shafts, Critical speeds, Damping effects

The vibration of a rotating shaft which passes through two critical speeds successively under the condition of the uniform acceleration rate is analyzed theoretically taking account of the damping force. The exact solution and its approximate expressions of the nonstationary vibration are derived and their calculated results with respect to various values of the critical speed ratio n and the acceleration parameter Ω_1 are shown. Both results have a good agreement in a wide speed range including the maximum amplitude.

81-2523

A Technique for Modelling Rotors from Measured Vibration Characteristics

G.B. Thomas and P. Littlewood

Central Electricity Generating Board, Harrogate, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 445-451, 6 figs, 1 table, 9 refs

Key Words: Rotors, Mathematical models, Natural frequencies, Mode shapes, Measurement techniques, Stiffness coefficients

The accuracy of rotordynamic calculations is governed by the quality of the available computer model, which for turbo-alternator plant includes three main elements: rotor, bearings and foundations. Existing rotor models are constructed from manufacturers' sectional data idealized empirically to include the stiffening effect of abrupt changes of diameter. A technique for measuring the natural frequencies and modal shapes of individual rotors is described. The measurements were originally intended for comparison with calculations but a method was later developed for calculating an effective stiffness profile from the measured modal shape which was then used to construct a new improved rotor model. Results of rotordynamic calculations from the existing and improved computer models are presented and compared with measured data. The technique has also been used successfully for locating the axial position of rotor cracks.

81-2524

A Contribution for the Calculations of Intermittent Vibrations of Electrically Driven Rotors

U. Hollburg

Technische Universität, Berlin, Germany, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 339-346, 7 figs, 8 refs

Key Words: Motors, Rotors, Shafts, Amplitude analysis

During the planning of driving mechanisms, consisting of an electromotor, a coupling for the abutting shafts and a processing machine, it is necessary to assess the maximum ratings of the shafts produced by bending and torsional moments. Knowledge is required of the maximum amplitude during intermittent working conditions. Intermittent phenomena of motion of overcritical rotors appear mainly during the running-up since the bending (torsional critical speed) must be passed through until the nominal values are reached. In order to judge the vibrational behavior at the very beginning, the simultaneous consideration of the mechanical system and the electromagnetic process is indispensable. For the description of the various models, a symbolic rotor system is chosen from the many possible driving mechanisms. The continuous bending and torsional elastic shafts with circular cross sections are mounted orthotropically. These shafts are connected by a coupling which is assumed to be elastic. Mathematically, the problem is described by partial differential equations but the complete analytical solution is not obtainable. Thus the problem will be approximately solved by, first of all, determining the Eigenmode of the appointed conservative structure for a discretized finite element model. By means of a connected model transformation a set of ordinary nonlinear differential equations is obtained for which a numerical solution is possible.

81-2525

Torsional Vibrations During the Starting Process in Driving Systems with Three Phase Motors

H. Peeken, C. Troeder, and G. Diekhans
Inst. of Machine Elements and Machine Design,
Technical Univ. Aachen, Germany, Vibrations in
Rotating Machinery, Proc. 2nd Intl. Conf., Church-
ill College, Cambridge, UK, Sept 1-4, 1980, organized
by Instn. Mech. Engrs., pp 427-435, 16 figs, 2 tables,
3 refs

Key Words: Motors, Torsional vibration, Shafts, Drive shafts,
Rotating machinery

Induction and synchronous machines produce an oscillation torque on starting which causes strong torsional excitation in connected machinery. A method to measure the air gap torques of the machines in driving systems is presented. With the help of a mathematical model of the machines, it is possible to calculate by digital simulation the torsional response in shaft systems considering that electrical and mechanical system are coupled. Parameter variations in the mechanical system show the dominant effects influencing the air gap torque produced during starting.

81-2526

Investigation of a D.C. Motor Vibration Problem

D. France and H. Grainger
Dynamics Section, Weir Pumps Ltd., UK, Vibrations in
Rotating Machinery, Proc. 2nd Intl. Conf., Church-
ill College, Cambridge, UK, Sept 1-4, 1980, organized
by Instn. Mech. Engrs., pp 83-90, 9 figs, 2 refs

Key Words: Motors, Vibration source identification, Reso-
nant frequencies, Mountings, Elastomers

A severe vibration problem was experienced with a D.C. motor used to provide the drive for a paper making machine. The vibration frequency was found to be at the rotor slot number multiplied by rotational speed and distinct resonant regions were evident within the motor operating speed range. The paper describes the various steps taken to identify the excitation source and determine the characteristics of the resonant modes of vibration. Various solutions to the problem were considered and are described. The final solution was achieved by use of an elastomeric mounting arrangement for the motor bearings.

81-2527

Computation of Vibrations of the Coupled System Machine-Foundation

E. Krämer

Technische Hochschule Darmstadt, German Federal
Republic, Vibrations in Rotating Machinery, Proc.
2nd Intl. Conf., Churchill College, Cambridge, UK,
Sept 1-4, 1980, organized by Instn. Mech. Engrs.,
pp 333-338, 10 figs, 2 tables

Key Words: Interaction: rotor-foundation, Journal bearings,
Rotors, Foundations, Stiffener effects, Vibration response

A procedure is given for computing the unbalance vibrations of rotor-foundation systems. First the foundation is calculated separately. Its influence on the rotor system is represented by its dynamic stiffness at the connecting points to the rotor. With this the expense for computation is reduced to an acceptable level. According to some studies, in many cases it may be possible to assume the foundation as a rigid supporting base.

81-2528

Vibration Analysis of Large Rotor-Bearing-Foundation-Systems Using a Model Condensation for the Reduction of Unknowns

M. Jäcker

Technical Univ., Berlin, Germany, Vibrations in
Rotating Machinery, Proc. 2nd Intl. Conf., Churchill
College, Cambridge, UK, Sept 1-4, 1980, organized
by Instn. Mech. Engrs., pp 195-202, 10 figs, 4 refs

Key Words: Rotors, Interaction: rotor-foundation

For the dynamic analysis of many rotating structures it is necessary to take into account the dynamic behavior of their foundations. The high analysis costs due to the known complexity of the system can considerably be reduced by a reduction of the unknowns which is based on the speed-independent modal properties of the system components (modal condensation, component mode method). The technique is applied to different linear dynamic problems (stationary and transient response, critical speeds, stability) in a consistent manner. Numerical examples are given for the stationary response problem.

81-2529

Defining the Machine/Foundation Interface

P.E. Simmons

Petrochemical Div., ICI Ltd., Wilton, Middlesbrough,
Cleveland, OH, Vibrations in Rotating Machinery,
Proc. 2nd Intl. Conf., Churchill College, Cambridge,

UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 5-8, 5 figs, 1 ref

Key Words: Interaction: rotor-foundation, Rotors, Foundations

As turbo-machines get larger their dynamic behavior is increasingly affected by the flexibility of their bearings, support structures and foundations. Also larger machines tend to require taller and generally more flexible foundations which are inadequately represented in the machine designer's mathematical model. There is a need for a system which adequately defines the interface and quantifies those characteristics of the foundations which are important to the machine designer. The purpose of this paper is to suggest a standard system of defining the interface which would enable the civil engineer to present the dynamic characteristics of the foundation in a form which the machine designer can use in an improved mathematical model to determine the dynamic behavior of the machine.

81-2530

Stresses of Turbo-Generator Shafts and Foundations Caused by Electrical System Faults

Th. Jainski

Technical Univ., Berlin, Germany, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 9-16, 10 figs, 11 refs

Key Words: Interaction: rotor-foundation, Rotors, Foundations, Electric systems

Turbo-generator shafts and foundations are transiently excited by electrical system faults like terminal short circuits, faulty synchronizing, clearing of network short circuits near to the power plant. Abnormal mechanical stressing in rotor and foundation is caused by pulsating electromagnetic forces. They have to be taken into account by dynamic stress investigations of both structures. An accurate determination of local stress values demands complex mathematical models (FEM) and time-consuming numerical investigations (time-history-method) in order to solve the equations of motion. A large FEM-modeled turbo-shaft and foundation were treated by the exact but time-consuming time-history-method and the response-spectra-method as an economical method of approximation considering the dynamic character of the problem. In addition, the dynamic stress of foundations was evaluated by a quasi static analysis according to the old German Standard DIN 4024.

81-2531

Seismic Response of a Flexible Rotor

T. Shimogo and M. Nakano

Keio Univ., Japan, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 321-326, 20 figs, 4 tables, 4 refs

Key Words: Rotors, Flexible rotors, Seismic response

The results of seismic response analysis of a flexible rotor supported by two bearings, in which the dynamic properties are represented by linear springs and dampers, are presented. For the simplification of a theoretical treatment the rotor is represented as either a lumped or a uniformly distributed parameter system, and gyroscopic moments are included. The seismic excitations acting on two bearings are assumed to be a stationary Gaussian random process with a dominant frequency such as the El Centro earthquake waveform. In particular, the influences of a flexibility of rotor upon the seismic responses; i.e., the relative displacement of the rotor, the dynamic loading of the bearings, and so on, are studied. Numerical examples of a generator-rotor of 350MW steam power plant indicate the fact that the maximum r.m.s. responses are considerably bigger than those obtained on the assumption of a rigid rotor, due to a decreasing fundamental resonance frequency. Influence of rotor speed on the seismic response is also examined.

81-2532

Dynamics of High Speed Rotative Assemblies

D.A. Thurgood

British Aerospace Dynamics Group, Hatfield Div., UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 389-393, 7 figs, 1 table, 1 ref

Key Words: Compressors, Rotary compressors, Turbomachinery, Balancing techniques, Damping

Presentation is made of the development experience of a series of high speed turbocompressor units for aircraft air-conditioning systems with particular reference to aspects of balancing, shaft response and damping, and excitations from angular contact ball bearings.

81-2533

Analysis and Design of Centrifugal Pumps Considering Rotor Dynamics

M. Takagi, O. Matsushita, T. Ino, K. Kikuchi, and K. Komatsu

Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 43-51, 16 figs, 1 table, 11 refs

Key Words: Pumps, Centrifugal pumps, Friction excitation

In this paper rotational bending stress analysis of centrifugal pump rotors, imbalance response analysis, stability analysis of self-excited vibration and unsteady response analysis due to rubbing are developed. Systematic tests corresponding to these analyses are carried out using actual multi-stage centrifugal pumps. The calculated values agreed well with the experimental values with regard to the stability-threshold speed, and the steady state rotational bending stresses. Qualitative agreement was obtained with regard to the behavior of transient stress due to rubbing. On the basis of these results, methods of estimating the vibration responses and bending stresses in the high speed large-scale multi-stage centrifugal pumps, and pump design methods considering these factors are established.

RECIPROCATING MACHINES

81-2534

Energy Conservation and Noise Control in Pneumatic Devices and Systems, Part II - Percussive Tools, Blow-offs and Air Ejectors

M.D. Oviatt

Richard K. Miller & Associates, Inc., Alpharetta, GA, Plant Engineering, 35 (16), pp 116-118 (Aug 6, 1981) 2 figs

Key Words: Hand tools, Noise reduction

Noise reduction techniques of hand held reciprocating tools, such as chipping hammers, needle scalars, sand rammers, rock drills, pavement-breakers, blow-off nozzles, and air ejectors, are presented.

METAL WORKING AND FORMING

(See No. 2664)

STRUCTURAL SYSTEMS

BUILDINGS

(Also see Nos. 2561 and 2691)

81-2535

The Tenth Sir Richard Fairey Memorial Lecture: Sound Transmission in Buildings

M. Heckl

Institut f. Technische Akustik, Technische Universität Berlin, D-1000 Berlin 10, Germany, J. Sound Vib., 77 (2), pp 165-189 (July 22, 1981) 22 figs, 2 tables, 27 refs

Key Words: Buildings, Sound transmission

Sound transmission through walls, ceilings, windows, doors, etc., depends on (1) mass per unit area, (2) bending stiffness, (3) damping, (4) variation in bending stiffness (because of struts or other anisotropies), (5) stiffness and damping of interlayers and sound bridges (in cases of double walls), (6) size and shape of partitions, (7) mounting conditions, (8) influence of flanking walls, (9) unwanted effects such as slits, etc. The first three parameters and to a certain degree also the fourth and fifth can be dealt with theoretically by investigating walls of infinite size. In this way many of the results obtained in buildings can be explained at least qualitatively. The influences of size, shape, mounting conditions and the influence of flanking transmission can be understood best by applying energy balance equations, and in this way the average behavior of reasonably large constructions can be explained.

81-2536

Approximate Method for Lateral Load Analysis of High-Rise Buildings

F.K.E.C. Mortelmans, G.P.J.M. de Roeck, and D.A. Van Gemert

Struct. Engrg. Dept., Katholieke Universiteit Leuven, Belgium, ASCE J. Struc. Div., 107 (ST8), pp 1589-1610 (Aug 1981) 16 figs, 1 table, 7 refs

Key Words: Framed structures, Multistory buildings, Buildings, Wind-induced excitation, Columns

An approximate method for the design of long, high-rise buildings under horizontal wind loading is described. The method is based on the reduction of the framed structure to one built-in column with equivalent bending and torsional stiffnesses. Discrete actions of the horizontal members on the columns are distributed over the story heights. The floors are treated as rigid in the horizontal plane. The calculation is reduced to the solution of a system of four linear equations; the determination of internal actions only requires some very simple operations. The accuracy of the method is demonstrated by comparison to the displacement method.

81-2537

Torsional Coupling and Earthquake Response of Simple Elastic and Inelastic Systems

C.L. Kan and A.K. Chopra

Dept. of Civil Engrg., Univ. of California, Berkeley, CA, ASCE J. Struc. Div., **107** (ST8), pp 1569-1588 (Aug 1981) 16 figs, 1 table, 8 refs

Key Words: Buildings, Earthquake response, Torsional response, Lateral response

The effects are analyzed of torsional coupling on the earthquake response of simple one-story structures in elastic and inelastic ranges of behavior. The structures considered are symmetrical about one principal axis of resistance, resulting in coupling only between lateral displacement along the perpendicular axis and the torsional displacement. Torsional coupling arising only from eccentricity between centers of mass and elastic resistance is considered. Systems with several resisting elements are idealized by a single element model. Response of such a model to a selected earthquake ground motion are presented for a range of the basic structural parameters. The response quantities presented include maximum lateral and torsional deformations of the system as well as maximum deformations of individual columns. The response in the inelastic range of behavior is effected by torsional coupling to generally a lesser degree than elastic response.

TOWERS

81-2538

Measurements of Wind and Deformation on a High Radio Tower. Part 3. Measurement (Wind- und Verformungsmessungen an einem Funkturm. Teil 3. Messungen)

W. Neuerburg

Maschinenlaboratorium 2 der Fachhochschule für Technik Esslingen, Kanalstr, Esslingen, Germany, Techn. Messen-ATM, 7/8, pp 275-280 (July/Aug 1981) 13 figs, 1 ref
(In German)

Key Words: Towers, Wind induced excitation, Experimental test data

The wind loadings on a high tower structure and the coherent effects of static and dynamic responses were studied by means of versatile measurement equipment. Wind pressures against the tower wall, the deformation and oscillation of the structure and the free-streaming wind were measured with reference to the time.

FOUNDATIONS

(Also see Nos. 2527, 2529, 2530)

81-2539

Plastic Models in Turbomachinery Foundation Studies

R.L. Bannister and J.K. Aneja

Westinghouse Electric Corp., Lester, PA, ASCE J. Engr. Mech. Div., **107** (EM4), pp 649-667 (Aug 1981) 13 figs, 1 table, 22 refs

Key Words: Turbomachinery, Machine foundations, Resonant frequencies, Mode shapes, Experimental test data, Model testing

Over a period of years, the static and dynamic behavior of turbomachinery foundations have been studied with scaled plastic models. Experimental data from several investigators show the type of information that can be obtained for resonant frequencies, mode shapes and response levels in the laboratory. Model test data are compared with measurements made on full-size structures and also calculated from analytical models. Accuracy is dependent on the degree to which similitude requirements are met. Experimental results are also presented to show how structural models have been used to determine the effect of foundation termination, rotor unbalance and bearing support stiffness.

UNDERGROUND STRUCTURES

81-2540

Numerical Simulations of Earthquake Effects on Tunnels for Generic Nuclear Waste Repositories

K.K. Wahi, B.C. Trent, D.E. Maxwell, R.M. Pyke, and C. Young

Science Applications, Inc., Fort Collins, CO, 132 pp (Dec 1980)
DP-1579

Key Words: Underground structures, Tunnels, Nuclear waste depositories, Rocks, Seismic waves, Earthquake response, Numerical analysis

The objectives of this generic study were to use numerical modeling techniques to determine under what conditions seismic waves generated by an earthquake might cause instability to an underground opening, or cause fracturing and joint movement that would lead to an increase in the permeability of the rock mass. Three different rock types (salt, granite, and shale) were considered as host media for the repository located at a depth of 600 meters. Special

material models were developed to account for the nonlinear material behavior of each rock type. The sensitivity analysis included variations in the in situ stress ratio, joint geometry, pore pressures, and the presence or absence of a fault. Three different sets of earthquake motions were used to excite the rock mass.

HARBORS AND DAMS

81-2541

Earthquake Analysis of Concrete Gravity Dams Including Dam-Water-Foundation Rock Interaction
A.K. Chopra and P. Chakrabarti
Univ. of California, Berkeley, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (4), pp 363-383 (July-Aug 1981) 9 figs, 1 table, 19 refs

Key Words: Dams, Concretes, Earthquake damage, Interaction: structure-fluid

A general procedure for analysis of the response of concrete gravity dams, including the dynamic effects of impounded water and flexible foundation rock, to the transverse (horizontal) and vertical components of earthquake ground motion is presented. The problem is reduced to one in two dimensions, considering the transverse vibration of a monolith of the dam. The system is analyzed under the assumption of linear behavior for the concrete, foundation rock and water. The complete system is considered as composed of three substructures -- the dam, represented as a finite element system, the fluid domain, as a continuum of infinite length in the upstream direction, and the foundation rock region as a viscoelastic half-plane. The structural displacements of the dam are expressed as a linear combination of Ritz vectors, chosen as normal modes of an associated undamped dam-rock system. The effectiveness of this analytical formulation lies in its being able to produce excellent results by considering only a few Ritz vectors. The generalized displacements due to earthquake motion are computed by synthesizing their complex frequency responses using Fast Fourier Transform procedures. The stress responses are calculated from the displacements. An example analysis is presented to illustrate results obtained from this analytical procedure. Computation times for several analyses are presented to illustrate the effectiveness of the procedure.

81-2542

Simulation of Strong Earthquake Motion with Contained-Explosion Line Source Arrays, Report on Task 6: Feasibility of Earth Dam Testing
P.N. Agrawal and J.R. Bruce

SRI International, Menlo Park, CA, Rept. No. NSF/RA-800421, 50 pp (Sept 1980)
PB81-174096

Key Words: Dams, Dynamic tests, Earthquake simulation

This study explores the feasibility, scope, and cost of dynamic testing of earth and rock-filled dams using explosives to generate the required earthquake-like ground motions. It was concluded that the response of dams to high-level sustained earth shaking, representative of actual earthquakes, can be investigated with explosive array techniques. The dams should be of small to moderate size and should be constructed in a special field test site with moderately strong native soil (not rock). Earth shaking would be provided by contained-explosion arrays that can produce the high-level sustained motion in repeated tests without replacement. It was also concluded that application of strong motion from explosive arrays is not practical because of the risk of damage to the dam or its surroundings.

81-2543

Hydrodynamic and Foundation Interaction Effects in Earthquake Response of a Concrete Gravity Dam
A.K. Chopra and S. Gupta
Univ. of California, Berkeley, CA, ASCE J. Struc. Div., 107 (ST8), pp 1399-1412 (Aug 1981) 15 figs, 3 tables, 8 refs

Key Words: Dams, Concretes, Earthquake response

The displacement and stress responses are presented for Pine Flat Dam to the S69E component of the Taft ground motion only, and to the S69E and vertical components acting simultaneously. For each of these excitations, the response of the dam is analyzed four times corresponding to the following four sets of assumptions: (a) Rigid foundation, hydrodynamic effects excluded; (2) rigid foundation, hydrodynamic effects included; (3) flexible foundation, hydrodynamic effects excluded; and (4) flexible foundation, hydrodynamic effects included. Based on these results, the separate effects of dam-water interaction and dam-foundation rock interaction, and the combined effects of the two sources of interaction, on earthquake response of dams are investigated.

CONSTRUCTION EQUIPMENT

81-2544

Evaluation of Vibratory Rollers for Bomb Damage Repair
K.J. Knox

Engrg. and Services Lab., Air Force Engrg. and Services Ctr., Tyndall AFB, FL, Rept. No. AFESC/ESL-TR-80-43, 71 pp (Aug 1980)
AD-A096 534

Key Words: Compactors, Vibratory techniques, Vibratory tools, Airports

Four vibratory rollers in the 8.5 to 17-ton range were evaluated for use in bomb damage repair of airfields. The rollers were tested for their compaction ability on grade crushed limestone. After this initial testing the two most promising rollers were tested by repairing simulated bomb craters using 24-inch thick layers of crushed limestone compacted only from the surface. These repairs were tested with F-4 load-craft traffic.

81-2545
Effect of Barriers on Propagation of Construction Noise
H.S. Gill
Inst. of Sound and Vib. Research, Southampton Univ., UK, Rept. No. ISVR-TR-113, 147 pp (Dec 1980)
PB81-166829

Key Words: Construction equipment, Noise barriers

The study reported is primarily concerned with investigating the effect of barriers on propagation of construction equipment noise and to examine the suitability of some of the more recent and widely used barrier theories. In addition, this study investigates the attenuation afforded by real sized cuttings and embankments with controlled loudspeaker sound source.

81-2546
Measurement and Prediction of Construction Plant Noise
H.S. Gill
Inst. of Sound and Vib. Research, Southampton Univ., UK, Rept. No. ISVR-TR-112, 230 pp (Sept 1980)
PB81-166837

Key Words: Construction equipment, Noise prediction, Noise measurement

The purpose of this report is to summarize the results of a study concerned with the prediction and measurement of noise exposure levels from construction machinery on a site. The relevance of this subject is illustrated by reference to national and international standards and legislation. This study was consummated through the development and validation of prediction and measurement methodologies by considering the following topics: propagation characteristics of noise from stationary and mobile sources over realistic ground surfaces; directivity patterns of noise from construction equipment; transmission of loss characteristics by a building facade; and noise monitoring from construction sites.

81-2547
Assessment and Propagation of Noise from Conventional and 'Quiet' Pile Drivers
H.S. Gill
Inst. of Sound and Vib. Research, Southampton Univ., UK, Rept. No. ISVR-TR-110, 184 pp (Sept 1980)
PB81-168866

Key Words: Pile drivers, Noise generation, Sound propagation

This report summarizes the results of a study aimed at defining some of the important basic characteristics of noise from conventional pile drivers, which are considered to be one of the most significant sources of noise annoyance in the community during civil engineering projects, and a range of pile driving devices which were either adapted or designed specifically to generate noise levels below those normally expected from conventional impact pile drivers. The parameters studied were noise levels, spectra and waveform shapes. This study has shown that recent legislation and other stimuli have resulted in a range of pile driving devices whose use, where circumstances permit, results in 10 to 40 dB(A) lower equivalent sound levels being generated by the extensively treated piling rigs as compared with the conventional untreated piling rigs, these reduced noise levels being equal to or less than that produced by other construction site noise sources. In addition, this study investigates the propagation characteristics of noise from pile drivers and also indicates how the noise from such a source is affected by the interposition of a barrier.

POWER PLANTS

81-2548
Noise Prediction for Fossil Fuel Power Plants
S. Shimode and H. Fujita

Mech. Engrg. Res. Lab., Hitachi, Ltd., Tsuchiura, Ibaraki, Japan, Noise Control Engrg., 17 (1), pp 22-29 (July-Aug 1981) 12 figs, 2 tables, 14 refs

Key Words: Fossil power plants, Electric power plants, Industrial facilities, Noise reduction

Noise control for large plants is one of the major pollution problems in Japan. Development of a technology for reliable prediction of the noise field for such plants is described. Characteristics of both sound sources and propagation paths are discussed in detail, mainly in reference to turbine housings of fossil fuel power plants. Comparison of the predicted noise field of a power plant with actual measurement showed good agreement and confirmed the usefulness of the prediction program developed.

81-2549

Response of a Thermal Barrier System to Acoustic Excitation in a Gas Turbine Nuclear Reactor

W.S. Betts, Jr. and R.D. Blevins

General Atomic Co., San Diego, CA, Rept. No. CONF-810309-7, 11 pp (Nov 1980)

GA-A-16016

Key Words: Nuclear reactors, Thermal insulation, Acoustic excitation, Vibration analysis

A gas turbine located with a high-temperature gas-cooled reactor induces high acoustic sound pressure levels into the primary coolant (helium). This acoustic loading induces high cycle fatigue stresses which may control the design of the thermal barrier system. This study examines the dynamic response of a thermal barrier configuration consisting of a fibrous insulation compressed against the reactor vessel by a coverplate which is held in position by a central attachment fixture. The results of dynamic vibration analyses indicate the effect of the plate size and curvature and the attachment size on the response of the thermal barrier.

OFF-SHORE STRUCTURES

81-2550

Parameter Adjustment of a Model of an Offshore Platform from Estimated Eigenfrequencies Data

H. Natke and H. Schulze

Curt-Risch-Institut f. Schwingungs- und Messtechnik, Universität, Hannover, D-3000 Hannover 1, Fed.

Rep. Germany, J. Sound Vib., 77 (2), pp 271-285 (July 22, 1981) 7 figs, 2 tables, 16 refs

Key Words: Off-shore structures, Drilling platforms, Parameter identification techniques, Damping coefficients

A full scale dynamic test which was incomplete because of rough seas and bad weather conditions and a computational model of the research platform "Nordsee" were the starting points of the work described in this paper. The transient excitation used in the test produced vibrations in the lower frequency range with certain identifiable eigenfrequencies and damping ratios. The identified eigenfrequencies were used as the basis for mass adjustment of the computational model. The computational model consists of a 176 degrees of freedom system, in which the flexible constraints and the virtual mass of water are neglected. The most uncertain data were the masses of the deck body. Parameter sensibility investigations, and a priori knowledge of the system and the test conditions led to an adjustment of the mass matrix partitioned corresponding to subsystems. The adjustment was carried out in a factorial global way, in respect to the defined subsystems. The result is an optimum model corresponding to the chosen loss function; the residuum used concerns the inverse eigenfrequency.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 2564, 2565, 2653, 2684, 2685, 2686)

81-2551

Analyzing Noise with Finite Elements

Machine Des., 53 (18), pp 148-153 (Aug 6, 1981) 1 ref

Key Words: Motor vehicle noise, Automobiles, Noise generation, Finite element technique

The use of the finite element technique to study noise propagation in intricate cavities is demonstrated by applying it in the analysis of an automobile compartment boom noise. Such noise is produced by cavity resonance excited by wind, loading engine vibration and road roughness. Results of the analysis show that seat shape has a significant effect on cavity resonance, suggesting that some design change may eliminate the booming phenomena.

81-2552

Reduction of Combustion Noise and Structural Improvement of Its Transmission Path in Diesel Engine Design

Y. Watanabe

Nissan Diesel Motor Co., Ltd., Ageo-shi, Japan, Intl. J. Vehicle Des., 2 (3), pp 276-288 (1981) 15 figs, 2 tables, 3 refs

Key Words: Trucks, Diesel engines, Noise reduction, Structural modification effects

In order to provide a quieter diesel engine as an essential component of low-noise trucks, a two-year investigation of combustion noise and engine structural analysis was carried out. Influences of various variables related to combustion noise were observed on a Vee type two-cylinder engine, and the variables which seemed to be effective for noise control were confirmed on a multi-cylinder engine. Structural analysis was advanced by using improved measuring techniques such as applications of laser holography, transfer function and F.F.T. Furthermore, the adoption of accelerated running simulation on an eddy-current dynamometer made noise evaluation possible in an engine operating condition that was close to the actual vehicular situation. The target figure of engine noise reduction, 2 to 4 dB(A), could be almost achieved by cylinder block structural modification and turbocharging or by increasing the compression ratio for N.A. engines. Engine noise control techniques found to be effective and their problems are also discussed.

81-2553

Analysis of Wheel Rail Force and Flange Force During Steady-State Curving of Rigid Trucks

H. Weinstock and R. Greif

Transportation Systems Ctr., Cambridge, MA, ASME Paper No. 81-RT-5

Key Words: Trucks, Interaction: rail-wheel

The wheel/rail forces and flange forces resulting from steady-state curve negotiation are developed through analysis of a rigid two-axle truck. The analysis provides closed form relations for estimating wheel/rail forces, flange forces, truck angle of attack and sliding conditions for this type of truck as a function of curve radius. The wheel profiles are modeled by conical wheel treads with vertical wheel flanges and flange friction effects are included. The theory used includes both linear and nonlinear creep.

81-2554

An Application of Stereoscopic Techniques Using

Mobile High-Speed Cameras in Automotive Crash Simulation

A. Lozzi and J. Chapman

Dept. of Mech. Engrg., Univ. of Sydney, Australia, Intl. J. Vehicle Des., 2 (3), pp 299-307 (1981) 6 figs, 3 refs

Key Words: Collision research (automotive), Photographic techniques

Parallel axis stereophotography has been applied to record events of an automotive crash simulation. Two 16 mm, high frame rate, high acceleration cameras were used of the type developed for use on board military aircraft. The cameras travelled with the crashing vehicle, and were mounted on a rigid frame which was in turn attached to the floor pan of the vehicle. The crashes referred to here simulated car-to-pole side impacts. The cameras provided a stereoscopic record of events within the body shell's interior during the impact. Displacements and velocities of the anthropomorphic dummies seated in the body shell and of the intrusion caused by the pole, were determined using a single stereo photogrammetric method. Depth measurements were obtained with relative errors of about 1%, or 15 mm.

SHIPS

(See No. 2629)

AIRCRAFT

(Also see No. 2622)

81-2555

Structure-Borne Noise Prediction for a Single-Engine General Aviation Aircraft

J.F. Unruh

Southwest Res. Inst., San Antonio, TX, J. Aircraft, 18 (8), pp 687-694 (Aug 1981) 13 figs, 1 table, 9 refs

Key Words: Aircraft noise, Structure-borne noise, Interior noise, Noise prediction, Finite element technique

The usefulness of a deterministic modeling procedure employing structural-acoustic finite-element formulations is investigated for the prediction of structure-borne interior noise. Analytical predictions are compared to normal mode, forced harmonic response, and engine-running experimental data obtained during ground tests of a single-engine general aviation aircraft. From these comparisons, the modeling procedures are shown to be sufficiently accurate for structure-borne interior noise prediction.

81-2556

An Optimization Method for the Determination of the Important Flutter Modes

E. Nissim and I. Lottati

Technion - Israel Inst. of Tech., Haifa, Israel, J. Aircraft, 18 (8), pp 663-668 (Aug 1981) 11 figs, 4 tables, 9 refs

Key Words: Aircraft, Flutter, Optimization

An optimization method for the determination of the dominant flutter modes is presented in this paper. The method is based on the minimization of the quadratic values of sub-determinants derived from the equations of motion. The effectiveness of the method is illustrated by seven numerical examples.

81-2557

Forced Backward Whirling of Aircraft Propeller-Engine Systems

S.H. Crandall and J. Dugundji

Massachusetts Inst. of Tech., Cambridge, MA, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 265-270, 5 figs, 4 refs

Key Words: Aircraft engines, Propellers, Propeller blades, Whirling

Transverse excitation of a light aircraft engine block by the sequential firing of the cylinders can excite a natural mode of vibration which involves backward whirling of the engine at the excitation frequency and propeller blade vibration at a frequency that is the sum of the excitation frequency and the engine speed. The phenomenon is explained in terms of a simplified model with only two non-trivial degrees of freedom.

81-2558

Crashworthiness Design Parameter Sensitivity Analysis

A.E. Tanner

Boeing Vertol Co., Philadelphia, PA, Rept. No. USAAVRADCOM-TR-80-D-31, 281 pp (Feb 1981) AD-A096 550

Key Words: Aircraft, Crash research (aircraft), Crashworthiness, Design techniques

This program investigated the relationships between aircraft weight, the level of crashworthiness in the design, and the cost and weight associated with crashworthiness elements of the design. Accident and research data were reviewed and actual aircraft designs were analyzed with respect to their levels of crashworthiness and potential improvements. Processing of the data yielded cost and weight curves for use in preliminary design. The curves provide the relationships between gross weight, mean empty weight, levels of crashworthiness, and selected design elements that contribute to crashworthiness for designs employing metallic or composite materials and having gross weights up to 50,000 pounds. Comparisons were made with the current ACAP analyses and results showed good agreement for the weight values and level of crashworthiness.

81-2559

Development of Advanced Techniques for Rotorcraft State Estimation and Parameter Identification

W.E. Hall, Jr., J.G. Bohn, and J.H. Vincent
Systems Control, Inc., (VT), Palo Alto, CA, Rept. No. NASA-CR-159297, 265 pp (Nov 1980) N81-19098

Key Words: Helicopters, Parameter identification techniques

An integrated methodology for rotorcraft system identification consists of rotorcraft mathematical modeling, three distinct data processing steps, and a technique for designing inputs to improve the identifiability of the data. These elements are as follows: (1) a Kalman filter smoother algorithm which estimates states and sensor errors from error corrupted data. Gust time histories and statistics may also be estimated; (2) a model structure estimation algorithm for isolating a model which adequately explains the data; (3) a maximum likelihood algorithm for estimating the parameters and estimates for the variance of these estimates; and (4) an input design algorithm, based on a maximum likelihood approach, which provides inputs to improve the accuracy of parameter estimates. Each step is discussed with examples to both flight and simulated data cases.

MISSILES AND SPACECRAFT

81-2560

Seismic Hazards Studies for Minuteman Missile Wings
J.C. Battis

Air Force Geophysics Lab., Hanscom AFB, MA,
Rept. No. AFGL-TR-80-0293, 73 pp (Sept 9, 1980)
AD-A096 720

Key Words: Missiles, Seismic response

Using standard methods of probabilistic seismic risk analysis, estimates of the seismic hazards for six Minuteman missile wings were evaluated. For each site, estimates of the site intensity, acceleration, velocity and displacement annual risk curves were made based on the historical seismicity within 1000 km of each site. Based on these curves, composite design response spectra for 10-, 100-, and 1000-year return period motions were calculated. Plots of the reported earthquake epicenters near each site were also generated. To conduct these studies, a new method for regional modification of peak acceleration attenuation functions was developed and is presented in the appendix to this report.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see No. 2568)

81-2561

Seismic Effectiveness of Tuned Mass Dampers

A.M. Kaynia, D. Veneziana, and J.M. Biggs
Massachusetts Inst. of Tech., Cambridge, MA, ASCE
J. Struc. Div., 107 (ST8), pp 1465-1484 (Aug 1981)
11 figs, 1 table, 22 refs

Key Words: Tuned dampers, Single degree of freedom systems, Earthquake response, Buildings

Time history analysis of one degree of freedom systems with and without a tuned mass damper, subjected to a set of historical earthquakes, shows that the peak response ratio (ratio between the peak responses with and without damper) depends primarily on damping constants and on earthquake duration. The same analysis reveals that response ratio values are widely scattered and that the mean response ratio is underestimated by conventional stationary random vibration calculations. Improvement is obtained by considering response movement and broadening of the response spectral density function caused by the damper. Based on these considerations, a probabilistic model is developed that gives the distribution of peak response of buildings modified by addition of a tuned mass damper in terms of the same distribution for the unmodified structures.

81-2562

Avoiding Compromise in Engine Mounting

R. Racca

Barry Controls, Barry Wright Corp., Diesel Progress
North American, 47 (8), pp 34-36 (Aug 1981)

Key Words: Mountings, Engine mounts

The author stresses the importance of proper mounting of an automobile engine, requiring a good understanding of the effect of dynamic loads on the engine. A dynamic analysis procedure is described.

81-2563

Design and Performance of Resonant-Cavity Parallel Baffles for Duct Silencing

P.T. Soderman

U.S. Army Research and Technology Lab., Ames
Res. Ctr., Moffett Field, CA, Noise Control Engrg.,
17 (1), pp 12-21 (July-Aug 1981) 18 figs, 1 table,
25 refs

Key Words: Silencers, Baffles, Ducts, Noise reduction

To control noise emission from large ducts, designers often choose some variation of parallel baffles filled with fibrous material. The acoustic performance of such silencers can be very good, but in severe environments they are susceptible to clogging, erosion and settling. There is an alternative - resonant-cavity parallel baffles. This type of baffle, either empty or with a thin absorbent lining pinned to an internal septum, is virtually immune to the above problems. An analytical and experimental study of resonant-cavity baffle silencers, including comparisons with fiberglass-filled baffles, is described.

81-2564

Fundamental Study on Semi-Actively Controlled Pneumatic Servo Suspensions for Rail Cars

K. Jindai, K. Kasai, K. Terada, Y. Kakehi, and F. Iwasaki

Japanese Natl. Railways, Tokyo, Japan, ASME Paper
No. 81-RT-6

Key Words: Railroad cars, Suspension systems (vehicles), Semiactive isolation

Semi-actively controlled suspension systems were devised to reduce the vibrations of railroad passenger cars. Two

vertical and one lateral pneumatic servo cylinders were mounted parallel to the air springs on each truck. The acceleration signal of the car body above each cylinder was transferred independently to each controller, and the vertical and lateral controllers were adjusted to approximate the results of the optimum analysis of vertical vibration mode and yawing mode respectively.

81-2565

An Experimental Comparison Between Semi-Active and Passive Suspensions for Air-Cushion Vehicles

D. Hrovat and D.L. Margolis

Dept. of Mech. Engrg., Wayne State Univ., Detroit, MI, Intl. J. Vehicle Des., 2 (3), pp 308-321 (1981) 9 figs, 2 tables, 15 refs

Key Words: Suspension systems (vehicles), Ground effect machines, Dampers, Active damping, Semiactive isolation, Passive isolation

An experimental heave mode model of a tracked air cushion vehicle incorporating on-off semi-active (SA) damper suspension is described. Preliminary tests are conducted to assess the SA pneumatic damper characteristics. For identical sinusoidal ground inputs, the totally passive and on-off SA damping schemes are compared in terms of sprung mass vibration isolation properties. It is shown that the semi-active suspension offers significant advantages over the corresponding passive suspensions, while at the same time requiring only a small amount of control energy.

BLADES

81-2566

Further Studies of Bladed Disc Vibration: Effects of Packeting

D.J. Ewins

Imperial College of Science and Tech., London, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 97-102, 5 figs, 12 refs

Key Words: Blades, Turbomachinery, Tuning

Various studies made in recent years of the effects of blade mistuning on the vibration characteristics of turbomachine bladed disc assemblies have provided an understanding and

explanation of many of the complex blade vibration phenomena observed under operating conditions. The concepts and techniques introduced in those studies have now been further developed to explore a new range of conditions; namely, where the 'mistuning' is no longer 'small' and is introduced deliberately. Such conditions prevail in bladed assemblies where the blades are grouped in packets either for convenience of assembly (as in steam turbines) or in order to induce a significant detuning of a certain assembly mode. The characteristics of such assemblies are described and their relationship to the corresponding properties of a symmetrical or tuned system established, since the computational effort required to analyze a packeted bladed disc is very much greater than for its continuously-shrouded counterpart.

81-2567

Stall Flutter of Linear Cascade in Compressible Flow

S. Kaji

Univ. of Tokyo, Tokyo, Japan, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 209-214, 6 figs, 5 refs

Key Words: Cascades, Jet engines, Fans, Flutter

Stall and non-stall bending mode flutter in high subsonic and supersonic flows is analyzed by the semi-actuator disc theory. Transonic two-dimensional cascade test data are used for the estimation of total pressure-loss change due to airfoil oscillation. Occurrence of 'resonance flutter' which is different from usual stall flutter is predicted. This flutter arises near the cascade resonance conditions for highly loaded cascades in high Mach number flows. Flutter boundaries obtained for subsonic flows and supersonic flows show quite different variations against the change in flow incidence. It is also shown that the direction of airfoil oscillation has a significant effect on flutter boundaries.

BEARINGS

(Also see Nos. 2506, 2527, 2659, and 2670)

81-2568

Gyroscopes with Ball Bearing Suspension

V.F. Zhuravlev and D.M. Klimov

Inst. for Problems in Mechanics, Moscow, USSR, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 367-368, 1 fig, 3 refs

Key Words: Bearings, Ball bearings, Gyroscopes, Vibration analysis

Ball bearing suspension, which is often used in gyroscopic devices, constitutes a complex system of many elastic bodies (balls, rings, retainers). Special coordinates introduced allow calculation of the potential energy of gyroscopic systems taking into account all possible imperfections in ball bearings. The linear equations of motion of rotor in nonideal ball bearings derived define the spectrum and the level of vibration. The nonlinear equations allow discovery of a few fine phenomena (such as impossibility of exact balancing of rotor in nonideal ball bearings, etc.).

81-2569

Experimental Study of an Inter-Shaft Squeeze Film Bearing

J.B. Courage

Rolls Royce, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 375-380, 10 figs, 8 refs

Key Words: Bearings, Rolling contact bearings, Squeeze-film dampers

The application of squeeze films to the static outer races of rolling element bearings is now common practice in gas turbine engines. However many engines also feature inter-shaft bearings where the benefits of squeeze films could be equally significant. This paper describes an experimental program that has been carried out on a model twin shaft rig to evaluate the feasibility of such a device.

81-2570

Rubber Surface Squeeze Film

Y. Hori, T. Kato, and H. Narumiya

Dept. of Mech. Engrg., The Univ. of Tokyo, Bunkyo-ku, Tokyo, Japan, J. Lubric. Tech., Trans. ASME, 103 (3), pp 399-405 (July 1981) 13 figs, 10 refs

Key Words: Bearings, Squeeze film bearings, Elastomers, Low frequencies, High frequency excitation

Numerical solutions for the squeeze film problem, in which one of the surfaces is made of rubber and moves sinusoidally, are presented. Viscoelasticity and incompressibility of the rubber are taken into account in the numerical procedures. The solutions agree well with the experiments. Variation of the squeeze film shape with time is measured by the moiré

topography. This will be one of the best methods for measuring the film thickness when the lubricating surface is made of soft materials like rubber.

81-2571

Some Damping and Stiffness Characteristics of Angular Contact Bearings under Oscillating Radial Load

T.L.H. Walford and B.J. Stone

Bearing Res. Ctr., Newark, Notts, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 157-162, 4 figs, 2 tables, 4 refs

Key Words: Bearings, Rolling contact bearings, Damping coefficients, Stiffness coefficients, Lubrication

Damping and stiffness measurements are presented for a pair of angular contact bearings which show damping increasing and stiffness decreasing as oil viscosity is reduced. A theoretical model is presented which indicates that the stiffness of the interfaces, between the races and the housing and shaft, is a very significant parameter and is the cause of the observed effect.

81-2572

Magnetic Bearings - A Novel Type of Suspension

G. Schweitzer and H. Ulbrich

Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 151-156, 10 figs, 12 refs

Key Words: Bearings, Magnetic bearings, Rotors

It is well known that a rotor can be supported without contact and without wear by suitable electromagnetic forces. The technical implementation of the basic idea, however, is still rather uncommon. By means of examples the state of the art and possible future trends of the theory and the application of magnetic bearings are demonstrated. One example, the full magnetic suspension of a centrifuge in a vacuum tube, is treated comprehensively.

81-2573

An Instrument for the Measurement of Long-Term

Variations of Vertical Bearing Alignments in Turbo-generators

A. Clapis, G.L. Lapini, and T. Rossini
Centro Informazioni Studi Esperienze, Milano, Italy,
Vibrations in Rotating Machinery, Proc. 2nd Intl.
Conf., Churchill College, Cambridge, UK, Sept 1-4,
1980, organized by Instn. Mech. Engrs., pp 119-124,
10 figs, 3 refs

Key Words: Bearings, Turbogenerators, Alignment, Measurement techniques

A special instrument, called ADE, is described, purposely developed to measure the long-term variations of vertical bearing alignments in turbogenerators. The instrument is based on the communicating vessel principle. A proper number of interconnected cups containing mercury are attached to the machine supports. The liquid level variations in the cups, due to their vertical movements, are measured by proximity transducers fixed on the cup tops. The paper presents a summary of results from measurements by the ADE system on two large turbogenerators where the alignment changes have caused vibration problems.

81-2574

Generation of Squeal/Chatter in Water-Lubricated Elastomeric Bearings

A.I. Krauter
Tech. Dept., Shaker Research Corp., Ballston Lake,
NY, J. Lubric. Tech., Trans. ASME, 103 (3), pp
406-413 (July 1981) 7 figs, 3 tables, 5 refs

Key Words: Bearings, Elastomeric bearings, Chatter

This paper presents results from an investigation concerned with vibrational characteristics of compliant-layer water-lubricated bearings. An experimental apparatus emulates the dynamic interactions between the propeller shaft and a water-lubricated elastomeric bearing stave. A computer model predicts the squeal tendency of the experimental apparatus. Correlations are obtained by using the apparatus to verify the predicted squeal tendency. Utilizing the computer model, the effects of varying system parameters on squeal/chatter are determined quantitatively. From the results obtained, it is found that the slope of the friction-speed curve and the effective structural damping are the most important parameters. It is concluded that the essential features of squeal/chatter have been identified and that the phenomenon can be modeled analytically.

81-2575

Dynamically Tuned Gyroscopes and Their Spin Axis Bearings

D.G. Bonfield and D.J. Haines

Univ. of Southampton, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 327-332, 3 figs, 3 tables, 5 refs

Key Words: Bearings, Gyroscopes, Tuning

British Aerospace work on rotor restraint and vibration problems which can limit dynamically tuned gyroscope performance is discussed. The work has resulted through careful design, development and control of critical parts in a series of dynamically tuned gyroscopes to meet missile, aircraft and ship guidance requirements. Gyro rotors mounted on a single gimbal and subject to excitation may now be trimmed to a drift rate of less than $0.1^\circ/\text{hour}$. For other applications a double gimbal, two axis free rotor unit has been developed in which a number of torsion flexing hinged elements are arranged in a manner similar to two interlaced Hooke's joints but where the freely pivoting hinges of the latter are replaced by torsion cross leaf springs and the intermediate frame members of the couplings act as dynamic gimbals. Drift rates of much less than the above are achieved with these units.

81-2576

Effects of Vibrations Generated by Spin Axis Bearings on Gyroscopic Northfinding Equipment

B.T. Trayner
Stevenage Div., British Aerospace Dynamics Group,
Stevenage, Herts SG1 2DA, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 347-352, 4 figs, 1 table, 3 refs

Key Words: Bearings, Gyroscopes, Beat frequency

The paper outlines a particular problem associated with the production of a first generation northfinder due to beating between the angular velocity of the two cages in the spin axis system. This beat frequency was troublesome when very low (with a period of up to 200 seconds) and very low values appeared with an occurrence rate which was higher than would be predicted by the bearing geometry. The practical solution to the problem which was adopted is given and the influence that this had on the design of a second generation northfinder is discussed.

81-2577

On the Steady State and Dynamic Performance Characteristics of Floating Ring Bearings

C.-H. Li and S.M. Rohde
Mech. Res. Dept., General Motors Res. Labs., Warren,
MI, J. Lubric. Tech., Trans. ASME, **103** (3), pp 389-
397 (July 1981) 18 figs, 13 refs

Key Words: Bearings, Floating ring journal bearings, Journal bearings, Periodic response

An analysis of the steady state and dynamic characteristics of floating ring journal bearings has been performed. The stability characteristics of the bearing, based on linear theory, are given. The transient problem, in which the equations of motion for the bearing system are integrated in real time was studied. The effect of using finite bearing theory rather than the short bearing assumption was examined. Among the significant findings of this study is the existence of limit cycles in the regions of instability predicted by linear theory. Such results explain the superior stability characteristics of the floating ring bearing in high speed applications. An understanding of this nonlinear behavior serves as the basis for new and rational criteria for the design of floating ring bearings.

81-2578

The Effects of Unbalance on Stability and Its Influence on Non-Synchronous Whirling

R.H. Bannister and J. Makdissy
Cranfield Inst. of Tech., UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instrn. Mech. Engrs., pp 395-400, 12 figs, 4 refs

Key Words: Bearings, Journal bearings, Hydrodynamic excitation, Whirling, Nonsynchronous vibration

When investigating the behavior of hydrodynamic journal bearings, the criteria for instability is usually defined as a single line on the stability map and no attempt is made to explain the possible working limits between the stable and unstable zones. The work presented is intended as an introduction, explaining the transitional stages of instability and suggests how to estimate the severity of instability by pattern recognition. The influence of nonlinearity of the oil film is also demonstrated, by staging the onset of instability and noting the stabilizing influence made to the bearing for varying magnitudes of unbalance force.

81-2579

On the Dynamic Behaviour of Gyroscopic Systems that Include Oil Lubricated Journal Bearings

H. McCallion and P.M. Ware

Dept. of Mech. Engrg., Univ. of Canterbury, Christchurch, New Zealand, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instrn. Mech. Engrs., pp 133-138, 6 figs, 7 refs

Key Words: Bearings, Journal bearings, Rotors, Shafts, Gyroscopes

Results are reported from a theoretical study into the influences of a number of system parameters on the stability of a family of systems in conical motion. Each member was comprised of a massive rotor, an elastic shaft and a journal bearing. Small oscillations about a steady running position were studied by linearizing the oil film characteristics and it was found that the higher natural frequency could be unstable even when its value was as high as 0.8 times the spin velocity of the shaft. Whirl velocities greater than 0.5 times the spin velocity are not usually associated with oil whip. It is also shown by numerical simulation that some members of this family of systems may be stable at low amplitudes and unstable at high amplitudes and vice versa.

81-2580

Identification of Journal Bearing Coefficients Using a Pseudo-Random Binary Sequence

I.U. Dogan, J.S. Burdess, and J.R. Hewit
Dept. of Mech. Engrg., Univ. of Newcastle upon Tyne, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instrn. Mech. Engrs., pp 277-281, 4 figs, 8 refs

Key Words: Bearings, Journal bearings, Parameter identification techniques, Stochastic processes, Spectrum analysis

A stochastic identification technique based upon spectral analysis has been developed to provide a dynamic model of a journal bearing. An outline of the basic theory is given and the results of experimental work carried out on a laboratory journal bearing are described. Direct and cross transfer functions are derived from the bearing response to pseudo binary excitation and the bearing coefficients determined by optimally fitting theoretical transfer functions to the experimental results.

81-2581

Experimental and Analytical Research on a Full Scale Turbine Journal Bearing

G. Diana, D. Borgese, and A. Dufour

Mechanics of Machinery Inst., Milan, Italy, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 309-314, 9 figs, 1 table, 7 refs

Key Words: Bearings, Journal bearings, Turbines

The purpose of the research is to determine the statistical and dynamical behavior of a large sized lubricated bearing. A testing campaign has been carried out on a full scale bearing of a low pressure turbine in a 320 MW turbo alternator. The results are compared with analytical ones.

81-2582

Experiments on the Dynamic Characteristics of Large Scale Journal Bearings

S. Hisa, T. Matsuura, and T. Someya

Turbine Works, Toshiba Corp., Yokohama, Japan, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 223-230, 9 figs, 1 table, 6 refs

Key Words: Bearings, Journal bearings, Stiffness coefficients, Damping coefficients

The dynamic characteristics of large scale journal bearings were studied with special reference to the 20-in. diameter load on pads bearing and 32-in. diameter elliptical bearing. Experiments were carried out in a full scale bearing test rig in which static loads up to 80 tons and dynamic loads between ± 3 and ± 9 tons with the frequency ranging from 20 Hz to 60 Hz can be imposed upon the test bearing. Stiffness and damping coefficients in both laminar and turbulent regime were obtained, and some features of the dynamic characteristics of the two bearings are discussed. It is also suggested that the outlet oil temperature should be used as the representative temperature for the oil film viscosity. Coefficients are applied for the unbalance response analysis of large steam turbogenerator rotors in service.

81-2583

Identification of Stiffness and Damping Coefficients of Journal Bearings by Means of the Impact Method

R. Nordmann and K. Schöllhorn

Technische Hochschule Darmstadt, Fed. Rep. Germany, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK,

Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 231-238, 12 figs, 4 refs

Key Words: Bearings, Journal bearings, Stiffness coefficients, Damping coefficients, Parameter identification techniques, Impact tests

This paper describes an identification method to find system parameters of rotating machines, especially the bearing stiffness and damping coefficients. A rigid rotor, running in journal bearings, is excited by a hammer (pulse testing). Input signals (forces) and output signals (displacements of the rotor) are transformed into the frequency domain and the complex frequency response functions are calculated. Analytical frequency response functions, which depend on the bearing coefficients, are fitted to the measured functions. Stiffness and damping coefficients are the results of an iterative fitting process. Results for a cylindrical bearing are presented and compared with coefficients from other authors.

81-2584

Analytical Nonlinear Bearing Calculations Using a Variational Approach

L.E. Barrett, P.E. Allaire, and D.F. Li

Dept. of Mech. and Aerospace Engrg., Univ. of VA, Charlottesville, VA, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 247-252, 3 figs, 9 refs

Key Words: Bearings, Journal bearings, Variational methods

A solution to the variational equivalent of Reynolds equation for finite length plain cylindrical and segmented journal bearings is presented. An infinite trigonometric series expansion of the pressure field is assumed and the expansion coefficients are found by minimization of the variational principle. The method is intended for use in nonlinear time transient simulations of rotor-bearing systems where finite difference and finite element solutions are computationally too costly to be employed.

81-2585

Estimation of Seal Bearing Stiffness and Damping Parameters from Experimental Data

S.B. Childs, D.W. Childs, and J. Dresden

Texas A&M Univ., College Station, TX, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Church-

ill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 175-180, 4 figs, 1 table, 19 refs

Key Words: Test stands, Measurement techniques, Rotors, Seals, Bearings, Stiffness coefficients, Damping characteristics

A test stand has been constructed to measure displacements and forces related to high performance rotors and their bearings and seals. An existing code for solution of boundary value problems in ordinary differential equations is used to estimate the stiffness and damping parameters for the rotor-bearing-seal. Test results indicate that the test stand and method give a more reliable and economical means of estimating these coefficients than other published means.

GEARS

(Also see Nos. 2656, 2657, 2671, 2676)

81-2586

Vibration Spectra from Gear Drives

A.W. Lees and P.C. Pandey

Scientific Services Dept., Ratcliffe-on-Soar, Nottingham, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 103-108, 4 figs, 3 refs

Key Words: Gear drives, Vibration response spectra

Manufacturing errors are known to have a major influence on the dynamic performance and integrity of gear drives. For example, in large pulverizing mill drive trains, some of the low-speed gears are so heavily loaded that they suffer significant wear quite early in life. Usually there is enough metal in the teeth to give many years' service but profile errors result in increased dynamic gear tooth forces in the worn gears, as well as in the other gears in the drive train. It is important to know the magnitude of these increased forces so that, if necessary, remedial action can be taken to avoid premature failure. The complete shaft/bearing system is analyzed as a set of segments, each segment terminated at a gear mesh. Equations of constraint are then applied which impose on the system an amplitude-controlled vibration (which may be both flexural and torsional). It is shown how this leads to a response which contains frequencies that are orders of shaft speed, as well as frequencies which are independent of shaft speed. Good agreement is observed between vibration spectra taken from operational plant items and spectra predicted theoretically.

COUPLINGS

81-2587

The Selection of Couplings for Engine Test Beds

C.A. Beard

Ricardo Consulting Engineers, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 115-118, 3 figs, 2 refs

Key Words: Couplings, Test facilities, Engines, Combustion engines, Whirling, Torsional response

Problems exist in the selection of couplings for high speed internal combustion engine testbeds. These are reviewed briefly and an approximate, but safe, method for selecting a suitable coupling for particular duties is given. Reference is made to the need to check whirling characteristics as well as the purely torsional aspects. A number of practical installation requirements are referred to briefly.

FASTENERS

81-2588

Vibration Aspects of Rolling Mill Horizontal Drives with Reference to Recent Coupling Development

C. Patterson, J.L. Wearing, and J.D. Fletcher

Dept. of Mech. Engrg., Univ. of Sheffield, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 315-320, 5 figs, 2 tables, 6 refs

Key Words: Joints (junctions), Universal joints, Metal working, Torsional vibration, Translational response, Vibration control

This paper presents a critical survey of the development and increasing industrial use of Hooke (Cardan) joints where high torques are involved. Their use in rolling mill horizontal drives in the metal processing industry is discussed as a specific example and the effects on operating and vibratory behavior identified. The use of these couplings reduces translational and torsional vibratory motion in the mill drives resulting in reduced maintenance, wear and power consumption and improved product quality.

81-2589

Lap Splices in Reinforced Concrete under Impact

T. Rezanoff, J.O. Jirsa, and J.E. Breen

Dept. of Civil Engrg., Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada, ASCE J. Struc. Div., 107 (ST8), pp 1611-1628 (Aug 1981) 9 figs, 4 tables, 10 refs

Key Words: Bonded structures, Joints (junctions), Beams, Concretes, Reinforced concrete, Impact response

The performance of lap splices subjected to impact loading was studied and compared with that of splices under static loading. Nineteen specimens were tested under impact loading, with failure produced in either one impact, in the three to five impacts of incrementally increasing magnitude, or under either unidirectional or reversed cycling of the impact load. Analytical studies were carried out to help evaluate the experimental data. The impact moment capacity of the splices tested was equal to or greater than the static moment capacity.

LINKAGES

81-2590

The Application of Finite Element Methods to the Dynamic Analysis of Flexible Spatial and Co-Planar Linkage Systems

W. Sunada and S. Dubowsky

School of Engrg. and Applied Science, Univ. of California, Los Angeles, CA, J. Mech. Des., Trans. ASME, 103 (3), pp 643-651 (July 1981) 13 figs, 2 tables, 24 refs

Key Words: Linkages, Finite element technique, NASTRAN (computer programs), Component mode synthesis

An analytical method is presented for the dynamics of spatial mechanisms containing complex-shaped, flexible links with application to both high-speed industrial machines and robotic manipulators. Existing NASTRAN-type finite element structural analysis programs are combined with 4 x 4 matrix dynamic analysis techniques and Component Mode Synthesis coordinate reduction to yield a procedure capable of analyzing complex, nonlinear spatial mechanisms with irregularly shaped links in great detail, yet producing a system of equations small enough for efficient numerical integration. The method is applied to two examples.

VALVES

81-2591

Pressure Relief Valve Noise Attenuation

T.R. Bordelon and J.F. Etherington

Dresser Industries, Alexandria, LA, ASME Paper No. 81-PVP-38

Key Words: Valves, Pressure regulators, Noise reduction

Noise sources related to safety relief valve discharge piping systems are identified. A brief discussion of noise terminology is presented in conjunction with a method of estimating the magnitude of noise sources. Methods to reduce noise levels along with silencer selection and installation guidelines are presented.

SEALS

(Also see No. 2585)

81-2592

Labyrinth Seal Effects on Rotor Whirl Instability

B.T. Murphy and J.M. Vance

Dept. of Mech. Engrg., Texas A&M Univ., College Station, TX, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 369-373, 3 figs, 1 table, 6 refs

Key Words: Seals, Rotors, Whirling

The destabilizing effect of labyrinth seals on rotor whirl was first identified by Alford in 1965. Alford's analytical model included the assumption of choked flow at both the inlet and outlet blades of a two blade seal. This paper points to other information which indicates that choked flow can exist only at the exit blade. Under the latter assumption an analysis is performed for a multiblade labyrinth seal. The effects on rotor response and whirl stability are discussed.

81-2593

Flow Induced Spring Constants of Labyrinth Seals

H. Benckert and J. Wachter

Institut fuer Thermische Stroemungsmaschinen, Univ. of Stuttgart, Stuttgart, Germany, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill

College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 53-63, 13 figs, 14 refs

Key Words: Rotors, Seals, Compressors, Fluid-induced excitation

Self-excited rotor vibrations which are a function of output are being increasingly observed in high-performance turbomachinery, in particular high-pressure compressors. A possible source of these rotor instabilities lies in the dynamic behavior of the labyrinth seals. Information on flow-induced spring constants in these types of machines is necessary to achieve a more effective vibration analysis. The work presented deals with the force patterns in eccentric-mode labyrinth seals, the exciting lateral force components perpendicular to the rotor displacement plane, and the restoring force components in this plane. The discussion includes the effects of operational parameters such as the differential pressure ratio, speed and entry flow conditions as well as the geometry of the labyrinth on the spring characteristics of these components. Stability calculations for a high-pressure steam turbine and a radial compressor demonstrate the application of the results.

81-2594

Elastohydrodynamic Lubrication of Offset O-Ring Rotary Seal

M.S. Kaisi

Kaisi Engrg., Inc., Houston, TX, J. Lubric. Tech., Trans. ASME, 103 (3), pp 414-427 (July 1981) 27 figs, 21 refs

Key Words: Shafts, Seals, Elastomeric seals, Lubrication, Elastohydrodynamic properties

A fundamental research into the lubrication mechanism and operation of a new type of rotary shaft seal has been conducted. Optical interference technique was successfully used to study the film profiles with optically smooth elastomer seals. Elastohydrodynamic lubrication was found to exist over a wide range of operating conditions. A study of the other performance variables for the Offset-Seal define its useful application range to be between the Packing-Gland and Face-Seal.

81-2595

An Analysis of Mechanical Face Seal Vibrations

I. Etsion and Y. Dan

Dept. of Mech. Engrg., Technion, Haifa, Israel, J.

Lubric. Tech., Trans. ASME, 103 (3), pp 428-435 (July 1981) 4 figs, 21 refs

Key Words: Seals, Rings, Vibration analysis

The motion of a flexibly mounted ring in a mechanical face seal is described in its major three degrees of freedom. The equations of motion include fluid film as well as flexible support forces and moments. These equations are linearized using small perturbation analysis. It is shown that for small perturbation the axial motion is uncoupled with the two angular ones and is always stable. A condition for angular stability is derived relating seal operating conditions to its geometry and other design parameters.

81-2596

Analysis of High Pressure Oil Seals for Optimum Turbocompressor Dynamic Performance

R.G. Kirk and J.C. Nicholas

Turbo Machinery Group, Ingersoll-Rand Co., Phillipsburg, NJ, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 125-131, 10 figs, 3 refs

Key Words: Seals, Turbocompressors, Rotors, Computer-aided techniques, Vibration analysis

The influence of high pressure oil seal rings on the response and stability of turbocompressors is discussed and a method of analysis presented which can be automated for digital computer simulation. The method of analysis is summarized for calculation of the dynamic characteristics including the influence of sealing pressure and thermal equilibrium of the oil film. The results of automated dynamic simulations of turbocompressor systems, including the influence of oil seals, are presented for both steady-state response and dynamic stability. The advantages and disadvantages of the oil seals with regard to vibration performance are discussed for supercritical operation.

STRUCTURAL COMPONENTS

BARS AND RODS

81-2597

Apparent Complex Young's Modulus of a Longitudinally Vibrating Viscoelastic Rod

T. Pritz

Central Research and Design Inst. for Silicate Industry, 1034 Budapest, Becs ut 126/128, Hungary, J. Sound Vib., 77 (1), pp 93-100 (July 8, 1981) 5 figs, 1 table, 19 refs

Key Words: Rods, Viscoelastic properties, Wave propagation, Longitudinal vibration

Longitudinal vibration of a viscoelastic rod with a finite lateral dimension is theoretically analyzed on the basis of the approximate Love theory. The frequency range where the Love theory gives good approximation and its accuracy in that range are determined. The theory predicts that the wave propagation in a viscoelastic rod is not governed solely by the complex Young's modulus of the material at higher frequencies, due to the lateral motion, but by its apparent value. It is shown that the apparent dynamic Young's modulus is smaller and the apparent loss factor is larger than the corresponding actual values for the material. The differences between the apparent and actual values depend on the lateral dimension to wavelength ratio and on the complex elastic constants as well.

BEAMS

(Also see No. 2511)

81-2598

Dynamic Response of a Beam with a Geometric Nonlinearity

S.F. Masri, Y.A. Mariamy, and J.C. Anderson
Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA, J. Appl. Mechanics, Trans. ASME, 48 (2), pp 404-410 (June 1981) 9 figs, 17 refs

Key Words: Beams, Geometric effects, Viscous damping, Harmonic excitation, Random excitation

Analytical and experimental studies were made of the dynamic response of a system with a geometric nonlinearity, which is encountered in many practical engineering applications. An exact solution was derived for the steady-state motion of a viscously damped Bernoulli-Euler beam with an unsymmetric geometric nonlinearity, under the action of harmonic excitation. Experimental measurements of a mechanical model under harmonic as well as random excitation verified the analytical findings. The effect of various dimensionless parameters on the system response was determined.

81-2599

Beam Models for Predicting Dynamic Elastic Response

V.H. Neubert and V.P. Rangaiah
Pennsylvania State Univ., State College, PA, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (4), pp 355-361 (July-Aug 1981) 5 figs, 2 tables, 5 refs

Key Words: Beams, Bernoulli-Euler method, Natural frequencies, Transient response, Lumped parameter method

Further investigation of the three-parameter lumped mass model for the prediction of natural frequencies and transient response of Bernoulli-Euler clamped-clamped beams has resulted in a revised model, which is slightly superior to the original model as it is applicable over a wider frequency range.

81-2600

Static and Dynamic Analyses of Thick Beams of Bimodular Materials

C.W. Bert and A.D. Tran
School of Aerospace, Mech. and Nuclear Engrg., Univ. of Oklahoma, Norman, OK, Rept. No. OU-AMNE-81-7, 68 pp (July 1981) 21 figs, 14 tables, 58 refs

Key Words: Beams, Timoshenko theory, Transient response, Asymmetry, Stiffness

This report deals with the behavior of beams made of bimodular materials, which have one value for the elastic modulus in tension and another in compression. The transfer-matrix approach is used to investigate the small-deflection response to a variety of loadings, both static and transient. The beam is modeled as a Timoshenko beam; i.e., both transverse shear deformation and rotatory inertia are included. Within each field element, provision is made for a neutral-surface position (locus of points having a zero value for the total axial normal strain) that may vary linearly with axial position within the element. The report consists of two distinct parts: Part I covers the static behavior, while Part II deals with transient dynamic behavior.

CYLINDERS

(Also see Nos. 2536, 2629, 2673)

FRAMES AND ARCHES

81-2601

Post-Elastic Dynamics of Three-Dimensional Frames

A.G. Gillies and R. Shepherd

Beca, Carter, Hollings & Ferner, Consulting Engrs., Wellington, New Zealand, ASCE J. Struc. Div., 107 (ST8), pp 1485-1501 (Aug 1981) 10 figs, 1 table, 4 refs

Key Words: Framed structures, Concretes, Reinforced concrete, Seismic design, Earthquake resistant structures

The time-history response of a three-dimensional reinforced concrete frame structure to concurrent earthquake ground motions is analyzed. Yielding is allowed in both beams and columns by a series of yield surface options selected according to the principal structural actions of the component elements. Comparisons between the behavior patterns arising from unidirectional and concurrent earthquake loading indicate that the nonlinear response predicted by a full three-dimensional analysis is significantly different from the response based on a planar frame idealization. Concurrent loading causes asymmetric distribution of yield as a result of the interaction of the orthogonal displacement components, and this gives rise to an eccentricity between the mass and the instantaneous center of stiffness at some levels in the building. Nominally symmetric buildings can develop torsional responses in moderate earthquakes.

PANELS

(Also see No. 2650)

81-2602

Sound Transmission through Elastically Supported Sandwich Panels into a Rectangular Enclosure

S. Narayanan and R.L. Shanbhag
Dept. of Appl. Mechanics, Indian Inst. of Tech., Madras, India, J. Sound Vib., 77 (2), pp 251-270 (July 22, 1981) 5 figs, 3 tables, 14 refs

Key Words: Panels, Sandwich structures, Viscoelastic core-containing media, Enclosures, Sound transmission

Sound transmission through viscoelastic sandwich panels into rectangular enclosures is investigated in the low frequency range (0 - 1000 Hz). Both harmonic and stationary random external pressure fields are considered. Two opposite edges of the plate are simply supported while the other two edges are elastically supported. A forced damped normal mode analysis is used for response calculations. Numerical results are presented for different parameters of the viscoelastic core.

PLATES

81-2603

Elastic Instability of a Heated Annular Plate under Lateral Pressure

J. Tani

Inst. of High Speed Mechanics, Tohoku Univ., Sendai, Japan, J. Appl. Mechanics, Trans. ASME, 48 (2), pp 399-403 (June 1981) 7 figs, 16 refs

Key Words: Plates, Annular plates, Thermal excitation

On the basis of the dynamic version of the nonlinear von Kármán equations, a theoretical analysis is performed on the elastic instability of a uniformly heated, thin, annular plate which has suffered a finite axisymmetric deformation due to lateral pressure. The linear free vibration problems around the finite axisymmetric deformation of the plate are solved by a finite-difference method. By examining the frequency spectrum with various asymmetric modes, the critical temperature rise under which the axisymmetric deformation becomes unstable due to the bifurcation buckling is determined, which is found to jump up to 7.2 times within a range of very small lateral pressure.

81-2604

Vibration of Thick Rectangular Plates of Bimodulus Composite Material

C.W. Bert, J.N. Reddy, W.C. Chao, and V.S. Reddy
School of Aerospace, Mech. and Nuclear Engrg., The Univ. of Oklahoma, Norman, OK, J. Appl. Mechanics, Trans. ASME, 48 (2), pp 371-376 (June 1981) 6 tables, 20 refs

Key Words: Plates, Rectangular plates, Finite element technique, Small amplitudes

A finite-element analysis is carried out for small-amplitude free vibration of laminated, anisotropic, rectangular plates having arbitrary boundary conditions, finite thickness shear moduli, rotatory inertia, and bimodulus action (different elastic properties depending upon whether the fiber-direction strain is tensile or compressive). The element has five degrees of freedom, three displacements and two slope functions, per node. An exact closed-form solution is also presented for the special case of freely supported single-layer orthotropic and two-layer, cross-ply plates. This solution provides a benchmark to evaluate the validity of the finite-element analysis. Both solutions are compared with numerical results existing in the literature for special cases (all for ordinary, not bimodulus, materials), and good agreement is obtained.

81-2605

Nonlinear Theory for Flexural Motions of Thin Elastic Plate, Part 1: Higher-Order Theory

N. Sugimoto

Dept. of Mech. Engrg., Faculty of Engrg. Science,
Osaka Univ., Toyonaka, Osaka, Japan, J. Appl.
Mechanics, Trans. ASME, 48 (2), pp 377-382 (June
1981) 21 refs

Key Words: Plates, Flexural vibration

This paper develops a comprehensive higher-order theory for flexural motions of a thin elastic plate, in which the effect of finite thickness of the plate and that of small but finite deformation are taken into account. Based on the theory of nonlinear elasticity for a homogeneous and isotropic solid, the nonlinear equations for the flexural motions coupled with the extensional motions are systematically derived by the moment asymptotic expansion method. Denoting by ϵ the ratio of the thickness of the plate to a characteristic wavelength of flexural motions, an order of characteristic deflection is assumed to be ϵ^2 and that of a characteristic strain ϵ^3 . The displacement and stress components are sought consistently up to the next higher-order terms than those in the classical theory.

81-2606

Nonlinear Theory for Flexural Motions of Thin Elastic Plate, Part 2: Boundary-Layer Theory Near the Edge

N. Sugimoto

Dept. of Mech. Engrg., Faculty of Engrg. Science,
Osaka Univ., Toyonaka, Osaka, Japan, J. Appl.
Mechanics, Trans. ASME, 48 (2), pp 383-390 (June
1981) 13 refs

Key Words: Plates, Flexural vibration, Elastic properties, Boundary layer excitation

This paper deals with, as a continuation of Part 1 of this series, the boundary-layer theory for flexural motions of a thin elastic plate. In the framework of the higher-order theory developed in Part 1, three independent boundary conditions at the edge of the plate are too many to be imposed on the essentially fourth order differential equations. To overcome this difficulty, a boundary layer appearing in a narrow region adjacent to the edge is introduced. Using the matched asymptotic expansion method, uniformly valid solutions for a full plate problem are sought. The boundary-layer problem consists of the torsion problem and the plane problem. Three types of the edge conditions are treated, the built-in edge, the free edge, and the hinged edge. Depending on the type of edge condition, the nature of the boundary layer is characterized. After solving the boundary-layer problem, "reduced" boundary conditions relevant to the higher-order theory are established.

SHELLS

(Also see No. 2673)

81-2607

Dynamic Stability of Truncated Conical Shells under Pulsating Torsion

J. Tani

Inst. of High Speed Mechanics, Tohoku Univ., Sendai,
Japan, J. Appl. Mechanics, Trans. ASME, 48 (2), pp
391-398 (June 1981) 7 figs, 1 table, 13 refs

Key Words: Shells, Conical shells, Torsional excitation, Periodic excitation

The dynamic stability of clamped, truncated conical shells under periodic torsion is analyzed by the Galerkin method in conjunction with Hsu's results. The instability regions of practical importance are clarified for relatively low frequency ranges. Numerical results indicate that under the purely periodic torsion only the combination instability region exists but that with an increase in the static torsion the principal instability region becomes most significant. The relative openness of the instability regions is found to depend sensitively on the circumferential phase difference of two vibration modes excited simultaneously at the resonance with the same circumferential wave number.

81-2608

Vibrations of Cylindrical Shells with Time-Dependent Boundary Conditions

S.Y. Lu

Univ. of Florida, Gainesville, FL, ASME Paper No.
81-PVP-21

Key Words: Shells, Cylindrical shells, Time-dependent parameters, Boundary condition effects

Dynamic edge effects on the vibrations of elastic shells are studied by separation of variables. The linear nonhomogeneous differential equations are satisfied by separating the displacement functions into two parts: a free vibration solution and a particular solution which satisfies the time-dependent boundary conditions. The theory is applied to the solution of the clamped-clamped cylinder with oscillating edges.

81-2609

The Effects of Wall Discontinuities on the Propagation of Flexural Waves in Cylindrical Shells

C.R. Fuller

Inst. Sound Vib. Res., Southampton Univ., UK,
Rept. No. ISVR-TR-106, 64 pp (Mar 1980)
PB81-168858

Key Words: Shells, Cylindrical shells, Pipes (tubes), Vibration isolation, Discontinuity-containing media, Flexural waves

The transmission of flexural type waves through various discontinuities in the walls of cylindrical shells is investigated. Theoretical curves of transmission loss are obtained for different circumferential wavenumbers and wave types, as functions of frequency. Material stiffness and extensional phase speed, together with the relationship between radial vibration amplitude and total wave power of propagation, are important factors which are found to strongly influence wave transmission through discontinuities. Some practical results useful for predicting the performance of typical pipe isolators (in vacuo) are obtained.

81-2610

Wave Propagation in a Thin-Walled Viscoelastic Tube Due to Sudden Release of External Loading

T.B. Moodie, J.B. Haddow, and R.J. Tait

Dept. of Mathematics, Univ. of Alberta, Edmonton, Alberta, Canada, Intl. J. Engrg. Sci., 19 (11), pp 1441-1448 (1981) 2 figs, 4 refs

Key Words: Shells, Cylindrical shells, Tubes, Viscoelastic properties

An approximate thin shell theory is used to analyze the dynamic response of an axially constrained incompressible viscoelastic cylindrical tube, due to the sudden release of an axially symmetric uniformly distributed line loading. It is assumed that the tube is sufficiently long that end effects can be neglected. The analysis is based on the linear theory of viscoelasticity and a standard viscoelastic material is considered. Numerical results are obtained by the Fast Fourier Transform algorithm and are presented graphically for a wide range of parameter values.

81-2611

Damage Characteristics of an Infinite Cylindrical Shell Excited by a Transient Acoustic Wave

T.L. Geers and C.L. Yen

Palo Alto Res. Lab., Lockheed Missiles and Space Co., Inc., Palo Alto, CA, Rept. No. LMSC-D686495, 29 pp (Mar 1981)
AD-A096 686

Key Words: Shells, Cylindrical shells, Submerged structures, Transient response, Sound waves, Interaction: structure-fluid

An analytical/computational technique previously developed for determining the geometrically and constitutively nonlinear response of a submerged, infinite cylindrical shell to a transverse, transient acoustic wave is used to study the damage behavior of the shell. Incident waves of rectangular pressure-profile are considered, nonlinear transient response computations are performed, and damage results are described in terms of iso-damage curves based on extensional set strain. Results generated through the use of the doubly asymptotic approximation for treatment of the fluid-structure interaction differ appreciably from their exact counterparts.

81-2612

Modal Response of Circular Cylindrical Shells with Structural Damping

A.W. Leissa and K.M. Iyer

Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH, J. Sound Vib., 77 (1), pp 1-10 (July 8, 1981) 4 figs, 7 tables, 12 refs

Key Words: Shells, Circular shells, Cylindrical shells, Periodic excitation, Damping effects, Hysteretic damping, Modal analysis

Although a vast literature exists dealing with the free vibration of circular cylindrical shells, relatively little can be found for the problem of dynamic response due to sinusoidally varying exciting forces, especially when damping exists. In the present work the response of a shell subjected to a sinusoidal radial pressure is studied, when the pressure has the same distribution as the normal mode shape. Structural (hysteresis) damping is considered. For a unit amplitude of exciting pressure, the lowest frequency modes are found to yield the largest resonant response. Because of a small amount of mode coupling, the peak amplitudes are found to be not quite inversely proportional to the strength of the damping, and there is a slight shift in the locations of the resonant peaks.

81-2613

The Effect of Viscosity on Free Vibrations of Submerged Fluid-Filled Spherical Shells

T.C. Su

Dept. of Civil Engrg., Texas A&M Univ., College Station, TX, J. Sound Vib., 77 (1), pp 101-125 (July 8, 1981) 13 figs, 16 refs

Key Words: Shells, Spherical shells, Submerged structures, Fluid-induced excitation, Fluid-filled containers, Viscosity effects

In order to clarify the effect of fluid viscosity on the vibration of submerged elastic shells, the axisymmetric free oscillations of a fluid-filled spherical shell immersed in a sound field are studied. The dynamic response of the shell is determined by the classical normal mode method, while a boundary layer approximation is employed for the fluid medium. In the absence of viscosity, the shell motion is always damped due to the compressibility of the fluid outside the shell. It is shown that, except for the appearance of natural frequencies with a large damping component, the presence of surrounding fluid outside a fluid-filled shell produces only small changes in the real part of the frequency spectra. The analysis of the influence of viscosity reveals that the viscosity has essentially no effect on the frequencies of shells of moderate thickness. However, the viscous damping is predominant for the non-radiating modes of a fluid-filled submerged shell and the damping is due solely to viscosity for all modes if the outer fluid is assumed incompressible.

PIPES AND TUBES

81-2614

Comparison of LMFBR Piping Response Obtained Using Response Spectra and Time History Methods

G. Hulbert

Westinghouse Advanced Reactors Div., Madison, PA, ASME Paper No. 81-PVP-28

Key Words: Piping systems, Seismic response, Spectrum analysis

The dynamic response to a seismic event is calculated for a piping system using a response spectrum analysis method and two time history analysis methods. The results from the analytical methods are compared to identify causes for the differences between the sets of analytical results. Comparative methods are also presented which help to gain confidence in the accuracy of the analytical methods in predicting piping system structural response during seismic events.

81-2615

The Use of the Split Ring in Modeling Ductile Axial Crack Extension in Pipes

A. Emery, M. Perl, A. Kobayashi, and W. Love

Dept. of Mech. Engrg., Univ. of Washington, Seattle, WA, J. Pressure Vessel Tech., Trans. ASME, 103 (2), pp 151-154 (May 1981) 6 figs, 16 refs

Key Words: Pipes (tubes), Crack propagation

An earlier described ring model for the calculation of axial crack propagation in pipes is investigated numerically. The model assumes that the pipe may be divided into a series of rings. Those rings behind the crack are split and those ahead are whole. By calculating the time history of the opening of the ring behind the crack tip and relating this opening displacement to a fracture criterion, the history of the crack tip extension may be computed.

81-2616

A Sensitivity Study on Numerical Analysis of Dynamic Girth Crack Propagation

A.S. Kobayashi, A.F. Emery, W.J. Love, and A. Jain
Dept. of Mech. Engrg., Univ. of Washington, Seattle, WA, J. Pressure Vessel Tech., Trans. ASME, 103 (2), pp 169-174 (May 1981) 9 figs, 1 table, 20 refs

Key Words: Pipes (tubes), Crack propagation

Dynamic motion of pre-existing girth crack in an axially stressed, 18-in-diameter 316 stainless steel pipe in the presence of large-scale yielding was analyzed by a finite difference shell code. A critical crack tip opening angle (CTOA) was used as a dynamic fracture criterion and the sensitivities of dynamic crack propagation to differences in CTOA, finite differences mesh sizes, initial crack sizes and initial crack bluntnesses, were analyzed numerically. Hold-off times for the onset of dynamic crack propagation nearly doubled and tripled, while terminal crack velocities decreased about 22 percent and 47 percent when the CTOA was increased from 0.10 to 0.19 and to 0.30, respectively. Doubling of the axial length of the initial crack length and an overdriving condition simulated by a larger CTOA did not change the terminal crack velocity.

81-2617

Fluid Elastic Vibration of Tube Array in Cross Flow

H. Tanaka and S. Takahara

Aero-Hydraulics Res. Lab., Nagasaki Technical Inst., Mitsubishi Heavy Industries Ltd., Nagasaki, Japan, J. Sound Vib., 77 (1), pp 19-37 (July 8, 1981) 17 figs, 2 tables, 10 refs

Key Words: Heat exchangers, Tube arrays, Fluid-induced excitation

It is well-known that a cylinder bundle vibrates in a cross flow. Studies of the vibration have been made and it has been established that the vibration is a fluid elastic vibration. However, this theory, which is based on quasi-static fluid forces, does not always hold good for all vibration phenomena. In the theory used in this paper unsteady fluid dynamic forces are considered, which are induced by the vibrating cylinders. Since theoretical prediction of unsteady fluid dynamic forces is difficult, model tests were conducted to measure the fluid forces. The equations of motion of the cylinders were deduced and critical velocities were calculated by using the measured unsteady fluid dynamic forces. Critical velocity tests were also conducted with cylinders supported by elastic spars. The calculated critical velocities coincided well with the test results. Effects of fluid density on the critical velocity were studied and it was found that the critical velocity in a low density fluid like air is proportional to the one half power of the mass damping parameter, as predicted by the previous theory. However, the critical velocity in a high density fluid is less influenced by the mass damping parameter. The effects of detuning of the natural frequency on the critical velocity were also considered.

81-2618

Ductile Fracture of Pipes and Cylindrical Containers with a Circumferential Flaw

F. Erdogan and F. Delale

Dept. of Mech. Engrg. and Mechanics, Lehigh Univ., Bethlehem, PA, J. Pressure Vessel Tech., Trans. ASME, 103 (2), pp 160-168 (May 1981) 14 figs, 1 table, 20 refs

Key Words: Pipes (tubes), Fatigue life, Crack propagation, Shells

The paper deals with the problem of ductile fracture of a pipe or cylindrical container having a relatively long and deep circumferential part-through crack or a through crack and subjected to a uniform axial membrane load in the crack region. After describing the evolution of the ductile fracture process, first the results of the elasticity solution for the circumferentially cracked cylindrical shell based on the Reissner's transverse shear theory are presented. The elastic-plastic part-through crack problem is then considered. In the analysis the plastic deformations are approximated by a perfectly plastic layer similar to the conventional Dugdale model. The load carrying capacity of the cylinder is then estimated in various ways by using the crack opening stretch along the leading edge of the crack as the critical load factor.

81-2619

Continuum Solution of Simulated Pipe Whip Problem

M. Lashkari and V.I. Weingarten

Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA, ASCE J. Struc. Div., 107 (ST8), pp 1443-1463 (Aug 1981) 25 figs, 1 table, 8 refs

Key Words: Pipe whip, Nuclear power plants, Piping systems

The pipe whip problem is a highly nonlinear problem which, except for special conditions, is usually solved numerically. When a dynamic load is applied to the base of a pipe (striker) whose end impacts another pipe (target), it is possible for both the striker and the target to experience plastic deformations during impact. A finite element solution considering the nonlinear impact problem with material nonlinearity has been carried out. At the point when the material becomes plastic, high frequency oscillations can set up in the continuum model. Experimental data indicate that these oscillations quickly disappear due to material damping. The effects of plasticity are considered, as are Rayleigh damping and nonlinear damping in the target material.

DUCTS

(Also see No. 2563)

81-2620

Flow-Acoustic Coupling in Ducts

P.O.A.L. Davies

Inst. Sound Vib. Res., Univ. of Southampton, Southampton, UK, J. Sound Vib., 77 (2), pp 191-209 (July 22, 1981) 10 figs, 2 tables, 22 refs

Key Words: Ducts, Discontinuity-containing media, Sound generation

Experimental data for two mechanisms of sound generation at area discontinuities in flow ducts are described and discussed. The first step in the process is the development of an ordered train of vortices in the shear layer produced by a separating flow. Though not themselves strong radiators of sound, such vortices can excite resonators strongly. The acoustic field of the resonator provides the sound waves which synchronize the vortex motion, producing a self-sustaining oscillation. Alternatively, synchronization of the vortex motion with an incident acoustic field from a source upstream can enhance the sound by transferring energy from the mean flow.

BUILDING COMPONENTS

81-2621

Effective Width of Floor Systems for Application in Seismic Analysis

F.S. Cotran and W.J. Hall

Dept. of Civil Engrg., Univ. of Illinois at Urbana-Champaign, Rept. No. STRUCTURAL RESEARCH SER-486, UILU-ENG-80-2021, NSF/RA-800428, 96 pp (Nov 1980)
PB81-168296

Key Words: Frames, Floors, Steel, Concretes, Seismic excitation

Effective width coefficients for floor systems have been developed for use in the analysis of frames subjected to lateral seismic loads. The method described covers a wide range of practical values of the slab dimensions and can be applied to both steel and concrete frames and to cases of flat slabs as well as slabs with supporting beams. The investigation is based on a parametric study of typical interior panels of floor systems, with and without supporting beams, using elastic finite element analysis to model the behavior of the floor system when the frame is subjected to lateral loads. The theoretical derivation of the method and the procedure employed for the finite element analysis is covered. Results of the study and a proposed simplified method of analysis for estimating the composite properties are presented. Simple examples illustrate application of the method, emphasizing seismic analysis and the resistance of floor systems under dynamic loads.

ELECTRIC COMPONENTS

GENERATORS

(See No. 2525)

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2545, 2546, 2547, 2548, 2650)

81-2622

A Comparison of Community Response to Aircraft Noise at Toronto International and Oshawa Municipal Airports

S.M. Taylor, F.L. Hall, and S.E. Birnie

Dept. of Geography, McMaster Univ., Hamilton, Ontario, Canada, J. Sound Vib., 77 (2), pp 233-244 (July 22, 1981) 2 figs, 4 tables, 15 refs

Key Words: Airports, Traffic noise, Aircraft noise, Human response

Debate continues over the validity of a single dose-response relationship to describe annoyance due to transportation noise. Doubts about the appropriateness of a single relationship have centered primarily on the issue of differential response to the same noise level for different sources; e.g., aircraft, road traffic and trains. However, recent work suggests that response may vary for different types of the same source, namely aircraft, dependent upon the character, and specifically the number, of operations. Recent data collected around Toronto International and Oshawa Municipal airports permit a test of differences in four aggregate response variables. For the same NEF level, the percent at all annoyed at the two airports is not statistically different. The percent highly annoyed and the percent reporting speech interference are both significantly greater at Toronto but the percent reporting sleep interruption is greater at Oshawa. These differences can be explained in terms of the operational characteristics of the two airports.

81-2623

Industrial Noise Pollution - Part 2: Identifying and Controlling Industrial Noise Sources

R.L. Bannister

Steam Turbine-Generator Div., Westinghouse Electric Corp., Lester, PA, Mech. Engrg., 103 (8), pp 24-29 (Aug 1981) 5 figs, 30 refs

Key Words: Noise generation, Industrial facilities

It has been reported that the original proposed OSHA workplace noise standards of 85 dB would have cost industry between \$18 billion and \$31 billion (in 1976 dollars) to meet. The compromise standards that OSHA has now worked out will allow 90 dB but will still cost industry about \$250 million. To comply with these newly established requirements, industry will have to examine everything from the design of its products to its manufacturing processes. The causes of excessive noise will have to be determined and effective and economical solutions will then have to be employed either to reduce the noise to acceptable levels or to shield the worker from its damaging impact.

81-2624

Materials for Noise and Vibration Control

W.E. Purcell

S/V, Sound and Vibration, 15 (7), pp 4-30 (July 1981)

Key Words: Materials, Noise reduction, Vibration control, Acoustic absorption, Noise barriers, Vibration damping, Vibration isolation

A comprehensive mini-handbook for the selection and application of commonly available noise and vibration control materials. Basic information is provided on the characteristics of sound absorptive, sound barrier, vibration damping, and vibration isolation materials.

81-2625

Investigation of a Parametric Acoustic Receiving Array for Mobile Applications

C.R. Clubertson, R.A. Lamb, and D.F. Rohde

Applied Res. Labs., Univ. of Texas at Austin, Austin, TX, Rept. No. ARL-TR-80-53, 40 pp (Nov 5, 1980) AD-A096 563

Key Words: Acoustic arrays, Parameter excitation, Under-water sound

The parametric acoustic receiving array (PARRAY) exploits the nonlinearity of acoustic waves in water to achieve directional reception of low frequency acoustic waves using only two high frequency transducers and associated electronics. In mobile applications the parametric receiver will be required to operate under the influence of sensor motion, and in water that is sometimes turbulent. This report describes these two areas of technical risk which are pertinent to the successful implementation of PARRAYs on submarine platforms. Analysis, fabrication, and testing of a phase-locked loop receiver is described.

SHOCK EXCITATION

81-2626

A Note on Velocity Inversion of Diffracted Waves

J.K. Cohen and N. Bleistein

Math. and Computer Science Dept., Univ. of Denver,

Denver, CO 80208, Wave Motion, 3 (3), pp 279-282 (July 1981) 4 figs, 12 refs

Key Words: Wave propagation

In a recent article, the authors developed and solved an integral equation for determining small variations in propagation speed. Since the field data is high frequency data on the geophysical scale, it is important to verify that the inversion scheme correctly produces phenomena associated with high frequency data. The inversion results obtained for the case of a data set containing an edge and for the case of a data containing a buried focus are presented.

81-2627

Earthquake Research for the Safer Siting of Critical Facilities

J.L. Cluff

Natl. Academy of Sciences, Washington, DC, 59 pp (1980)

DOE/CH/93003-4

Key Words: Life line systems, Earthquake damage

The task of providing the necessities for living, such as adequate electrical power, water, and fuel, is becoming more complicated with time. Some of the facilities that provide these necessities would present potential hazards to the population if serious damage were to occur to them during earthquakes. Other facilities must remain operable immediately after an earthquake to provide life-support services to people who have been affected. The purpose of this report is to recommend research that will improve the information available to those who must decide where to site these critical facilities, and thereby mitigate the effects of the earthquake hazard.

81-2628

Effect of Earth Media on the Seismic Motion of Embedded Rigid Structures

J.J. Fedock and H.L. Schreyer

Dept. of Civil Engrg., Univ. of Santa Clara, Santa Clara, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (4), pp 311-327 (July-Aug 1981) 11 figs, 1 table, 26 refs

Key Words: Interaction: soil-structure, Seismic waves, Seismic response

A finite element analysis is performed to determine the influence of the choice of a constitutive model for the earth medium upon the response to seismic waves of an embedded rigid structure. The seismic forcing function is characterized by Rayleigh waves with amplitude parameters adjusted to provide identical free-field motion at a surface reference point for one particular sand represented with elastic, plastic and viscoelastic models. Within the limitations of the analysis, the result is that the steady-state rigid body motions of the embedded structure are essentially identical for these constitutive relations and, consequently, it is appropriate to use an elastic representation for the earth medium.

81-2629

Dynamic Crack Propagation in Precracked Cylindrical Vessels Subjected to Shock Loading

C.H. Popelar, P.C. Gehlen, and M.F. Kanninen
Dept. of Engrg. Mechanics, The Ohio State Univ.,
Columbus, OH, J. Pressure Vessel Tech., Trans.
ASME, 103 (2), pp 155-159 (May 1981) 3 figs,
1 table, 4 refs

Key Words: Cylinders, Crack propagation, Ships, Blast response

Previous work has shown that a speed-independent dynamic fracture toughness property can be used in an elastodynamic analysis to describe crack initiation and unstable propagation under impact loading. In this paper, a further step is taken by extending the analysis from simple laboratory test specimens to treat more realistic crack-structure geometries. A circular cylinder with an initial part-through wall crack subjected to an impulsive loading on its inner surface is considered. The crack is in a radial-axial plane and has its length in the axial direction long enough that a state of plane strain exists at the center of the crack. Crack growth initiation and propagation through the wall is then calculated. It is found that, once initiated, crack propagation will continue until the crack penetrates the wall. Crack arrest within the wall does not appear to be possible under the conditions considered in this paper.

VIBRATION EXCITATION

(Also see No. 2624)

81-2630

The Description of Random Vibration

J.D. Robson

Mech. Engrg. Dept., Univ. of Glasgow, UK, Intl. J. Vehicle Des., 2 (3), pp 255-275 (1981) 7 figs

Key Words: Random vibration, Structural response, Probability density function

This paper considers the whole problem of the description of random processes, with the two objects of revealing the requirements of description in their most general form and indicating in their proper context the simplifications of Gaussianity and stationarity which give rise to the most commonly used results in random vibration analysis. Single-variate processes are considered first, the additional complications of two-variate processes are then treated, and the general n-variate problem is covered.

81-2631

An Elementary Investigation of Local Vibration

R.E.D. Bishop and S. Mahalingam
Dept. of Mech. Engrg., Univ. College London, UK,
J. Sound Vib., 77 (2), pp 149-163 (July 22, 1981)
8 figs, 3 refs

Key Words: Harmonic excitation

It is well known that, if a system is subjected to harmonic forced excitation, the response may be resonant only in some localized part of the system. One may refer to a resonant "subsystem" which may, or may not, be "small." The familiar reed vibrometer exemplifies a small resonant subsystem while a tuned absorber is a resonant subsystem that is not small. The implications of this are explored for the particular case of a subsystem that is linked to the remainder of the vibrating system at a single generalized co-ordinate.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 2532 and 2565)

81-2632

An Attractive Method for Displaying Material Damping Data

D.I.G. Jones

Air Force Wright Aeronautical Labs., Wright Patterson AFB, OH, J. Aircraft, **18** (8), pp 644-649 (Aug 1981) 13 figs, 17 refs

Key Words: Damping coefficients, Damping materials, Data presentation, Nomographs

This paper describes the development of a new reduced-temperature nomogram which greatly facilitates the display and correlation of complex modulus data for a linear thermorheologically simple viscoelastic damping material in such a way that the effects of frequency and temperature can be simultaneously taken into account. The method is based on the well-known temperature-frequency equivalence principle, which allows one to modify the frequency by a factor depending on temperature alone in such a way that complex modulus data points at a given frequency and temperature can be combined into a single set of curves, representing the loss factor and modulus as a function of a single variable, known as the reduced frequency. The superimposition of temperature isotherms completes the nomogram and thereby greatly expands the usefulness of the reduced-frequency graphs by allowing display on a single graph of complex modulus data at any frequency and temperature. This allows the possibility of generating and transmitting engineering data on viscoelastic material behavior to be used in many areas where such materials are being considered for vibration control.

81-2633

Dynamic Pressure Determinations in a Squeeze-Film Damper

R. Holmes and M. Dede

School of Engrg. and Appl. Sciences, Univ. of Sussex, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 71-75, 4 figs, 8 refs

Key Words: Dampers, Squeeze film dampers, Rotors

A comparison of predicted and measured pressures in a squeeze-film damper under dynamic loading is presented. The relation between these pressures and vibration orbits resulting from rotor unbalance is elucidated.

81-2634

Theoretical and Experimental Investigation into the Effectiveness of Squeeze-Film Damper Bearings without a Centralizing Spring

R.A. Cookson and S.S. Kossa

Applied Mechanics Group, Cranfield Inst. of Tech., UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 359-366, 7 figs, 1 table, 10 refs

Key Words: Dampers, Squeeze film dampers, Bearings, Turbomachinery

An analytical technique has been developed for determining the effectiveness of squeeze-film damper bearings which do not have a centralizing spring. Squeeze-film damper bearings supporting both rigid and flexible rotors have been analyzed and their performance expressed in terms of non-dimensional system parameters. This analysis has indicated certain clearly defined regions, within the framework of these system parameters, in which the designer should work if he is to produce an effective vibration inhibiting device. An experimental investigation has confirmed that the squeeze-film damper bearing without a centralizing spring can be a very effective method of reducing some forms of vibration in turbomachines.

FATIGUE

(Also see No. 2519)

81-2635

Presentation of Failure Analysis Data by the Fatigue Fracture Mechanics Diagram

R.H. Sailors

American Magotteux Corp., Pulaski, TN, ASME Paper No. 81-PVP-11

Key Words: Crack propagation, Fatigue life, Graphic methods

The integrated crack growth rate equation is presented in graphical form as cyclic stress range versus initial flaw size for various constant cyclic lines. The upper bound of the graph is described by single cycle fracture and lower bound is described by an "engineering defined" threshold value of stress intensity. In many instances the fatigue fracture mechanics diagram simplifies presentation of failure analysis data. It also can illustrate the cause of failure whether it be single or multicycle, and indicate corrective measures needed to avoid repetition of the failure.

81-2636

Dynamic Fracture Initiation in Metals and Preliminary Results on the Method of Caustics for Crack Propagation Measurements

L.B. Freund, J. Duffy, and A.J. Rosakis

Brown Univ., Providence, RI, ASME Paper No. 81-PVP-15

Key Words: Fatigue life, Crack propagation, Metals

Progress is described in the use of an experimental method for studying fracture initiation under dynamic loading conditions in metals. The instrumentation provides unambiguous records of instantaneous average stress on the unfractured ligament and of instantaneous crack opening displacement.

81-2637

An Analysis of, and Some Observations on, Dynamic Fracture in an Impact Test Specimen

T. Nishioka, M. Peri, and S.N. Atluri
Georgia Inst. of Tech., Atlanta, GA, ASME Paper No. 81-PVP-18

Key Words: Fatigue life, Crack propagation, Steel

Numerical simulations of crack-propagation histories in four cases of dynamic tear test experiments on 4340 steel are performed. The influence of the loss of contact of the specimen at various times with either the supports or the tup or both is critically examined. In each case, the variation of the dynamic K-factor for the simulated crack-propagation history is directly computed.

81-2638

Evaluation of Dynamic Load Combination Fatigue Damage

Z.N. Ibrahim and S.A. Gabraiel
Sargent & Lundy Engineers, Chicago, IL, ASME Paper No. 81-PVP-20

Key Words: Fatigue life, Root mean squares

The results of the basic and parametric analyses presented in the preceding sections support the engineering practice of adopting the common cycle elimination technique to evaluate the fatigue damage of the combined, uncorrelated, simultaneous occurrences. This includes employing the square root of sum of squares of the maximum response amplitude and/or range of each of these occurrences, throughout the execution of the cycle elimination process.

81-2639

Fatigue Design in Mining Size Reduction Equipment

V. Svalbonas
Koppers Co., Inc., York, PA, ASME Paper No. 81-PVP-9

Key Words: Mines (excavations), Equipment, Fatigue life

The mining size reduction equipment industry is reviewed regarding efforts to obtain a consistent fatigue design philosophy. Serious structural failures, which have prompted various company efforts in this area, are reviewed. Basic fatigue data are being gathered with the goal of providing consistent design, fabrication and nondestructive examination programs.

81-2640

Parameters and Micromechanisms of Fatigue Crack Growth in Sheet Magnesium Alloy Samples

N.M. Grinberg and V.A. Serdyuk
Physico-Technical Inst. of Low Temperatures, Ukrainian Academy of Sciences, Lenin's Prospect, Kharkov, USSR, Intl. J. Fatigue, 3 (3), pp 143-148 (July 1981) 2 figs, 2 tables, 26 refs

Key Words: Fatigue life, Crack propagation

Growth rates of part-through and through fatigue cracks have been measured for two magnesium alloys - MA12 and IMV6 - and the micromechanisms of fatigue fracture were studied at all stages of growth. Conclusions about the peculiarities of the kinetics and micromechanisms of part-through and through crack growth, depending on the applied stress amplitudes and alloy structure, are made from a comparison of the results obtained.

81-2641

Tests to Determine the Fatigue Strength of Steel Castings Containing Shrinkage

L.P. Pook, A.F. Greenan, M.S. Found, and W.J. Jackson
Natl. Engrg. Lab., East Kilbride, Glasgow, UK, Intl. J. Fatigue, 3 (3), pp 149-156 (July 1981) 12 figs, 5 tables, 18 refs

Key Words: Fatigue tests, Steel

Fatigue tests were carried out on low strength steel castings containing deliberately introduced shrinkage defects. Failure

in most tests originated at defects which could be identified on radiographs, but on the basis of the radiographs, it would not have been possible to predict either the site of the failure or the fatigue strength of the individual specimens. Even gross center-line defects had little effect on the fatigue strength of specimens tested in four point bending, although substantially decreasing the strength of specimen tested in tension. A fracture mechanics analysis was attempted but was not satisfactory due to the difficulty in estimating the stress intensity factors for the irregular flaws concerned and because of excessive yielding in many specimens.

81-2642

Growth of Surface Fatigue Cracks in a Steel Plate

O. Vosikovsky and A. Rivard

Physical Metallurgy Res. Labs., Ottawa, Ontario, Canada, Intl. J. Fatigue, 3 (3), pp 111-115 (July 1981) 8 figs, 1 table, 11 refs

Key Words: Fatigue (materials), Crack propagation, Steel, Pipelines

The growth rates of surface fatigue cracks, both on the surface and within the plate, have been measured on an X65 pipeline steel plate. To calculate stress intensity ranges the finite-element solution by Raju and Newman has been used. The resulting fatigue crack growth rates are in good agreement with those measured on single-edge notched specimens. The variation in shape of a growing surface fatigue crack is analyzed and compared with other published measurements and analytical predictions by Nair.

81-2643

Probability of Fatigue Failure as a Statistic

A. Tsurui

Engrg. Dept., Kyoto Univ., Kyoto, Japan, Intl. J. Fatigue, 3 (3), pp 125-127 (July 1981) 7 refs

Key Words: Fatigue life, Random excitation, Statistical analysis

The probability of failure is treated as a statistic from the viewpoint that the probability can be determined only through experimental data. On the basis of a statistical theory for large samples, an asymptotic distribution function for the probability of fatigue failure under stationary random external loading is given and a simple policy for fatigue-proof design is proposed.

81-2644

Stress Intensity Factors for Fatigue Cracking of Round Bars

A.S. Salah el din and J.M. Lovegrove

Civil Engrg. Dept., Southampton Univ., Southampton, UK, Intl. J. Fatigue, 3 (3), pp 117-123 (July 1981) 11 figs, 2 tables, 18 refs

Key Words: Fatigue life, Bars

The stress intensity factor for a single edge crack of either straight or circular front in a round bar has been determined using both the degenerated quarter-point isoparametric finite element and experimental fatigue crack growth data, and compared with values found by earlier investigators. The results of this study confirm that the stress intensity factors for straight edged surface cracks are lower in round bars than in square bars and a comparison of finite element and experimental results indicates that the effective stress intensity factor at the centre of the fatigue crack front in a round bar is 17% greater than its theoretical value. A correction function is proposed to account for the effect on the stress intensity factor of the circular boundary of a round bar.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

81-2645

A New Way to Capture Elusive Signals

C. Somers

Biomation Div., Gould Inc., Santa Clara, CA, Mach. Des., 53 (10), pp 111-115 (May 7, 1981)

Key Words: Wave analyzers, Measuring instruments

Recently developed devices for capturing high-speed transient signals, the waveform recorders, are described. They are used in applications requiring high speed monitoring of multiple sensors. Monitoring of stress and strain data from high-rate dynamic tests is a typical example.

81-2646

A Matched Impedance, Electrostatic Approach to Hydrophone Design

J.A. Clark

Acousto-Optics Lab., Catholic Univ. of America, Washington, DC, J. Sound Vib., 77 (1), pp 51-59 (July 8, 1981) 4 figs, 15 refs

Key Words: Hydrophones, Sound transducers, Design techniques

A new type of acoustically transparent capacitor hydrophone is described and demonstrated. The hydrophone is built with a dielectric material between the capacitor plates which is similar in acoustic impedance to that of water. A theoretical model of this matched impedance type of capacitor hydrophone is developed and compared with a theory of air-filled capacitor hydrophones. Unlike the earlier air-filled types of capacitor hydrophones, the sensitivity is found to be independent of frequency and of parameters determining the capacitance of the hydrophone. Amplitude transmission ratios greater than 96% demonstrate the acoustical transparency of the device.

81-2647
Combining Holography with Speckling for Vibration Analysis

J. Politch

Dept. of Physics and Dept. of Aeronautical Engrg., Technion City, Haifa, Israel, Israel J. Tech., 18 (5), pp 275-280 (1980) 9 figs, 13 refs

Key Words: Vibration analysis, Holographic techniques, Speckle metrology techniques, Optical methods

Time average holographic reconstruction describes a family of fringes, proportional to contours of equal height of vibration, without being able to identify directly the "hills" and the "valleys" of the vibrating object. Time average speckle shearing interferometric reconstruction describes another family of fringes, proportional to the contours of equal slope of vibration. Combining the two families of fringes, it is possible to define at every point of a vibrating surface the amplitude and the relative phase of the mechanical vibration.

81-2648
The Acoustics of Violin Plates

C.M. Hutchins

Scientific American, 245 (4), pp 171-186 (Oct 1981)

Key Words: Violins, Musical instruments, Natural frequencies, Mode shapes, Measurement techniques

Modern tests of the vibrational properties of the unassembled top and back plates of a violin are described.

81-2649
Qualifying Fixtures for Shaker Control with a Micro-modal Analyzer

L. Enochson and P.J. Traveaux

Time Series Associates, Palo Alto, CA, TEST, 43 (4), pp 14-19, 22 (Aug/Sept 1981) 15 figs, 4 tables

Key Words: Test facilities, Shakers, Vibration analysis

In a laboratory specializing in environmental vibration qualifications, a specially designed test fixture was found to cause unusual vibrations. Modal survey performed on the test fixture is described and solutions are given.

81-2650
Measurement of Transmission Loss of Panels by the Direct Determination of Transmitted Acoustic Intensity

M.J. Crocker, P.K. Raju, and B. Forssen

Ray W. Herrick Labs., School of Mech. Engrg., Purdue Univ., West Lafayette, IN, Noise Control Engrg., 17 (1), pp 6-11 (July-Aug 1981) 8 figs, 21 refs

Key Words: Panels, Sound transmission loss, Measurement techniques

A new method for the determination of the transmission loss of panels has been developed. This method involves the measurement of the incident and transmitted acoustic intensities. The incident intensity is determined from measurements of the space-averaged sound pressure level in a reverberation room on the source side of the panel. The transmitted intensity is measured directly, using a two-microphone technique. One advantage of this new method is that it uses one reverberation room instead of two as used in the conventional transmission suite method. Another advantage is that it makes possible the identification of the energy transmitted through different parts of composite panels.

DYNAMIC TESTS
(Also see Nos. 2585, 2587)

81-2651
Digital Experimental Techniques Applied to Low Frequency Shake Phenomena

J.M. O'Keeffe, W.G. Sutcliffe, I. Scheelke, and U. Proepper
SDRC-Engineering Services (UK/Scan), Ltd., SAE
Paper No. 810094

Key Words: Steering gear, Vibration control, Low frequencies, Structural modification effects, Automobiles

Digital experimental techniques have been used to investigate the dynamic behavior of vehicles. A test program applied these techniques to provide design insight into low frequency shake phenomena. Operating tests defined the forces responsible for low frequency shake using narrow band spectra and order tracking techniques. Total deformation patterns were measured under operating conditions to determine the controlling elements participating in the vibration perceived at the steering wheel. Modal testing of the vehicle provided a mathematical model of the car over the frequency range 10-50 Hz. This model predicted the effect of modifications to the vehicle before they were implemented. The change in steering column response was monitored to assess the effect of these changes. Analytical predictions were confirmed by testing the modified vehicle.

81-2652

Digital Numerically Controlled Oscillator

A. Cellier, D.C. Huey, and L.N. Ma
NASA, Lyndon B. Johnson Space Ctr., Houston,
TX, U.S. PATENT-4 241 308, 8 pp (Dec 23, 1980)

Key Words: Oscillators, Computer-aided techniques

The frequency and phase of an output signal from an oscillator circuit are controlled with accuracy by a digital input word. Positive and negative alterations in output frequency are both provided for by translating all values of input words so that they are positive. The oscillator reference frequency is corrected only in one direction, by adding phase to the output frequency of the oscillator. The input control word is translated to a single algebraic sign and the digital 1 is added thereto. The translated input control word is then accumulated.

81-2653

Designing Perturbed Test Tracks for Evaluating Rail Vehicle Dynamic Performance

R. Brantman, A.B. Boghani, and A.D. Little
Rail Dynamics Projects, Structures and Mechanics

Branch, Transportation Systems Ctr., Cambridge,
MA, ASME Paper No. 81-RT-7

Key Words: Railroad cars, Dynamic tests, Test facilities

Perturbed tracks provide a controlled means for evaluating the performance of rail vehicles in various dynamic modes, such as hunting, rock-and-roll, pitch-and-bounce, yaw-and-sway, and dynamic curving. This paper describes a systematic approach for designing such tracks and illustrates the methodology as it has been applied to the preliminary design of the tangent and curved perturbed tracks for the stability assessment facility for equipment.

81-2654

Harmonic Optimization of a Periodic Flow Wind Tunnel

J.P. Retelle, Jr., J.M. McMichael, and D.A. Kennedy
U.S. Air Force Academy, CO, J. Aircraft, **18** (8), pp
618-623 (Aug 1981) 7 figs, 1 table, 10 refs

Key Words: Test facilities, Wind tunnels, Periodic excitation

This work describes a wind-tunnel modification designed to superpose on the mean velocity sinusoidal longitudinal velocity fluctuations with minimal harmonic content. The technique is presented in light of a theoretical analysis of the low-frequency performance illustrating how harmonic suppression can be achieved with this particular design. Velocity fluctuations are produced by a system of primary rotating vanes and a bypass containing a secondary set of rotating vanes. Experimental data on tunnel performance are also presented. A significant reduction of the second harmonic content of the free-stream velocity oscillations was achieved by adjustment of the bypass flow.

DIAGNOSTICS

(Also see No. 2679)

81-2655

The Role of Sum and Difference Frequencies in Rotating Machinery Fault Diagnosis

R.L. Eshleman

Vibration Inst., Clarendon Hills, IL, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 145-149, 5 figs, 4 refs

Key Words: Diagnostic techniques, Rotating machinery, Sum and difference frequencies

Increased complexity of rotating machinery and demands for higher speeds and greater power have created complex vibration problems. Instrumentation is now available to perform sophisticated frequency analyses of complex vibration signals. This paper is concerned with correlating machinery faults to sum and difference frequencies. Such phenomena as misalignment, antifriction bearing and gear defects, oil whirl, rubs, trapped fluid, and mass unbalance can often be related to sum and difference frequencies.

81-2656

Fault Diagnosis of Gears Using Spectrum Analysis J.I. Taylor

Vibration Specialists, Inc., Tampa, FL, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 163-168, 9 figs, 3 refs

Key Words: Diagnostic techniques, Gears, Spectrum analysis, Sum and difference frequencies

Procedures for identifying gear defects and gear meshing problems are described. A defective tooth or teeth generate and excite specific frequencies and pulses. Analysis of the time signal, spectrum frequencies, shape, amplitude, and sum and difference frequencies will reveal which gears have defective teeth, the number of defective teeth on each gear, the number of gears that have defective teeth, and the location of defective teeth with respect to some reference point. The importance of early identification of gear problems is stressed. An actual case history is presented.

81-2657

Advances in the Application of Cepstrum Analysis to Gearbox Diagnosis

R.B. Randall

Brüel & Kjaer, Naerum, Denmark, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 169-174, 7 figs, 7 refs

Key Words: Diagnostic techniques, Gearboxes, Cepstrum analysis

A review of the experience gained in the application of the cepstrum technique to the identification of families of uniformly spaced sidebands in gearbox vibration spectra is

given. After a discussion of the types of faults which give rise to such sidebands, a number of practical points in the calculation and interpretation of the cepstrum are discussed. Making use of a number of practical examples, the advantages of the cepstrum are elucidated with respect to diagnostic power and repeatability (lack of sensitivity to secondary effects).

81-2658

A New Analysis Procedure for Noise and Vibration Diagnosis of Rotating Machinery

G. Hauser

Ingenieurbüro f. Technische Akustik, W. Germany, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 381-387, 13 figs

Key Words: Diagnostic techniques, Rotating machinery, Noise source identification, Fourier analysis

The time-synchronous time-window analysis is used for noise and vibration diagnosis especially when very compact constructions with a high degree of pulses in noise behavior are examined. In order to locate noise sources, the vibrations of several channels are analyzed in short takes, so that there is an exact coordination with the mechanical process of the machine. The synchronization procedure is achieved through an angle encoder which controls the analyzing system, so that the parts of the mechanical processes are in effect close to the shaft angle in question with an exactitude of 0.1° angle and therefore independent of speed.

81-2659

Investigating Bearing Failures

J.K. Bailey, L.R. Stenander, and R.C. Cooper

TRW Bearings Div., Jamestown, NY, Power Transm. Des., 23 (8), pp 29-33 (Aug 1981)

Key Words: Bearings, Ball bearings, Failure analysis

By studying photographs, much can be learned about premature ball bearing failure that would otherwise be difficult to communicate. A graphic representation of common conditions is presented to help determine some sources of difficulty.

BALANCING

(Also see No. 2532)

81-2660

Protect Against Large Rotor Unbalance

M.L. Adams

Univ. of Akron, OH, Power, 125 (7), pp 52-54 (July 1981) 6 refs

Key Words: Bearings, Rotors, Unbalanced mass response

Two catastrophic failures initiated by large rotor unbalance in turbine/generators with fixed-arc journal bearings in fossil-fired plants are described. The data obtained by a nonlinear vibration analysis suggests that such failures could be prevented by pivoted-pad bearings.

81-2661

A Unified Approach to Flexible Rotor Balancing: Outline and Experimental Verification

M.S. Darlow, A.J. Smalley, and A.G. Parkinson

Mechanical Technology, Inc., Latham, NY, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 437-444, 6 figs, 3 tables, 13 refs

Key Words: Balancing techniques, Rotors, Flexible rotors, Unified balancing approach, Influence coefficient method, Modal balancing technique

The logical development of an improved balancing procedure is to incorporate certain features of both the influence coefficient and modal methods to combine the advantages of each while eliminating the corresponding disadvantages. Such a unified approach, Unified Balancing Approach (UBA) has been developed and verified experimentally. In this paper, the influence coefficient and modal methods are reviewed to the extent necessary to provide the basis for the unified approach. The UBA procedure is outlined emphasizing its relationship to the parent techniques, and experimental results are presented which verify the effectiveness of this balancing method and illustrate its advantages in a practical application.

81-2662

Development of High-Speed Balancing Technology - Part 1 - Effects of Laser Metal Removal on Material

Properties and Part 2 - Balancing of Supercritical Shaft under Torque Load

R. DeMuth and E. Zorzi

Mechanical Technology, Inc., Latham, NY, Rept. No. NASA CR-165314, 93 pp (Jan 1981)

Key Words: Balancing techniques, Rotors, Flexible rotors

This report presents the tasks performed in the continuous high-speed balancing technology investigation to determine the effects of laser material removal on material properties and establish a balancing methodology that could control unbalance response with the application of axial torque, evaluate this methodology by experimental testing, and compare predicted and experimental results. Also covered in this report is the development, implementation, and testing of an influence coefficient approach to balancing a long, slender shaft under applied-torque conditions.

81-2663

Automatic Balancing of Rotors

A.A. Gusarov and L.N. Shatalov

GOSNII Mashinovedenia, Moscow, USSR, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 457-461, 3 figs, 2 refs

Key Words: Rotors, Balancing techniques, Computer-aided techniques

Methods of automatically balancing rotors are classified. Two methods currently in use are described and some of their limitations outlined. A detailed description is given of a new technique employing a controllable electrohydraulic impact to discharge rapidly solidifying liquids on to the light side of an unbalanced rotor.

81-2664

Automatic Balancing of Grinding Wheels

H. Kaliszer

Mech. Engrg. Dept., Univ. of Birmingham, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 421-426, 8 figs, 11 refs

Key Words: Balancing techniques, Wheels, Grinding machinery, Computer-aided techniques

A detailed analysis is given of the existing balancing methods with special emphasis of automatic methods including an adaptive control of the balancing cycle. General economic aspects of selecting the most suitable balancing procedure is also given.

81-2665

Balancing of a Double Overhung Compressor with Skewed Wheels and a Bowed Shaft

D.J. Salamone, E.J. Gunter, and L.E. Barrett
Centritech Corp., Houston, TX, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 259-264, 10 figs, 4 tables, 13 refs

Key Words: Rotors, Compressors, Balancing techniques

This paper includes the effects of a bowed shaft and skewed impeller wheels on the dynamic response and balancing of a double overhung compressor operating near the third critical speed. It is demonstrated that a two plane balance with a single correction weight at each impeller is insufficient to balance this rotor throughout the entire speed range. However, the system can be successfully balanced by the simultaneous application of couple corrections at each of the two overhung impellers.

81-2666

Balancing Flexible Rotors as a Problem of Mathematical Programming

M. Balda
Central Res. Inst., SKODA National Corp., Czechoslovakia, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 253-257, 1 fig, 2 tables, 15 refs

Key Words: Rotors, Flexible rotors, Balancing techniques, Minimax technique

It is shown that the problem of balancing flexible rotors is a problem of minimax, which is of a nonlinear nature in the general case. It may be solved either by algorithms of mathematical programming or by special algorithms for nonlinear minimax. There are cases for which the problem remains linear within particular iteration steps and may be solved as an L_p -approximation over a complex domain.

81-2667

Balancing of Flexible Rotor with Variable Mass

L.J. Cvetičanin
Technic of Sciences, V. Vlahovića, Novi Sad, Yugoslavia, Mech. Mach. Theory, 16 (5), pp 507-516 (1981) 14 figs, 18 refs

Key Words: Rotors, Flexible rotors, Balancing techniques

A method is given for balancing a flexible rotor with variable mass by use of a method for balancing a flexible rotor with constant mass. The result is a counterweight whose static mass moment varies with time.

81-2668

Processing Surplus Information in Computer Aided Balancing of Large Flexible Rotors

J. Drechsler
Balancing and Vibration Control Dept., ASEA, Sweden, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 65-69, 1 fig, 1 table, 5 refs

Key Words: Balancing techniques, Computer aided techniques, Rotors, Flexible rotors

The theory of flexible rotor balancing has thoroughly investigated the minimum number of balancing planes and the minimum amount of information necessary to successful rotor balancing. Practical experience shows, however, that a consistent consideration of surplus balancing planes and surplus information yields much better results and cuts down the production time considerably. Advanced averaging techniques on surplus trial runs and surplus balancing speeds yield a reliable influence coefficient matrix and can even be used to improve the right hand side of the equation system. The continual check on the pivot element size during the elimination process reveals how many and which planes are most suitable to reduce the vibration level. The surplus planes can be used to cut down the magnitude of the balancing weights, thus indirectly improving the rotor performance at operating speed and overspeed considerably.

81-2669

Determination of the Unbalance and the Dynamic Characteristics of a Flexible Rotor under Non-Stationary Conditions

L.N. Shatalov

GOSNII Mashinovedeniya, Moscow, USSR, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 453-456, 2 figs, 9 refs

Key Words: Rotors, Flexible rotors, Balancing techniques

The determination of the unbalance distribution in a flexible rotor is the most difficult part of the balancing process. Investigations in this field are usually based on considerations of stationary or quasi-stationary vibrations. However, results derived by assuming a rotor to have a constant angular velocity may turn out to be not very acceptable, even for a relatively slow passage of the rotor through its critical speed. Such a divergence between the mathematical model and the actual behavior of a rotor system may give rise to errors in the determination of the unbalance distribution in the rotor. An investigation of the dynamic characteristics of flexible rotors in terms of an amplitude-phase-frequency characteristics analysis for a fast rotor transition through a critical speed is described. The rotor behavior is described by means of differential equations for non-stationary vibrations which are solved in terms of the asymptotic method of Bogolubov and Mitropolsky.

MONITORING

81-2670

Monitoring Rolling Contact Bearings under Adverse Conditions

A.G. Ray

Machinery Health Monitoring Group, Inst. Sound Vib. Res., Univ. of Southampton, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 187-194, 8 figs, 8 refs

Key Words: Monitoring techniques, Rolling contact bearings, Bearings

A significant proportion of rolling contact bearings must be monitored under conditions that can only be considered as adverse. Low and ultra high speeds, difficulty of access and the presence of other more powerful vibration sources are three of the more commonly met situations. In these the ability of currently used techniques to detect damage falls dramatically. The author considers aspects of the above mentioned problems; first describing in some detail the physical nature of the problem, suggesting some solutions and giving two examples of successful detection: the first at low speed, less than 1000 DN, and the second of a gas turbine main bearing failure. The latter is perhaps the most interesting as it was achieved by vibration analysis of the signal from an accelerometer on the outer casing and so combined three of the worst situations.

81-2671

The Specification and Development of a Standard for Gearbox Monitoring

R.M. Stewart

Machinery Health Monitoring Group, Inst. Sound Vib. Res., Univ. of Southampton, UK, Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 353-358, 3 figs, 1 table, 5 refs

Key Words: Monitoring techniques, Gear boxes

The principal objective of this paper is to "float" the idea of a monitoring standard for gearboxes. It is important to understand what such a term means in condition monitoring at the present time. It is a logical way of approaching the gearbox by appreciating the general nature of its problem, by defining and possibly proscribing the application of the various techniques at our disposal, and by laying out the sequence of steps that might be taken on the path towards implementation of a standard procedure. This paper has been written with machinery managers in mind rather than technicians in vibration analysis.

81-2672

Fine Tuning Mechanical Design

D. McCormick

Des. Engrg., 52 (8), pp 19-34 (Aug 1981) 6 figs

Key Words: Monitoring techniques, Measuring instruments

Machinery health monitoring instrumentation and its operation is described.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see No. 2608)

81-2673

A Finite Element Formulation for Fluid-Structure Interaction in Three-Dimensional Space

R.F. Kulak

Reactor Analysis and Safety Div., Argonne Natl. Lab., Argonne, IL, J. Pressure Vessel Tech., Trans. ASME, 103 (2), pp 183-190 (May 1981) 13 figs, 2 tables, 10 refs

Key Words: Interaction: structure-fluid, Finite element technique, Fluid-filled containers

A development is presented for a three-dimensional hexahedral hydrodynamic finite-element. Using trilinear shape functions and assuming a constant pressure field in each element, simple relations are obtained for internal nodal forces. Because the formulation is based upon a rate approach it is applicable to problems involving large displacements. This element is incorporated into an existing plate-shell finite element code. Diagonal mass matrices are used and the resulting discrete equations of motion are solved using an explicit temporal integrator. Results for several problems are presented which compare numerical predictions to closed form analytical solutions. In addition, the fluid-structure interaction problem of a fluid-filled, cylindrical vessel containing internal cylinders is studied.

MODELING TECHNIQUES

(Also see Nos. 2523, 2631)

81-2674

Simulation of Earthquake Ground Motions Using Autoregressive Moving Average (ARMA) Models
N.W. Polhemus and A.S. Cakmak

Dept. of Civil Engrg., School of Engrg. and Applied Science, Princeton Univ., Princeton, NJ, Intl. J. Earthquake Engrg. Struc. Dynam., 9 (4), pp 343-354 (July-Aug 1981) 7 figs, 6 tables, 11 refs

Key Words: Simulation, Earthquake simulation, Seismic excitation

Parsimonious representations of recorded earthquake acceleration time series are obtained by fitting stationary autoregressive moving average models after a variance-stabilizing transformation. Simulated acceleration series are then constructed by generating realizations from the fitted stationary models and applying the reverse transformation. As demonstrated on three components of a typical series, the response spectra for the observed and simulated series show good agreement for periods of less than eight seconds. The model parameters for the three components are very similar, suggesting a consistency which could be useful for identifying site-specific characteristics.

81-2675

Basic Course in Finite-Element Analysis - Advanced Techniques

N.F. Rieger and J.M. Steele

Stress Technology Inc., Rochester, NY, Machine Des., 53 (17), pp 97-100 (July 23, 1981)

Key Words: Finite element technique

The application of finite element technique for dynamic analysis is described.

NUMERICAL METHODS

81-2676

A New Branching Technique for the Static and Dynamic Analysis of Geared Systems

L.D. Mitchell

Mech. Engrg. Dept., Virginia Polytechnic Inst. and State Univ., Vibrations in Rotating Machinery, Proc. 2nd Intl. Conf., Churchill College, Cambridge, UK, Sept 1-4, 1980, organized by Instn. Mech. Engrs., pp 37-42, 5 figs, 2 tables, 13 refs

Key Words: Gears, Branched systems, Transfer matrix method

The dynamic analyses of gear-driven drive systems for their dynamic response have traditionally been done by equivalent dynamic system methods. This method and other nodal-based methods cause excessive computational bookkeeping. This paper proposes the use of multi-rotored transfer matrices. The rotors are coupled by a modified Hibner-type transfer matrix at each gear mesh. This method automatically includes the detailed bookkeeping within the matrix operations. The theory is presented, a mesh transfer matrix developed, and a benchmark example solved by conventional means and by the new coupling method. Numerical results are presented for the case of machining error in the gear teeth.

STATISTICAL METHODS

81-2677

Principle of Supplementarity of Damping and Isolation in Noise Control

G. Maidanik

David W. Taylor Naval Ship Res. and Dev. Ctr., Bethesda, MD, *J. Sound Vib.*, **77** (2), pp 245-250 (July 22, 1981) 2 figs, 8 refs

Key Words: Statistical energy analysis, Noise reduction, Damping effects, Isolation

The elements of the statistical energy analysis of a complex dynamic system are briefly reviewed. The explicit form of the analysis is given for a complex consisting of two basic dynamic systems. The analysis is cast in a form that underlies the principle of supplementarity of damping and isolation. Briefly, the principle states that in situations in which the application of either damping or isolation to selected strategic portions of a complex dynamic system does not perform satisfactorily in controlling a noise problem, the supplemental application of damping and isolation may perform effectively.

PARAMETER IDENTIFICATION

81-2678

Non-Parametric Identification of a Class of Non-Linear Close-Coupled Dynamic Systems

F.E. Udawadia and C.-P. Kuo

Univ. of Southern California, Los Angeles, CA, *Intl. J. Earthquake Engrg. Struc. Dynam.*, **9** (4), pp 385-409 (July-Aug 1981) 11 figs, 6 tables, 29 refs

Key Words: System identification techniques

A non-parametric identification technique for the identification of arbitrary memoryless non-linearities has been presented for a class of close-coupled dynamic systems which are commonly met within mechanical and structural engineering. The method is essentially a regression technique and expresses the nonlinearities as series expansions in terms of orthogonal functions. Whereas no limitation on the type of test signals is imposed, the method requires the monitoring of the response of each of the masses in the system. The computational efficiency of the method, its easy implementation on analogue and digital machines and its relative insensitivity to measurement noise make it an attractive approach to the non-parametric identification problem.

81-2679

The Integration of Nonlinear Stochastic Systems with Applications to the Damage and Ambiguity Identification

W. Wedig

Z. angew. Math. Mech., **61** (1), pp 7-20 (Jan 1981) 7 figs, 10 refs

Key Words: System identification techniques, Diagnostic techniques

The paper investigates nonlinear stochastic systems with piecewise linear characteristics whose multi-dimensional distribution densities are piecewise gaussian and therefore exactly calculable taking into account the necessary continuity and normalization conditions. Applying this approach to a cracked bending oscillator, a spectral analysis is performed leading to the new phenomenon that the one degree of freedom system possesses two resonances the distance of which is a measure for the damage extension.

DESIGN TECHNIQUES

81-2680

Design Sensitivity Analysis of Planar Mechanism and Machine Dynamics

E.J. Haug, R. Wehage, and N.C. Barman

Materials Div., College of Engrg., Univ. of Iowa, Iowa City, IA, *J. Mech. Des., Trans. ASME*, **103** (3), pp 560-570 (July 1981) 8 figs, 5 tables, 14 refs

Key Words: Design techniques, Plane mechanisms, Optimum design, Computer aided techniques

A method of formulating and automatically integrating the equations of motion of quite general constrained dynamic systems is presented. Design sensitivity analysis is carried out using a state space adjoint variable method that has been employed extensively in optimal control and structural design optimization. Both dynamic analysis and design sensitivity analysis formulations are automated and numerical solution of state and adjoint differential equations are carried out using a stiff numerical integration method that treats mixed systems of differential and algebraic equations. A computer code that implements the method is applied to two numerical examples.

COMPUTER PROGRAMS

81-2681

Desktop Instruments for Modal Analysis

L. Enochson

Time Series Associates, Palo Alto, CA, Mach. Des., 53 (10), pp 81-86 (May 7, 1981)

Key Words: Measuring instruments, Modal analysis

Microcomputer-based desk top modal analyzers are described which can be operated by individuals unfamiliar with computer programming. In a typical modal analysis, a stick-figure model is developed to represent the geometry of the structure. The structure is then excited and the vibration data fed from transducers into the analyzer. The analyzer displays frequency-response functions from which the user determines the structural resonances where the largest deflections are produced. The analyzer then displays the animated mode shapes for these selected frequencies. By observing how the structure deforms for each of the various modes, the analyst can evaluate the stability of the structure and modify it if necessary to damp out excessive vibration.

81-2682

Evaluation of ADINA. Part I. Theory and Programing Descriptions

T.Y. Chang and J. Padovan

College of Engrg., Akron Univ., Akron, OH, Rept. No. AUE-801, 135 pp (June 8, 1980)

AD-A096 678

Key Words: Computer programs, Finite element technique

An evaluation of 1977 ADINA, a general purpose nonlinear finite element program, was conducted. The evaluation work consists of the review of its theoretical basis, nonlinear static and dynamic solution algorithms, and program architecture. A discussion of the program is made with respect to its nonlinear analysis capability and limitations.

81-2683

Evaluation of ADINA. Part II. Operating Characteristics

J. Padovan and T.Y. Chang

College of Engrg., Akron Univ., Akron, OH, Rept. No. AUE-802, 158 pp (June 8, 1980)

AD-A096 681

Key Words: Computer programs, Eigenvalue problems, Finite element technique

An advanced evaluation of the various solution algorithms available in the 1977 ADINA was made. The main objective

of the evaluation work is to assess the inherent characteristics of the nonlinear static, dynamic and eigenvalue solution branches of the program. Several benchmark problems were run to establish the numerical characteristics of the solution algorithms adopted by ADINA.

81-2684

Truck and Tractor-Trailer Dynamic Response Simulation, Volume 1. Summary Report

T.D. Gillespie, C.C. MacAdam, G.T. Hu, J. Bernard, and C. Winkler

Highway Safety Res. Inst., Univ. of Michigan, Ann Arbor, MI, Rept. No. UM-HSRI-79-85-1, FHWA-RD-79-123, 22 pp (Dec 1980)

PB81-174526

Key Words: Computer programs, Articulated vehicles, Ride dynamics, Braking effects

A computer program for simulating the braking and directional response of heavy vehicles has been developed for the Federal Highway Administration as a tool for investigation of the effects of increased truck size and weight. Designated as the 'Truck and Tractor-Trailer Dynamic Response Simulation - T3DRS:V1,' the program is capable of simulating trucks, tractor-semitrailers, doubles and triples combinations. Modeling for the vehicle components has been adapted from earlier simulations produced under sponsorship of the Motor Vehicle Manufacturers Association.

81-2685

Truck and Tractor-Trailer Dynamic Response Simulation, Volume 2. Technical Report

T.D. Gillespie, C.C. MacAdam, G.T. Hu, J. Bernard, and C. Winkler

Highway Safety Res. Inst., Univ. of Michigan, Ann Arbor, MI, Rept. No. UM-HSRI-79-85-2, FHWA-RD-79-124, 130 pp (Dec 1980)

PB81-174534

Key Words: Computer programs, Articulated vehicles, Ride dynamics, Braking effects

A computer program for simulating the braking and directional response of heavy vehicles has been developed for the Federal Highway Administration as a tool for investigation of the effects of increased truck size and weight. Designated as the 'Truck and Tractor-Trailer Dynamic Response Simulation - T3DRS:V1,' the program is capable of simulating

trucks, tractor-semitrailers, doubles and triples combinations. Modeling for the vehicle components has been adapted from earlier simulations produced under sponsorship of the Motor Vehicle Manufacturers Association.

form in FORTRAN. The results of NORM2L are compared with those of other computer programs.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

81-2686

Truck and Tractor-Trailer Dynamic Response Simulation - T3DRS:VI. Volume 3. User's Manual

T.D. Gillespie, C.C. MacAdam, and G.T. Hu
Highway Safety Res. Inst., Univ. of Michigan, Ann Arbor, MI, Rept. No. UM-HSRI-79-38-1, FHWA-RD-79-125, 276 pp (Dec 1980)
PB81-174542

Key Words: Computer programs, Articulated vehicles, Ride dynamics, Braking effects

This document is a User's Manual for the computer-based mathematical simulation program entitled 'Truck and Tractor-Trailer Dynamic Response Simulation - T3DRS:VI' developed in 1979 by the Highway Safety Research Institute/University of Michigan. This manual provides an introduction to the simulation program with a description of its external characteristics sufficient for a user to submit a run and interpret the output obtained.

81-2687

NORM2L: An Interactive Computer Program for Acoustic Normal Mode Calculations for the Pekeris Model

D.D. Ellis
Defence Research Establishment Atlantic, Dartmouth, Nova Scotia, Rept. No. DREA-TM-80/K, 74 pp (Dec 1980)
AD-A096 548

Key Words: Computer programs, Normal modes, Elastic waves, Wave propagation, Sound propagation, Underwater sound

The interactive computer program, NORM2L, calculates the discrete normal modes and acoustic propagation loss for the Pekeris model of the ocean. The Pekeris model is a simple two-layer model in which the two layers represent the sea-water and seabed. For many shallow-water environments, the model is a reasonable approximation to the actual physical situation and can be used to investigate acoustic propagation at low frequencies. For ease of future expansion and modification, the program NORM2L is written in modular

81-2688

Vibrations in Rotating Machinery

Proc. of Second Intl. Conf. held at Churchill College, Cambridge, UK on Sept 1-4, 1980, organized by the Applied Mechanics Group of the Institution of Mechanical Engineers, 461 pp

Key Words: Proceedings, Rotating machinery, Bearings, Shafts, Mechanical drives, Gear drives, Balancing techniques

Papers presented at this conference include the seismic response of flexible rotors, modal dynamic simulation of flexible shafts in hydrodynamic bearings, drive trains in printing machines, vibration spectra from gear drives, balancing of flexible rotors as a problem of mathematical programming, and many others. Abstracts of individual papers are listed in the appropriate sections of this issue of the Digest.

TUTORIALS AND REVIEWS

81-2689

A 'Road Map' for Stress Analysis

T.G. Krulick
Fuller Co., Bethlehem, PA, Mach. Des., 53 (18), pp 139-143 (Aug 6, 1981)

Key Words: Stress analysis

Procedures for solving various stress problems are presented by means of three charts. Chart A shows how to handle static loads in both brittle and ductile materials. Chart B covers reversing loads on ductile structures. Chart C treats fluctuating loads, uniaxial or combined, in ductile materials.

81-2690

Three Traps to Avoid in Noise Control

T.H. Rockwell

Acoustical Consultant, Chesterland, OH, Plant
Engrg., 35 (16), pp 99-100 (Aug 6, 1981) 2 figs

Key Words: Noise reduction, Machinery vibration, Machinery noise

The aim of this article is to clarify some of the acoustics fundamentals of machinery noise control. It briefly discusses sound absorption, machinery vibration and noise measuring instrumentation.

**CRITERIA, STANDARDS, AND
SPECIFICATIONS**

81-2691

Logical Analysis of Tentative Seismic Provisions

J.R. Harris, S.J. Fenves, and R.N. Wright

Ctr. for Building Tech., U.S. Dept. of Commerce,
Natl. Bureau of Standards, Gaithersburg, MD, ASCE
J. Struc. Div., 107 (ST8), pp 1629-1641 (Aug 1981)
6 figs, 2 tables, 4 refs

Key Words: Standards and codes, Buildings, Seismic design, Earthquake resistant structures

A study is described of the format and expression of the Tentative Provisions for the Development of Seismic Regulations for Buildings developed by the Applied Technology Council. The methods of analysis employed provide objective measures of clarity, completeness and consistency, as well as an alternative formal representation with which to examine the correctness of the provisions. The formal representation of the seismic provisions and the findings of the analysis will assist those concerned with the future development of the provisions and their implementation within the various national standards and model codes.

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Curved Beams
 1910 1662 1783 2386 87 768 609
 337

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 1961

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 1041 1257

Cushioning
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 1182

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 440 592 2133 2176 2178 599
 2222

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 770 771 612 973 974 95 96 878 2179
 1010 1911 1252 1253 1254 855 346 2388 2389
 1050 2131 2132 2123 1494 1715 1836 2629
 1100 2161 2413 1664 2415

Cylindrical Beams
 1337 1338

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 120 121 782 403 124 1015 426 1017 118 119
 360 771 1012 783 1014 1275 1016 1677 368 359
 1010 781 1282 973 1944 1405 1276 2407 1498 1679
 1280 1011 1682 1013 2164 1715 1676 1678 2409
 1680 1681 1762 1673 2105 2406 2608 2609
 1940 1941 1942 1943 2165
 2180 2161 2162 2163
 2390 2611 2612
 2410
 2610

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Damage Prediction
 243 254 735
 2225

Damped Modes
 1756

Damped Structures
 1070 2391 2022 1923 2144 1376 407 1078
 2023

Damped Systems
 1760 2143 2208
 2218

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 875

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 1080 421 2213 214 875 2116 419
 2633 2214 2565 1989
 2634

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580	1041	2212	213	1584	1805	1076		2058	1079	530	1411	1142	1473	854	1145	2356	877	1778	789
1200	1081	2532				2126			1309	750	2281	1892	1893	1104	1565	2646	2427	1958	959
									1319	1510		1992	2013	1244	2425			2358	1199
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1340				384	2585			2218						1674					1789
														2394					
Damping Coefficients										Detectors									
590	1651	422	223		725	316		308	1129	1530		1872						2078	
1660	1911	542	603		1725	586		518	1339										
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2230	2571	1642	1193		2105	2376		1758		1110									
2550		2582	1653		2215	2466		1828		Diagnostic Techniques									
		2632	2583							1110	1111	442	443	444	185	696	677	698	699
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1560		502	1903	294	605	826	377	348	219	2470	1501	1362	1363	1364	2475	2016	2017	1108	1369
2050		2522		424	825	1556	2677		499			1541	1542		1574	2655	2656	2657	1738
2170		2612		584					2049			2251							2468
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2026

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2620 1321 2162 1014 1045 1046 1667 78 389
2445 1968 2609

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use Disks

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56

Disks

use Disks (Shapes)

Disks (Shapes)

2040 1091 1002 2143 224 1936 1258
2112 2363 994 1178
2362 2148
2512

Displacement Analysis

1953

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1092 434 105 668
435

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433 1996

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1005 1006 1008

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189

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574

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170 381 382 383 624 135 136 1037 1288 1959
380 1291 1032 573 1034 565 1036 1957 1958
610 1471 1292 1033 1234 1035 1506
1290 1961 2422 1293 1294 1295 1956
1690 2421 1853 2174 1505
1960 2173 1955
2420 2423 2175
2620 2563

Duffing's Differential Equation

1770

Dynamic Absorbers

2093

Dynamic Balancing

703

Dynamic Buckling

120 121 122 123 664 1665 366 97 88
361 1692 784 796 347 2408
2121

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851 2306 2059
2476

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Dynamic Loads

use Dynamic Response

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1071

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1040 1934 88

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1773 1774

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1201

Dynamic Response

1440 821 2272 743 2114 195 346 367 318 79
1151 2113 1897 1208 229
2099

Dynamic Shear Modulus

2466

Dynamic Stability

1761 1412 1394 585 656 498

Dynamic Stiffness

70 1041 732
1901

Dynamic Stress Concentration

2024 1699

Dynamic Structural Analysis

1060 81 712 843 1224 825 166 1057 18 199
431 1754 1135 336 198 709
2401 2264 766 1558

Dynamic Structural Response

use Dynamic Response

Dynamic Synthesis

1654

Dynamic Systems

1561 2262 2263 466 1768
2261

Dynamic Tests

180 31 2542 233 24 25 1536 1197 598 309
540 181 543 694 685 1667 888 559
930 541 603 1314 1605 1539
1580 1251 1313 1854
2653

Dynamic Vibration Absorption (Equipment)

1140 54 1236 298 419
1989

Dynamic Weighing Method

741 1096

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Ears

1267

Earthquake Damage

371 1192 243 254 795 2066 2627 1198
1591 1423 1424
2541

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1318

Earthquake Resistant Design

use Earthquake Resistant Structures

Earthquake Resistant Structures

2601 1673 2195 1777 738
2691

Earthquake Response

180 731 242 153 244 1255 1596 1277 1838
260 1921 1712 1503 1594 1705 2176 2537
820 2561 1962 1673 2044
860 2392 1963
2540 2543

Earthquake Simulation

2542 1194 637
2674

Earthquakes

891 1072 823 2194 1826 797 1319
1831 2309

Eigenvalue Problems

710 221 842 193 924 2025 196 457 1118 1119
870 1941 1522 2683 1754 2495 456 2477 2478
2022

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use Eigenvalue Problems

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1265

Elastic Foundations

790 775 2157 778 1249
1259

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2400 252 1936
2312

Elastic Media
2490 2191 1302 413 405 1086 1059
1552 1983 1526 1319

Elastic-Plastic Properties
361 664 126
1344 1066
1346

Elastic Properties
252 1345 86 837
426 997
2606 1347
1527
2397

Elastic Waves
1300 171 713 974 145 136 847 388 389
991 733 1034 1035 1046 1697 848 1699
1301 1043 1044 1045 1696 1827 1698
1961 1303 1294 1305 2446 1967 2028
2181 2443 1304 1695 2447 2448
2421 1374 2687
1514
2444

Elastically Restrained Edges
100

Elasticity

1789

Elasticity Theory
996 1107

Elastodynamic Response
2202 1527

Elastohydrodynamic Properties
2594

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2574 1646
1886

Elastomeric Dampers
831 656

Elastomeric Seals
2594

Elastomers
2570 631 1885 1886 2097 58
1651 2526 1528

Elastoplastic Properties
2260 2172 45 1349

Electric Drives
532

Electric Generators
use Electric Power Plants

Electric Power Plants
791 394 25 26 887 28
1811 1415 386 1427 208
1146 738
1416 1488
2548

Electric Systems
2530

Electric Vehicles
233 899

Electromagnetic Properties
1814

Electronic Instrumentation
1734 626 1357
696

Elevated Railroads
919
1439

Enclosures
1030 1031 2602 943 14 816 98 1029
1013 1028

Energy Absorbers
use Energy Absorption

Energy Absorption
1880 1222 904 45 906 1637 789
1990 2092 2094 755 1426 2097
2352 2354 905 1636
2355

Energy Dissipation
902 103 2184 1195
2192 1873 1805

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Failure Detection
2471 2402 2403 2404 696 2018 2289
2444

Fan Blades
950 1533

Fan Noise
1581 2047
1861 2297

Fans
1580 951 1413 1174 525 226 517 68
1581 1533 1414 875 526 727
1811 1853 1784 1415 726 1427
1957
2567

Fast Fourier Transform
2012 674 526 69
1364 2086 1089

Fast Fourier Transformation
use Fast Fourier Transform

Fatigue Life
470 1 12 163 64 165 326 227 238 599
600 41 1342 1083 164 265 836 317 258 659
660 191 1992 1163 224 285 856 327 1188 1219
1200 211 2222 1343 834 895 1186 1187 1218 1719
1440 321 1603 894 1085 1566 1617 1298 2109
1660 481 1993 1084 1625 2016 1717 1348 2439
1720 661 2303 1524 1645 2636 1787 1438 2519
1870 791 2373 1544 1795 1837 1718 2639
2220 1111 2643 1564 2635 2077 1788
2440 1341 1834 2107 1938
2460 1371 1994 2117 2368
1871 2304 2367 2438
1991 2644 2427 2618
2221 2637 2638

Fatigue (Materials)
1530 162 835 659
2642

Fatigue Strength
use Fatigue Life

Fatigue Tests
680 2441 1083 1084 205 236 237 438 1189
2641 2343 1344 325 916 327 2369
2374 835 1346 437
1085 1546 1347

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Fatigue Tests (continued)
1185
1345
1525
2375

Feedback Control
1116

Fiber Composites
340 612 2354 2355 2297 88 2149
1342 2407 998 2439

Fiberglass
2183

Fiberscopes
176

Field Test Data
1630 1204

Filters
2460 1731 2002 2003 179
2471 2472

Finite Difference Technique
862 123 84 2155 1496 2227 939
1642 1506
1656

Finite Difference Theory
use Finite Difference Technique

Finite Displacement Method
963 1375

Finite Element Technique
250 1 142 343 4 365 46 37 8 99
460 361 362 353 114 455 196 77 68 459
730 1131 492 403 364 505 246 1277 398 469
750 1381 722 453 454 855 346 1387 408 539
760 1711 732 663 474 1005 556 1477 418 749
780 2321 862 783 884 1375 706 1687 458 969
860 2491 892 813 974 1595 736 1937 878 989
890 2551 1132 843 984 1935 776 2127 928 1119
1010 1642 1033 1484 2025 1056 2177 1438 1219
1130 1672 1293 1914 2275 1086 2377 1478 1269
1150 2082 1393 2274 2555 1126 2058 1279
1330 2102 1463 2294 2675 1506 2088 1909
1410 2282 1963 2504 1826 2128 1929
1950 2512 2053 2604 2126 2138 1979
1960 2682 2283 2166 2148 2019

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2080	2503	2196	2168	2069
2190	2673	2386	2188	2219
2380	2683		2258	2419
2490			2478	
2590				

Finite Strip Method

983	616	1257	558
-----	-----	------	-----

Flexibility Coefficients

2042	1133	1137	2108
		2377	

Flexible Couplings

510	333	794
-----	-----	-----

Flexible Foundations

724	1946	1828	2049
-----	------	------	------

Flexible Rotors

500	491	2662	223	2474	1115	486	487	2668	499
700	701		493		1365	1366	1807		1409
1170	1741		723		1405	1406	2667		2669
	2531		1173		1565	2666			
	2661		1743						
			1813						

Flexible Shafts

2296	2509
------	------

Flexural Response

2101	333	1889
------	-----	------

Flexural Stiffness

1060	1405
------	------

Flexural Vibration

100	91	492	1663	94	225	986	1247	618	109
340	111	1082	1903	1014	325	1456	1337	1168	1249
1250	341	1532	2103	1264	625	1926	1577	1178	1259
1660	351	1852	2153	1924	975	2386	1927	1258	2399
1720	611	1932		2154	1655	2606	1987	1268	
	1001	2332		2214	1935		2157	1338	
	1261			2384	2155				
	1671			2424	2605				
	1941								
	2161								
	2411								

Flexural Waves

970	2151	1272	944	2455	2609
		2162	1014		

Flight Tests

1727

Flight Vehicle Equipment Response

2241

Flight Vehicles

560	1085	929
	2235	

Floating Bodies

use Floating Structures

Floating Ice

1854

Floating Ring Journal Bearings

73	2577
----	------

Floating Structures

826

Floors

2621	1823	385	1038
		1635	

Flow-Induced Excitation

use Fluid-Induced Excitation

Flow-Induced Vibration

use Fluid-Induced Excitation

Fluid Amplifiers

1075

Fluid Couplings

1677

Fluid Damping

use Viscous Damping

Fluid Drives

10	546
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Fluid-Filled Containers

790	411	783	374	1275	1946	1277	1018	1279
1010	1951	1673	784	1675		1947	1028	1949
1950	2481	2613	1674	1945		2347	1278	
2160		2673					2348	

Fluid-Film Bearings

580	581	1892	315	1406	79
1740	761				509
					869

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Fluid-Induced Excitation

130	131	132	23	134	95	96	127	158	129
740	391	262	133	374	485	116	377	208	349
770	791	572	373	604	1275	346	1267	378	519
990	951	922	503	1024	1795	606	1427	488	759
1200	971	992	623	1254	2415	716	1737	518	939
1490	991	1602	653	1764		736	1787	948	979
2170	1021	1722	993	1834		1026	1947	1288	1509
	1031	1912	2593	1944		1496	2417	1788	2169
	1491	2072	2413	2364		1676	2617	1808	
	1551	2142	2613			1686			
	1661					1836			
	1711					1896			
	1841					2116			
	2051					2146			
	2131					2416			

Fluid-Induced Vibrations use Fluid-Induced Excitation

Fluid Mechanics

2478

Fluids

2452 1675 2347

Flutter

950	881	92	43	404	415	66	1137	158	759
1620	961	752	1153		2275	286	2037	938	769
1790	1621	872	1533		2345	726	2567	2038	929
2040	1791	1152	1623			1526			1139
2360	2041	1452				1666			1619
	2101	1792				2086			1869
		1902				2516			1889
		2102				2556			2039

Flywheels

1639

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942 1704 1637

Follower Forces

601 92 1334 1526
1261

Footings

250

Force Apportioning Method

420

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2052 1477 1478

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2243 2244

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1092

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1756

Forced Response Strain Energy Method

1386

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871 342 83 504 1535 1068 2399
492 1003 554
1772 1063
1253

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2090

Fossil Power Plants

890 1811 1416 1287 2548
1427

Foundation Excitation

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Foundations

220 253 1804 1805 526 1827 1828 1829
1180 1825 536 2527 2529
1740 1936
1830
2530

Four Bar Mechanisms

2491

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973 354 1728 2319
1924 2138
2658

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1052 984 356 998
1234
2024

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1090 171 172 1926 447
1730 1091 1312 2016 2647
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50 51 52 53 754 935 1876 537 568 49
150 861 912 903 934 2046 817 1468 569
570 911 1232 1233 1444 1877 1878 689
1570 941 1632 1573 1469
1630 1231 2622 1633 1629
2350 1631 1863 1879
2351 2349

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155

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20 921 273 2074
1850

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10 1224 1025 9

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305 546 1027 1598
1026 1147

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1485

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1482

Hydrodynamic Damping
524 356

Hydrodynamic Excitation
770 71 1912 1513 1254 1595 1636 927 418 1499
1210 2072 1954 1856 1597 2188
2380 2314 2066 2067 2578
2317

Hydrofoil Craft
2081 404 279

Hydrophones
1722 1735 2646
2495

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425 1066
655
1495

1758 2199

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Ice

1854

Impact Dampers
use Shock Absorbers

Impact Force

2273

818

Impact Noise

2184

Impact Response

1350 611 152 403 574 35 357 58 359
2081 1072 563 974 355 467 68 2179
1823 1934 665 757 108 2589
2125 847 958
2145 2387 1238
2235 2408

Impact Shock

636

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Impact Tests

2583

1516 837

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1571 1513
2493

1499

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1 503

877 488

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2432

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1360

1693

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1391 392 813 395 816 247 628 629
2431 2623 815 2006 887 2548 1879
1515 907
1975

Industrial Noise

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Influence Coefficient Matrix

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Influence Coefficient Method

700 871 2474 1365
2020 1901
2661

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1270 361 762 1264 2398 339

Initial Value Problems

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Instrumentation

1748

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1357

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1560 1552 1373 194 1135 97 848
2270 1772 2264 847

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1555

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1604

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1203 206 748

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20 691 272 183 34 65 207 2099
690 921 1202 2553 274 945 1437 (cont'd)

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 920 1852 1434 1355
 2332 1435

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 2508

Interaction: Rotor-Foundation
 2530 2527 2528 2529

Interaction: Rotor-Stator
 281 39

Interaction: Shiphull-Machinery
 37 928

Interaction: Shock Waves - Boundary Layer
 1054

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 732 793 885 1936 1827 1828 819
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1910 1931 1672 1913 384 1925 1926 1257 1118 2159
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 530 331 302 393 304 245 546 247 538 19
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1411 1242 1133 1874 1386 1789	1790 1791 2142 1034 995 1666 2177 978 1919											
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1875	850 201 202 203 244 465 306 1137 1138 679											
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1670 1922 1263 104 115 2396 1928 2399	2130 501 1776											
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2308	780 1023 1094 1095 1946 897 898											
	2515											
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451 562 1075	650 501 1065 2027											
1141 1042 1535												
1551 2482	Passive Isolation											
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550 2231 252 2143 204 406 2577 358 89
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1378 2379
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990 992 993 1068 1379
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1785 2418

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140 621 622 793 1284 375 786 127 128 789
790 781 792 1393 1954 785 1286 787 208 1499
1500 1501 1952 1503 2414 1285 1796 1287 788 1689
2171 1953 1505 1896 1497 1018 2609
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990 991 992 613 614 625 776 617 988 539
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2371 1849

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1270 1922 1263 984 1765 776 2157 618
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use Rotatory Inertia Effects										220	301	2	3	4	315	486	487	488	69
										490	491	212	223	604	445	506	497	498	219
Rotary Pumps										500	501	222	493	724	495	606	507	508	489
1179										580	521	492	503	864	505	656	587	518	499
										700	581	522	523	874	605	716	697	588	509
										870	701	702	603	954	1115	876	867	868	589
Rotary Wings										1170	871	722	723	1154	1175	1176	1177	1168	869
use Propeller Blades										1180	951	872	873	1394	1225	1226	1247	1228	1229
										1400	1361	1152	953	1404	1365	1366	1407	1408	1409
Rotating Blades (Turbomachinery)										1410	1401	1172	1153	1584	1405	1406	1577	1538	1809
use Rotor Blades										1540	1721	1402	1173	1724	1565	1586	1807	1578	2009
										1640	1801	1582	1743	2104	1585	1646	2047	1808	2049
Rotating Machinery										1740	2051	1652	1803	2294	2505	1806	2507	2048	2239
2293 1804 1805										2050	2101	1892	1813	2474	2515	2506	2517	2518	2509
2525										2280	2291	2292	1893	2514	2585	2516	2527	2528	2529
2655										2290	2301	2572	2513	2524	2665	2596	2667	2668	2579

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2360	2511	2592	2523	2666	2669	2250	183 634 925 1737
2510	2521	2662	2593				1604
2530	2531		2633			Screws	
2660	2661		2663			600	599
Rotors (Machine Elements)				Seals			
use Rotors						1582 603 604 605 336 1537 2118 959	
Rubber						2592 2593 764 2585 606 1897	
use Elastomers						2594 2595 716 2117	
Runway Roughness						2106	
290	1461			288	289	2596	
				Seat Belts			
						181 1632	2327
				Seismic Analysis			
						1590 261 882 1283 1255 1198 1779	
						1601 1502 2383 1915	
						2171 2312	
				Seismic Barriers			
							2068
Safety Belts				Seismic Design			
use Seat Belts						240 241 792 153 384 735 16 17 248 379	
Safety Restraint Systems						1320 261 1422 253 794 1195 216 1167 468 479	
2330	181	1222	277			2601 2192 1143 1144 1825 376 1777 1158 1399	
		1632	2327			2691 2193 1835 1166 2317 1318 2309	
Sand						2195 1916 1398	
			2466 1197	Seismic Detectors			
Sandwich Laminates							2078
use Sandwich Structures				Seismic Excitation			
Sandwich Panels						250 821 242 1983 154 1705 416 737 1158 1279	
use Panels and Sandwich Structures						1661 892 2383 684 2135 736 2097 1498 2189	
Sandwich Structures						2621 1072 2433 1144 796 1948	
341	2602	2395	1928 2139			1962 2064 2066 2098	
2141			2219			2062 2674 2178	
SAP (Computer Programs)				Seismic Isolation			
		813				60	2097 2098
Satellite Antennas				Seismic Response			
use Spacecraft Antennas						30 251 372 773 24 15 386 27 28 29	
Satellites						260 771 772 783 344 25 806 257 368 239	
			1128			370 891 782 793 764 545 1706 267 688 259	
						400 2311 822 883 804 795 1916 847 798 399	
						800 2531 1022 893 824 825 2136 2177 1038 799	
Saws						820 2392 1193 884 1385 1518 889	
	2362	2055 2056	1479				

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890	1423	1424	1595		2628	1099					
2070	1823	2134	1785			2419					
2560	2193	2194	1825								
		2614									
Seismic Response Spectra											
		194									
Seismic Waves											
2540			255		1517	1158	1319				
					2067	2068					
					2628						
Self-Excited Vibrations											
490	561	1172	1063		1295	516	1327		489		
1210	1481	2102	2213		1485	1286			1329		
1710									1479		
2200									1689		
Semiactive Isolation											
		2564	2565								
Semitrailers											
						1278					
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		2132									
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		1534									
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1410	2521	1162	1403	1404	2295	486		868	1169		
1720		1802	2253	1564	2525	2296		1168	2519		
1800		2522		2524				2688	2579		
2520				2594							
Shafts (Machine Elements)											
720	721	512	1173	484	5	6	7	708	219		
1170	831		1543		225	1366	857	2048	669		
1580	1171				475	1576	1807				
	1181					1405					
	1411					1575					
	1741										
Shakedown Theorem											
								1349			
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	2242				1106	1197		2649			
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										576	

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1270 1699

Shells
120 121 122 123 124 125 126 117 118 119
360 361 362 363 364 365 366 617 368 259
620 1011 1012 973 1014 855 426 1007 1008 359
1280 1041 1282 1013 1684 865 1016 1017 1498 469
1680 1281 1682 1673 1944 1005 1276 1677 1678 1009
1940 1681 1942 1683 2164 1015 1676 2167 2168 1679
2160 1941 2162 1943 2254 1945 2166 2407 2408 1939
2390 1951 2612 2163 2145 2406 2607 2608 2159
2410 2161 2613 2165 2618 2409
2610 2361 2609
2611

Shells of Revolution
1281
1951

Ship Hulls
922 863 116 37 2198 1609
1532 973

Ship Vibration
750 1532 863 1608 749
923

Shipboard Equipment Response
2080 2211 924 37 2079

Shipping Containers
635 2076 467
917

Ships
70 552 704 925 926 37 38 279
1162 2334 1855 1856 927 278 2629
2335 928
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2092 1473 214 575 299
2095

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26

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			1860 1611	1695 1047 1308 2179
Sound Attenuation			1920 2611	1955 1697 1448
610 1292 633 1214			2180	1698
2422			2410	1968
Sound Detectors	1735		2430	2028
		Spacecraft	210 411 1332	294 295 296 1627 48 559
Sound Generation			560 421 1402	1465 1666 2347 1568 1079
2620 2362	2428		1400 1401 1582	1875 1716 2088 2089
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1732		Spacecraft Components	561 562 2013	566 557 558
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	2459		2291 1582	1466 558
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	314 2325 2006			2438
	1704			
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1013 1196			434	2647
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		use Spectrum Analysis		
Sound Propagation		Spectral Energy Distribution Techniques		
1310 1581 1812 2173 614 136 1857 2179		160 681 682 194 1385 2206 1628		
1610 2421 2423 624 1036 2547 2339		1690		
1860 1506 2687		Spectrum Analysis		
2420		40 2071 2382 2233 464 675 2486 2657 448 1179		
Sound Reflection		2230 2231 2443 2444 2656 1138		
630 1698		2580 2614 1518		
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	2646	Spectrum Analyzers	432 674 676 137 1728	
Sound Transmission		Spheres		
630 621 1032 933 104 1015 106 128 349			1695 427 2179	
1960 1031 1292 634 1465 1016 1698 1919			2437	
1971 2602 2535 1956 1958 1959				
2426		Spherical Bearings	320 761	77
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2650 613 1294 2175				

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1683 1007 2408 1939
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813 2058

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62 1235 2358
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1241 2112 2113 2114 325 327 1168
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2570 71 213 2634 75 2049
1523 2569
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2370 2261 2 1553 1684 725 2027 2478 1579
2480 2371 742 1694 1395
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794 1165 376 737
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1850 1871 542 913 144 2276 2497 1408 639
1972 2033 1628
2643 2498

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200 2677 2499

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1100 144

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2497 2498

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2290

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use Periodic Excitation

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1641 1742

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1150 1721 972 2373 1194 1185 236 237 238 1189
1750 2441 1192 1704 1195 1186 597 1188
2641 2352 2064 1525 2176 1187 2178
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2354 2097
2374 2637
2424

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1692

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1986

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2140

98

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350

992

343

780

993

990

Stiffened Shells

1940

2164 1015 1276 2167

Stiffened Structures

1903 2384

978

Stiffener Effects

2515

2167

2527

Stiffness

2600

1584 235

2295

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560

1641

1582

313

884

725

586

308

319

590

1651

1642

603

2204

885

656

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929

820

2291

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1133

2585

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1758

1129

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2571

1683

1386

1828

1239

2110

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1809

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2376

2583

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1136 1127 1928

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1550 191

844 845

227 458 2259

2260 711

1634

957 728

2310 971

868

2580 1461

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2228

Stodola Method

1663

Storage

646

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782 783 784

1673

Stress Waves

2445

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2223 2224

2689

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1015

Strings

960

608 2379

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1765

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1764

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use Structural Members

Structural Members

1870 1081 1692 533 834 625 1296 667 1298 1039

1691

1163

1004

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2176

1157

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1964

2426

1297

2178

1737

2177

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2651 2552

2367

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1950	1951	1673	1274	1275	1277	248	1279		
			1674			1278	1949		
						1948			
						2348			
Taxiing Effects									
					947				
Taylor Series									
	2422					1778			
Temperature Effects (Excitation)									
use Thermal Excitation									
Test Data									
use Experimental Data									
Test Equipment and Instrumentation									
2010		1733	437	205	1106	1537	548	1209	
				2235		2107	1358		
				2465		2287	1538		
Test Facilities									
690	691	182	233	484	2015	1786	477	438	2649
		692	693	694			2467	658	
		2653	2014				2587	838	
			2234					2238	
			2654					2468	
Text Fixtures									
use Test Facilities									
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		183							
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								2289	
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				2585					
Testing Apparatus									
use Test Equipment and Instrumentation									
Testing Equipment									
use Test Equipment and Instrumentation									

Testing Instrumentation
use Test Equipment and Instrumentation

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use Test Equipment and Instrumentation

Testing Techniques									
180	681	432	2013	684	45	686	687	548	439
1090	1101	682		1164	215	1536	757	688	559
1340	1271			1574	1105	2246	1087	1298	719
2240	2011			2374	1165	2466	1357	1618	889
				2464	2245		1887	2328	1199
							2237		1209
							2287		1339
									2289

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1184 235

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1122

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1188

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1280		1902	2603		1235	1266	67	1178	1689
		1942			2405				2029

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2549

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2200 1897 1978

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167

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2282

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70		1642	583			2106			78
590									
2110									

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Time-Dependent Excitation

1913 94 126 137

Time-Dependent Parameters

431 1292 907 2608
1771

Time Domain Method

1190 201 192 1733 1954 675 826 847 1228 679
1420 931 1102 2485 2486 1847 1609
1101 1752 2279
1351
1731

Timoshenko Theory

1410 91 92 983 625 767 768 1659
2600 2382 2115 1248 1899

Tire Characteristics

1205 1887
1845

Tires

63 946 1887 308 309
1476 2359

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2166

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2457

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62

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352 2396 2607 1169
1589

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1821 333 1205 857 1889
2101 1253 1705 1477 2189
1965 2537
2587

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720 521 652 93 324 225 86 527 1168 339
950 651 1082 1663 1664 625 666 1247 2298
1720 1171 1162 1903 1814 1655 876 1417 2588
1800 1532 2103 1964 1815 1816
2510 2054 2525
2384
2494

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Towed Systems

1490

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240 1593 534 248 249
1190 1803 1824 2538 1999

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1436 59

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747

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2303 2304

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743 744 745 577 578
1208

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12 385

Traffic Noise

150 811 52 13 634 1206 807 808 149
810 911 912 913 1844 907 908 809
910 1352 1233 1974 1207 909
1882 2073 1877
2622

Traffic Sign Structures

900 901 1314 1516

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742 743 744 745 906
904 905 2356
1605

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2360 671 672 673 1726 1097 1098
2012 1723
2473

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1071 382 383 1124 2086 1627 948

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2490	1261	92	114	2676	337	98	1419	1040	1671	1662	983	1935	2386	1927	998	109			
2510	1822	994		2417	968			1680	2332	1493					1668	779			
				2048						2103					2518	1929			
Transformation Techniques										Transverse Vibration									
			2484							1923									
Transient Excitation										Trees (Plants)									
2391	723	2125		1017	2198	1009				1974									
				1087															
Transient Response										Trucks									
2080	531	362	663	204	1265	436	117	2188	959	2350	61	1232	1433	1844	1605	1606	1097	1098	
2600	2271	472	1123	354		1146	1007	2258	2299		741	2552	2553	1854	1845				
	2611	2292	1833	474		1236	1267	2298	2409					2074	2325				
			2023	1024			1527	2599						2324					
			2033	1134			2167												
				1724															
				1954															
				2414															
Translational Inertia Effects										Trusses									
				1896			1009								976				
Translational Response										Tube Arrays									
840	1921			1825		667	2588					2413		2415		2617			
						1477													
Transmissibility										Tubes									
										130	131	132	133	134	96	377	378	129	
										1020		2412	373	374	346	1797	638	1019	
										2170			403	1234	1496		1288	1289	
										2610					1796		1798	1799	
																		2169	
Transmission Lines										Tuned Dampers									
2120	961	962	2213	534	1245	1656				300	2561				2217	658			
	1161									830									
Transmission Matrix Methods										Tuned Frequencies									
						1577				720									
										950									
Transmission Systems										Tuning									
															2575	2566	1227		
Transportation Effects										Tunnels									
571				635	2076	567				2540				804					
2241						2077													
Transportation Noise										Turbine Blades									
							149			2100	312	2363			66		1478	579	
																	759		
																	2029		
Transportation Systems										Turbine Components									
										1721	1992		504		1806				
													604						
Transportation Vehicles																			
						2077													

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1810	222			865							
				1745							
Turbines											
1810	2581	1742				1888					
	2052										
Turbocompressors											
				2596							
Turbofan Engines											
	1291					2297					
	1451										
Turbofans											
1580		1413									
Turbogenerators											
1740	2513			2506	2507						
	2573										
Turbomachinery											
220	511	72	653	1394	485	596	707	508	39		
1740	1641	512	1893	2634	2505	1806	1117	2508	489		
2280	2051	702				1996	1367		1579		
		732				2566			2539		
		2532									
Turbomachinery Blades											
2361	952	313		485							
		2103									
Turbomachinery Noise											
				1174							
Turbulence											
	131	933	614		2416	2047					
	391		774								
	2051		1944								
Turbulent Friction											
		1763									
Two-Degree of Freedom Systems											
		963		1556	1387						

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1180	1411	722	493	1804	5	76	2517	1408	509		
2050		732						2518	1409		
2660									1739		
Underdamping											
								2208			
Underground Explosions											
	2191						1517		1979		
Underground Structures											
2540	1421	1022	793	254	255	26	797	368	619		
	1501	1252	1503	794	795	796		798	2419		
			2043	1594	1785			1498			
								2418			
Underride Guards use Guard Rails											
Underwater Explosions											
2080	471	552			2255				1049		
		2432							2079		
Underwater Pipelines											
		1953	1954		896						
Underwater Sound											
	151	1312	673	1504	1735	396	2687		1569		
	671	1702			2045				1969		
	1311				2625						
Underwater Structures											
620			1254	2065	56				2119		
1210			1504								
1490											
Unified Balancing Approach											
	2661										
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	1802							2588			
Urban Noise											
	1972	1233	144		1206				1879		
			1204		1876						
					2046						
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	1851										
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		2254									

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81 82 763 1485 1026 737 1488 369
781 602 1486 1487
1051 1896 1497
2591 2116

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1328 1329

Vanes
1
2201

Vans
2326

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1984

Variable Cross Section
1800 1261 92 1933 2294 1506 337 968
1910 1262 2143 777 1178
1922 2173 2417 1268
1932 2423 1588
2122
2152
2332

Variable Material Properties
2480 2161 1852 1173 2295 876 777 1809
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1344 1345

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2020 2454 1755
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TECHNICAL NOTES

A. Leissa and Y. Narita

Vibrations of Free Circular Plates Having Elastic Constraints and Added Mass Distributed along Edge Segments

J. Appl. Mechanics, Trans. ASME, 48 (1), pp 196-198 (Mar 1981) 3 figs, 6 refs

M.A.M. Torkamani

Method of Direct Solution to Inverse Problems

ASCE J. Engrg. Mechanics Div., 107 (2), pp 424-429 (Apr 1981) 2 figs, 6 refs

P.R. Brazier-Smith, D. Butler, and J.R. Halstead
The Determination of Propagation Path Lengths of Dispersive Flexural Waves through Structures

J. Sound Vib., 75 (3), pp 453-457 (Apr 8, 1981) 4 figs, 4 refs

S.M. Correa, D.L. Sengupta, and W.J. Anderson
Inflight Aircraft Vibration Modes and Their Effect on Aircraft Radar Cross Section

J. Aircraft, 18 (4), pp 318-319 (Apr 22, 1981) 4 figs, 6 refs

J.R. Kuttler and V.G. Sigillito

On Curve Veering

J. Sound Vib., 75 (4), pp 585-588 (Apr 22, 1981) 2 figs, 2 tables, 4 refs

C.T. Leung, N.W.M. Ko, and K.H. Ma

Heat Transfer from a Vibrating Cylinder

J. Sound Vib., 75 (4), pp 581-582 (Apr 22, 1981) 1 fig, 4 refs

S.V. Kulkarni and K.B. Subrahmanyam

Reissner Method Calculations of Natural Frequencies of Torsional Vibrations of Tapered Cantilever Beams

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T. Irie, G. Yamada, and M. Tsujino

Natural Frequencies of Concavely Shaped Polygonal Plates with Simply Supported Edges

J. Acoust. Soc. Amer., 69 (5), pp 1507-1509 (May 1981) 2 figs, 1 table, 10 refs

R.E. Mickens

A Uniformly Valid Asymptotic Solution for $d^2y/dt^2 + y = a + ey^2$

J. Sound Vib., 76 (1), pp 150-152 (May 8, 1981) 8 refs

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J. Sound Vib., 76 (1), pp 146-149 (May 8, 1981) 2 refs

PERIODICALS SCANNED

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
ACTA MECHANICA Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Acta Mech.	JOURNAL OF ENGINEERING FOR POWER	J. Engrg. Power, Trans. ASME
ACUSTICA S. Hirzel Verlag, Postfach 347 D-700 Stuttgart 1 W. Germany	Acustica	JOURNAL OF ENGINEERING RESOURCES TECHNOLOGY	J. Engrg. Resources Tech., Trans. ASME
AERONAUTICAL JOURNAL Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. J.	JOURNAL OF LUBRICATION TECHNOLOGY	J. Lubric. Tech., Trans. ASME
AERONAUTICAL QUARTERLY Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. Quart.	JOURNAL OF MECHANICAL DESIGN	J. Mech. Des., Trans. ASME
AIAA JOURNAL American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	AIAA J.	JOURNAL OF PRESSURE VESSEL TECHNOLOGY	J. Pressure Vessel Tech., Trans. ASME
AMERICAN SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS ASCE United Engineering Center 345 East 47th St. New York, NY 10017		APPLIED ACOUSTICS Applied Science Publishers, Ltd. Ripple Road, Barking Essex, UK	Appl. Acoust.
JOURNAL OF ENGINEERING MECHANICS DIVISION	ASCE J. Engrg. Me- chanics Div.	ARCHIVES OF MECHANICS (ARCHIWUM MECHANIKI STOSOWANEJ) Export and Import Enterprise Ruch UL, Wronia 23, Warsaw, Poland	Arch. Mechanics
JOURNAL OF STRUCTURAL DIVISION	ASCE J. Struc. Div.	ASTRONAUTICS AND AERONAUTICS AIAA EDP 1290 Avenue of the Americas New York, NY 10019	Astronaut. & Aeronaut.
AMERICAN SOCIETY OF LUBRICATING ENGINEERS, TRANSACTIONS Academic Press 111 Fifth Ave. New York, NY 10019	ASLE, Trans.	AUTOMOBILTECHNISCHE ZEITSCHRIFT Franckh'sche Verlagshandlung Abteilung Technik 7000 Stuttgart 1 Pfizerstrasse 5-7 W. Germany	Autom- obiltech. Z.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS ASME United Engineering Center 345 East 47th St. New York, NY 10017		AUTOMOTIVE ENGINEER (SAE) Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale, PA 15096	Auto. Engr. (SAE)
JOURNAL OF APPLIED MECHANICS	J. Appl. Mechanics, Trans. ASME	AUTOMOTIVE ENGINEER (UK) P.O. Box 24, Northgate Ave. Bury St., Edmunds Suffolk IP21 GBW, UK	Auto. Engr. (UK)
JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT AND CONTROL	J. Dyn. Syst., Meas. and Control, Trans. ASME	BALL BEARING JOURNAL (English Edition) SKF (U.K.) Ltd. Luton, Bedfordshire LU3 1JF, UK	Ball Bearing J.
JOURNAL OF ENGINEERING FOR INDUSTRY	J. Engrg. Indus., Trans. ASME	BROWN BOVERI REVIEW Brown Boveri and Co., Ltd. CH-5401, Baden, Switzerland	Brown Boveri Rev.
		BULLETIN DE L'ACADEMIE POLONAISE DES SCIENCES, SERIES DES SCIENCES TECHNIQUES Am Polona-Ruch 7 Krokowakie Przedmiescie, Poland	Bull. Acad. Polon. Sci., Ser. Sci. Tech.

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
BULLETIN OF JAPAN SOCIETY OF MECHANICAL ENGINEERS Japan Society of Mechanical Engineers Sanshin Hokusai Bldg. H-9 Yoyogi 2-chome Shibuya-ku Tokyo 151, Japan	Bull. JSME	HEATING/PIPING/AIR CONDITIONING Circulation Dept. 614 Superior Ave. West Cleveland, OH 44113	Heating/ Piping/ Air Cond.
BULLETIN OF SEISMOLOGICAL SOCIETY OF AMERICA Bruce A. Bolt Box 826 Berkeley, CA 94705	Bull. Seismol. Soc. Amer.	HYDRAULICS AND PNEUMATICS Penton/IPC, Inc. 614 Superior Ave. West Cleveland, OH 44113	Hydraulics & Pneumatics
CIVIL ENGINEERING (NEW YORK) ASCE United Engineering Center 345 E. 47th St. New York, NY 10017	Civ. Engrg. (N.Y.)	HYDROCARBON PROCESSING Gulf Publishing Co. Box 2608 Houston, TX 77001	Hydrocarbon Processing
CLOSED LOOP MTS Systems Corp. P.O. Box 24012 Minneapolis, MN 55474	Closed Loop	IBM JOURNAL OF RESEARCH AND DEVELOPMENT International Business Machines Corp. Armonk, NY 10504	IBM J. Res. Dev.
COMPUTERS AND STRUCTURES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Computers Struc.	INDUSTRIAL RESEARCH Dun-Donnelley Publishing Corp. 222 S. Riverside Plaza Chicago, IL 60606	Indus. Res.
DESIGN ENGINEERING Berkshire Common Pittsfield, MA 02101	Des. Engrg.	INGENIEUR-ARCHIV Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Ing. Arch.
DESIGN NEWS Cahners Publishing Co., Inc. 221 Columbus Ave. Boston, MA 02116	Des. News	INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS IEEE United Engineering Center 345 East 47th St. New York, NY 10017	IEEE
DIESEL AND GAS TURBINE PROGRESS Diesel Engines, Inc. P.O. Box 7406 Milwaukee, WI 53213	Diesel Gas Turbine Prog.	INSTITUTION OF MECHANICAL ENGINEERS, (LONDON), PROCEEDINGS Institution of Mechanical Engineers 1 Birdcage Walk, Westminster, London SW1, UK	IMechE Proc.
ENGINEERING MATERIALS AND DESIGN IPC Industrial Press Ltd. 33-40 Bowling Green Lane London EC1R, UK	Engrg. Mat. Des.	INSTRUMENT SOCIETY OF AMERICA, TRANSACTIONS Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222	ISA Trans.
ENGINEERING STRUCTURES IPC Science and Technology Press Ltd. Westbury House P.O. Box 63, Bury Street Guildford, Surrey GU2 5BH, UK	Engrg. Struc.	INSTRUMENTATION TECHNOLOGY Instrument Society of America 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709	InTech.
EXPERIMENTAL MECHANICS Society for Experimental Stress Analysis 21 Bridge Sq., P.O. Box 277 Westport, CT 06880	Exptl. Mechanics	INTERNATIONAL JOURNAL OF CONTROL Taylor and Francis Ltd. 10-14 Macklin St. London WC2B 5NF, UK	Intl. J. Control
FEINWERK U. MESSTECHNIK Carl Hanser GmbH & Co. D-800 Munchen 86 Postfach 860420 Fed. Rep. Germany	Feinwerk u. Messtechnik	INTERNATIONAL JOURNAL OF EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS John Wiley and Sons, Ltd. 650 Third Ave. New York, NY 10016	Intl. J. Earthquake Engrg. Struc. Dynam.
FORSCHUNG IM INGENIEURWESEN Verein Deutscher Ingenieur, GmbH Postfach 1139 Graf-Recke Str. 84 4 Düsseldorf 1 W. Germany	Forsch. In- genieurwesen	INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Engrg. Sci.

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INTERNATIONAL JOURNAL OF FATIGUE IPI Science and Technology Press Ltd. P.O. Box 63, Westbury House, Bury Street Guildford, Surrey, England GU2 5BH	Intl. J. Fatigue	JOURNAL OF ENGINEERING MATHEMATICS Academic Press 198 Ash Street Reading, MA 01867	J. Engrg. Math.
INTERNATIONAL JOURNAL OF MACHINE TOOL DESIGN AND RESEARCH Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mach. Tool Des. Res.	JOURNAL OF ENVIRONMENTAL SCIENCES Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	J. Environ. Sci.
INTERNATIONAL JOURNAL OF MECHANICAL SCIENCES Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mech. Sci.	JOURNAL OF FLUID MECHANICS Cambridge University Press 32 East 57th St. New York, NY 10022	J. Fluid Mechanics
INTERNATIONAL JOURNAL OF NONLINEAR MECHANICS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Nonlin. Mechanics	JOURNAL OF THE FRANKLIN INSTITUTE Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Franklin Inst.
INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING John Wiley and Sons, Ltd. 605 Third Ave. New York, NY 10016	Intl. J. Numer. Methods Engrg.	JOURNAL OF HYDRONAUTICS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Hydro- nautics
INTERNATIONAL JOURNAL FOR NUMERICAL AND ANALYTICAL METHODS IN GEOMECHANICS John Wiley and Sons, Ltd. Baffins Lane Chichester, Sussex, UK	Intl. J. Numer. Anal. Methods Geomech.	JOURNAL OF THE INSTITUTE OF ENGINEERS, AUSTRALIA Science House, 157 Gloucester Sydney, Australia 2000	J. Inst. Engr., Austral.
INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Solids Struc.	JOURNAL DE MECANIQUE Gauthier-Villars C.D.R. - Centrale des Revues B.P. No. 119, 93104 Montreuil Cedex-France	J. de mecanique
INTERNATIONAL JOURNAL OF VEHICLE DESIGN The International Assoc. of Vehicle Design The Open University, Walton Hall Milton Keynes MK7 6AA, UK	Intl. J. Vehicle Des.	JOURNAL OF MECHANICAL ENGINEERING SCIENCE Institution of Mechanical Engineers 1 Birdcage Walk, Westminster London SW1 H9, UK	J. Mech. Engrg. Sci.
ISRAEL JOURNAL OF TECHNOLOGY Weizmann Science Press of Israel Box 801 Jerusalem, Israel	Israel J. Tech.	JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Mechanics Phys. Solids
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JOURNAL OF AIRCRAFT American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Aircraft	JOURNAL OF PHYSICS: E SCIENTIFIC INSTRUMENTS American Institute of Physics 335 East 45th St. New York, NY 10017	J. Phys. E: Sci. Instrum.
JOURNAL OF THE AMERICAN HELICOPTER SOCIETY American Helicopter Society, Inc. 30 East 42nd St. New York, NY 10017	J. Amer. Helicopter Soc.	JOURNAL OF SHIP RESEARCH Society of Naval Architects and Marine Engineers 20th and Northhampton Sts. Easton, PA 18042	J. Ship Res.
		JOURNAL OF SOUND AND VIBRATION Academic Press 111 Fifth Ave. New York, NY 10019	J. Sound Vib.

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
JOURNAL OF SPACECRAFT AND ROCKETS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Spacecraft Rockets	NOISE AND VIBRATION CONTROL Trade and Technical Press Ltd. Crown House, Morden Surrey SM4 5EW, UK	Noise Vib. Control
JOURNAL OF TESTING AND EVALUATION (ASTM) American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	J. Test Eval. (ASTM)	NOISE CONTROL ENGINEERING P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603	Noise Control Engrg.
KONSTRUKTION Spring Verlag 3133 Connecticut Ave., N.W. Suite 712 Washington, D.C. 20008	Konstruktion	NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, TRANSACTIONS Bolbec Hall Newcastle upon Tyne 1, UK	NE Coast Instn. Engrs. Shipbldrs., Trans.
LUBRICATION ENGINEERING American Society of Lubrication Engineers 838 Busse Highway Park Ridge, IL 60068	Lubric. Engrg.	NUCLEAR ENGINEERING AND DESIGN North Holland Publishing Co. P.O. Box 3489 Amsterdam, The Netherlands	Nucl. Engrg. Des.
MACHINE DESIGN Penton Publishing Co. Penton Bldg. Cleveland, OH 44113	Mach. Des.	OIL AND GAS JOURNAL The Petroleum Publishing Co. 211 S. Cheyenne Tulsa, OK 74101	Oil Gas J.
MASCHINENBAUTECHNIK VEB Verlag Technik Oranienburger Str. 13/14 102 Berlin, E. Germany	Maschinen- bautechnik	PACKAGE ENGINEERING 5 S. Wabash Ave. Chicago, IL 60603	Package Engrg.
MECCANICA Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Meccanica	PLANT ENGINEERING 1301 S. Grove Avenue Barrington, IL 60010	Plant Engrg.
MECHANICAL ENGINEERING American Society of Mechanical Engineers 345 East 45th St. New York, NY 10017	Mech. Engrg.	POWER P.O. Box 521 Hightstown, NJ 08520	Power
MECHANICS RESEARCH AND COMMUNICATIONS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mechanics Res. Comm.	POWER TRANSMISSION DESIGN Industrial Publishing Co. Division of Pittway Corp. 812 Huron Rd. Cleveland, OH 44113	Power Transm. Des.
MECHANISM AND MACHINE THEORY Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mech. Mach. Theory	QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS Wm. Dawson & Sons, Ltd. Cannon House Folkestone, Kent, UK	Quart. J. Mechanics Appl. Math.
MEMOIRES OF THE FACULTY OF ENGINEERING, KYOTO UNIVERSITY Kyoto University Kyoto, Japan	Mem. Fac. Engrg. Kyoto Univ.	REVUE ROUMAINE DES SCIENCES TECHNIQUES, SERIE DE MECANIQUE APPLIQUEE Editions De L'Academie De La Republique Socialiste de Roumaine 3 Bis Str., Gutenberg, Bucurest, Romania	Rev. Roumaine Sci. Tech., Mecanique Appl.
MTZ MOTORTECHNISCHE ZEITSCHRIFT Franksche Verlagsbuchhandlung Pfeizerstrasse 5-7 7000 Stuttgart 1 W. Germany	MTZ Motor- tech. Z.	REVIEW OF SCIENTIFIC INSTRUMENTS American Institute of Physics 335 East 45th St. New York, NY 10017	Rev. Scientific Instr.
NAVAL ENGINEERS JOURNAL American Society of Naval Engineers, Inc. Suite 507, Continental Bldg. 1012 - 14th St., N.W. Washington, D.C. 20005	Naval Engr. J.	SAE PREPRINTS Society of Automotive Engineers Two Pennsylvania Plaza New York, NY 10001	SAE Prepr.
		SIAM JOURNAL ON APPLIED MATHEMATICS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Appl. Math.

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SIAM JOURNAL ON NUMERICAL ANALYSIS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Numer. Anal.	VDI FORSCHUNGSHEFT Verein Deutscher Ingenieur GmbH Postfach 1139, Graf-Recke Str. 84 4 Düsseldorf 1, Germany	VDI Forsch.
STROJNICKÝ ČASOPIS Red. Strojnického Časopisu ČSAV A SAV USTAV MECHANIKY STROJOV SAV Bratislava-Patronka, Dubrovská cesta, ČSSR Czechoslovakia	Strojnický Časopis	VEHICLE SYSTEMS DYNAMICS Swets and Zeitlinger N.V. 347 B. Herreweg Lisse, The Netherlands	Vehicle Syst. Dyn.
S/V, SOUND AND VIBRATION Acoustic Publications, Inc. 27101 E. Oviatt Rd. Bay Village, OH 44140	S/V, Sound Vib.	VIBROTECHNIKA Kauno Polytechnikos Institutas 2 Donelaičio g-ve 17 233000 Kaunas Lithuanian SSR	Vibro- technika
TECHNISCHES MESSEN - ATM R. Oldenburg Verlag GmbH Rosenheimer Str. 145 8 München 80, W. Germany	Techn. Messen-ATM	WAVE MOTION North Holland Publishing Co. P.O. Box 211 1000 AE Amsterdam The Netherlands	Wave Motion
TEST 61 Monmouth Road Oakhurst, NJ 07755	Test	WEAR Elsevier Sequoia S.A. P.O. Box 851 1001 Lausanne 1, Switzerland	Wear
TRIBOLOGY INTERNATIONAL IPC Science and Technology Press Ltd. Westbury House P.O. Box 63, Bury Street Guildford, Surrey GU2 5BH, UK	Tribology Intl.	ZEITSCHRIFT FÜR ANGEWANDTE MATHEMATIK UND MECHANIK Akademie Verlag GmbH Liepziger Str. 3-4 108 Berlin, Germany	Z. angew. Math. Mech.
TURBOMACHINERY INTERNATIONAL Turbomachinery Publications, Inc. 22 South Smith St. Norwalk, CT 06855	Turbomach. Intl.	ZEITSCHRIFT FÜR FLUGWISSENSCHAFTEN DFVLR D-3300 Braunschweig Flughafen, Postfach 3267 W. Germany	Z. Flugwiss
VDI ZEITSCHRIFT Verein Deutscher Ingenieur GmbH Postfach 1139, Graf-Recke Str. 84 4 Düsseldorf 1, Germany	VDI Z.		

SECONDARY PUBLICATIONS SCANNED

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SCIENTIFIC AND TECHNICAL AEROSPACE REPORTS Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402	STAR		

ANNUAL PROCEEDINGS SCANNED

INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL PROCEEDINGS Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	Inst. Environ. Sci., Proc.	THE SHOCK AND VIBRATION BULLETIN, UNITED STATES NAVAL RESEARCH LABORATORIES, ANNUAL PROCEEDINGS Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375	Shock Vib. Bull., U.S. Naval Res. Lab., Proc.
TURBOMACHINERY SYMPOSIUM Gas Turbine Labs Texas A&M University College Station, Texas	Turbomach. Symp.		

CALENDAR

FEBRUARY 1982

- 22-26 SAE Congress and Exposition [SAE] Detroit, MI (SAE Hqs.)

MARCH 1982

- 29-Apr 1 Design Engineering Conference and Show [ASME] Chicago, IL (ASME Hqs.)
- 30-Apr 1 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] Oak Brook, IL (Ronald L. Eshleman, Director, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)

APRIL 1982

- 14-16 Fatigue Conference & Exposition [SAE] Dearborn, MI (SAE Hqs.)
- 18-22 Gas Turbine Conference and Products Show [ASME] London, England (ASME Hqs.)
- 20-22 Mechanical Failures Prevention Group 35th Symposium [National Bureau of Standards] Gaithersburg, MD (Dr. James G. Early, National Bureau of Standards, Bldg. 223/Room A-113, Washington, DC 20234 - (301) 921-2976)
- 20-23 Institute of Environmental Sciences' 28th Annual Technical Meeting [IES] Atlanta, GA (IES, 940 E. Northwest Highway, Mt. Prospect, IL 60056 - (312) 255-1561)
- 22-23 13th Annual Pittsburgh Conference on Modeling and Simulation [School of Engineering, Univ. of Pittsburgh] Pittsburgh, PA (William G. Vogt or Merlin H. Mickle, Modeling and Simulation Conf., 348 Benedum Engrg. Hall, Univ. of Pittsburgh, Pittsburgh, PA 15261)
- 26-30 Acoustical Society of America, Spring Meeting [ASA] Chicago, IL (ASA Hqs.)

MAY 1982

- 12-14 Pan American Congress on Productivity [SAE] Mexico City (SAE Hqs.)
- 24-26 Commuter Aircraft and Airline Operations Meeting [SAE] Savannah, GA (SAE Hqs.)

JUNE 1982

- 7-11 Passenger Car Meeting [SAE] Dearborn, MI (SAE Hqs.)

JULY 1982

- 13-15 'Environmental Engineering Today' Symposium and Exhibition [SEE] London, England (SEE, Owles Hall, Buringford, Herefordshire, UK)
- 19-21 12th Intersociety Conference on Environmental Systems [SAE] San Diego, CA (SAE Hqs.)

AUGUST 1982

- 16-19 West Coast International Meeting [SAE] San Francisco, CA (SAE Hqs.)

SEPTEMBER 1982

- 13-16 International Off-Highway Meeting & Exposition [SAE] Milwaukee, WI (SAE Hqs.)

OCTOBER 1982

- 4-6 Convergence '82 [SAE] Dearborn, MI (SAE Hqs.)
- 4-7 Symposium on Advances and Trends in Structural and Solid Mechanics [George Washington Univ. and NASA Langley Res. Ctr.] Washington, DC (Prof. Ahmed K. Noor, Mail Stop 246, GWU-NASA Langley Res. Ctr., Hampton, VA 23665 - (804) 827-2897)
- 12-15 Stapp Car Crash Conference [SAE] Ann Arbor, MI (SAE Hqs.)
- 25-28 Aerospace Congress & Exposition [SAE] Anaheim, CA (SAE Hqs.)

NOVEMBER 1982

- 8-12 Acoustical Society of America, Fall Meeting [ASA] Orlando, Florida (ASA Hqs.)
- 8-12 Truck Meeting & Exposition [SAE] Indianapolis, IN (SAE Hqs.)
- 14-19 American Society of Mechanical Engineers, Winter Annual Meeting [ASME] Phoenix, AZ (ASME Hqs.)

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ASQC:	American Society for Quality Control 161 W. Wisconsin Ave. Milwaukee, WI 53203	SVIC:	Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375
ASTM:	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	URSI-USNC:	International Union of Radio Sciences - U.S. National Committee c/o MIT Lincoln Lab. Lexington, MA 02173
CCCAM:	Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada		
ICF:	International Congress on Fracture Tohoku Univ. Sendai, Japan		

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Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

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Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].

Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

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A sample reference list is given below.

1. Pletzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).
5. Lendehi, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).
7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

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