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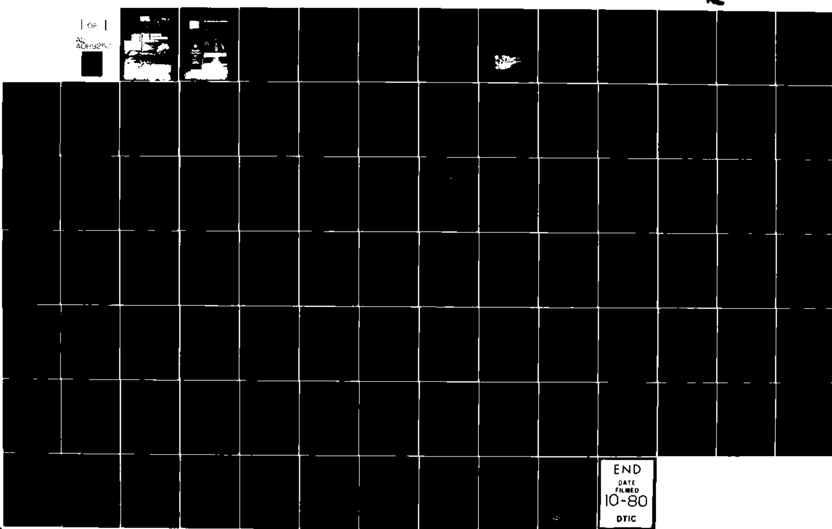
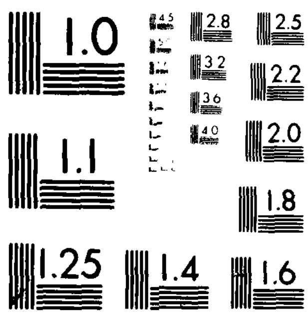
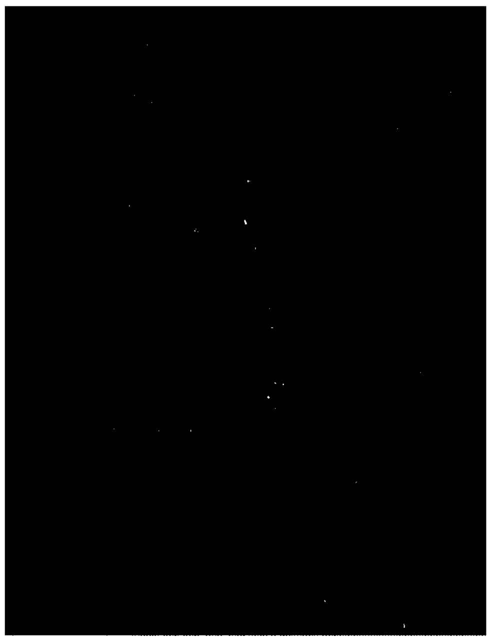




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A



SVIC NOTES

SPECIFICATION PROBLEMS REVISITED

The use of general purpose test specifications for system shock and vibration test requirements has increased during the past few years. This type of specification is convenient to use but it is not without its problems. During the past year we have received an increased number of requests for information that are related to shock and vibration test specifications. The problems can be grouped into two categories, the lack of any documented rationale and the misapplication of specifications.

The lack of published criteria behind a specification has been a continuing source of many specification problems, some of the consequences are:

- Use of specifications that are based more on tradition than reality.
- Meaningless test results.
- Use of outmoded specifications that are unsuitable for modern systems.
- Unneeded specification development programs.
- Misapplication and misinterpretation of specifications.

The improper application of shock and vibration test specifications is the next topic to be explored. Many general purpose shock and vibration test specifications are often misused because those who are responsible for applying them lack the knowledge of dynamics to properly do the job.

Specifications that lack clarity contribute to this problem. Very often the scope and the intent of the provisions of a specification are not stated; this is another reason why specifications are often improperly applied. The end consequences are meaningless test results and wasted money. Some extreme examples are cited to illustrate the preceeding points. Random vibration workmanship tests, up to 2 Khz, were imposed on large shipboard electronics cabinets weighing up to 1000 lbs. A vibration test for shipboard equipment was imposed on large shore-based electronic equipment which was transported as shipboard cargo.

Let us briefly consider what has been done and what might be done to solve these specification problems. The criteria for some shock and vibration test requirements have been published. Further work on this particular specification problem is necessary because the rationale behind many general purpose shock and vibration test specifications is still unknown. Furthermore, these same shock and vibration test specifications should be reviewed and those that are outmoded should be cancelled.

The number of improperly applied specifications might be reduced by publishing their rationale within the specification document. The scope and intent of all of its provisions should be clearly stated so that there can be no question whether they apply to component or complete assemblies. This only provides guidance for those who have to apply or interpret system shock and vibration test requirements. Sound engineering judgement must be used in order to properly apply specifications.

In conclusion I would like to call your attention to the advance program for the 51st Shock and Vibration Symposium in this issue of the SHOCK AND VIBRATION DIGEST. One of the sessions will deal with specifications. I would also like to call your attention to the plenary lecture prior to this session which will be delivered by Colonel Ben Swett.

R.H.V.

EDITORS RATTLE SPACE

SYMPOSIUM NOTES

This issue of the DIGEST contains the preliminary program for the 51st Shock and Vibration Symposium sponsored by the Shock and Vibration Information Center (SVIC). The symposium will be held at San Diego in October.

The Symposium has been the meeting highlight of the year for many engineers in the shock and vibration field. It is a principal forum for exchange of technology on shock. Many classical achievements in shock were first presented at the Symposium. It is the only major conference at which classified sessions are scheduled; these allow the interchange of classified technical information. Note that the program for the 51st Symposium contains papers on many aspects of shock and vibration of interest to engineers in testing and analysis. In addition, a general session containing presentations of general interest will be held.

Last year at the 50th Symposium plenary sessions, including the Elias Klein Memorial Lecture featuring honored and well-known speakers on various technical topics, were scheduled for the first time. This innovation -- like the short topic sessions introduced earlier -- proved to be an overwhelming success. Again this year both types of sessions will be held. Edward Noonan, Col. Ben H. Swett, and Robert Dyrdahl will give plenary lectures titled "An Approach to the Limitation and Control of Shipboard Vibration", "Department of Defense Directive 5000.40: Reliability and Maintainability", and "Necessary and Sufficient Qualifications for Shock", respectively. Mr. Noonan will present the Elias Klein Memorial lecture. I believe personally these talks alone will make the Symposium worthwhile for most engineers.

Over the years many outstanding engineers in our field have been active at the Symposium. It is with sadness that I mention the passing of Professor John Snowdon, who was a frequent contributor to the Symposium and a major contributor to the field of shock and vibration. A leading researcher in the field of isolation and damping, he contributed greatly to the Symposium and to Societies (ASME and ASA) involved in developing technology. John will be missed by his colleagues and technical acquaintances. I extend my sincerest sympathy to his wife Ann and children.

R.L.E.

VIBRATION IN JET ENGINES

M. Lalanne*

***Abstract** - This review deals with vibration in jet engines. It is oriented toward prediction of the behavior of blades, disc blades, axisymmetric structures, and rotors and toward the possibilities of vibration control.*

A typical modern jet engine includes three main parts [27]

- compressor stages
- combustion chamber
- turbine stages

It is generally difficult to know the forces of excitation in rotating machinery, especially in jet engines. Thus, in the operating range, coincidences between the resonance frequencies of the engine elements and the well-known multiples of the speed of rotation are avoided. Numerical methods, now generally based on the finite element method, are systematically used to predict resonance frequencies and the associated mode shapes. This leads to the possibility of determining dangerous resonance frequencies for the rotating parts of the engine from the Campbell diagram [67]. If a resonance occurs, the structure can be slightly modified or attempts can be made to control the vibration level.

This review deals mostly with prediction method and vibration control. The following are presented

- blades
- disc and blades, axisymmetric structures
- rotor
- vibration control

This review is roughly limited to work performed in the past ten years; flutter and experimental aspects are not presented. Beam type blades are not considered as they have already been dealt with [50-52]. A review by Rieger [55] and the April 1975 issue of the JOURNAL OF AIRCRAFT are also important references.

Aarnes and White [1] have presented the propulsion system, airframe integration program, and the development of the main structural analysis systems used by the Boeing Company. They detailed the modeling of stationary and rotating components [1]. Improvement of the structural integration program and such examples as the 747/JT 9D have been given [14]. The aircraft engine design method based on experimental stress analysis techniques and used by the General Electric Company is available [40]. The method includes several static and dynamic tests and some finite element calculations. The method used by Pratt and Whitney Aircraft of Canada for integrating small turbine engine such as those of the PT6 series is available for marine or surface transportation, helicopters, and aircrafts [8].

BLADES

An isoparametric thick shell element has been used to obtain the resonance frequencies and associated mode shapes of a thick blade at rest [2]. This work was extended to include second order terms in strains and to account for the effect of rotation; the buckling phenomenon was also described [7]. Henry and Lalanne [25, 26] used a triangular flat plate element in area coordinates to obtain the frequencies and mode shapes of thin shell type rotating blades.

Trompette and Lalanne [68, 71] used an isoparametric thick shell element to determine the dynamic behavior of rotating thick blades. They discussed the effect of the platform and the root for a turbine blade and showed that, for a particular blade, the effect of temperature could be more important than

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the effect of rotation. The calculation of gas turbine blades and some results on steady-state stresses due to centrifugal effects have been published [41]. The general equations of a rotating blade and the determination of a super parametric thick shell element are available [63]. Chamis [9] presented calculations from Nastran and holographic experiments for several kind of laminated composite blades. A three-dimensional finite element method and a conjugate stress technique were used to analyze the vibrations, determine steady-state stresses, and obtain a fatigue life estimation [49]. A modal analysis of compressor blades was made by impulse excitation [6]. The vibration effects of distortion in fan and compressor blading have been discussed [12], and some important considerations and comments for the design of blades in vibration conditions have been given [13]. Hall and Armstrong [23] determined the behavior of blades of uniform cross section using the finite difference technique; the blades were connected by either a tight or a slack shroud. Finite elements were used to study the free and forced dynamic behavior of a packet of blades in tangential displacement; results were given as functions of the number of blades [58]. Thomas and Belek [64] also calculated by the finite element method the free vibration of a straight blade pack(. The free vibration of rotating shrouded airfoil packet of blades has been investigated; the effects of such parameters as stagger angle, rotational speed, and disc radius were examined [65].

The potential and kinetic energies of blades and of the segment connecting the blades were used to calculate frequencies and mode shapes of rotating blades in a packet [74]. The vibrational strength analysis of a turbine blade and the calculation of turbine blades in packets have been investigated by the finite element method [72]. Holographic measurements were also in experiments to study the behavior of a packet of six turbine blades [72]. The agreement of results was satisfactory. The behavior of shrouded fan blades has been studied using a viscous damping model at the shroud interface and a component method based on a substructure including one blade and a portion of shroud [61]. The results were compared with Nastran, and an application was performed on a typical fan blade [61].

DISC AND BLADES - AXISYMMETRIC STRUCTURES

Kirkhope and Wilson [38, 39] analyzed disc, rim, and blade vibration, including the effects of rotation. They used the finite element method; the results were in good agreement with experimental results. The receptance method was used to analyze the vibration of a disc blades shroud assembly [11]. A bladed disc was analyzed by a wave propagation technique and a matrix difference method [57]. The finite element method was used to analyze the behavior of a rotating disc blade shroud assembly [47]. The vibration characteristics of an asymmetric cross-sectional rotating bladed disc was studied using a finite element method associated with a wave propagation technique [66].

A differential equation using a Runge Kutta integration and a shooting method were used to analyze the behavior of disc blade assemblies [29]. Differential equations of disc blade assemblies have been derived and used to obtain solutions with a Runge Kutta method [62]. Bekh and Vorobev [5] derived expressions for the potential and kinetic energies of disc and blades and also examined the influence of asymmetry on blades. A simple and efficient model for determining the stresses due to detuning in compressor blades has successfully been applied to an aircraft engine [15].

Ewins [17-20] studied, both experimentally and theoretically, the detuning effect on the frequencies on disc and blade assemblies by the receptance method. A theoretical study of the damped forced response of bladed discs utilized the receptance method; the mistuning effect was also analyzed [21]. A study was concerned with the influence of mistuning on the assembly of disc and blades and also on the vibratory stress level [16]. Srinivasan and Frye [60] performed analyses and experiments on the mistuning effect, and peak vibratory stress level of high-pressure turbine blades. A fatigue life of mistuned blades was estimated by a stochastic approach [59]. Experimental and finite element results on the frequencies and mode shapes of axisymmetric parts of a jet engine modeled by thin shell elements and thick elements are available [42, 69]. The problems that arise in labyrinth air seal failures have been described [3]. Engine structures using shell elements [37] have been modeled.

ROTOR

Vance and Royal [73] studied rotor dynamics of small engines, particularly the prediction of critical speed balancing, prediction and control of bearing support properties, nonsynchronous excitation, and the behavior of hydrodynamic bearings. The possibility of matching flexibilities by a modal comparison algorithm has been investigated; the example used was a high pressure compressor rotor [46]. The advantages and disadvantages of hard and soft mountings have been discussed; the method of analysis was applied to the T700 Engine [45]. The dynamic response of a viscous damped two-shaft jet engine was analyzed using a transfer matrix method [28]. The transient behavior of a dual jet engine rotor was studied with a modal representation; the effects caused by a blade loss were calculated [10]. The effects of squeeze-film damper bearings on the steady state and transient unbalance responses of aircraft engine rotors have been investigated [22].

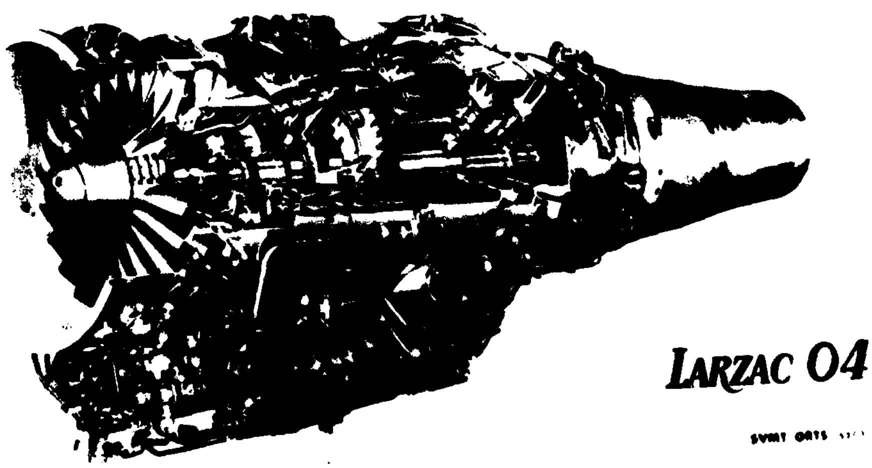
VIBRATION CONTROL

Unfortunately, the magnitude of an exciting force is difficult to predict with the exception of such simple cases as a two-dimensional incompressible flow [53]. Rieger and Wicks [54] used a hydraulic analogy to determine the excitation forces in three different stages of a steam turbine.

At near-resonant conditions large-amplitude vibration should be controlled; it is thus important to be able to predict the available damping and sometimes to introduce additional damping. A review of the damping properties of turbine blades, including internal damping, blade groups, and friction damping, has been published [56]. Aerodynamic damping of turbine blades has been determined [35, 36], and the energy dissipation due to intershroud relative motion slipping has been analyzed [4]. Slip motion in the root has also been included in the dynamic analysis of compressor blades [32, 33].

Attempts have been made to use an encapsulated tuned damper, made with a beam, to reduce vibration levels in turbine blades [31, 48]. A high-temperature stator vane coated with enamel has been used for adding structural damping [30]. The dynamic behavior of the coated blades has been predicted; results were in good agreement with experiments for the value of the modal damping [70]. A multilayer damping treatment was shown to be very successful in reducing the vibration level of TF 30 engine inlet guide vane [24].

A promising attempt has been made by Stetson and Harrison to redesign blades by a perturbation method to obtain specific vibrational properties [75].



Cross-sectional View of Jet Engine

SUGGESTIONS

A better understanding of the conditions at the junctions of the blade roots is necessary in some cases to improve the prediction of the dynamic behavior. More work must be done before damping is understood. Aerodynamic damping, structural damping, and most importantly, damping caused by slips in shrouds or at the root of blades must be studied. It is also very important to obtain information of aerodynamic forces in order to be able to calculate the forced response of blades. The control of vibration, perhaps with tuned dampers or some other damping treatment, should be investigated experimentally and then applied at the development level of jet engines.

ACKNOWLEDGEMENTS

The reviewer is very grateful to Professor Rao, from I.I.T. New Delhi, when he was visiting Professor at I.N.S.A. for his very useful discussions and to the S.N.E.C.M.A. for the sectional view of the jet engine.

REFERENCES

1. Aarnes, M.N. and White, J.L., "Propulsion System and Airframe Structural Integration Program," J. Aircraft, 12 (4), pp 234-242 (1975).

2. Ahmad, S., Anderson, R.G., and Zienkiewicz, O.C., "Vibration of Thick Curved Shells with Particular Reference to Turbine Blades," J. Strain Anal., 5 (3), pp 200-206 (1970).

3. Alford, J.S., "Nature, Causes and Prevention of Labyrinth Air Seal Failures," J. Aircraft, 12 (4), pp 313-318 (1975).

4. Bielawa, R.L., "An Analytical Study of the Engine Dissipation of Turbomachinery Bladed Disc Assemblies due to Intershroud Segment Rubbing," J. Mech. Des., Trans. ASME, 100 (2), pp 222-228 (1978).

5. Bekh, M.V. and Vorobev, Y.S., "Calculating the Vibrations of Bladed Discs of Turbomachines with Their Asymmetry Taken in Account," Strength Matls., 8 (3), pp 339-343 (1976). Translated from Problemy Prochnosti.

6. Bolleter, U., Uberl, J., and Buehlman, E., "Modal Analysis of Compressor Blades by Means of Impulse Excitation," AGARD Conf. Proc. 248, paper 18 (1979).

7. Bossak, M.A.J. and Zienkiewicz, O.C., "Free Vibration of Initially Stressed Solids, with Particular Reference to Centrifugal Force Effects in Rotating Machinery," J. Strain Anal., 8 (4), pp 245-252 (1973).

8. Bottman, M. and Blinco, R.K., "Small Turbine Engine Integration in Aircraft Installations," AGARD Conf. Proc. 248, paper 23 (1979).

9. Chamis, C.C., "Vibration Characteristics of Composite Fan Blades and Comparison with Measured Data," J. Aircraft, 14 (7), pp 644-647 (1977).

10. Childs, D.W., "A Modal Transient Rotor Dynamics Model for Dual Rotor Jet Engine Systems," J. Engr. Indus., Trans. ASME, 98 (3), pp 876-882 (1976).

11. Cottney, D.J. and Ewins, D.J., "Towards the Efficient Vibration Analysis Shrouded Bladed Disc Assemblies," J. Engr. Indus., Trans. ASME, 96 (3), pp 1054-1059 (1974).

12. Danforth, C.E., "Distortion Induced Vibration in Fan and Compressor Blading," J. Aircraft, 12 (4), pp 216-225 (1975).

13. Danforth, C.E., "Blade Vibration: Some Key Elements in Design Verification," J. Aircraft, 12 (4), pp 333-342 (1975).

14. Dunning, T.E., Aarnes, M.N., and Bailey, G.L., "Engine Aircraft Integration, an Overview," AGARD Conf. Proc. 248, paper 20 (1979).

15. Dye, R.C.F. and Henry, T.A., "Vibration Amplitudes of Compressor Blades Resulting from Scatter in Blade Natural Frequencies," J. Engr. Power, Trans. ASME, 91 (3), pp 182-188 (1969).

16. El Bayouny, L.E. and Srinivasan, A.V., "Influence of Mistuning on Rotor Blade Vibrations," AIAA J., 13 (4), pp 460-464 (1975).

17. Ewins, D.J., "Effects of Detuning upon the Forced Vibration of Bladed Discs," J. Sound Vib., 9 (1), pp 65-79 (1969).

18. Ewins, D.J., "A Study of Resonance Coincidence in Bladed Discs," J. Mech. Engr. Sci., 12 (5), pp 305-312 (1970).

19. Ewins, D.J., "Vibration Characteristics of Bladed Disc Assemblies," J. Mech. Engr. Sci., 15 (3), pp 165-185 (1973).

20. Ewins, D.J., "Vibration Modes of Mistuned Bladed Discs," J. Engr. Power, Trans. ASME, 98 (3), pp 349-355 (1976).

21. Ewins, D.J. and Sadasiva Rao, Y.V.K., "A Theoretical Study of the Damped Forced Vibration Response of Bladed Discs," ASME Winter Mtg., pp 29-43 (1976).

22. Gunter, E.J., Barret, L.E., and Allaire, P.E., "Design of Nonlinear Squeeze Film Dampers for Aircraft Engines," J. Lubric. Tech., Trans. ASME, 99 (1), pp 57-64 (1977).

23. Hall, R.M. and Armstrong, E.K., "The Vibration Characteristics of an Assembly of Interlock Shrouded Turbine Blades," ASME Winter Mtg., pp 1-13 (1976).

24. Henderson, J.P., Parin, M.L., Rogers, L.C., and Paul, D.B., "Engine Evaluation of a Vibration Damping Treatment for Inlet Guide Vanes," ASME Paper No. 79-GT-163.

25. Henry, R., "Calcul des Coques Minces en grandes Déformations par les Éléments Finis. Application aux Aubes de Compresseur en Rotation," Dr. Ing Thesis, University C Bernard, Lyon (1973).

26. Henry, R. and Lalanne, M., "Vibration Analysis of Rotating Compressor Blades," J. Engr. Indus., Trans. ASME, 96 (3), pp 1028-1035 (1974).

27. Henry, R., "Le Calcul des Structures de Moteur d'avion," Techniques Francaises, Transports, 1, pp 1-3 (1977).

28. Hibner, D.H., "Dynamic Response of Viscous Damped Multishaft Jet Engine," J. Aircraft, 12 (4), pp 305-312 (1975).

29. Irretier, H., "Coupled Vibration of Blades in Bending Bending Torsion and Discs in Out of Plane and In Plane Motion," ASME Paper No. 79-DET-90.

30. Jones, D.I.G. and Cannon, C.M., "Control of Gas Turbine Stator Blade Vibration by Means of Enamel Coating," J. Aircraft, 12 (4), pp 226-230 (1975).

31. Jones, D.I.G., Nashif, A.D., and Stargardter, H., "Vibrating Beam Dampers for Reducing Vibrations in Gas Turbine Blades," J. Engr. Power, Trans. ASME, 97 (1), pp 111-116 (1975).

32. Jones, D.I.G., "Effect of Slip on Response of a Vibrating Compressor Blade," ASME Paper No. 77-WA/GT-30.

33. Jones, D.I.G. and Muszynska, A., "Vibration of a Compressor Blade with Slip at the Root," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 48, Pt. 2, pp 53-61 (1978).

34. Jones, D.I.G., "High Temperature Damping of Dynamic Systems," Shock Vib. Dig., 11 (5), pp 13-18 (1979).

35. Kaminer, A.A., Balalaev, V.A., and Nastenko, N.Y., "Determination of the Aerodynamic Damping of Bending Twisting Oscillations of Turbomachine Blades in Air Streams," Strength Matls., 8 (3), pp 268-272 (1976).

36. Kaminer, A.A., Balalaev, V.A., and Nastenko, N.Y., "Determination of Aerodynamic Damping during Torsional Vibrations of Turbine Blades," Strength Matls., 8 (3), pp 296-299 (1976).

37. Kielb, R.E., "Modeling Engine Static Structures with Conical Shell Finite Element," J. Aircraft, 12 (4), pp 230-233 (1975).

38. Kirkhope, J. and Wilson, G.J., "Analysis of Coupled Blade-Disc Vibration in Axial Flow Turbines and Fans," 12th Struc., Struc. Dynam., Matl. Conf., Paper 71-375 (1971).

39. Kirkhope, J. and Wilson, G.J., "A Finite Element Analysis of the Vibration Modes of Bladed Discs," J. Sound Vib., 49 (4), pp 469-482 (1976).

40. Koff, B.L., "Aircraft Engineer Design Using Experimental Stress Analysis Techniques," AGARD Conf. Proc. 248, paper 3 (1979).

41. Lalanne, M., Henry, R., and Trompette, P., "Rotating Blade Analysis by the Finite Element Method," IUTAM Symp. Dynam. Rotors, pp 299-318 (1975).

42. Lalanne, M. and Zabukovec, C., "Frequencies and Mode Shapes in Jet Engines," ASME Paper No. 76-DET-89.

43. Lalanne, M., Trompette, P., Henry, R., and Ferraris, G., "Analyse des Vibrations de Moteurs," AGARD Conf. Proc. 248, paper 2 (1979).

44. Levy, S. and Wilkinson, J.P.D., The Component Element Method in Dynamics, McGraw Hill (1976).

45. Magge, N., "Philosophy, Design, and Evaluation of Soft Mounted Engine Rotor Systems," J. Aircraft, 12 (4), pp 318-324 (1975).

46. Marmol, R.A. and Akin, J.T., "Rapid Verification of Engine Rotor and Case Flexibilities by a Modal Comparison Algorithm," J. Aircraft, 12 (4), pp 242-246 (1975).

47. Mota Soares, C.A., Petyt, M., and Salama, A.M., "Finite Element Analysis of Bladed Discs," ASME Winter Mtg., pp 73-91 (1976).

48. Parin, M.L. and Jones, D.I.G., "Encapsulated Tuned Dampers for Jet Engine Component Vibration Control," J. Aircraft, 12 (4), pp 293-295 (1975).

49. Peterson, M.R., Anderson, R.G., Stockton, R.J., and Tree, D.J., "Three Dimensional Finite Element Techniques for Gas Turbine Blade Life Prediction," AGARD Conf. Proc. 248, paper 9 (1979).

50. Rao, J.S., "Natural Frequencies of Turbine Blading, a Survey," Shock Vib. Dig., 5 (10), pp 3-16 (1973).

51. Rao, J.S., "Turbine Blade Excitation and Vibration," Shock Vib. Dig., 9 (3), pp 15-22 (1977).

52. Rao, J.S., "Turbomachine Blade Vibration," Shock Vib. Dig., 12 (2), pp 19-26 (1980).

53. Rao, J.S., "Computer Program for Determining Unsteady Blade Forces of an Elementary Turbomachine Stage," Tech. Memo 75 WRL M11, Rochester Inst. Tech. (1975).

54. Rieger, N.F. and Wicks, A.L., "Measurement of Non Steady Forces in Three Turbine Stage Geometries Using the Hydraulic Analogy," J. Engr. Power, Trans. ASME, 100 (14), pp 525-532 (1978).

55. Rieger, N.F., "Finite Element Analysis of Turbomachine Blade Problems," ASME Des. Engr. Div., pp 93-120 (1977).

56. Rieger, N.F., "Damping Properties of Turbine Blades," Shock Vib. Dig., 11 (4), pp 3-5 (1979).

57. Salama, A.M., Petyt, M., and Mota Soares, C.A., "Dynamic Analysis of Bladed Discs by Wave Propagation and Matrix Difference Techniques," ASME Winter Mtg., pp 45-56 (1976).

58. Salama, A.M. and Petyt, M., "Dynamic Response of Packets of Blades by the Finite Element Method," J. Mech. Des., Trans. ASME, 100 (4), pp 660-666 (1978).

59. Sogliero, G. and Srinivasan, A.V., "Fatigue Life Estimates of Mistuned Blades via a Stochastic Approach," AIAA J., 18 (3), pp 318-323 (1980).

60. Srinivasan, A.V. and Frye, H.M., "Effects of Mistuning on Resonant Stresses of Turbine Blades," ASME Winter Mtg., pp 57-71 (1976).

61. Srinivasan, A.V., Lionberger, S.R., and Brown, K.W., "Dynamic Analysis of an Assembly of Shrouded Blades Using Component Modes," J. Mech. Des., Trans. ASME, 100 (3), pp 520-527 (1978).

62. Stupina, N.N., "An Investigation of Coupled Vibrations of a Disc with Twisted Blades," Strength Matls., 8 (3), pp 315-320 (1976).

63. Thomas, J. and Mota Soares, C.A., "Dynamic Analysis of Rotating Turbine and Compressor Blading," IME Conf. Vib. Rot. Mach., pp 231-237 (1976).

64. Thomas, J. and Belek, H.T., "Free Vibration of Blade Packets," J. Mech. Engr. Sci., 19 (1), pp 13-21 (1977).

65. Thomas, J. and Sabuncu, M., "Dynamic Analysis of Rotating Asymmetric Cross Section Blade Packet," ASME Paper No. 79-DET-93.

66. Thomas, J. and Sabuncu, M., "Vibration Characteristics of Asymmetric Cross Section Bladed Disc under Rotation," ASME Paper No. 79-DET-94.

67. Traexler, J.F., "Turbomachinery Vibration," Shock Vib. Dig., 9 (8), pp 3-10 (1977).

68. Trompette, P. and Lalanne, M., "Vibration Analysis of Rotating Turbine Blade," ASME Paper No. 74-WA/DE-23.

69. Trompette, P. and Lalanne, M., "Frequencies and Mode Shapes of Geometrically Asymmetric Structures. Application to Jet Engines," Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 46, No. 5, pp 117-122 (1976).

70. Trompette, P., Paulard, M., Lalanne, M., Jones, D.I.G., and Parin, M., "Prediction of Modal Damping of Jet Engine Stator Vane Using Finite Element Techniques," ASME Paper No. 76-GT-60.

71. Trompette, P., "Etude dynamique des Structures. Effet de Rotation. Amortissement," Dr. Sci. Thesis., University C. Bernard, Lyon (1976).

72. Umemura, S., Mase, M., and Kadoya, Y., "Vibration Analysis of Grouped Blades of Turbines by the Finite Element Method," Tech. Rev., Mitsubishi Heavy Indus. Ltd. (June 1979).

73. Vance, J.M. and Royal, A.C., "High Speed Rotor Dynamics. An Assessment of Current Technology for Small Turboshaft Engines," J. Aircraft, 12 (4), pp 295-305 (1975).

74. Vorobev, Y.S. and Medvedev, N.G., "Investigation of Oscillations of Packets with Finite Number of Rotor Blades," Strength of Matls., 8 (3), pp 305-309 (1976).

75. Stetson, K.A. and Harrison, I.R., "Redesign of Structural Vibration Modes by Finite Element Inverse Perturbation," ASME Paper No. 80-GT-167.

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

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

This issue of the DIGEST contains articles about squeeze-film damping of rotordynamic systems and pneumatic shock absorbers and isolators.

Dr. R. Holmes of the University of Sussex, Sussex, UK, has written a paper describing the roles of the squeeze-film damper when used in parallel with a flexible element in a vibration isolator and when used in series with flexible pedestals or frame of a rotordynamic system.

Dr. M.S. Hundal of the University of Vermont, Burlington, Vermont, has written a review of the literature published in the last several years on shock absorbers and isolators that utilize pneumatic dampers.

SQUEEZE-FILM DAMPING OF ROTORDYNAMIC SYSTEMS

R. Holmes

Abstract - This article describes the roles of the squeeze-film damper when used in parallel with a flexible element in a vibration isolator and when used in series with flexible pedestals or frame of a rotor-dynamic system.

An annulus of oil between the outer race of a rolling-element bearing (or the bush of an oil-film bearing) and its housing is often used as a multi-directional damping element to control shaft and rotor vibrations in turbomachinery. This damping element, known as a squeeze-film, can be accompanied by a flexible element in a parallel combination that constitutes a vibration isolator. Its purpose is to artificially reduce the natural frequencies of the rotating system so that the speed range of high vibration amplitudes and transmitted forces will be traversed well before the normal operating speed range is reached. The squeeze-film damper acts simply as a device to reduce such amplitudes and transmitted forces to acceptable limits.

Alternatively, a squeeze-film damper is often used alone between a bearing and its housing, in which case its role is solely one of damping with no intended effects on the natural frequencies of the rotating system. The resulting simpler mechanical design avoids problems of fatigue in any introduced flexible element. Because squeeze-film dampers are used alone and because many turbines run above the rigid rotor (bounce) modes anyway, flexible elements are dispensed with for the most part in such applications as aeroengines. Rotation of the outer race of any rolling-element bearing is prevented by anti-rotation pins, also called dogs. The engine bounce modes have frequencies that depend on the rotor mass and its transverse moment of inertia, as well as the flexibility of the support structure. The insertion of squeeze-film dampers between the rotor bearings and the support structure thus gives a series combination of mass, damper, and spring; both excessively light and excessively heavy damping offer little advantage.

THE SQUEEZE-FILM DAMPER AS A PARALLEL ELEMENT OF A VIBRATION ISOLATOR

For the application of a squeeze-film damper as a parallel element, most analyses [1] assume that concentric vibration orbits exist when the rotor is running. These orbits occur either as a result of preloading in the spring element or because the dynamic loading is large compared to the static loading. The latter is possible in the vicinity of a system natural frequency.

The squeeze-film is a nonlinear damper, however, and the designer must guard against two classical disadvantages of such damping, namely jump phenomena and sub-synchronous response. The former can arise in situations in which cavitation occurs in the squeeze-film [1]. Because of the nonlinearity of the squeeze-film, the graph of forced response versus force-frequency can be distorted to such an extent that large vibrations (and hence transmitted forces) can be maintained for an extended speed range during run-up before jumping down to an acceptably low level. Indeed, a jump-up with continuing increase in rotor speed can also be predicted under certain circumstances, although this does not appear to have been recorded experimentally.

Sub-synchronous response has also been recorded in systems with squeeze-film isolators [2] and can be predicted whether or not cavitation is assumed to occur in the squeeze-film. Agreement between theoretical predictions and experimental findings is fairly good for uncavitated squeeze-film isolators, but if cavitation can take place, uncertainties as to its likely extent for a given dynamic loading and supply pressure make predictions difficult [3].

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Despite these reservations the use of squeeze-film isolators in practical installations [1, 2, 4, 5] usually results in smoother running of the equipment concerned.

Because the flexible element of a squeeze-film isolator is usually quite soft, it is not always possible to assume circular concentric orbits of vibration of the rotor center when the rotor is subjected to unbalance forces. If, however, any vibrations are assumed to have amplitudes less than about one third of the radial clearance (a reasonable assumption in many practical situations) then linear damping coefficients [6, 7] can be assigned to the squeeze-film and used in the linear analysis of rotor-bearing systems. For any larger vibrations quasi-linear (amplitude dependent) coefficients can be specified [6] and again used in linear analyses, albeit in an iterative fashion.

THE SQUEEZE-FILM DAMPER AS A SERIES ELEMENT IN A BEARING HOUSING

The amount of damping provided by the squeeze-film in a bearing housing is quite critical. Assume that this damping is linear; its effect in series combination with the rotor mass and housing flexibility is shown in the figures. They show that there is likely an optimum value of damping b to assure reasonable levels of rotor vibration relative to the engine frame (Figure 1) and the bearing housing (Figure 2) and of transmissibility (Figure 3).

Complications are introduced by the nonlinearity of the squeeze-film; its damping increases greatly with eccentricity ratio ϵ. Figure 2 indicates that, for moderate values of unbalance eccentricity u, high values of ϵ can arise over a wide frequency range, particular-

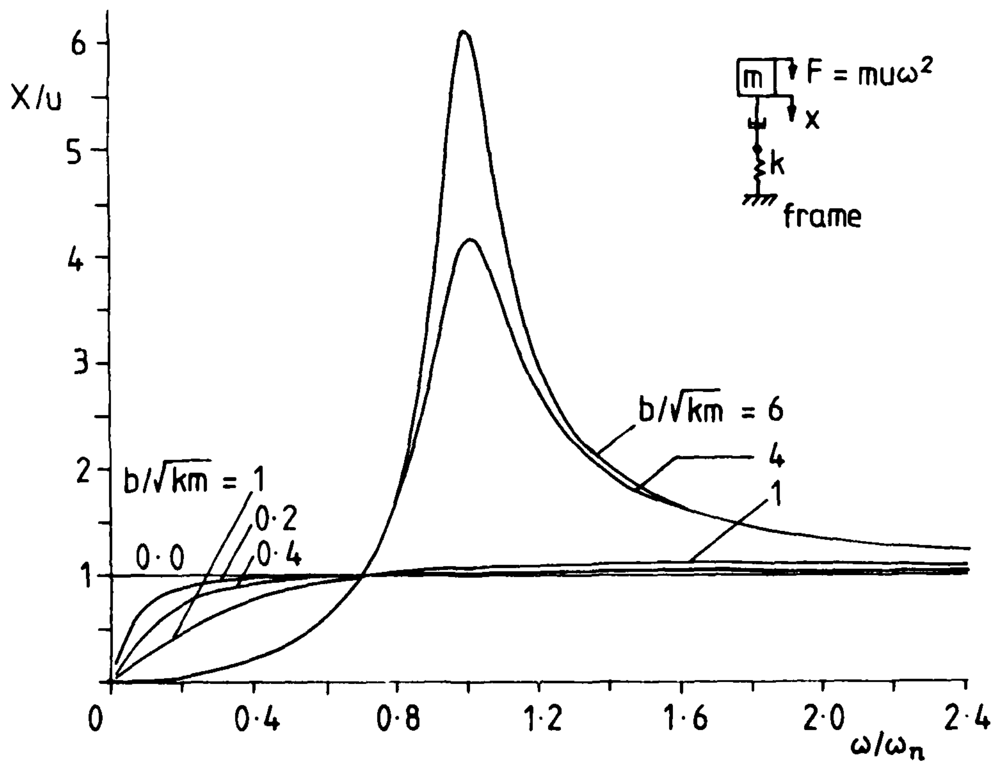

Figure 1. Rotor Vibration Amplitude Relative to the Engine Frame

ly at low values of b. Under these conditions the apparent benefits of low damping indicated in Figure 1 and Figure 3 may not be realized.

Because a squeeze-film damper is in effect a journal bearing in which the inner member does not rotate, it is not possible to assign to it any linear stiffness coefficients that might allow the oil film to take gravity or any other static load. Any lift emanates from nonlinear effects, making analysis somewhat cumbersome. For certain operating conditions, such as in the regions of critical speeds where any static load is small compared to the dynamic load, circular concentric orbits could possibly be assumed [8]. Quasi-linear amplitude-dependent coefficients could then be used. Linear analyses could thus be carried out to obtain the vibration orbits in an iterative fashion. Transmitted forces could then be computed.

For cases in which the static load is not small, a nonlinear analysis is called for and has been used by some investigators [1, 3]. Such an analysis requires specification of the cavitation effect, which has a profound influence on both the static and the dynamic load-carrying capacity. For example, it can be shown [3] that the assumption of an uncavitated film leads to the complete elimination of load-carrying capacity.

The evolution of aeroengine squeeze-film dampers has taken somewhat different courses in different countries. In the United Kingdom a simple type of squeeze-film geometry features a central circumferential groove at the oil inlet and end seals at the outlet. These impose simple boundary conditions on the dynamic pressure distributions occurring in the squeeze-films and make computation relatively easy. On the other hand, in the U.S.A. at least one large

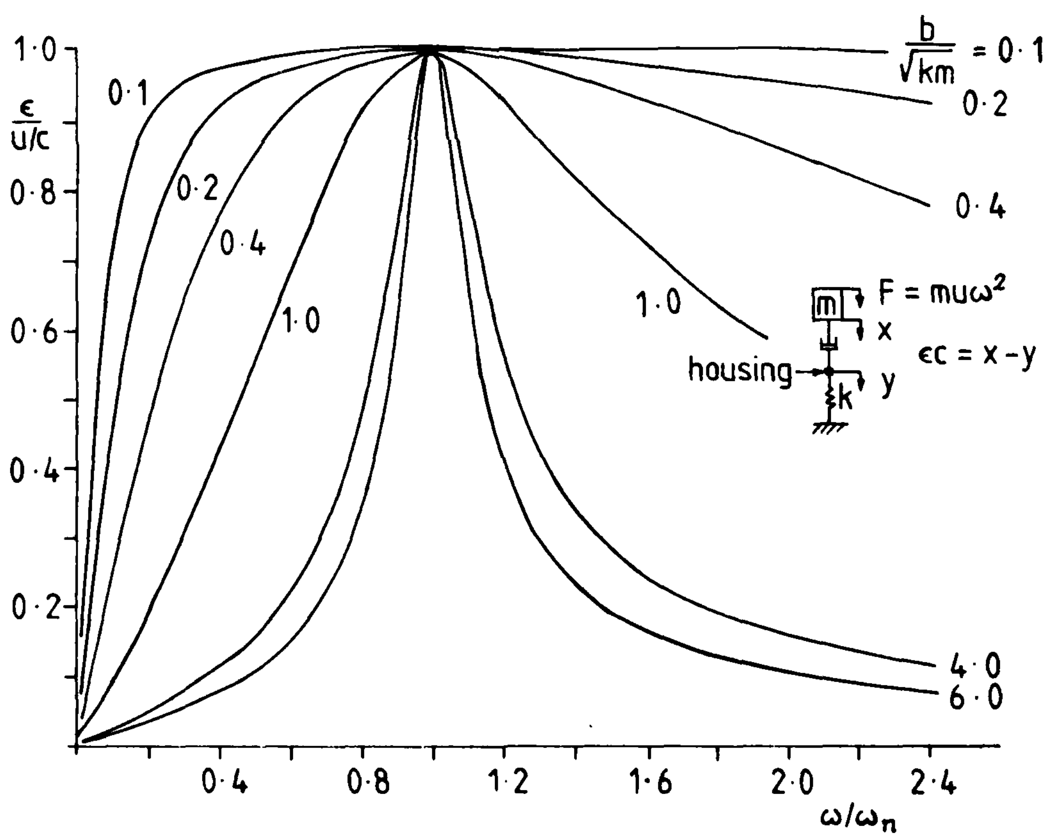

Figure 2. Rotor Vibration Amplitude Relative to the Bearing Housing

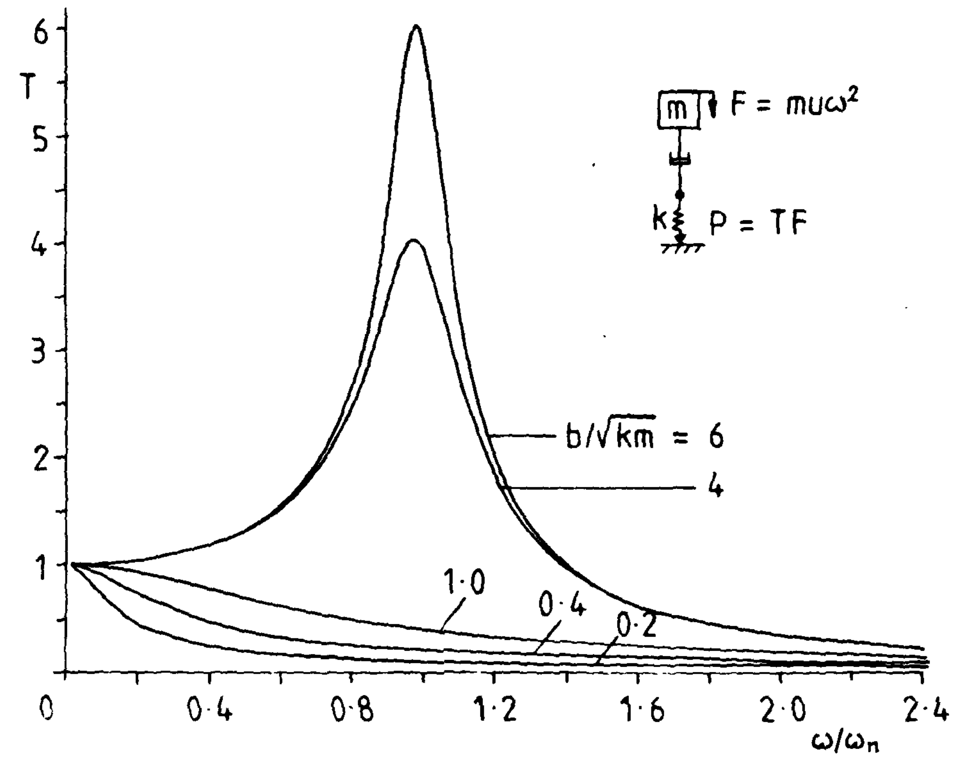

Figure 3. Transmissibility

engine manufacturer increases damping capacity with squeeze-film dampers supplied from one or more oil holes in a central axial plane; one of various types of seal is at the outlet. An effective mathematical model is difficult but has been attempted with some success by Marmol and Vance [9] and by Bansal and Hibner [10].

RECOMMENDATIONS FOR FUTURE RESEARCH

The parameters of a squeeze-film should be represented under non-concentric whirling conditions in some sort of quasi-linear fashion for programs for the solution of linear multi-degree-of-freedom rotor-bearing systems.

One method of attack might be as follows. Assume that, for whatever reason, vibration takes place in the clearance circle of a squeeze-film damper about some mean eccentricity ratio. The experience of journal-bearing operation indicates that four damping coefficients can be assigned to the squeeze-film provided that vibration amplitudes are not more than about one third of the radial clearance. Because the mean eccentricity ratio depends on the value of the dynamic force, these damping coefficients would also be dependent on dynamic force. Then, following the analogy of a conventional journal bearing, the specification of four local stiffness coefficients is called for. Such stiffness coefficients would account for the lift generated by a squeeze-film and, being nonlinear, would again depend on the value of the dynamic load causing the vibration. The coefficients could perhaps be found from measurements of amplitude and average phase relative to unbalance along mutually perpendicular axes. A tabulation could thus be made of all eight coefficients against dynamic force for use in linear multi-degree-of-freedom programs. Such an empirical procedure might offer a means for assessing the performance of complex machinery employing squeeze-film dampers.

REFERENCES

1. Gunter, E.J., Barrett, L.E. and Allaire, P.E., "Design of Non-linear Squeeze-film Dampers for Aircraft Engines," J. Lubric. Tech., Trans. ASME, 99 (1), p 57 (Jan 1977).

2. Nikolajsen, J.L. and Holmes, R., "Investigations of Squeeze-film Isolators for the Vibration Control of a Flexible Rotor," J. Mech. Eng. Sci. (1979).

3. Holmes, R. and Humes, B., "An Investigation of Vibration Dampers in Gas-turbine Engines," Proc. 52nd AGARD Symp., Cleveland, U.S.A. (Oct 1978).

4. Glienicke, J. and Stanski, U., "External Bearing Damping - A Means of Preventing Dangerous Shaft Vibrations in Gas Turbines and Exhaust Turbo-chargers," 11th Intl. Congress of Machinery and Combustion, Barcelona, pp 287-311 (Apr 1975).

5. Gunter, E.J., Barrett, L.E., and Allaire, P.E., "Stabilization of Turbo-machinery with Squeeze-film Dampers - Theory and Applications," Paper No. C233/76, Proc. Inst. Mech. Engrs. Conf. Vibrations in Rotating Machinery, Cambridge (1976).

6. Holmes, R., "The Damping Characteristics of Vibration Isolators Used in Gas Turbines," J. Mech. Eng. Sci., 19 (6), pp 271-277 (1977).

7. Tønnesen, J., "Experimental Parametric Study of a Squeeze-film Bearing," J. Lubric. Tech., Trans. ASME, pp 206-213 (Apr 1976).

8. White, D.C., "Squeeze-film Journal Bearings," Ph.D. Thesis, Cambridge (1970).

9. Marmol, R.A. and Vance, J.M., "Squeeze-film Damper Characteristics for Gas Turbine Engines," ASME Paper No. 77-DET-18.

10. Bansal, P.N. and Hibner, D.H., "Experimental and Analytical Investigation of Squeeze-film Damper Forces Induced by Offset Circular Whirl Orbits," J. Mech. Des., Trans. ASME, 100 (July 1978).

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LITERATURE REVIEW - PNEUMATIC SHOCK ABSORBERS AND ISOLATORS

M.S. Hundal*

Abstract - Literature published in the last several years on shock absorbers and isolators that utilize pneumatic dampers is reviewed. Topics for further investigation are mentioned.

The use of pneumatic dampers in vibration and shock absorbers and isolators offers the advantages of cleanliness and lower cost in comparison with hydraulic dampers. On the other hand, pneumatic dampers tend to be bulkier and springy. This paper is concerned with shock absorption and isolation problems. Their mathematical relationship [1] is shown in Figure 1 for a single-degree-of-freedom system. In Figure 1(a) an absorber brings a moving mass to rest. The equation of motion is

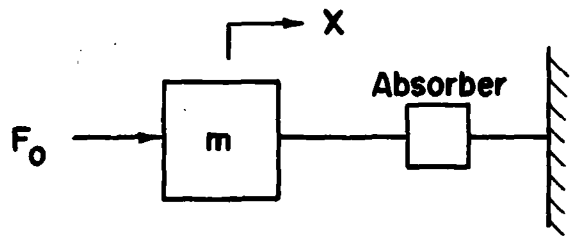
$$m\ddot{x} + F_a = F_o \qquad (1)$$

F_a is the absorber force, and F_o is an external force on the mass. In Figure 1(b) an excitation displacement u is applied to the mass through an isolator. With $\delta = u - x$, the equation for this case is

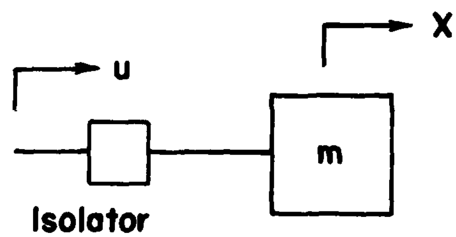
$$m\ddot{\delta} + F_i = m\ddot{u} \qquad (2)$$

F_i is the isolator force. Equations (1) and (2) are of similar form.

Pneumatic dampers have found far greater application in vibration isolation than in shock attenuation. There is little published literature in the area of shock isolation and absorption. One possible reason is that the equations describing the behavior of pneumatic elements are nonlinear. The analysis of shock response is thus a transient problem and precludes linear approximations if reliable results are to be obtained.



(a)



(b)

Figure 1. Shock Absorber (a) and Shock Isolator (b)

LITERATURE REVIEW

Carey and Hadeler [2] have presented graphical results for use in designing air dashpots. Eshleman and Rao [3] investigated shock isolation characteristics of six types of elements: helical coil spring, ring spring, friction snubber, liquid spring, pneumatic spring, and solid rubber elastomer. They conducted experiments with masses of 600 and 960 pounds, displacement inputs of 5 inches peak-to-peak, 150

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in./sec maximum velocity, and 80 g and higher accelerations. Analytical response was obtained by numerical integration. Continuum elements were analyzed by solving one-dimensional wave equation. No analysis of the pneumatic spring was presented. Numerical results included maximum mass acceleration and displacement. No comparison of the effectiveness of the various isolators was given.

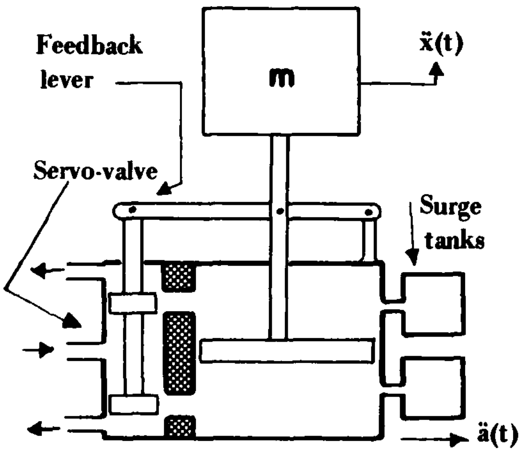

Figure 2. Active Mechano-Pneumatic Shock Isolator [4]

Ruzicka [4] presented analytical and experimental results of active vibration and shock isolation methods. He discussed mechano-pneumatic and electrohydraulic isolators. Details of the analysis were not given, but it appears that linearized equations were used for the pneumatic elements. Natural frequencies with mechano-pneumatic isolator were in the range of 0.5 to 20 Hz. A schematic diagram of the system is shown in Figure 2. The transient response to acceleration step excitation is shown in Figure 3. The use of integral displacement control reduces the steady-state relative displacement of the mass to zero and permits vibration isolation in the presence of sustained acceleration. The results presented for the pneumatic shock isolator were qualitative in nature.

Fox and Steiner [5] analyzed the operation of a passive pneumatic shock isolator. The system is shown in Figure 4. The set of nonlinear equations was numerically integrated. Results were presented for four values of volume ratio $N = V_D/V_L$: 1.08, 1.3, 1.64, and 2.2. Figure 5 shows typical results obtained; the damping ratio was found from the ratio of two successive peaks using linear system analogy. As shown, the peak acceleration reaches a minimum for a certain area ratio. Other investigators have also presented experimental results that correlated well with analytical results.

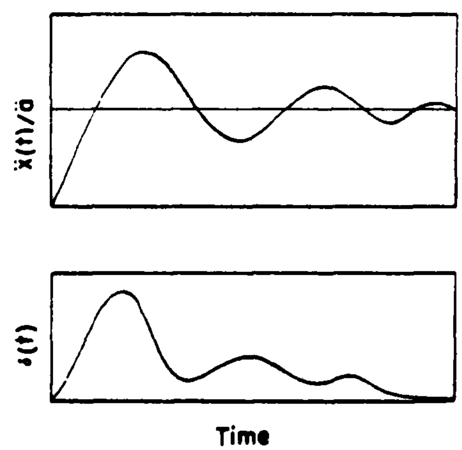

Figure 3. Absolute Acceleration and Relative Displacement Response of Isolated Mass for Step Acceleration Input [4]

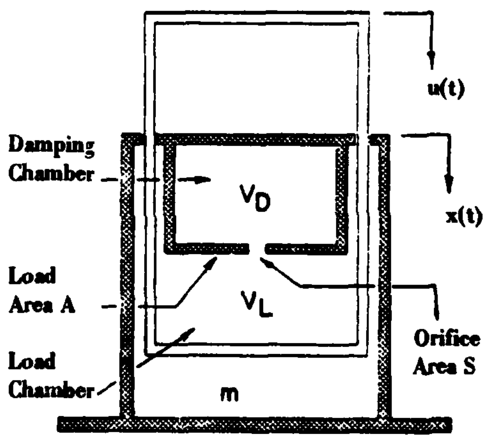

Figure 4. Passive Pneumatic Shock Isolator [5]

Analytical and experimental results for the performance of a pneumatic shock absorber have been given by Takahashi [6]. He dealt with a specific application: the carriage return mechanism of a printer. The system is shown schematically in Figure 6. The impact velocity of the mass was dependent on its initial displacement. The flow characteristics of the damper orifice, which was cylindrical in shape, were obtained from experimental data. The system equations were put in dimensionless form and numericaly integrated. The following results were presented in terms of dimensionless variables and parameters: displacement and pressure vs. time for various values of initial velocity and velocity and pressure vs. displacement for various values of initial preload and orifice size. Experimental results of displacement showed close correlation with those obtained analytically, but analytically peak pressures were lower. A useful

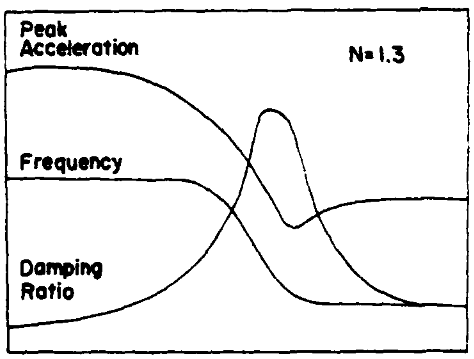

Figure 5. Typical Response Characteristics of Pneumatic Isolator [5]

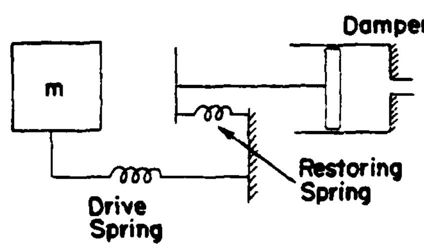

Figure 6. Shock Absorber for Printer Carriage Return [6]

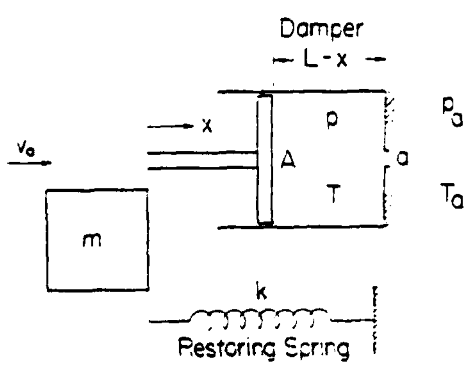

Figure 7. Pneumatic Shock Absorber with Constant Area Orifice Damper [7]

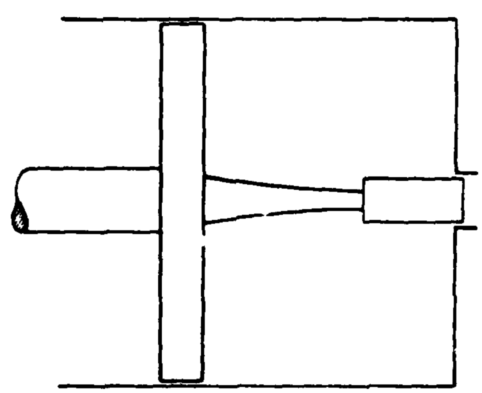

Figure 8. Pneumatic Damper with Two-Stage Variable Area Orifice [7]

set of results showed optimal damping and corresponding operate times. The results are helpful in guiding a designer to optimal system designs.

Hundal [7] presented a generalized analysis of a shock absorber consisting of a pneumatic damper in parallel with a spring, as shown in Figure 7. The nonlinear equations were non-dimensionalized in terms of variables of displacement, velocity, and pressure, parameters were mass, stiffness, and orifice area ratio. He treated the case of the standard orifice of fixed area. Results presented in a tabular form showed maximum mass acceleration and cylinder pressure for ranges of values of the three parameters. Again, such results in dimensionless form are helpful as a design guide. Maximum values of mass and area parameters for which the mass comes to a stop at the end of its stroke are given, as are parameter values for which mass cannot be stopped. The performance of a damper with a variable area orifice was also analyzed (see Figure 8). The orifice remains closed for first part of the stroke, after which its area is made to change in such a way that mass acceleration remains constant (see Figure 9). The performances and sizes of five different types of shock absorbers were compared: spring only; hydraulic damper with variable area orifice, incompressible fluid; hydraulic damper, fluid compressibility considered; pneumatic damper with constant area orifice; and pneumatic damper with variable area orifice, both in parallel with pneumatic spring.

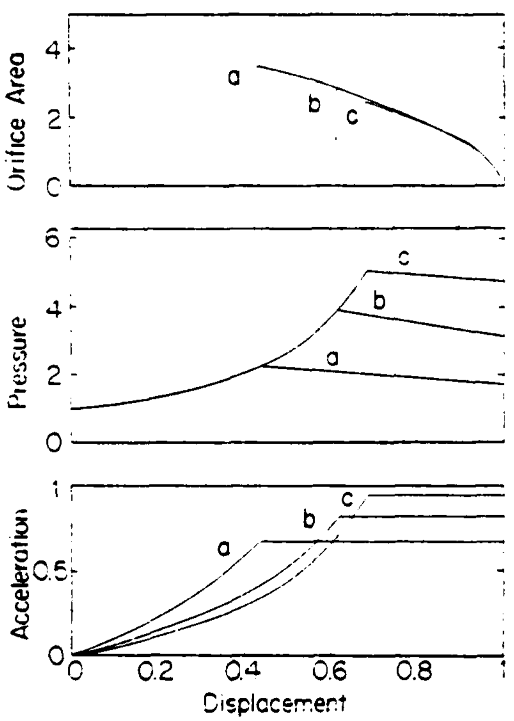

Figure 9. System Response for Different Stiffness and Mass Parameters [7]

CONCLUDING REMARKS

The published literature on pneumatic shock isolators and absorbers is limited. Suggested topics for further work include detailed analyses of pneumatic shock isolators, an orderly comparison of their performance with other types of isolators, and development of design guides.

REFERENCES

1. Harris, C.M. and Crede, C.E., Shock and Vibration Handbook, Chapter 31, "Theory of Shock Isolation," McGraw-Hill (1961).

2. Carey, T. and Hadeler, T.T., "Air Snubber Graphs," Product Engr., 35 (23), p 86 (1964).

3. Eshleman, R.L. and Rao, P.N., "The Response of Mechanical Shock Isolation Elements to High Rate Input Loading," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 40, Pt. 5, pp 217-234 (Dec 1969).

4. Ruzicka, J.E., "Active Vibration and Shock Isolation," SAE Trans., 77, pp 2872-2886 (1969).

5. Fox, G.L. and Steiner, E., "Transient Response of Passive Pneumatic Isolators," Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 42, Pt. 4, pp 85-91 (Jan 1972).

6. Takahashi, T., "Air Dashpot Energy Absorption Characteristics," Rev. Elect. Commun. Lab., 22 (1, 2), pp 71-81 (Jan-Feb 1974).

7. Hundal, M.S., "Analysis of Performance of Pneumatic Impact Absorbers," J. Mech. Des., Trans. ASME, 100, pp 236-241 (Apr 1978).

BOOK REVIEWS

ASYMPTOTIC WAVE THEORY

M. Roseau
Elsevier-North Holland Publ. Co., P.O. Box 211, Amsterdam, The Netherlands, and 52 Vanderbilt Ave., New York, NY 10017, 1978

Professor Roseau has presented asymptotic solutions to various wave equations with emphasis on applications. Both linear and nonlinear problems of wave propagation in open channel are treated. Also treated are linear elastic wave propagation and linear water waves. Emphasis throughout is on asymptotic solutions. Although each subject has been dealt with in monographs and books in the past, this book is not another in that list. Rather, it presents a clear and elegant treatment of the asymptotic techniques that have proved to be fruitful in solving problems that arise in these three areas.

The book is divided into eight chapters. The first five chapters lay the mathematical groundwork necessary to solve the problem of wave propagation in a continuous medium. In the last three chapters the author presents solutions to some representative problems from the three subject areas mentioned above.

A rigorous introduction to the theory of Laplace and Fourier transforms is presented in Chapter I. The second and third chapters deal with the Gamma and Bessel functions. The scalar wave equations and its solutions in rectangular, cylindrical, and spherical coordinates are presented in Chapter III. The concept of group velocity is introduced and treated in a vigorous manner. Finally, the problem of reflection of a spherical wave at a plane surface is treated in this chapter. Asymptotic evaluation of integrals is discussed in Chapter 4. The asymptotic expansion of the integrals arising in the spherical wave reflection from a plane surface is presented, as are asymptotic expansions of Hankel and Legendre functions. The book is novel in that it includes a chapter (Chapter 5) on Scattering Matrix Theory; both the direct and inverse problems are discussed. Chapters 6, 7, and 8 deal respectively with selected problems of open channel flow, linear elastic waves, and water waves.

The book has been very carefully written and should be useful to students and research workers in wave theory.

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INDUSTRIAL NOISE AND VIBRATION CONTROL

J.D. Irwin and E.R. Graf
Prentice-Hall, Inc., Englewood Cliffs, NJ, 1979

The authors have written a very fine textbook for a serious undergraduate engineering course. Each chapter concludes with a well thought out group of problems; answers to the odd-numbered members are provided toward the end of the book. In addition, after new concepts are introduced, illustrative examples are worked out. Simpler drill problems with answers are presented where helpful to the student.

Many aspects of airborne acoustics are touched upon, and the basic concepts underlying noise control technology are explained in detail. Chapters covering sound waves, decibels, and directivity; psychological effects (NC and PNC); regulations (EPA, OSHA) and noise meausres (L_{eq}, L_{dn}); instrumentation; noise characteristics of common industrial and residential sources; room acoustics; noise isolation techniques; and airborne noise attenuation are provided.

A novel and welcome addition to numerous recent similar books in the general field of noise and vibration control is a detailed discussion of machinery vibrations, balancing, and diagnostic techniques. Picturesque Lissajous patterns showing the phase and amplitude ratio of horizontal and vertical shaft displacements provide an up-to-date glimpse of a measurement specialty seldom discussed in the general literature.

The illustrations, mainly line drawings, include errors, some of which indicate poor communication between authors and draftsman. The typography, headings, index, and table of contents of this 400-odd page book are of high quality. The chapters on vibrations are noticeably less rigorous compared to the acoustical and noise control chapters. The language is, in some cases, colloquial, and redundant information is frequent. The section on vibration instrumentation is somewhat shallow and for the most part does not guide the reader to specific manufacturers or instruments.

Alghough the development of the acoustical topics is clear and logical, there are numerous indications that the book's primary value is as a textbook rather than as a reference book for the practicing engineer. The references and general bibliography provided for each and every chapter do, however, include much of the practical detailed information, not presented in the text, that is needed to solve real industrial noise and vibration problems.

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AN INTRODUCTION TO RANDOM VIBRATION AND SPECTRAL ANALYSIS

D.E. Newland
Longman's Inc., New York, NY, 1978

We meet random vibration in noise of transportation vehicles, turbulent flow of jet streams, and jet engine noise.

This book consists of 14 chapters and is divided into two sections. The first section of eight chapters has to do with understanding random vibration. The second section discusses digital analysis of stochastic processes.

Chapters I and II introduce the probability density function and its application. The probability distribution function, joint probability distribution, ensemble averaging, and higher order Gaussian distribution are also covered.

Chapters III and IV present sample discussions of auto and cross correlation as well as the relationship between Fourier series and Fourier integrals. Chapter V explains the relationship of spectral density to correlation and its application to narrow-band and broadband processes. Cross spectral density and its relationship to cross correlation are given.

Chapters VI and VII describe the frequency response method, the impulse response method, and the relationship between them. Response of an arbitrary input and transmission of random vibration are considered. The author discusses the interrelationship of correlation and spectral density.

Chapter VIII considers statistics of narrow-band processes. The well-known crossing analysis and peak distribution are discussed, as is the frequency of maximum values. This is a short but terse interpretation of the Rayleigh (narrow-band) process.

Chapter IX introduces stochastic data processing and the fast Fourier transform (FFT) method of data reduction. Subjects considered include variance of measurements, analysis of finite length records, smoothing procedures using rectangular spectral windows, and confidence limits using chi-square probability density functions.

Chapters X and XI contain discussions on topics that comprise the heart of modern day digital analysis and data reduction: discrete Fourier transforms, aliasing (an important requirement in data reduction), calculation of spectral estimates, and spectral windows. Spectral smoothing is considered, as is the fast Fourier transform (FFT) data reduction procedure. The author explains this procedure in very simple language and shows how variable amplitude data can be analyzed.

Chapters XII and XIII describe the more sophisticated aspects of FFT and various alternative algorithms. Pseudo- or artificial random processes are introduced. Direct use of pseudo-random binary signals, generation of the spectrum of multi-level processes, and generation of random numbers is given, as is synthesis of correlated noise sources.

Chapter XIV provides applications to response of a resonant mode to broadband excitation, fatigue, and failure due to random vibration via Rayleigh (narrow-band) testing. The Palmgren-Miner hypothesis is given but, based upon the reviewer's experience, it is of limited value. The narrow-band S/N curve is derived from sinusoidal S/N data. It is based upon higher truncation ratios -- i.e., maximum peak stress to rms stress -- and overestimates the actual data (random). The chapter includes applications to road surface irregularities, simulation of random environments including cross spectral terms, and frequency response and coherence functions.

The reviewer considers this paper-bound book an excellent discussion of random vibration and digital stochastic analysis. The table of nomenclature is excellent and the subject, which can be mathematically difficult, is presented in simple terms. A minor shortcoming of the book is the lack of discussion of acoustic noise (sonic fatigue) applied to aerospace vehicles and gas-type nuclear reactors. A short section on acoustics would be beneficial as would some computer programs showing how spectral analysis and correlation using the FFT can be used. This book is well worth the money.

H. Saunders
General Electric Company
Schenectady, NY 12345

SHORT COURSES

SEPTEMBER

UNDERWATER ACOUSTICS

Dates: September 8-12, 1980
Place: University Park, Pennsylvania
Objective: This is a concentrated course designed to cover the basic principles of underwater acoustics as well as current research and recent developments in the field. The course is intended to serve as an introductory course for those who are new to the field but have the appropriate educational background; and as a refresher course for scientists, engineers, program managers, and administrators engaged in underwater acoustics. Topics will include: basic acoustics, sonar concepts; ambient noise; reverberation; underwater acoustics transmission; transducer concepts; nonlinear acoustics/parametric arrays; target physics; and flow noise.

Contact: Robert E. Beam, Conference Coordinator, Pennsylvania State University, Faculty Building, University Park, PA 16802 - (814) 865-5141.

9TH ANNUAL INSTITUTE ON THE MODERN VIEW OF FATIGUE AND ITS RELATION TO ENGINEERING PROBLEMS

Dates: September 8-12, 1980
Place: Schenectady, New York
Objective: This course will emphasize the relationships of our current physical and phenomenological understanding of fatigue to the engineering treatment of the problem. The curriculum will be built around the several stages of the fatigue process including consideration of the plastic zone, crack nucleation and early growth, crack propagation in the plastic regime, crack propagation in the elastic regime, and failure. Examples from service failures will be introduced when appropriate.

Contact: Graduate Studies and Continuing Education, Union College, Wells House, 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

DIGITAL SIGNAL PROCESSING

Dates: September 9-12, 1980
Place: Dallas, Texas
Dates: September 16-19, 1980
Place: Chicago, Illinois
Dates: September 23-26, 1980
Place: Salt Lake City, Utah
Dates: September 30 - October 3, 1980
Place: Boston, Massachusetts
Objective: A course designed to provide the attendee with a comprehensive yet basic knowledge of theory, design, implementation and applications of digital signal processing techniques. Heavy emphasis is placed on the practical applications of time series analysis: curve fitting, vibration control, modal testing, shock spectra, wave form control, real time control, etc. Instructional laboratories and equipment demonstrations by manufacturer.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

FATIGUE ANALYSIS

Dates: September 10-11, 1980
Place: Cincinnati, Ohio
Objective: The growing understanding of the important factors in the fatigue failure process coupled with the accumulation of new, correctly obtained, fatigue test data and material property and behavior data, has led to the practical application of fatigue analysis methods. The vast improvements in stress analysis, both computerized design analysis (finite element methods, etc.) and experimental testing techniques (digital Fourier analysis, cycle counting methods, etc.) have enabled engineers and designers to get a more fundamental understanding of fatigue. The seminar will address the topics of cyclic stress-strain behavior of metals, fatigue properties of metals and cumulative damage procedures.

Contact: Mrs. Gayle Lyons, SDRC Seminar Coordinator, Structural Dynamics Research Corp., 2000 Eastman Dr., Milford, OH 45150 - (513) 576-2594.

MODAL VIBRATION TESTING IBRAHIM TECHNIQUE

Dates: September 11-12, 1980

Place: Atlanta, Georgia

Dates: October 9-10, 1980

Place: Boston, Massachusetts

Objective: Theory and use of the ITD method. Determining modal vibration parameters through a computational procedure utilizing a structure's free decay response or random response data, without the need for measuring the input forces. Free software.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

9TH ADVANCED NOISE AND VIBRATION COURSE

Dates: September 15-19, 1980

Place: Institute of Sound and Vibration Research, University of Southampton, UK

Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures, including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise, which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise, and environmental noise and planning.

Contact: Mrs. O.G. Hyde, ISVR Conference Secretary, The University of Southampton, S09 5NH UK-Southampton (0703) 559122, Ext. 2310 or 752, Telex: 47661.

MODAL ANALYSIS

Dates: September 17-19, 1980

Place: Cleveland, Ohio

Objective: This seminar will provide information on new techniques for identifying dynamic structural weaknesses. The sessions include the use of state-of-the-art instrumentation and software for creating a dynamic structural model in the computer. Techniques will be demonstrated for mode shape calculation and animated displays, computation of mass, stiffness and damping values and modal manipulation methods.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

SHOCK AND VIBRATION MEASUREMENT TECHNOLOGY

Dates: September 23-25, 1980

Place: Laguna Hills, California

Objective: This application-oriented seminar is structured to give engineers and senior technicians a review of the basics and an opportunity to broaden their working knowledge in all aspects of accelerometer selection, installation, cabling, conditioning and calibration. A forum on pyrotechnic testing and pyrotechnic simulation will also be given.

Contact: Tony Schneider, Endevco, Rancho Viejo Road, San Juan Capistrano, CA 92675 - (714) 493-8181.

VIBRATION CONTROL

Dates: September 29 - October 3, 1980

Place: Pennsylvania State University

Objective: This seminar will be of interest and value to engineers and scientists in industry, government, and education. Topics for consideration include dynamic mechanical properties of viscoelastic materials; structural and constrained-layer damping; isolation of machinery vibration from rigid and nonrigid substructures; isolation of impact transients; reduction of vibration in beams, plates, shells, periodic structures, stiffened plates, and rings and ring segments; and characteristics of multi-resonant vibrators. Each student will receive bound lecture notes and copies of six textbooks for his permanent reference.

Contact: Professor John C. Snowdon, Seminar Chairman, Applied Research Laboratory, Pennsylvania State University, P.O. Box 30, State College, PA 16801.

OCTOBER

MACHINERY VIBRATION ANALYSIS SEMINARS

Dates: October 1-2, 1980

Place: Houston, Texas

Objective: These two day seminars on machinery vibration analysis will be devoted to the diagnosis and correction of field vibration problems. The material is aimed at field engineers. The sessions will include lectures on the following topics: basic vibrations; critical speeds, resonance; torsional vibrations; instrumentation, including transducers, recorders, analyzers, and plotters; calibration; balancing and vibration control; identification of unbalance, misalignment, bent shafts, looseness, cavitation, and rubs; advanced diagnostic techniques; identification of defects in gears and antifriction bearings by spectrum analysis; and correction of structural foundation problems.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

VIBRATION DAMPING

Dates: October 6-9, 1980

Place: Dayton, Ohio

Objective: This course is designed to teach vibration damping fundamentals, analytical methods and experimental techniques required to design and apply damping treatments which sill solve vibration problems. The course is comprised of lectures, workshops, and laboratory demonstrations of methods used to measure damping material properties, to apply damping materials to structures, and to test damped and undamped structures. Computerized approaches for incorporating damping into new and existing structures and techniques for using viscoelastic materials for reducing noise will be discussed. The practical approach to problem solutions will be emphasized. The design techniques presented will be applicable to the design of viscoelasticity damped structures and will include use of newly established approaches which make use of both specialized and routine finite element analysis. The course content of this course is up-dated annually to reflect the latest developments of vibration damping technology.

Contact: Mr. Dale H. Whitford, Research Institute - KL 501, University of Dayton, Dayton, OH 45469 - (513) 229-4235.

VIBRATION TESTING

Dates: October 6-9, 1980

Place: San Diego, California

Objective: Topics to be covered are: exciters, fixtures, transducers, test specifications and the latest computerized techniques for equalization, control, and protection. Subjects covered include dynamics and dynamic measurements of mechanical systems, vibration and shock specifications and data generation. Demonstrations are given of sine random and shock testing and of how test specifications are met.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

SENSORS, INSTRUMENTATION AND MEASUREMENTS

Dates: October 7-10, 1980

Place: Dallas, Texas

Dates: October 14-17, 1980

Place: Chicago, Illinois

Dates: October 21-24, 1980

Place: Salt Lake City, Utah

Dates: October 28-31, 1980

Place: Boston, Massachusetts

Objective: A course for individuals involved in the selection and calibration of sensors and measurement instrumentation, the taking of dynamic measurements, performing modal or signature analysis, etc. Course includes laboratories on sensors and signal conditioning, data archiving, IEEE Bus, calculators, computers and analyzers. Instructional laboratories and equipment demonstrations by manufacturer.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

BLASTING AND EXPLOSIVES SAFETY TRAINING

Dates: October 8-10, 1980

Place: Nashville, Tennessee

Dates: October 22-24, 1980

Place: Casper, Wyoming

Dates: November 5-7, 1980
Place: Hershey, Pennsylvania
Dates: November 19-21, 1980
Place: Lexington, Kentucky
Dates: December 3-5, 1980
Place: Kansas City, Missouri
Dates: December 10-12, 1980
Place: Williamsburg, Virginia
Objective: This course is a basic course that teaches safe methods for handling and using commercial explosives. We approach the problems by getting at the reasons for safety rules and regulations. Helps provide blasters and supervisors with a practical understanding of explosives and their use - stressing importance of safety leadership. Familiarizes risk management and safety personnel with safety considerations of explosives products and blasting methods.

Contact: E.I. du Pont de Nemours & Co. (Inc.), Applied Technology Division, Wilmington, DE 19898 - (302) 772-5982/774-6406.

SCALE MODELING IN ENGINEERING DYNAMICS
Dates: October 20-24, 1980
Place: San Antonio, Texas
Objective: The course will begin with a drop test demonstration of damage to model and prototype cantilever beams made from different materials. These tests help to introduce the concepts of similarity and of physical dimensions which are preliminary to any model analysis. Formal mathematical techniques of modeling will then be presented including the development of scaling laws from both differential equations and the Buckingham Pi Theorem. A number of sessions then follow wherein the instructors present specific analyses relating to a variety of dynamic vibrations and transient response problems. The problems are selected to illustrate the use of models as an analysis tool and to give examples of variations on different modeling techniques. Types of problems presented include impact, blast, fragmentation, and thermal pulses on ground, air and floating structures.

Contact: Wilfred E. Baker, Southwest Research Institute, 6220 Culebra Road, P.O. Box 28510, San Antonio, Texas 78284 - (512) 684-5111, Ext. 2303.

DIGITAL SIGNAL PROCESSING
Dates: October 28-30, 1980
Place: Atlanta, Georgia
Objective: The mathematical basis for the fast Fourier transform calculation is presented, including frequency response, impulse response, transfer functions, mode shapes and optimized signal detection. Convolution, correlation functions and probability characteristics are described mathematically and each is demonstrated on the Digital Signal Processor. Other demonstrations include spectrum and power spectrum measurements; relative phase measurements between two signals; and signal source location.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

NOVEMBER

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION
Dates: November 3-7, 1980
Place: Huntsville, Alabama
Dates: December 8-12, 1980
Place: Anaheim, California
Dates: February 2-6, 1981
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

FINITE ELEMENTS: BASIC PRINCIPLES AND PRACTICAL ASPECTS
Dates: November 10-14, 1980
Place: Tucson, Arizona
Objective: The purpose of this course is to provide structural engineering practitioners with an understanding of the fundamental principles of finite element analysis, to describe applications of the

method, and to present guidelines for the proper use of the method and interpretation of the results obtained through it. Emphasis will be placed upon the linear analysis of frameworks, plates, shells and solids, dynamic analysis will also be treated. Daily workshop sessions will utilize the GIFTS interactive graphics finite element system, which is a popular stand along analysis capability and which also serves as a pre- and post-processor for such widely used programs as SAP and NASTRAN.

Contact: Dr. Hussein Kamel, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-1650/626-3054.

18TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 10-14, 1980
Place: Tucson, Arizona
Objective: This course will cover the following subjects: reliability engineering theory and practice; mechanical reliability; risk analysis; reliability testing and demonstration; maintainability engineering, product liability; and reliability and maintainability management.

Contact: Dr. Dimitri Kececioglu, Aeronautical Engineering, Bldg. 16, University of Arizona, Tucson, AZ 85721 - (602) 626-2495/626-3901/626-3054.

MACHINERY VIBRATION IV

Dates: November 11-13, 1980
Place: Cherry Hill, New Jersey
Objective: Lectures and demonstrations on vibration measurement rotor dynamics and torsional vibration are scheduled. General sessions will serve as a review of the technology; included are the topics of machine measurements, modal vibration analysis, and vibration and noise. The rotor dynamics sessions will include: using finite element, transfer matrix, and nonlinear models; vibration control including isolation, damping, and balancing. The sessions on torsional vibration feature fundamentals, modeling measurement and data analysis, self-excited vibrations, isolation and damping, transient analysis, and design of machine systems.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

MODAL ANALYSIS, SUBSTRUCTURING AND TESTING

Dates: November 11-14, 1980
Place: Chicago, Illinois
Dates: November 18-21, 1980
Place: Dallas, Texas
Dates: December 2-5, 1980
Place: Salt Lake City, Utah
Dates: December 9-12, 1980
Place: Boston, Massachusetts
Objective: A state-of-the-art presentation on structural analysis techniques combined with laboratory demonstrations. Covers mechanical structures, modes of vibration, modal analysis, structural testing, finite element modeling and substructuring including structural dynamics modification techniques. Instructional laboratories and equipment demonstrations by manufacturer.

Contact: Onstead and Associates, Inc., 1333 Lawrence Expressway, Bldg. 100, Suite 103, Santa Clara, CA 95051 - (408) 246-7656.

DECEMBER

MACHINERY VIBRATION ANALYSIS

Dates: December 10-12, 1980
Place: New Orleans, Louisiana
Objective: The course covers causes, effects, detection, and solutions of problems relating to rotating machines. Vibration sources, such as oil and resonant whirl, beats, assembly errors, rotor flexibility, whip, damping, eccentricity, etc. will be discussed. The effect on the overall vibration level due to the interaction of a machine's structure, foundation, and components will be illustrated.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 5-9, 1981

Place: Tucson, Arizona

Objective: The objective of this short course and workshop is to provide practical information on engineering applications of probabilistic and statistical methods, and design under random vibration environments. Modern methods of structural and mechanical reliability analysis will be presented. Special emphasis will be given to fatigue and fracture reliability.

Contact: Dr. Paul H. Wirsching, Associate Professor of Aerospace and Mechanical Engineering, The University of Arizona, College of Engineering, Tucson, AZ 85721 - (602) 626-3159/626-3054.

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

INTER-NOISE SEMINAR ANNOUNCED

An intensive short course on principles and applications of noise control will be presented on December 4, 5, and 6, 1980 at the Hotel Inter-Continental in Miami, Florida, immediately preceeding INTER-NOISE 80, the Ninth International Conference on Noise Control Engineering. The presentations on the first day will cover fundamentals of acoustics and noise control and will be given by Malcolm J. Crocker, Editor-in-Chief, NOISE CONTROL ENGINEERING and Professor of Acoustics, Purdue University and by William W. Lang, Program Manager, Acoustics Technology, IBM. The presentations on the following days will be given by noise control specialists from industry, government and universities and will cover: in-plant noise control, design of facilities for noise control, noise measurements and data reduction, and acoustical standards used in noise measurements. The registration fee for the Seminar is $395.

For further information, contact: INTER-NOISE 80 Conference Secretariat, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719.

UNIVERSITY PRESS OF VIRGINIA ANNOUNCES NEW PUBLICATION

The University Press of Virginia is pleased to announce publication of: Innovative Numerical Analysis for the Engineering Sciences; Edited by R. Shaw, W. Pilkey, A. Lakis, A. Chaudouet, R. Wilson, C. Marino, and B. Pilkey; $40.00.

Innovative Numerical Analysis is a state-of-the-art guide to problem-solving in a wide range of applied engineering fields. The volume contains over eighty articles on numerical analysis for problems in structures, solid mechanics, fracture mechanics, fluids, structure-field interaction, diffusion, acoustics, mathematics, and electromagnetics. The essays are the work of over 130 leading authorities from around the world and constitute the Proceedings of the Second International Symposium for Innovative Numerical Analysis in Applied Engineering Science (Montreal, June, 1980). No comparable volume exists.

The fourteen articles on structures cover, among other areas, dynamic systems analysis, pipes, shells, plates, elastic prismatic members, gun dynamics, and bridges. The eighteen solid mechanics essays touch upon torsion problems and elastostatic displacement, as well as other topics. Twenty articles on fluids cover potential-flow problems, hydraulic jumps, aircraft trailing vortices, convection-diffusion, gas and fluid dynamics, moving boundary problems, airfoil design, and other fluid-related problem areas.

A variety of new numerical methods are presented in the twelve articles of the mathematics section. These range from specific topics, such as mixed boundary integral methods, to general discussions of new numerical methodology, shortcuts, and formulas. The book includes four essays on fractures, six on structure-fluid interaction, two on diffusion, one on acoustics, and three on electromagnetics.

The editors of the volume represent a wide range of academic and professional fields.

Publication date: 30 June 1980. 6 x 9. 811 pp., index. ISBN 0-8139-0867-1. LC 80-14005.

For further information, contact: The University Press of Virginia, Box 3608, University Station, Charlottesville, VA 22903 - (804) 924-3468.

SAE AEROSPACE CONGRESS AND EXPOSITION

"Recent Experiences and Advances in Dynamic Testing and Analysis" will be the title of the SAE Aerospace Congress and Exposition held October 13-16, 1980 at the Los Angeles Convention Center.

The following is a list of the papers to be presented at the seminar:

- Dynamic Testing of Nuclear Power Plant Structures/An Evaluation
  Dr. H. Joseph Weaver, Lawrence Livermore Laboratory
- Digital Control Techniques for Three-Axis Vibration-Testing System
  Strether Smith and Dr. Richard Stroud, Synergistic Technology, Inc.
  Larry Johnson, Wyle Laboratories
- Developments Toward Active Control of Space Structures
  Dr. Richard Stroud, George Hamma and Strether Smith, Synergistic Technology, Inc.
  M.G. Lyons, Lockheed Palo Alto Research Laboratory
- Applications of Structural Dynamics Modification
  Mark R. Herbert and Donald W. Kientzy, Structural Measurement Systems, Inc.
- Utilizing Modal Testing in System Analysis to Affect Design and Predict Structural Performance
  Ralph Brillhart, Steven Beck, David Hunt and John Van Benschoten, Structural Dynamics Research Corporation
- Measurement of Tube/Tube Support Clearance via Induced Vibration Analysis
  Don C. Barrett, Dr. Terry D. Scharton and Charles C. Kidd, ANCO Engineers, Inc.
- Dynamic Testing and Acoustic Analysis of Concrete Dams
  Dr. M.W. Dobbs, R.S. Keowen, R.E. Cooper, Jr., K.O. Blakely, and P.A. Martinez, ANCO Engineers, Inc.
- Some Vibration Characteristics of a Space Shuttle Tile/Strain-Isolator Pad
  Robert Miserentino, Dr. Larry D. Pinson, and Sumner A. Leadbetter, NASA Langley Research Center
- Variability Associated with Seismic Testing Methods
  Ramaswami Vasudevan, Decision Analysis Co., Inc.
  Robert D. Campbell, Structural Mechanics Associates

For further information, contact: Roy W. Mustain, Rockwell Space Systems Group, AB 97, 12214 S. Lakewood Blvd., Downey, CA 90241

ENVIRONMENTAL STRESS SCREENING SEMINAR

The Orange County Chapter of the Institute of Environmental Sciences will hold a one-day seminar on Environmental Stress Screening, October 24, 1980 at Griswold's Inn, Fullerton, California.

The topic of this seminar is on the changing role of Environmental Stress Screening designed for management and engineering, interested in improving product performance, reliability and quality through the detection and correction of part and workmanship defects. The disciplines addressed will include test, quality, design, reliability and program management.

Changes are taking place rapidly in many aspects of the procurement and deployment of military systems - changes to produce significant improvements in reliability, availability, and maintainability of manufactured components and systems.

The area of greatest attention, controversy and change is that of environmental stress screening, performed during the manufacturing cycle to stimulate material and workmanship defects for identification and correction. To inform and update all persons interested in this subject, the Orange County Chapter of the IES is pleased to present this one day seminar on Environmental Stress Screening. The selected speakers will explain environmental stress screening, describe current work, and discuss many of the controversial issues of change. All non-tutorial papers include actual test data with facts and results to prove that stress screening does indeed have a high dollar payoff. At the conclusion of the individual presentations, a panel session will summarize the present status, and provide a forum for discussion of the future directions of environmental stress screening.

Neil Mandel, Hughes Aircraft, El Segundo, California, is the keynote speaker of this seminar. The six presentations by members of government and industry will be followed by a panel discussion focusing on the problems in selling managers for the need of environmental stress screening on present and future programs.

For further information, contact: Dick Donahue, Hughes Aircraft Co., Bldg. TC16, M.S. C108, P.O. Box 3310, Fullerton, CA 92634

ADVANCE PROGRAM

51ST SHOCK AND VIBRATION SYMPOSIUM

October 21-23, 1980

San Diego, California

United States Navy
will be your host for this Symposium

THE SHOCK AND VIBRATION
INFORMATION CENTER

GENERAL INFORMATION

CONFERENCE LOCATION: Registration, Information, and Unclassified Technical Sessions are at the Holiday Inn at the Embarcardero, San Diego, CA. A classified session will be held at the Naval Ocean Systems Center, San Diego, CA. Details on these sessions are available to qualified attendees from the Shock and Vibration Information Center.

Travel orders for U.S. Government employees should indicate the Holiday Inn at the Embarcadero as the main conference location.

REGISTRATION: Registration forms are available from the Shock and Vibration Information Center. It is suggested that those interested take prompt action since ADVANCE REGISTRATION BY MAIL IS STRONGLY RECOMMENDED. ADVANCE SECURITY CLEARANCE IS ESSENTIAL for attendance at the CLASSIFIED SESSIONS.

Fee: Registration fee covers the cost of the proceedings of the 51st Shock and Vibration Symposium. There is no fee for SVIC Annual Subscribers and for participants. Since the registration fee covers only the cost of the proceedings, there will be no reduced fee for part time attendance. The schedule of fees is as follows:

Subscriber Registration (for employees of
SVIC Annual Subscribers) . . . . No Fee
Participant Registration (Authors,
Speakers, Chairman, Cochairman). . . . . . . No Fee
General Registration (All others)
Payable to Disbursing Officer, NRL) . . . $100.00

On-Site Registration: Pre-registrants may obtain their badges or last minute unclassified registration may be accomplished at the following times:

Holiday Inn at the Embarcadero
Monday, October 20 . . . . 7:00 - 9:00 PM
Tuesday, October 21 . . . . 1:00 PM - 4:00 PM
Wednesday, October 22 . . . . . 8:00 AM - 4:00 PM
Thursday, October 23 . . . . . . 8:00 AM - 2:00 PM

INFORMATION: An information and message center will be located in the registration area. The phone number in the registration area is 714-232-3861. Ask for the Shock and Vibration Symposium. Telephone messages and special notices will be posted near the registration desk. All participants should check regularly for messages or timely announcements. Participants will not be paged in the sessions.

CLASSIFIED SESSIONS: Attendance at these sessions is contingent upon the establishment of a valid security clearance and Need-To-Know. Inquire at the Shock and Vibration Information Center for further information.

OUTSIDE ACTIVITIES: A special planned program of outside activities is available to spouses. (Inquire at SVIC for details.)

SPECIAL TOUR: It is likely that a special tour of technical interest will be planned for the morning of Friday, October 24, 1980 for those who wish to stay over. Details will be available in the Final Program.

LODGING: A block of rooms has been reserved at the Holiday Inn at the Embarcadero for those attending the Symposium. All reservations may be made by forwarding a request to the Holiday Inn at the Embarcadero, 355 North Harbor Drive, San Diego, CA (Phone: 714-232-3861). Mention the 51st Shock and Vibration Symposium. It is recommended that hotel reservations be made well in advance of the meeting and, in no case later than 6 October 1980.

COMMITTEE MEETINGS: Space is available to schedule meetings for special committees and working groups at the Symposium. To reserve space contact SVIC. A schedule of special meetings will be printed in the final program.

SVIC STAFF:

Mr. Henry C. Pusey, Director
Mr. Rudolph H. Volin
Dr. J. Gordan Showalter
Mrs. Carol Healey (Secretary)
Mrs. Elizabeth A. McLaughlin (Secretary)

Shock and Vibration Information Center
Naval Research Laboratory, Code 5804
Washington, D.C. 20375

Telephone: 202-767-2220
Autovon: 297-2220

PUBLICATIONS

PROCEEDINGS: THE SUMMARIES OF PRESENTED PAPERS will be published in advance. These summaries are longer than the usual abstract and contain enough detail to evaluate their usefulness to you as an individual. By receiving these in advance, you may more effectively choose the papers you wish to hear. IN ORDER TO RECEIVE THE SUMMARIES IN ADVANCE, BE SURE YOUR REGISTRATION IS IN OUR HANDS BY 3 October 1980.

SHOCK AND VIBRATION BULLETIN No. 51: Papers presented at the 51st Symposium will, at the author's request, be reviewed and published in the Bulletin after approval by two reviewers. The discussion following these papers will be edited and published with the respective papers. Registrants who have paid the registration fee or have satisfied the registration requirements will receive a copy of the Bulletin. Additional sets of the 51st Bulletin will be sent to Annual Subscribers. Others may purchase the Bulletin from the Shock and Vibration Information Center. The price is $100.00 for each set delivered in the United States.

OTHER PUBLICATIONS: Sample copies of current publications of the Shock and Vibration Information Center may be examined at the registration area. Order blanks are available for those wishing to use them.

51st SYMPOSIUM PROGRAM COMMITTEE

Mr. J.R. Sullivan
Naval Sea Systems Command
Washington, D.C. 20360

Mr. Dave Hurt
Naval Sea Systems Command
Washington, D.C. 20360

Dr. Kent Goering
Defense Nuclear Agency
Washington, D.C. 20305

Mr. Michael Condouris
U.S. Army Electronics R&D Command
Ft. Monmouth, NJ 07703

Mr. Sumner Leadbetter
NASA - Langley Research Center
Hampton, VA 23665

OPENING PLENARY SESSION

(Unclassified) **Tuesday, October 21**
2:00 P.M. **Pacific Ballroom A**

Chairman: Dr. Richard Swim, Superintendent, Marine Technology Division, Naval Research Laboratory, Washington, D.C.

Keynote Address: Mr. James E. Colvard, Deputy Chief of Naval Material, Naval Material Command, Washington, D.C

AN APPROACH TO THE LIMITATION AND CONTROL OF SHIPBOARD VIBRATION

Elias Klein Memorial Lecture presented by
Mr. E.F. Noonan, Consultant, NKF Engineering Associates, Inc., Vienna, VA

Session 1 (Unclassified) **Tuesday, October 21**
3:40 P.M. **Pacific Ballroom A**

SUBMARINE SHOCK

Chairman: Dr. William W. Murray, David W. Taylor Naval Ship R&D Center, Bethesda, MD

Cochairman: Dr. Michael Pakstys, General Dynamics/ Electric Boat Division, Groton, CT

1. Methods for Calculating Submarine Hull Stresses When Subjected to Shocks - B. BRAUN, Kockum AB, Malmo, Sweden

2. Calculated Responses in Hull-Mounted Items of Equipment in Submarines Compared with Measurements Carried out During Shock Tests - K. HELLQVIST, Kockum AB, Malmo, Sweden

3. Presentation of a Computer-Assisted Measuring System Using PCM-Technique with 128 Analog Measuring Channels and Facilities for Signal-Analysis - K. HELLQVIST, Kockum AB, Malmo, Sweden

4. Presentation of a Large-Scale Submarine Shock Test Carried out as Part of the Swedish Shock Design Development Program - K. HELLQVIST, Kockum AB, Malmo, Sweden

Session 2 (Unclassified) **Tuesday, October 21**
3:40 P.M. **Pacific Ballroom D**

SHIP DYNAMICS

Chairman: Dr. Edward V. Palmer, David W. Taylor Naval Ship R&D Center, Portsmouth, VA

Cochairman: Mr. Mike Hattamer, Puget Sound Naval Ship Yard, Bremerton, WA

1. Lateral Dynamics of C4 Missile - F.H. WOLFF, Westinghouse Research & Development Center, Pisstburgh, PA

2. Response of Hydrofoil Strut-Foil Systems After Impact with "Dead-Head" Logs - H.S. LEVINE, Weidlinger Associates, Menlo Park, CA and A.P. MISOVEC, Weidlinger Associates, Portsmouth, VA

3. Transient Response Analysis of a Large Radar Antenna - E. MELLER and W.A. LODEN, Lockheed Missiles and Space Company, Palo Alto, CA and W. WOLTNORIST, Lockheed Electronics Company, Plainfield, NJ

4. Active Stabilization of a Ship Borne Crane - J. SVOBODA and S. SANKAR, Concordia University, Montreal, Quebec, Canada

PLENARY LECTURE

9:00 A.M. Pacific Ballroom D **Wednesday, October 22**

DEPARTMENT OF DEFENSE INSTRUCTION 5000.40: RELIABILITY AND MAINTAINABILITY

Colonel Ben H. Swett, Office of the Undersecretary of Defense for Research and Engineering, Washington, D.C.

Session 3 (Unclassified) **Wednesday, October 22**
10:00 A.M. **Pacific Ballroom D**

ENVIRONMENTAL TESTING

Chairman: Mr. James W. Daniel, U.S. Army Missile R&D Command, Redstone Arsenal, AL

Cochairman: Mr. E. Ken Stewart, U.S. Army Armament R&D Command, Dover, NJ

1. Vibration Qualification of Equipment Mounted in Turboprop Aircraft - L.G. SMITH, Hughes Aircraft Company, Fullerton, CA

2. A Unique Way to Fixture Small Electronic Components for Vibration and Shock Testing - S.M. LANDRE, Harris Corporation, Melbourne, FL

3. Random Impact Vibration Tester - W.D. EVERETT, Pacific Missile Test Center, Point Mugu, CA

4. Optimizing Pre and Post Pulses for Shaker Shock Testing - R. FANDRICH, Harris Corporation, Melbourne, FL

5. Parameters for Use of Reverberent Acoustic Chambers for Testing Air-Carried Missiles - T.W. ELLIOTT, Pacific Missile Test Center, Point Magu, CA

6. Impact Criteria for Composite Airframes - P.C. DURUP, Lockheed-California Company, Burbank, CA

Session 4 (Unclassified) **Wednesday, October 22**
10:00 A.M. **Pacific Ballroom D**

SPECIFICATIONS AND RELIABILITY

Chairman: Mr. Robert Hancock, Vought Corporation Systems Division, Dallas, TX

Cochairwoman: Mrs. Phyllis Bolds, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH

1. Myths and Sacred Cows in Shock and Vibration - H.J. CARUSO, Westinghouse Electric Corporation, Baltimore, MD

2. The Effects of Avionics Environmental Vibration on the Seals of PC Board-Mounted Hybrid Packages - G.G. HARMAN, W.J. KEERY, National Bureau of Standards, Washington, D.C. and K.A. HARMISON, Naval Avionics Center, Indianapolis, IN

3. 'Quick Look' Assessment and Comparison of Vibration Specifications - J.H. SCHMIDT, The Marquardt Company, Van Nuys, CA

4. Vibration Test Level Criteria for Aircraft Equipment - P.S. HALL, Air Force Wright Aeronautical Laboratories, Wright Patterson AFB, OH

5. Fatigue Life Prediction for Simultaneous Stress and Strength Variances under Random Vibration - R.G. LAMBERT, General Electric Company, Utica, NY

6. New Dynamic Testing Requirements for Nuclear Power Plant Structures and Equipment: An Overview - G.C. KAO, A.E. MELIGI and R.L. HUMPHREYS, Sargent and Lundy Engineers, Chicago, IL

Session 5 (Unclassified) **Wednesday, October 22**
2:00 P.M. **Pacific Ballroom A**

DAMPING AND ISOLATION

Chairman: Mr. E.V. Thomas, David W. Taylor Naval Ship Research and Development Center, Annapolis, MD

Cochairman: Mr. Ahid Nashif, Anatrol Corporation, Cincinnati, OH

1. Application of Tuned Damping to Improve Performance of a Large High-Energy Laser Precision Pointing System - C. CHENG, L.B. DUNCAN, and R.E. HOLMAN, Hughes Aircraft Company, Culver City, CA

2. Improved Apparatus for Obtaining Dynamic Properties of Viscoelastic Materials - W.M. MADIGOSKY and G.F. LEE, Naval Surface Weapons Center, White Oak, Silver Spring, MD

3. The Modal Strain Energy Finite Element Analysis Methods and Its Application to Damped Laminated Beams - L. ROGERS, AFWAL/Flight Dynamics Lab/FIBA, Wright-Patterson AFB, OH, C.D. JOHNSON and D.A. KEINHOLZ, Anamet Laboratories, Inc., San Carlos, CA

4. Dynamic Behaviour of Lathe Spindles with Elastic Supports Including Damping by Finite Element Analysis - T.S. SANKAR, S. SANKAR, and A.M. SHARAN, Concordia University, Montreal, Quebec, Canada

5. Finite-Element Modeling Techniques for Constrained Layer Damping - R.E. HOLMAN, Hughes Aircraft Company, Culver City, CA

6. Finite Element Analysis of Viscoelastically Damped Sandwich Structures - M.L. SONI, University of Dayton, Dayton, OH

7. Pneumatic Vibration Control Using Active Force Generators - S. SANKAR and R. GUNTUR, Concordia University, Montreal, Quebec, Canada

8. The Experimental Performance of an "On-Off" Active Damper - E.J. KRASNICKI, Lord Corporation, Erie, PA

Session 6 (Unclassified) **Wednesday, October 22**
2:00 P.M. **Pacific Ballroom D**

DYNAMIC ANALYSIS

Chairman: Mr. George Morosow, Martin Marietta Corporation, Denver, CO

Cochairman: Mr. Jess Jones, NASA Marshall Space Flight Center, Huntsville, AL

1. Similitude Analysis and Testing of Prototype and 1:13.8 Scale Model of an Offshore Platform - N.G. DAGALAKIS and C.S. YANG, University of Maryland, College Park, MD and C.S. LI, National Taiwan University, Taipei

2. Vibrations of a Beam under Moving Loads by a Finite Element Formulation Consistent in Spatial and Time Coordinates - J.J. WU, Benet Weapons Laboratory, Watervliet, NY

3. Dynamic Behaviour of Axisymmetric Structures with a Slight Dissymetry - M. LALANNE, J. DER HAGOPIAN and M. CONTE, Institut National Des Sciences Appliquees, Cedex, France

4. On Nonlinear Response of Multiple Blade Systems - A. MUSZYNSKA, University of Dayton Research Institute, Dayton, OH; D.I.G. JONES and T. LAGNESE, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH; and L. WHITFORD, Aeronautical Systems Division, Wright Patterson AFB, OH

5. Media-Structure Interaction Computations Employing Frequency Dependent Mesh Sizes with the Finite Element Method - A.J. KALINOWSKI and C.W. NEBELUNG, Naval Underwater Systems Center, New London, CT

6. A Method for Predicting the Error Induced by Guyan Reduction - G.L. FOX, NKF Engineering Associates, Inc., Vienna, VA

7. An Improvement to Shaiths Method for the Vibration Analysis of Branched Systems - B. DAWSON, Polytechnic of Central London, London, England and M. DAVIES, University of Surrey, England

8. Effective Dynamic Reanalysis of Large Structures - B.P. WANG, Sperry Marine Systems, Charlottesville, VA and F.H. CHU, RCA/Astro, Princeton, NJ

PLENARY LECTURE

9:00 A.M. Pacific Ballroom A **Thursday, October 23**

NECESSARY AND SUFFICIENT QUALIFICATIONS FOR SHOCK

Mr. Robert Dyrdahl, The Boeing Company
Seattle, WA

Session 8 (Unclassified) **Thursday, October 23**
10:00 A.M. **Pacific Ballroom A**

SHOCK TESTING

Chairman: Mr. John Favour, Boeing Company, Seattle, WA

Cochairman: Mr. Kenneth Cornelius, David W. Taylor Naval Ship R&D Center, Bethesda, MD

1. An Improved Recursive Formula for Calculating Shock Response Spectra - D.O. SMALLWOOD, Sandia National Laboratories, Albuquerque, NM

2. Development of a Multiaxial Force-Pulse Generator - R.D. CROWSON, Waterways Experiment Station, Vicksburg, MS; F.B. SAFFORD, Agbabian Associates, El Segundo, CA; W.J. SCHUMAN, Jr., Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD; and R. FREIBERG, Army Electronic R&D Command, Fort Monmouth, NJ

3. Analysis of Energy-Absorbing Shock Mounts - V.H. NEUBERT, Pennsylvania State University, University Park, PA

4. A Theory for the Calculation of Explosive Deposition Profiles from the Spray Painting of Light Initiated Explosive - F.H. MATHEWS, Sandia National Laboratories, Albuquerque, NM

5. A Surface Loading Technique Employing Mild Detonating Fuze - D.L. SHIREY, Sandia National Laboratories, Albuquerque, NM

6. EDESS: An Electromagnetically-Driven Explosive-Shock Simulator - F.J. SAZAMA and J.B. WHITT, Naval Surface Weapons Center, Silver Spring, MD

Session 9 (Unclassified) **Thursday, October 23**
10:00 A.M. **Pacific Ballroom D**

SHOCK ANALYSIS

Chairman: Dr. Hansen Huang, Naval Research Laboratory, Washington, D.C.

Cochairman: Mr. Charles Moening, The Aerospace Corporation, El Segundo, CA

1. An Evaluation of: Doubly Asymptotic Approximation; Staggered Solution Schemes; USA-STAGS - R.S. DUNHAM, R.J. JAMES, A.S. KUSHNER, and D.E. RANTA, Pacifica Technology, Del Mar, CA

2. The Bend-Buckling of a Ring-Stiffened Cylindrical Shell Due to Whipping Excitations - K.A. BANNISTER, Naval Surface Weapons Center, Silver Spring, MD

3. Study of Penetration Forces for Supersonic UMT, Multitarget Warhead Designs - J.C.S. YANG, University of Maryland, College Park, MD; R. HASSETT, Department of Energy, Washington, D.C.; and H. WALPERT and J. RICHARDSON, Naval Surface Weapons Center, Silver Spring, MD

4. A Finite Element Model for Failure Initiation in Shock Loaded Structural Materials - D.W. NICHOLSON, Naval Surface Weapons Center, Silver Spring, MD

5. A Shock Response Spectrum Method of Solution for Displacement Forcing - F.C. NELSON, College of Engineering, Tufts University, Medford, MA

6. On Combining Modal Responses in the Shock Spectrum Method of Analysis - S.C. LIN and J.J. CULLENS, Bettis Atomic Power Laboratory, West Mifflin, PA and S.S. GASSEL, SKF Industries, Inc., King of Prussia, PA

Session 10 (Unclassified) **Thursday, October 23**
2:00 P.M. **Pacific Ballroom D**

ANALYSIS

Chairman: Dr. Ben Wada, Jet Propulsion Laboratory, Pasadena, CA

Cochairman: Mr. Paul Dunn, Aerospace Corporation, Los Angeles, CA

1. A Parametric Study of the ITD Modal Identification Algorithm - R.S. PAPPA, NASA Langley Research Center, Hampton, VA and S.R. IBRAHIM, Old Dominion University, Norfolk, VA

2. Analysis of Subcritical Response Measurements from Aircraft Flutter Tests - J.C. COPLEY, Royal Aircraft Establishment, Farnborough, Hants, England

3. Structural Synthesis of Ground Transport Vehicle Suspension Systems - P. WOODS and S. BARRETT, Martin Marietta Corporation, Denver, CO

4. Dynamic Response of Progressively Damaging Structures - M.G. SRINIVASAN, Argonne National Laboratory, Argonne, IL and G.U. FONSEKA and D. KRAJCINOVIC, University of Illinois at Chicago Circle, Chicago, IL

5. Transportation Vibration Effects on Unitized Corrugated Containers - T.J. URBANIK, USDA Forest Service, Forest Products Laboratory, Madison, WI

6. Flight Vibration Environment for SLV(E)-01 - S.A. PALANISWAMI and G. MUTHURAMAN, Vikram Sarabhai Space Centre, India

7. Aircraft Response to Operations on Rapidly Repaired Battle Damaged Runways and Taxiways - T.G. GERARDI, Air Force Wright Aeronautical Laboratories, Wright-Patterson AFB, OH and L.R. CALDWELL, Air Force Engineering Services Center, Tyndall AFB, FL

8. Shock, Vibration and Fatigue in Transportation Industry T.V. SESHADRI, Fruehauf Corporation, Detroit, MI

Session 11 (Unclassified) **Thursday, October 23**
2:00 P.M. **Pacific Ballroom A**

SHORT DISCUSSION TOPICS

Chairman: Mr. Sumner Leadbetter, NASA Langley Research Center, Hampton, VA

Cochairman: Mr. Michael Condouris, U.S. Army Electronics R&D Command, Fort Monmouth, NJ

This session will program papers covering progress reports on current research efforts and unique ideas, hints, and kinks on instrumentation, fixtures, testing, analytical short cuts, and so forth. It is intended to provide a means for up-to-the-minute coverage of research programs and a forum for the discussion of useful ideas and techniques considered too short for a full-blown paper.

Complete titles of short talks will be published in the final program.

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

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

STRUCTURAL SYSTEMS

Bridges
Buildings
Towers
Foundations
Underground Structures
Harbors and Dams
Roads and Tracks
Construction Equipment
Pressure Vessels
Power Plants
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Ships
Aircraft
Missiles and Spacecraft

BIOLOGICAL SYSTEMS

Human
Animal

MECHANICAL COMPONENTS

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Tires and Wheels
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Gears
Clutches
Couplings
Fasteners
Linkages
Valves
Seals
Cams

STRUCTURAL COMPONENTS

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Cables
Bars and Rods
Beams
Cylinders
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Membranes, Films, and Webs
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Shells
Rings
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DYNAMIC ENVIRONMENT

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Fatigue
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ANALYSIS AND DESIGN

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Numerical Methods
Statistical Methods
Parameter Identification
Mobility/Impedance Methods
Optimization Techniques
Design Techniques
Computer Programs

GENERAL TOPICS

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

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.

ABSTRACT CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2010, 2039, 2040, 2056, 2062, 2102, 2121, 2159)

80-1981

Forced Resonances in Rotating Shafts - The Combined Effects of Bending and Torsion

W. Kellenberger

Brown Boveri Rev., 67 (2), pp 117-121 (Feb 1980) 5 figs

Key Words: Shafts (machine elements), Rotating structures, Flexural vibration, Torsional vibration, Coupled response

Forced combined resonances are the result of the combined effects of flexural and torsional vibrations which have a mutual effect on each other. This coupling effect means that flexural and torsional vibrations in the rotating shaft may only be dealt with separately when these two types of vibration do not occur simultaneously. This contribution examines, by deriving the appropriate equations, the effect of these coupled vibrations on the shaft.

80-1982

Dynamic Reduction in Rotor Dynamics by the Finite Element Method

K.E. Rouch and J.S. Kao

Advanced Tech. Center, Allis-Chalmers Corp., Milwaukee, WI, J. Mech. Des., Trans. ASME, 102 (2), pp 360-368 (Apr 1980) 7 figs, 3 tables, 17 refs

Key Words: Rotors (machine elements), Matrix reduction method, Finite element technique, Critical speeds

The use of dynamic reduction of finite element matrices in rotor dynamics analysis is shown to offer advantages of computational efficiency and modeling accuracy. Solution procedures and sample results for comprehensive rotor dynamics program for design purposes are presented. The basic reduction approaches have been extensively used in general structural analysis.

80-1983

Forced Vibrations of a Single Stage Axial Compressor Rotor

J.A. Fabunmi

Kaman Aerospace Corp., Old Windsor Rd., Bloomfield, CT 06002, J. Engr. Power, Trans. ASME, 102 (2), pp 322-328 (Apr 1980) 9 figs, 13 refs

Key Words: Rotary compressors, Rotors (machine elements), Modal analysis, Compressor blades, Resonant response

A semi-empirical method, utilizing modal analysis based on experimentally obtained mode shapes has been used to study the vibration response of a 23-bladed axial compressor rotor. The system mode shapes, characterized by the blade deflections at resonance, are more or less irregular depending upon the proximity of the system frequencies to the blade cantilever frequencies. The response of the detuned bladed disk assembly to various types of harmonic excitations are shown to be predictable if sufficient experimental information is available about the resonant modes and frequencies of the system.

80-1984

The Influence of the Blading Surface Roughness on the Aerodynamic Behavior and Characteristic of an Axial Compressor

K. Bammert and G.U. Woelk

Inst. for Turbomachinery and Gasdynamics, Univ. of Hannover, Germany, J. Engr. Power, Trans. ASME, 102 (2), pp 283-287 (Apr 1980) 9 figs, 1 table, 6 refs

Key Words: Compressors, Compressor blades, Surface roughness, Aerodynamic characteristics

For investigation of the influence of the surface quality on the efficiency, flow rate, pressure ratio, and the shifting of the characteristic curves, systematic measurements were taken on a three-stage axial compressor with smooth and uniformly rough blading.

80-1985

Stability Analysis of Rotor-Bearing Systems Using Component Mode Synthesis

D.A. Glasgow and H.D. Nelson

U.S. Air Force Academy, CO, J. Mech. Des., Trans. ASME, 102 (2), pp 352-359 (Apr 1980) 3 figs, 7 tables, 7 refs

Key Words: Rotor-bearing systems, Stability, Component mode synthesis

A method of component mode synthesis is presented for the analysis of multishaft rotor-bearings systems. The motion of each component of the system is described as the superposition of constraint modes associated with boundary coordinates and constrained precessional modes associated with internal coordinates. The constrained precessional modes for each component are truncated and the reduced component equations are assembled to yield a set of system equations.

80-1986

Dynamics and Control of Large Horizontal-Axis Axisymmetric Wind Turbines

M.S. Hirschbein

Ph.D. Thesis, Univ. of Delaware, 471 pp (1979)
UM 8006484

Key Words: Wind turbines, Rotors (machine elements), Towers, Periodic excitation, Wind-induced excitation

The dynamic response of the entire rotor-tower wind turbine system is examined. It is intended to provide insight into the nature and solution of dynamic problems that may be encountered during the operation of large horizontal-axis, axisymmetric wind turbines. The numerical results are presented for a 3-bladed, 300 ft. diameter wind turbine driving either constant or variable speed electrical power generating equipment.

80-1987

An Analysis of Aeroengine Fan Flutter Using Twin Orthogonal Vibration Modes

R.A.J. Ford and C.A. Foord

Advanced Research Lab., Rolls-Royce Ltd., P.O. Box 31, Derby, UK, J. Engr. Power, Trans. ASME, 102 (2), pp 376-381 (Apr 1980) 10 figs, 6 refs

Key Words: Fans, Engines, Flutter

A sophisticated model of the mechanical response of aeroengine fans is used to investigate flutter and provide additional insight into the physical mechanisms involved. The model incorporates twin orthogonal modes, which are two independent vibration patterns similar in shape and resonant frequency but displaced ¼ wave circumferentially in space.

RECIPROCATING MACHINES

(Also see Nos. 2089, 2160, 2162)

80-1988

Measurements and Diagnosis of Diesel Electric Locomotive Noise

P.J. Remington, M.J. Rudd, and R. Mason

Bolt, Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, Noise Control Engr., 14 (2), pp 66-73 (Mar/Apr 1980) 9 figs, 4 tables, 7 refs

Key Words: Locomotives, Diesel engines, Noise generation

Noise generated by an SD40-2 diesel electric locomotive was measured under a number of operating conditions. In pass-by tests at lower throttle settings and at modest speeds, wheel/rail noise is a significant contributor to the noise generated by a passing locomotive. At throttle 8, wheel/rail noise is not significant until speeds of 88 to 96 km/h are attained. The magnitude of the contribution of each major source to the noise signature of the locomotive was determined.

80-1989

A Combined Analytical and Experimental Approach for Evaluating Engine Design for Low Noise Levels

D.R. Burton, J.M. O'Keeffe, and R. Williams

Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 161-168, 4 figs, 3 tables, 3 refs

Key Words: Engine noise, Noise reduction, Design techniques

This paper describes a combined analytical and experimental approach to optimize the effects of possible vehicle modifications, necessitated by the external noise legislation, such as increase of stiffness, damping or mass, on structure borne noise, without expensive hardware changes. To demonstrate the application of this approach samples of engine system models are given.

80-1990

The Practical Reduction of Bare Engine Noise from a Conventional Diesel Engine

R.M. Windett, R.W. Johnson, H.L. Pullen, and N. Lalor

Truck Advanced Engine Engrg., Ford Motor Co. Ltd., Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 111-118, 9 figs, 1 table, 10 refs

Key Words: Diesel engines, Engine noise, Noise reduction

The paper describes how a current production diesel engine was developed to give reduced bare engine noise, by selection and evaluation of a range of noise reduction features capable of production within current manufacturing technology.

80-1991

Some New Results Concerning Parameters Influencing Piston Slap in Reciprocating Machinery

Y. Fujimoto, T. Suzuki, and Y. Ochiai

Dept. of Mech. Engrg., Tottori Univ., Japan, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 33-38, 8 figs, 1 table, 4 refs

Key Words: Reciprocating engines, Pistons, Noise reduction, Vibration control

Extensive observations of the pressure of the oil film over the piston skirt were made throughout the cycle and their correlations with piston-slap-induced vibrations were experimentally sought. Previously ring-groove friction was predicted to be important in that its increase slows down the movement of the piston, thus decreasing the piston-slap-induced vibrations. This study presents additional experimental evidence supporting this thesis.

80-1992

The Use of Finite Element Techniques for the Prediction of Engine Noise

D.M. Croker, N. Lalor, and M. Petyt

Inst. of Sound and Vibration Research, Univ. of Southampton, UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 131-140, 8 figs, 1 table, 11 refs

Key Words: Optimum design, Engine noise, Engine vibration, Noise prediction

A finite element technique is described for the optimization of low noise engines at the drawing board stage, using a simple computer model. Three physical model engine blocks of increasing complexity were constructed and tested experimentally. Their modal characteristics compare very favorably with predictions obtained from corresponding computer models.

POWER TRANSMISSION SYSTEMS

(Also see No. 2042)

80-1993

Industrial Vehicle Drive Line Design and Optimization for Low Noise and Vibration Levels

R. Padoan, G. Tantot, and B. Vuillaumier

Renault Vehicles Industrials, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 149-159, 8 figs, 7 refs

Key Words: Drive line vibration, Noise generation, Design techniques

This paper describes industrial vehicle driveline vibration phenomena -- their nature, causes and effects, and particularly the specific means for their estimation and reduction. These means are: computer calculation programs allowing either the optimization of the relative locations of the different components on the basis of forces field minimum criteria or vibration responses calculation, and experimental methods using the frequential analysis of the dynamic response of the transmission components and the specific corresponding transducers.

80-1994

Torsional Vibration in Tractor Power-Take-Off Drivelines

D.A. Crolla

Simon Engrg. Labs., University of Manchester, UK M13 9PL, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 91-97, 9 figs, 1 table, 9 refs

Key Words: Driveline vibrations, Torsional vibration, Tractors

A theoretical analysis of the tractor and machine power-take-off driveline using a simplified model is described. The effect of Hooke's joints, and non-linear elements such as backlash, overload and overrun clutches is calculated by computer simulation. The frequency response curves for the driveline of a typical 60 kW tractor and drum mower are presented. Field measurements of driveline torque loading experienced in work are described. The data are analyzed to provide design information on the torsional vibration behavior of a range of machines. By a combination of field measurements and theoretical analysis, potential methods of minimizing torsional vibration problems at the design stage are discussed.

80-1995

An Experimental Study of Vehicle Driveline Vibrations

S.P. Healy, T. Heppenstall, and D. Hodgetts
Cranfield Inst. of Tech., Cranfield, Beds, UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 69-81, 8 figs, 2 tables, 8 refs

Key Words: Driveline vibrations, Noise generation, Motor vehicle noise

The experimental results from a series of road tests on two vehicles are used as the basis of a study of the vibrations of drivelines and their influence on the interior noise of vehicles. The road tests and the data analyses are described. Tests were carried out on a sports car, with a manual shift transmission, and a saloon with an automatic transmission. Conclusions are drawn on the significance of the driveline vibrations for each case. The effects of a change of tires and a detuner-absorber were assessed.

80-1996

A 'Cad' System for the Analysis of Vehicle Driveline Noise

J.L. Hedges and J.K. Butler
Automotive Products Ltd., Leamington Spa, UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 39-46, 6 figs

Key Words: Driveline vibrations, Gear noise

A computer aided design system has been developed for the study of idle gear rattle and vibration problems in vehicle drivelines. The modular approach to driveline analysis has been used to recommend clutch designs capable of eliminating idle gear rattle and driveline vibration noise. Three examples of the use of the analysis are presented.

METAL WORKING AND FORMING

(See No. 2122)

MATERIALS HANDLING EQUIPMENT

80-1997

On a New Type of Vibrating Lift

J. Inque, Y. Araki, and S. Kubo
Dept. of Mechanical Engrg., Kyushu Univ., Higashi-ku Fukuoka, Japan, J. Mech. Des., Trans. ASME, 102 (2), pp 264-269 (Apr 1980) 6 figs, 3 tables, 3 refs

Key Words: Elevators, Materials handling equipment, Vibrators (machinery), Vibrating structures

This paper investigates in detail the new vibrating lift made by utilizing the principle of the self-synchronization of mechanical vibrators.

STRUCTURAL SYSTEMS

BRIDGES

80-1998

The Estimation of Earthquake-Generated Additional Tension in a Suspension Bridge Cable

H.M. Irvine
Massachusettes Inst. of Tech., Cambridge, MA, Intl. J. Earthquake Engr. Struc. Dynam., 8 (3), pp 267-273 (May/June 1980) 3 figs, 1 table, 11 refs

Key Words: Bridges, Suspension bridges, Cables (ropes), Seismic response, Seismic response spectra

A simple formula is derived for the peak additional cable tension that can be expected in a suspension bridge undergoing earthquake excitation. The method involves application of the response spectrum technique and rests on several plausible assumptions.

BUILDINGS

(Also see No. 2109)

80-1999

Analysis of Tentative Seismic Design Provisions for Buildings

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

National Bureau of Standards, Washington, D.C., Rept. No. NBS-TN-1100, 602 pp (July 1979)

PB80-129182

Key Words: Buildings, Seismic design

This report presents the results of a thorough study of the internal logic of the Tentative Provisions for the Development of Seismic Regulations for Buildings developed by the Applied Technology Council. The methods of analysis employed in the study provide objective measures of clarity, completeness, and consistency and an alternative form in which to examine the technical validity of the provisions. These methods include decision logic tables for examining individual provisions, information networks for representing the precedence among provisions, and classification of the provisions to study their scope and arrangement.

80-2000

Simple and Complex Models for Nonlinear Seismic Response of Reinforced Concrete Structures

M. Saiidi Mivahhed

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 200 pp (1979)

UM 8009156

Key Words: Buildings, Multistory buildings, Reinforced concrete, Concretes, Seismic response

Reinforced concrete structures undergo inelastic deformations when they are subjected to strong ground motions. Several analytical models have been developed to calculate the nonlinear response of structures. Despite the availability of high-speed digital computers, the solutions are involved and costly. The work reported here was a study of the possibilities of simplifying such analyses. The problem was considered at two levels: microscopic and macroscopic. In the first part of the study, a particular element of nonlinear analysis, the hysteresis model, was of concern. The second part of the study was the development of a simple analytical model to calculate the nonlinear displacement response of reinforced concrete structures.

80-2001

Behavior of Elastic and Inelastic Three-Dimensional Building Systems for Static Loads and Multicomponent Earthquakes

P. Kitipitayangkul

Ph.D. Thesis, Univ. of Missouri-Rolla, 394 pp (1979)

UM 8008399

Key Words: Buildings, Seismic response

An analytical study is presented for investigating the effect of interacting three-dimensional ground motions on the response behavior of elastic and inelastic building systems. The structures can be subjected to simultaneous input of static loads and multicomponent earthquake motions. The earthquake inputs can be applied in any direction of the structural plane.

80-2002

Response of Simple Structural Systems to Traveling Seismic Waves

J.R. Morgan

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 125 pp (1979)

UM 8009114

Key Words: Buildings, Seismic response

The results of studies of the dynamic response of a simple structural system with coupled translational and rotational degrees-of-freedom subjected to ground motion containing both translational and rotational components are presented. The investigation was carried out with a view toward assessing current building code procedures and arriving at bounds on the interrelationships between torsional and translational response. Comparisons of the results of the calculations with results obtained using current seismic building code approaches for buildings with real and accidental eccentricities are presented.

80-2003

Limited Slip Bolted Joints - A Device to Control the Seismic Response of Large Panel Structures

A.S. Pall

Ph.D. Thesis, Concordia Univ., Canada (1979)

Key Words: Buildings, Seismic design, Joints (junctions), Slip joints

This study is devoted to the development of limited slip bolted joints and the investigation of the seismic response of buildings using such joints. The results of nonlinear time history analyses have shown that energy dissipated by limited slip bolted joints can provide an improved solution to the problems engendered by severe ground motions.

80-2004

Inelastic Response Spectra for Aseismic Building Design

S.-S.P. Lai and J.M. Biggs

Dept. of Civil Engrg., Massachusettes Inst. of Tech., Cambridge, MA, ASCE J. Struc. Div., 106 (ST6), pp 1295-1310 (June 1980) 12 figs, 2 tables, 17 refs

Key Words: Buildings, Multistory buildings, Seismic design, Modal analysis

The variability of inelastic response spectra is investigated by time-history analysis using sets of artificial ground motions with different strong-motion durations.

80-2005

Analytical Methodology for Dynamic Building Response to Wind Loading

J.F.Y. Sidarous

Ph.D. Thesis, Colorado State Univ., 340 pp (1979)
UM 8010836

Key Words: Multistory buildings, Buildings, Wind-induced excitation, Frequency domain method, Spectrum analysis

The various aspects of the wind-excited motion of buildings and the resulting response characteristics that influence the serviceability of the structure are investigated.

TOWERS

(Also see No. 1986)

80-2006

Refined Analysis of the Seismic Response of Column-Supported Cooling Tower

C.S. Gran and T.Y. Yang

School of Aeron. and Astron., Purdue Univ., West Lafayette, IN 47907, Computers Struc., 11 (3), pp 225-231 (Mar 1980) 14 figs, 1 table, 5 refs

Key Words: Cooling towers, Towers, Shells, Beams, Seismic response, Finite element technique

A cooling tower in the 1200 MW Fossil Fuel Steam Generating Power Plant at Paradise, Kentucky (Tennessee Valley Authority) is studied. Half of the shell is modeled using orthotropic quadrilateral flat plate finite elements. The supporting columns and top ring beam are modeled by beam finite elements. The time-history response of 30 sec. to the North-South acceleration component of the 18 May 1940 El Centro earthquake is computed by the technique of modal superposition.

FOUNDATIONS

(Also see No. 2069)

80-2007

Progressive Settlements of Foundations on Cohesionless Soils Subjected to Vertical Vibratory Loadings

S. Leelanitkul

Ph.D. Thesis, Univ. of Akron, 121 pp (1980)
UM 8010682

Key Words: Foundations, Vibration excitation

A generalized triaxial analog was first developed to represent the dynamic soil response in the range of shearing strain amplitudes between approximately 10^{-5} in./in. and 10^{-2} in./in. The analog simulates the dynamic shearing stress-strain response of dry cohesionless soils by a modified hyperbolic relationship and the irrecoverable progressive strain as a function of the shearing strain amplitude. A governing equation was developed to relate with existing dynamic soil constitutive relationships. A method for progressive settlement analysis was then developed in which the shearing strain amplitude and number of loading cycles was related to the progressive strain. Comparisons of progressive strains observed from different types of dynamic tests at the same shearing strain amplitude show consistency of the method.

80-2008

Foundation Impedance Matrices by Substructure Deletion

G. Dasgupta

Columbia Univ., New York, NY, ASCE J. Engr. Mech. Div., 106 (EM3), pp 517-523 (June 1980) 3 figs, 4 refs

Key Words: Foundations, Impedance technique, Interaction: soil-structure, Seismic design

A numerical formulation is presented for a mathematical model of those soil regions bearing flexible embedded structures of arbitrary geometry. The computational difficulties associated with a strict continuum solution for the unbounded foundation domain with an irregular surface geometry, are alleviated by "subtracting" the impedance contribution of the embedded region from the impedance matrix of a foundation with a horizontal surface. The procedure could be utilized for soil-structure analysis in seismic design.

80-2009

Stepwise Solution to Vibrating Equipment Foundation Design

H.G. Sallenbach

Northern Natural Gas Co., Liberal, KS, Hydrocarbon Processing, 59 (3), pp 93-100 (Mar 1980) 4 figs, 7 tables, 8 refs

Key Words: Machine foundations, Vibrating foundations, Design techniques

Basic information from several articles and textbooks is compiled for a step-by-step approach to the design of foundations of reciprocating and rotating machinery that bridges the gap between simple solutions with limited restrictions and complicated solutions too impractical for general use. A table with equations required to go through a step-by-step analysis of a vibrating foundation is included.

80-2010

Unbalanced Response of a Large Rotor-Pedestal-Foundation System Using an Elastic Half-Space Soil Model

R.L. Ruhl, T.F. Conry, and R.L. Steger

Univ. of Illinois, Urbana, IL 61801, J. Mech. Des., Trans. ASME, 102 (2), pp 311-319 (Apr 1980) 6 figs, 5 tables, 25 refs

Key Words: Rotors (machine elements), Machine foundations, Unbalanced mass response, Elastic foundations

The unbalanced response of a large rotor-pedestal-foundation system using an elastic half space soil model was determined. The effective stiffness and damping terms between the foundation and soil were determined from the elastic half space soil model. The rigid body equations of motion of the foundation were derived subject to applied forces from the bearing-support structure and from the springs and dashpots representing the soil. This method of analysis should be the basis for the design of rotor-bearing-foundation-soil systems.

80-2011

Dynamics of Frame Foundations Interacting with Soil

L. Gaul

Inst. of Mechanics, Univ. of Hannover, Federal Republic of Germany, J. Mech. Des., Trans. ASME, 102 (2), pp 303-310 (Apr 1980) 12 figs, 10 refs

Key Words: Interaction: soil-structure, Machine foundations, Substructuring methods

The dynamic response of structures such as frame foundations for vibrating machinery is calculated. The interactions between a single structure and soil as well as the interaction through the underlying soil between two adjacent structures are taken into account. Mixed boundary value problems describing the interaction between viscoelastic soil and rigid bases of arbitrary shape are solved by superposition of analytical halfspace solutions. The influence of shear stresses at the interface between soil and base is bounded by the assumptions of perfectly smooth and perfectly welded contact. The response of the entire system is evaluated by coupling soil and founded structures by means of a substructure method.

80-2012

The Analysis of an Elastic Four-Bar Linkage on a Vibrating Foundation Using a Variational Method

B.S. Thompson

Dept. of Mech. Engrg., Wayne State Univ., Detroit, MI 48202, J. Mech. Des., Trans. ASME, 102 (2), pp 320-328 (Apr 1980) 1 fig, 13 refs

Key Words: Linkages, Machine foundations, Vibrating foundations, Variational methods

A variational method is employed to derive the equations of motion and the associated boundary conditions for a flexible crank-rocker linkage sited on a foundation which vibrates perpendicular to the plane of the mechanism. The links oscillate in axial, flexural and torsional modes, and the equations governing this behavior are systematically constructed using a variational theorem by permitting independent variations of the stress, strain, displacement and velocity parameters.

80-2013

Dynamic Pile Interaction

K.Y.C. Chung

Eng. Sc. D. Thesis, Columbia Univ., 82 pp (1979)
Um 8008710

Key Words: Pile structures, Interaction: soil-structure

Dynamic pile interaction is studied by evaluating the response of an elastic half-space subjected to a series of embedded horizontal forces that represent the reactions of an elastic pile. The response of the half-space is obtained by superposition of several known solutions from the theory of elasticity. Two equivalent schemes for calculating the response of the half-space are presented. Results of calculations using both methods are presented in the form of interaction factors which show the effects of spacing and geometry on the response of groups of elastic piles.

ROADS AND TRACKS

(Also see No. 2170)

80-2014

Predicting the Fatigue Life of Flexible Airfield Pavements -- A Recommended Approach

D.S. Decker

Civil Engrg. Research Facility, New Mexico Univ., Albuquerque, NM, Rept. No. AFESC/ESL-TR-79-26, 123 pp (July 1979)
AD-A079 747/2

Key Words: Airports, Pavements, Fatigue life

Current fatigue and routine design test methods for airfield pavements and examination of the effects of materials and environmental conditions on fatigue life are reviewed. The extensive literature review indicates a possibility that fatigue life may be estimated by correlating known fatigue parameters with results of routine design tests.

CONSTRUCTION EQUIPMENT

80-2015

Dynamic Disruption of Soils

V.L. Baladinskii

Dept. of Agriculture, Washington, D.C., Transl. of Dinamicheskoe Razrushenie Gruntov, Kiev, 1971. Rept. No. TT-79-59043, 228 pp (1979)
PB80-142888

Key Words: Soils, Frozen soils, Construction equipment

Theoretical and experimental studies on the disruption of strong and frozen soils by dynamic loads - impact, vibration, vitro-impact and high-speed cutting are presented. Achievements in the field of using dynamic methods of disruption in construction and mining are generalized for the first time. Constructions of vibration and vibro-impact earthmoving machines are described. The arrangement and constructions of different drives, methods of calculation and selection of earthmoving machines are discussed.

POWER PLANTS

(Also see No. 2063)

80-2016

Fluid-Structure Interactions in Pressure-Suppression Pools: Small-Scale Experiments and Analysis

P.W. Huber and Y.B. Javadi

Dept. of Mech. Engrg., Massachusettes Inst. of Tech., Cambridge, MA 02139, J. Pressure Vessel Tech., Trans. ASME, 102 (2), pp 194-201 (May 1980) 12 figs, 2 tables, 12 refs

Key Words: Interaction: structure-fluid, Plates, Submerged structures, Containment structures, Nuclear reactor containment

Experiments were conducted in a laboratory scale system to investigate fluid structure interaction effects on hydrodynamically induced boundary pressure histories. A single flexible member - a clamped circular plate - formed the base of a cylindrical water pool. Base plate thicknesses were varied to change the natural frequency of the plate pool system. The hydrodynamic transient was an air driven "pool swell" involving large liquid displacements and a complicated boundary pressure history. Pressures at various points on the pool boundary and strains on the flexible base were measured. A one-dimensional analysis of the perturbation pressure transients induced by the deflections of the flexible base is compared with the experimental results. Numerical solutions for the complete perturbed pressure histories are compared with the experiments. Ratios of the peak pressures in the flexible and rigid systems for a pressure pulse of variable duration are predicted analytically and compared with the experiments.

80-2017

Torsional Coupling in Seismic Response of Reactor Systems

M.F. Ishac
Ph.D. Thesis, McMaster Univ., Canada (1979)

Key Words: Nuclear power plants, Seismic design, Torsional response, Equipment response

It is the purpose of this thesis to consider the torsional effect in the seismic analysis of Nuclear Power Plant Reactor Systems and to illustrate the effect of the lateral-torsional coupling on the equipment response. The equipment and the building are treated separately and the building response are used as inputs for the equipment analysis. The second object of this study is to develop a simple procedure to compute floor response spectra of the torsionally coupled reactor building without a time-history analysis. And finally, the effect of torsional ground motion is investigated.

OFF-SHORE STRUCTURES

80-2018

Response of an Inflatable Offshore Platform to Surface Wave Excitations

V.J. Modi and A.K. Misra

Univ. of British Columbia, Vancouver, Canada, J. Hydronautics, 14 (1), pp 10-18 (Jan 1980) 4 figs, 1 table, 10 refs

Key Words: Off-shore structures, Inflatable structures, Water waves

The response to the ocean wave excitations of a neutrally buoyant inflatable offshore platform consisting of an array of three tapered inflatable legs attached to a central head, connected to a surface float by a cable is investigated. A Lagrangian formulation of the dynamics of the system is presented where the float and the central head are allowed to move vertically and the rotations of the array as well as the flexural displacements of the legs are superposed on this motion.

80-2019

Ambient Vibration Survey of Offshore Platform

S. Rubin

Vehicle Engrg. Div., Aerospace Corp., El Segundo, CA, ASCE J. Engr. Mech. Div., 106 (EM3), pp 425-441 (June 1980) 11 figs, 2 tables, 12 refs

Key Words: Off-shore structures, Vibration measurement

Natural frequencies and associated mode shape parameters for vibration modes of a steel platform were determined from measured ambient accelerations. The most accurate modes identified were the fundamental laterals and torsion, the second torsion, the third end-on, and a higher complex mode involving considerable vertical motion. Five other modes were identified by frequency and qualitatively by shape; 13 other modes, by frequency only. This is the first phase of a pilot study for the USGS on the feasibility of ambient vibration monitoring as an inspection technique for underwater failure.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 1988, 1995, 2041, 2062, 2137, 2142, 2149)

80-2020

In-Service Performance and Costs of Methods to Control Urban Rail System Noise. Second Test Series Report

H.J. Saurenman

DeLeuw, Cather and Co., Washington, D.C., Rept. No. DOT-TSC-UMTA-79-33; UMTA-MA-06-0099-79-4, 202 pp (Oct 1979)
PB80-132996

Key Words: Rail transportation, Noise generation, Noise reduction

This report presents the results of the final four phases of a seven-phase test program to determine the acoustic and economic effectiveness of resilient wheels, damped wheels, wheel truing, and rail grinding for reducing wheel/rail noise on urban rail transit systems.

80-2021

Some Aspects Concerning Noise Reduction of Passenger Cars with Diesel and Gasoline Engines

H. Hiereth and H.-P. Charzinski

Daimler Benz AG, Stuttgart, West Germany, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 83-90, 10 figs, 9 refs

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

The main noise sources of passenger cars are determined and possible level reductions are assessed. Secondary damping measures such as encapsulation are described. Vehicle-supported encapsulations of engines utilizing parts of the body are discussed in detail. Research vehicles were built. A description of design, function and practical realization of a vehicle-supported encapsulation including the necessary development of a new cooling system is given.

80-2022
A Practical Approach to Truck Noise Reduction

K.A. Atkins and B.J. Challen

Ricardo Consulting Engrs., Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 59-68, 9 figs, 1 table, 15 refs

Key Words: Motor vehicle noise, Trucks, Noise reduction

This paper describes a method of reducing the drive-by noise levels radiated from a 14 litre diesel engined truck by utilizing a combination of conventional noise reduction techniques applied to the engine. The combustion and mechanical exciting forces within the engine were lowered by turbocharging and low noise pistons respectively, coupled with a small reduction in the rated speed. The resultant radiated noise was largely attenuated by employing simple shielding arranged to form a tunnel around the engine and attached to the engine with isolation mounts. The paper also includes a method of calculating the radiated combustion and mechanical noise levels from an engine.

80-2023
Steady Turning of Tractor-Semitrailer Vehicles

F.O. Eke

Ph.D. Thesis, Stanford Univ., 128 pp (1980)
UM 8011630

Key Words: Articulated vehicles, Interaction: wheel-pavement

The steady-state turning behavior of tractor-semitrailer vehicles is examined by means of a model that consists of a system of rigid bodies possessing four degrees of freedom. Some motion variables such as path radius, towing angle, and tractor yaw rate are discussed to provide a physical understanding of the high speed response of the vehicle system. The common modeling assumption of ignoring the width of the vehicle, so that the wheels on opposite ends of an axle can be treated as a single wheel, is examined critically. The dependence of the understeer-oversteer characteristics on trailer loading, load transfer, and the position of the fifth-wheel is also explored.

80-2024
Static and Dynamic Overturn Immunity of Tractor-Semitrailers (Statische und dynamische Kippgrenzen von Sattelkraftfahrzeugen)

K.H. Schönfeld

Obentrautstrasse 68, 3000 Hannover 21, Automobiletech. Z., 82 (3), pp 119-124 (Mar 1980) 13 figs, 5 refs
(In German)

Key Words: Articulated vehicles, Ride dynamics, Time dependent parameters

A computer simulation of tractor-semitrailer ride dynamics up to its critical turning limits is presented, enabling the comparison of static overturn limits to various ride maneuvers in time domain. The wobble on uneven roads and the nonlinearities of vehicles, particularly springs, are also investigated.

SHIPS

80-2025
Longitudinal Stiffness Analyses for the Propulsion Shafting Systems of the Polar Class Icebreakers

L. Vassilopoulos and F.M. Hamilton

Maritech, Inc., Belmont, MA, Naval Engr. J., 92 (2), pp 179-195 (Apr 1980) 20 figs, 1 table, 15 refs

Key Words: Icebreakers, Shafts (machine elements), Axial excitation, Stiffness

To minimize and hopefully eliminate the vibratory responses of icebreakers, the USCG initiated several investigations. One topic was the axial stiffness of the shafting systems that is contributed by the thrust bearings, their housings and the foundations on which they rest. Aside from model test studies, numerical assessments were made of these stiffnesses using finite element methods and other techniques.

AIRCRAFT

(Also see Nos. 2040, 2073, 2103, 2110, 2111, 2177)

80-2026

Application of the Estimation-Before-Modeling (EB-M) System Identification Method to the High Angle of Attack/Sideslip Flight of the T-2C Jet Trainer Aircraft. Volume 1. Executive Summary

H.L. Stalford

Systems Div., Dynamics Research Corp., Wilmington, MA, Rept. No. R-303U, 1273-Vol-1, 60 pp (Nov 1979)

AD-A079 025/0

Key Words: Aircraft, Parameter identification technique

This report summarizes the development and application of the Estimation-Before-Modeling (EBM) method for aircraft parameter identification in the non-linear flight regime. The method utilizes a two-step approach wherein model independent states, forces and moments are first estimated and then state and control dependent model parameters are obtained using a Stepwise Multiple Linear Regression (SMLR) approach. In the second step (SMLR) the angle of attack and sideslip and control input space for all available flight data is divided into small subspaces and force and moment coefficients are modeled within each subspace. The method is applied to both simulated and actual flight data for a T-2C jet trainer aircraft in the stall and post-stall flight regimes.

80-2027

Application of the Estimation-Before-Modeling (EB-M) System Identification Method to the High Angle of Attack/Sideslip Flight of the T-2C Jet Trainer Aircraft. Volume II. Simulation Study Using T-2C Wind Tunnel Model Data

H L Stalford and S Ramachandran

Systems Div., Dynamics Research Corp., Wilmington, MA, Rept No. R-254U, 1273-VOL-2, 288 pp (June 1978)

Ad-A079 923/9

Key Words: Aircraft, Parameter identification technique

This report presents the results of a feasibility study of the Estimation-Before-Modeling (EBM) method for aerodynamic parameter identification in the stall/post stall flight regimes. The feasibility study is conducted by processing synthetic flight data generated by exciting a wind tunnel model of the Navy's T-2C, a light jet trainer aircraft.

80-2028

Application of the Estimation-Before-Modeling (EB-M) System Identification Method to the High Angle of Attack/Sideslip Flight of the T-2C Jet Trainer Aircraft. Volume III. Identification of T-2C Aerodynamics Stability and Control Characteristics from Actual Flight Test Data.

H.L. Stalford

Systems Div., Dynamics Research Corp., Wilmington, MA, Rept. No. R-287U, 1273-Vol-3, 256 pp (Apr 1979)

AD-A079 924/7

Key Words: Aircraft, Parameter identification technique

This volume presents the results of the application of the Estimation-Before-Modeling (EBM) System Identification Method to high angle of attack/sideslip flight test data of the T-2C Jet Trainer aircraft. Eighteen maneuvers consisting of over 600 seconds of 20 hertz data are processed.

80-2029

Noise Radiation from the Side Edges of Flaps

J.C. Hardin

NASA Langley Research Center, Hampton, VA, AIAA J., 18 (5), pp 549-552 (May 1980) 4 figs, 11 refs

Key Words: Aircraft wings, Sound transmission

The recently observed phenomenon of high noise radiation from the side edges of flaps in flow is investigated by way of a simple two-dimensional model problem. The model is based upon a physical picture of boundary layer vorticity being swept around the edge by spanwise flow on the flap. The model problem is developed and solved and the resulting noise radiation calculated. Further, a mathematical condition for the vortex to be captured by the potential flow and swept around the edge is derived.

80-2030

The Delta Wing in Oscillatory Gusts

M.H. Patel

Univ. College London, London, UK, AIAA J., 18 (5), pp 481-486 (May 1980) 12 figs, 2 tables, 22 refs

Key Words: Aircraft wings, Wind-induced excitation

This report describes systematic aerodynamic lift and pitching moment measurements on two sharp edged delta wings

of aspect ratio 1 and 2 in oscillatory vertical gusts of varying frequency parameter and gust amplitude. The effects of the nonlinearity associated with the separated flow region are explored and the influence of the potential flow and the vortex induced lift on the measured oscillating forces are discussed with implications that may be of value for developing or validating theoretical models.

80-2031

Flutter Analysis of a NACA 64A006 Airfoil in Small Disturbance Transonic Flow

T.Y. Yang, P. Guruswamy, A.G. Striz, and J.J. Olsen
Purdue Univ., West Lafayette, IN, J. Aircraft, 17 (4), pp 225-232 (Apr 1980) 10 figs, 4 tables, 16 refs

Key Words: Flutter, Airfoils, Computer programs

Flutter analyses are performed for a NACA 64A006 airfoil pitching and plunging in small-disturbance, unsteady transonic flow. Flutter results are presented as plots of flutter speed and corresponding reduced frequency vs one of the four parameters: airfoil/air mass density ratio, position of mass center, position of elastic axis, and freestream Mach number.

80-2032

DYLOFLEX. A Computer Program for Flexible Aircraft Flight Dynamic Loads Analyses with Active Controls

B. Perry III, R.I. Kroll, R.D. Miller, and R.C. Goetz
NASA Langley Research Center, Hampton, VA, J. Aircraft, 17 (4), pp 275-282 (Apr 1980) 13 figs, 7 refs

Key Words: Aircraft, Active control, Computer programs

This paper describes and illustrates the capabilities of the DYLOFLEX computer program system. DYLOFLEX is an integrated system of computer programs for calculating dynamic loads of flexible airplanes with active control systems. A brief discussion of the engineering formulation of each of the nine DYLOFLEX programs is described. The capabilities of the system are illustrated by the analyses of two example configurations.

80-2033

Aerodynamic-Structural Analysis of Dual Bladed Helicopter Systems

B.P. Selberg, D.L. Cronin, K. Rokhsaz, J.R. Dykman, and C.J. Yager
Dept. of Mech. and Aerospace Engrg., Missouri Univ., Rolla, MO, Rept. No. NASA-CR-162754, 46 pp (Feb 1980)
N80-17061/6

Key Words: Rotary wings, Helicopter rotors, Aerodynamic characteristics, NASTRAN (computer programs), Computer programs

The aerodynamic and structural feasibility of the birotor blade concept is assessed. The inviscid flow field about the dual bladed rotor was investigated to determine the aerodynamic characteristics for various dual rotor blade placement combinations with respect to blade stagger, gap, and angle of attack between the two blades.

80-2034

Integration of Nondestructive Testing Methods into Design for Structural Integrity Assurance

F.H. Immen and W.L. Andre
U.S. Army Aviation R & D Command Research and Tech. Labs., Ames Research Center, Moffett Field, CA, J. Amer. Helicopter Soc., 25 (2), pp 35-41 (Apr 1980) 7 figs, 6 refs

Key Words: Helicopters, Fatigue life, Nondestructive tests

The paper discusses the role nondestructive testing plays in assuring structural integrity during the rotorcraft life cycle. Suggested quantitative methods are presented for establishing fatigue critical component life accounting for NDT reliability. Economic justification for adopting an on-condition philosophy based on NDT reliability and cost is presented.

80-2035

The Influence of Engine/Fuel Control Design on Helicopter Dynamics and Handling Qualities

W.A. Kuczynski, D.E. Cooper, W.J. Twomey, and J.J. Howlett
Sikorsky Aircraft Div., United Technologies Corp., Stratford, CT, J. Amer. Helicopter Soc., 25 (2), pp 26-34 (Apr 1980) 19 figs, 7 refs

Key Words: Helicopters, Torsional response, Transient response, Design techniques, Computerized simulation

Recent analytical and experimental studies have shown that dynamic interaction is present between the engine/fuel control and the rotor/airframe systems, beyond the classical, low frequency, rotor/drive system torsional coupling. The design of the engine/fuel control system has been found to have an important influence on this interaction. Studies have shown that the transient response in the rotor speed degree of freedom is affected by the state of the rotor aerodynamics during the conditions of high torque demand and that the engine/fuel control system can influence the damping in the aircraft handling qualities modes. These interactions are described, drawing upon both flight test experience and analysis.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 2066, 2105)

80-2036

Highway Noise: Sloped Barriers as an Alternative to Absorptive Barriers

C.W. Menge
Bolt, Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, Noise Control Engr., 14 (2), pp 74-78 (Mar/Apr 1980) 8 figs, 1 table, 9 refs

Key Words: Noise barriers, Geometric effects, Traffic noise

A one-block section of a community was modeled to examine the effectiveness of sloped highway noise barriers and to determine the optimum location and slope angle for the barriers. The model results were then applied to an entire four-block study area, and through computer analysis, a complete system of noise barriers was designed for effective noise control in the community.

80-2037

Comparison of Measured and Predicted Impedance at Grazing Incidence

H.C. Lester and T.L. Parrott
NASA Langley Research Center, Hampton, VA, AIAA J., 18 (5), pp 504-508 (May 1980) 6 figs, 4 tables, 9 refs

Key Words: Acoustic linings, Ducts, Acoustic impedance

The acoustic performance of a nominal locally reacting liner specimen mounted in a grazing incidence impedance tube is analyzed. Measured standing wave ratios and null positions are compared with those predicted by a finite-element algorithm.

80-2038

The Use of Mechanical Impedance Data in Predicting Vibration Isolation Efficiency

A. Granhäll and T. Kihlman
Dept. of Building Acoustics, Chalmers Univ. of Tech., S-412 96 Göteborg, Sweden, Noise Control Engr., 14 (2), pp 88-93 (Mar/Apr 1980) 7 figs, 1 table, 11 refs

Key Words: Machinery noise, Structure-borne noise, Vibration isolation, Mechanical impedance

The general lack of structure-borne sound source data is discussed. A simple vibration isolator was analyzed in one dimension using the mechanical impedances in an analog circuit. The resulting formulas and measured impedance data were used to predict the insertion loss of a vibration isolator at low frequencies.

80-2039

Application of Impact Damping to Rotary Printing Equipment

E. Skipor and L.J. Bain
Systems Development, Rockwell International, Chicago, IL 60650, J. Mech. Des., Trans. ASME, 102 (2), pp 338-343 (Apr 1980) 11 figs, 6 refs

Key Words: Shock absorbers, Printing, Rotary presses, Rotating structures

This paper describes the theoretical and experimental work leading to the application of an impact damper to the image carrying cylinder of a web-fed printing press. The need for such a device arises from the desire to overcome a traditional limit on the operating speed of a press of this kind. This limit is the onset of an unacceptable anomaly in the finished print known as streaking. Streaking is caused by vibratory bending of the image carrying cylinders in a direction perpendicular to their axis of rotation. The selection of design parameters for an impact damper intended to reduce these vibrations was the objective of the study reported herein.

80-2040

The RSRA Active Isolation/Rotor Balance System

W.A. Kuczynski and J. Madden
Sikorsky Aircraft Div., United Technologies Corp., Stratford, CT, J. Amer. Helicopter Soc., 25 (2), pp 17-25 (Apr 1980) 17 figs, 2 tables, 5 refs

Key Words: Aircraft equipment, Rotors (machine elements), Vibration isolators, Active isolation

The Rotor Systems Research Aircraft (RSRA) includes provisions for the installation of an Active Transmission Isolation/Rotor Loads Balance System (AIBS). The purpose of this system is to allow aircraft operation, with an arbitrary rotor system, over a wide rotor speed range and maneuver envelope without vibration envelope restrictions, while simultaneously providing measurement of rotor system loads. The design and development of the system, culminating in its successful shakedown flight test evaluation are reviewed.

80-2041

Compact Self-Damped Pneumatic Isolators for Road Vehicles

E. Esmailzadeh
Dept. of Mech. Engrg., Tehran Univ. of Tech., Tehran, Iran, J. Mech. Des., Trans. ASME, 102 (2), pp 270-277 (Apr 1980) 13 figs, 19 refs

Key Words: Pneumatic isolators, Vibration isolation, Ground vehicles

Better isolation of vibration and minimum resonant transmissibility of a self-damped pneumatic isolator is achieved when the incorporated surge tank possesses a large volume compared to that of the isolator. This implies that the self-damped pneumatic isolator employed in vibration isolation for road vehicles is quite bulky and not practical for isolation systems where space and mass are the main limitations. It is also assumed that the surge tank has a fixed volume which is independent of relative motions of the body and the wheel. These drawbacks have been avoided by introducing a smaller surge tank, in the form of another pneumatic isolator, which is placed between the wheel and the road surface. It is shown that these two pneumatic isolators together with the capillary restrictor provide the damping mechanism in the form of the self-damped pneumatic isolator.

80-2042

The Transmission of Piston Forces to the Mounts of an Engine

D. Hodgetts and A.M. McDonald
Cranfield Inst. of Tech., UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 1-8, 8 figs, 6 refs

Key Words: Engine mounts, Crankshafts, Whirling

An experimental and theoretical study of the transmission of piston inertia and gas pressure forces to the mounts of a conventional four cylinder in-line engine is described. The study is concerned in particular with the transmission of forces at frequencies which are second order and twice engine speed. The results refer mainly to the forces at the rear mounts of the engine at a gearbox extension. The paper concludes with comments on the significance of the engine mounting system in the reduction of force transmission when a crankshaft whirls.

80-2043

The Potential for Active Suspension Systems

H.B. Sutton
Bolton Inst. of Tech., Auto. Engr. (SAE), 4 (2), pp 21-24 (Apr/May 1979) 5 figs, 44 refs

Key Words: Suspension systems (vehicles), Active isolation

The limitations of passive suspensions are discussed and compared with the potential advantages of active suspensions. Approaches to suspension design in recent years and new mathematical procedures that can be applied are also outlined.

80-2044

Whirling Response and Stability of Flexibly Mounted, Ring-Type Flywheel Systems

T.L.C. Chen and C.W. Bert
School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK, J. Mech. Des., Trans. ASME, 102 (2), pp 369-378 (Apr 1980) 14 figs, 2 tables, 21 refs

Key Words: Energy storage systems, Flywheels, Whirling, Unbalanced mass response

An eight-degree-of-freedom analysis of high-performance, composite-material flywheel systems is presented. Free whirling, stability, and response to unbalance and initial tilt are analyzed. Numerical results are presented for some specific flywheel systems.

80-2045

Optimum Absorber Parameters for Simple Systems

G.B. Warburton and E.O. Ayorinde

Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham, UK, Intl. J. Earthquake Engr. Struc. Dynam., 8 (3), pp 197-217 (May/June 1980) 11 figs, 2 tables, 21 refs

Key Words: Absorbers (equipment), Beams, Plates, Shells, Cylindrical shells, Harmonic response

The authors show that optimum parameters for absorbers, which are attached to beams and plates, can be obtained simply and accurately from those for an equivalent one-degree-of-freedom main system. This depends upon the concept of an effective mass for the elastic body and the representation of its response by the single relevant mode.

80-2046

Minimizing Structural Vibrations with Absorbers

E.O. Ayorinde and G.B. Warburton

Dept. of Mech. Engrg., Univ. of Benin, Benin City, Nigeria, Intl. J. Earthquake Engr. Struc. Dynam., 8 (3), pp 219-236 (May/June 1980) 7 figs, 6 tables, 16 refs

Key Words: Absorbers (equipment), Beams, Plates, Shells, Cylindrical shells, Harmonic response

Cylindrical shells are considered as examples of dynamically complex structures, for which the ratio of the natural frequencies of adjacent modes tends towards unity. It is shown that as dynamic complexity increases optimum absorber parameters for the reduction of resonant response deviate increasingly from those for an equivalent single degree-of-freedom system. Absorbers can be used also to reduce the random response of structures. Simple expressions for optimum parameters are given for an undamped main system, which has one degree of freedom and is subjected to white noise excitation. Optimum absorber parameters for beams, plates and cylindrical shells show similar quali ive behavior for random and harmonic response with the concept of an equivalent single degree-of-freedom system being applicable only for the simpler structures.

SPRINGS

80-2047

Stick-Slip Induced Noise Generation in Water-Lubricated Compliant Rubber Bearings

B. Bhushan

Mechanical Tech. Inc., Latham, NY 12110, J. Lubric. Tech., Trans. ASME, 102 (2), pp 201-210 (Apr 1980) 19 figs, 17 refs

Key Words: Bearings, Elastomeric bearings, Test models, Noise generation, Stick-slip excitation

An experimental model for the study of the mechanism of noise generation in water-lubricated compliant rubber bearings is described. It employs a transparent glass slider rubber against a Buna-N rubber section in order to permit direct measurement of the different aspects of the vibration phenomena, and to be able to observe the type of rubber motion that occurs at the sliding interface. The paper contains both conclusions and recommendations for corrective means which would lead toward silent operation.

TIRES AND WHEELS

(See No. 2023)

BLADES

(Also see No. 2033)

80-2048

Experimental Investigation on the Vibration of Blades Due to a Rotating Stall

K. Ishihara and M. Funakawa

The Technical Lab., Kawasaki Heavy Industries, Akashi, Japan, Bull. JSME, 23 (117), pp 353-360 (Mar 1980) 20 figs, 1 table, 2 refs

Key Words: Blades, Compressor blades, Stalling

In order to grasp the unsteady aerodynamic force acting on blades due to a rotating stall, properties such as velocity, pressure fluctuations and vibrations of blades are measured and relations between them are studied by using a single stage compressor.

80-2049

Friction Damping of Resonant Stresses in Gas Turbine Engine Airfoils

J.H. Griffin

Government Products Div., Pratt & Whitney Aircraft, West Palm Beach, FL 33402, J. Engr. Power, Trans. ASME, 102 (2), pp 329-333 (Apr 1980) 7 figs, 7 refs

Key Words: Turbine blades, Coulomb friction, Resonant response

The resonant response of a turbine airfoil attenuated through use of a Coulomb damper is analyzed. Parameters that control the damper's effectiveness are identified and characteristics of an optimized system are described. The results of the analysis are confirmed by laboratory tests.

80-2050

A 3rd Element Model with Substructuring for Predicting the Influence of Structural Discontinuities on Composite Rotor Blades

I.A. Yargicoglu

Ph.D. Thesis, Univ. of Texas at Austin, 212 pp (1979)

UM 8009955

Key Words: Blades, Rotor blades, Discontinuity-containing media, Composite structures, Substructuring methods, Finite element technique

Procedures are presented for the analysis of large structural systems. Three-dimensional finite element models are developed for composite rotor blade type structures. The analysis includes the determination of the flexibility and natural frequency mode shape characteristics of the structure. Particular attention is given to the substructuring techniques to improve the computational efficiency during the formation and solution of the resulting finite element equations.

80-2051

Aerodynamic and Aeroelastic Characteristics of Oscillating Loaded Cascades at Low Mach Number. Part I: Pressure Distribution, Forces and Moments

H. Atassi and T.J. Akai

Dept. of Aerospace and Mech. Engrg., Univ. of Notre Dame, Notre Dame, IN 46556, J. Engr. Power, Trans. ASME, 102 (2), pp 344-351 (Apr 1980) 18 figs, 1 table, 11 refs

Key Words: Airfoils, Turbomachinery blades, Blades, Aerodynamic characteristics

A complete theory is developed for the analysis of oscillating airfoils in cascade in uniform incompressible flows. The theory fully accounts for the geometry of the airfoils and cascade parameters. It is shown that the strong mean velocity gradient near the leading edges of the airfoils significantly affects the unsteady pressure, forces and moments acting upon the airfoils.

80-2052

Aerodynamic and Aeroelastic Characteristics of Oscillating Loaded Cascades at Low Mach Number. Part II: Stability and Flutter Boundaries

T.J. Akai and H. Atassi

Dept. of Aerospace and Mech. Engrg., Univ. of Notre Dame, Notre Dame, IN 46556, J. Engr. Power, Trans. ASME, 102 (2), pp 352-356 (Apr 1980) 13 figs, 1 table, 11 refs

Key Words: Aerodynamic characteristics, Flutter, Turbine blades, Flexural vibration, Torsional vibration, Coupled response

The aerodynamic coefficients obtained from the analysis developed in Part I of this paper are utilized here to investigate stability and flutter boundaries for loaded cascades of airfoils with finite thickness. Combined bending and torsional oscillations for different stiffness ratios are studied for compressor and turbine cascades. The results show very significant effects of blade geometry and mean flow incidence on the stability and flutter boundaries.

80-2053

Turbine Blade Vibration Due to Partial Admission

R. Pigott

Technical Operations Div., Westinghouse Electric Corp., Philadelphia, PA 15235, Intl. J. Mech. Sci., 22 (4), pp 247-264 (1980) 17 figs, 8 refs

Key Words: Blades, Turbine blades, Vibration response, Shock excitation

A method is given for analyzing the vibrations of turbine blades during partial admission. The combined effects of shock loading as the blades enter and leave the arc of admission, and nozzle wake loading in the arc of admission are included. By separating these two effects, the dependence of blade stress on natural frequencies, running speed, number of nozzles, number of blades per row, number of blades per group and damping is illustrated. Apparatus for determining experimentally the exact nature of the steam loading acting on the blades is described.

80-2054

The Time-Variant Aerodynamic Response of a Stator Row Including the Effects of Airfoil Camber

S. Fleeter, W.A. Bennett, and R.L. Ray

Detroit Diesel Allison, Div. of General Motors Corp., P.O. Box 894, Indianapolis, IN 46206, J. Engr. Power, Trans. ASME, 102 (2), pp 334-342 (Apr 1980) 18 figs, 3 tables, 7 refs

Key Words: Aerodynamic characteristics, Turbomachinery blades, Compressor blades, Blades

An experimental investigation was conducted to quantitatively determine the validity and applicability of state-of-the-art transverse gust cascade analyses. This was accomplished by obtaining fundamental time-variant forced response data at realistic values of key parameters in a large-scale, low-speed, single-stage research compressor.

BEARINGS

(Also see Nos. 2153, 2156)

80 2055

Development of a Helicopter Rotor Hub Elastomeric Bearing

P. Donguy

Société Européenne de Propulsion, Saint-Medard-en-Jalles, France, J. Aircraft, 17 (5), pp 346-350 (May 1980) 15 figs, 6 refs

Key Words: Bearings, Elastomeric bearings, Helicopter rotors, Rotors (machine elements)

Recent advances in the field of elastomeric bearings for light helicopter rotor hubs are presented. Test results were obtained from different types of bearings and the analyses of these data resulted in the hydroflex bearing. This bearing encloses a liquid in the bearing and significantly increases service life. This paper presents a review of the analyses of the test data and describes the hydroflex bearing.

80 2056

Experimental-Theoretical Comparison of Instability Onset Speeds for a Three Mass Rotor Supported by Step Journal Bearings

J C. Nicholas, L.E. Barrett, and M.E. Leader

Turbo Engrg. Sciences, Ingersoll-Rand Co., Phillipsburg, NJ 08865, J. Mech. Des., Trans. ASME, 102 (2), pp 344-351 (Apr 1980) 12 figs, 8 tables, 12 refs

Key Words: Bearings, Journal bearings, Rotor-bearing systems, Stability, Optimum design

Theoretically predicted instability onset speeds are compared to the experimental instability threshold speeds for a simple three mass flexible rotor supported by five geometrically different sets of step journal bearings and a set of two axial groove bearings. The theoretical stability analysis predicts the general trends in the experimental data.

80-2057

A Study of Squeeze Film Bearings

S. Simandiri

Ph.D. Thesis, Univ. of New South Wales, Australia (1979)

Key Words: Squeeze-film bearings, Rigid rotors, Rotors (machine elements), Unbalanced mass response

This thesis investigates the unbalance behavior of centrally preloaded rigid motors running in rolling element bearings which in turn are mounted at one or both ends in squeeze film bearing supports. In the latter case, the investigation is restricted to symmetric rotors resulting in cylindrical motion of the rotor about the bearing axis. Assuming that the fluid film behavior may be adequately described by Reynolds equation for constant fluid properties, and that steady state conditions have been reached with the journal describing synchronous circular orbits about the bearing axis, extensive theoretical design data are presented which show the effect of the relevant system parameters on the unbalance force transmissibility, and the corresponding journal vibration amplitude over a wide range of operating conditions.

GEARS

(Also see Nos. 1996, 2163, 2164, 2174)

80-2058

Vibration Measurements on Planetary Gears of Aircraft Turbine Engines

M. Botman

Pratt & Whitney Aircraft of Canada Ltd., Longueuil, Quebec, Canada, J. Aircraft, 17 (5), pp 351-357 (May 1980) 15 figs, 1 table, 10 refs

Key Words: Gearboxes, Turbine engines, Vibration measurement

A variety of dynamic measurements taken on PT6 reduction gearboxes over a number of years is reviewed. Peculiar behavior found in these tests is discussed, such as load sharing among planets, responses due to gear errors, and a dynamic instability.

80-2059

Study on Bending Fatigue Strength of Helical Gears (1st Report, Effect of Helix Angle on Bending Strength)

S. Oda and Y. Shimatomi

Faculty of Engrg., Tottori Univ., Tottori, Japan, Bull. JSME, 23 (117), pp 453-460 (Mar 1980) 16 figs, 2 tables, 8 refs

Key Words: Gears, Helical gears, Fatigue life

The effect of helix angle on the root fillet stresses and the bending fatigue strength of helical gear teeth with a comparatively small face width was investigated. The investigation was based on the principle of superposition and the moment-image method and compared with the results of strain-gage investigation. The effect of helix angle on bending fatigue strength was also examined using the bending fatigue testing machine for cylindrical gears.

80-2060

Study on Bending Fatigue Strength of Helical Gears (2nd Report, Bending Fatigue Strength of Casehardened Helical Gears)

S. Oda, Y. Shimatomi, and N. Kawai

Faculty of Engrg., Tottori Univ., Tottori, Japan, Bull. JSME, 23 (117), pp 461-468 (Mar 1980) 13 figs, 3 tables, 14 refs

Key Words: Gears, Helical gears, Fatigue life

Casehardened helical gears with different degrees of helix angle and comparatively small face width were tested using the bending fatigue testing machine of hydraulic type. The effects of partial loading (maldistribution of load) on the root stresses and the bending fatigue strength of helical gear teeth were investigated experimentally and the relationship between the bending fatigue strength of a helical gear and that of its virtual spur gear was discussed by carrying out a bending fatigue test for the virtual spur gear. The existing equations for bending strength of cylindrical gears were compared on the basis of the experimental results.

80-2061

Dynamic Response and Loading of Gears in Drive Systems (Dynamisches Verhalten und Beanspruchung von Getrieben in Antriebssystemen)

Ch. Troeder, H. Peeken, and Diekhans

VDI Bericht, No. 332, pp 241-261 (1979) 21 figs, 9 refs

(In German)

Key Words: Gears, Parametric excitation, Couplings

The response of gears during simultaneous external and internal excitation is investigated. In the calculation of gear vibration the properties of transmission steps located between the drive and the driven ride of machinery are taken into consideration, as well as those of other elements, such as couplings, with linear and nonlinear characteristics.

80-2062

Modern Analysis Techniques Associated with Gearbox and Axle Noise

S.A. Andrews

BL Cars Limited, Longbridge, UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 47-57, 11 figs, 5 refs

Key Words: Axles, Gear noise, Noise source identification, Motor vehicle noise

Techniques and methods which can identify sources or likely reasons for axle and gearbox noise and vibration are described. This analysis data can then be used to guide a manufacturing plant in improvements in quality by the control of manufacturing tolerances.

LINKAGES

(See No. 2012)

VALVES

80-2063

Response of a 4-Inch Nuclear Power Plant Valve to Dynamic Excitation

S.F. Masri and S.J. Scott

Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA, Rept. No. NUREG/CR-1317, 318 pp (Feb 1980)

Key Words: Valves, Nuclear power plants, Dynamic tests

Experimental laboratory studies of a valve for nuclear power plant application were conducted to determine characteristic structural dynamic response relationships between various magnitudes and types of forced excitation. A 4-in. gate valve weighing approximately 160 lb was investigated. The forced dynamic excitation consisted of swept-sine, sine dwell, random, and shock base acceleration that were generated by an electrodynamic shaker or a shock machine. For each type of excitation, different magnitudes and directions of acceleration were applied. Acceleration and strain data were recorded on analog tape and subsequently analyzed, including the determination of transmissibility ratio, power spectral density, time histories, and shock spectra.

CAMS

80-2064

The Characterization of Cam Drive System Windup

L.E. Szakallas and M. Savage

Clecon, Inc., Cleveland, OH, J. Mech. Des., Trans. ASME, 102 (2), pp 278-285 (Apr 1980) 12 figs, 26 refs

Key Words: Cam followers, Cams, Mechanical drives, Self-excited vibrations

The vibration in a cam driven mechanism due to drive system windup can be a serious problem at high speeds. By dimensional analysis, two ratios are established to characterize the level of vibration. Maximum drive system windup and maximum radial follower force ratios are presented in chart form to characterize the vibration level. Systems studied are harmonic and cycloidal rises with open and closed track cam surfaces.

STRUCTURAL COMPONENTS

CABLES

80-2065

Nonlinear Static and Dynamic Deformations of Viscoelastic Cables

B.J. Sullivan and S.C. Batterman

Franklin Inst. Research Lab., Philadelphia, PA, ASCE J. Engr. Mech. Div., 106 (EM3), pp 543-564 (June 1980) 9 figs, 3 tables, 16 refs

Key Words: Cables (ropes), Viscoelastic properties, Nonlinear response

The rate equation method is used in this work to facilitate the analyses of finite deflection problems involving viscoelastic cables. In addition, the rate equation method has been extended to allow changes in the original cross-sectional area to the cable to occur as its deformation takes place. To illustrate the details of the technique, static and dynamic geometrically nonlinear deformations of viscoelastic cables and hoops under various loadings are investigated and numerical results are presented for several cases. The accuracy of the rate equation method as applied to viscoelastic cables of contracting cross-sectional area is verified through comparisons of the rate equation solutions with solutions obtained through quasi-analytic techniques.

BEAMS

(Also see No. 2115)

80-2066

Modern Optimal Control Methods Applied in Active Control of a Cantilever Beam in Bending Vibration

K.D. Sanborn

School of Engrg., Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/GA/AA/79D-9, 71 pp (Dec 1979)
AD-A079 859/5

Key Words: Beams, Cantilever beams, Flexural vibration, Vibration control, Active control

The equations of motion for a cantilever beam in bending vibration are developed in state vector form using a normal mode approximation. A linear optimal control system generates a feedback control proportional to the state which is represented by modal amplitudes and velocities determined using position information from sensors. The observer gain matrix and the feedback control gain matrix are both determined from a steady state optimal regulator which minimizes the related quadratic performance index. Control is applied through point force actuators.

80-2067

Stability of a Nonuniform Cantilever Subjected to Dissipative and Nonconservative Forces

R.C. Kar
Dept. of Mech. Engrg., Indian Inst. of Tech., Kharagpur - 721302, India, Computers Struc., 11 (3), pp 175-180 (Mar 1980) 10 figs, 5 refs

Key Words: Beams, Cantilever beams, Flutter

The stability of a tapered cantilever beam subjected to a circulatory force at its free end is investigated. The effects of internal and external damping are included in the partial differential equation of motion. An adjoint variational principle has been used to determine approximately the values of the critical flutter load of the system. Graphs which demonstrate the variation of the critical flutter load with taper, damping and tangency coefficient are presented.

80-2068

Analytical and Experimental Studies of a Beam with Geometric Nonlinearity

Y.A. Mariamy
Ph.D. Thesis, Univ. of Southern California (1980)

Key Words: Beams, Harmonic excitation, Bernoulli-Euler method, Geometric effects

Analytical and experimental studies of the dynamic response of a system with a geometric nonlinearity which is encountered in many practical engineering applications are described. An exact solution for the steady-state motion of a viscously damped Bernoulli-Euler beam with an unsymmetric geometric nonlinearity, under the action of harmonic excitation is derived. Experimental measurements with a mechanical model verify the analytical findings. A study of the effect of various parameters on the system response is determined. Major conclusions based on this investigation are presented.

80-2069

Loads Moving on Beam Supported by Layered Elastic Foundation

V.N. Shah, R.D. Cook, and T.C. Huang
Westinghouse Electric Corp., Pittsburgh, PA, J. Mech. Des., Trans. ASME, 102 (2), pp 295-302 (Apr 1980) 11 figs, 15 refs

Key Words: Beams, Elastic foundations, Moving loads, Pasternak foundations, Winkler foundations, Finite element technique

A finite element method is applied to analyze the dynamic response of a beam supported by layered inertial foundation and subjected to moving loads. The foundation is represented by the modified Pasternak model or by the Winkler model. The moving loads are simulated by a concentrated force, a point-mass or a spring-mass-damper system. The equations of motion are represented by a system of second-order ordinary differential equations with variable coefficients.

CYLINDERS

(Also see No. 2176)

80-2070

Calculations of Added Mass and Damping Coefficients for Hexagonal Cylinders in a Confined Viscous Fluid

C.I. Yang and T.J. Moran
Argonne National Lab., Argonne, IL 60439, J. Pressure Vessel Tech., Trans. ASME, 102 (2), pp 152-157 (May 1980) 8 figs, 4 tables, 6 refs

Key Words: Cylinders, Fluid-induced excitation, Harmonic response, Nuclear reactor components, Seismic response, Stiffness coefficients, Damping coefficients

A finite element model is formulated and computations performed for the hydrodynamic reactions of harmonically oscillating hexagonal cylinders in an incompressible, viscous fluid. Regular hexagonal cylinders pack closely together, increasing the hydrodynamic coupling effect. The formulation is based on a velocity and pressure approach assuming the amplitude of the motion is sufficiently small to allow linearization of the Navier-Stokes equations. The equations of motion are discretized through a Galerkin process with a six-node triangular finite element mesh. C^0-type elements and mixed interpolation functions are used with quadratic functions for velocity and linear functions for pressure. The hydrodynamic reactions, in terms of added mass and damping coefficients, of an hexagonal cylinder oscillating in a confined circular cylinder and an array of seven hexagonal cylinders in a confined domain are computed. The effects of the size of the gap between adjacent cylinders and the frequency of oscillation are studied.

FRAMES AND ARCHES

80-2071

Inelastic Response of Space Frames to Dynamic Loads

E.A. Uzgider

Dept. of Civil Engrg., Univ. of Missouri, Rolla, MO, Computers Struc., 11 (1-2), pp 97-112 (Feb 1980) 14 figs, 2 tables, 19 refs

Key Words: Framed structures, Elastoplastic properties, Computer program

A numerical method for the analysis of three-dimensional frames loaded dynamically into the inelastic range is developed. The elasto-plastic force-deformation behavior at the ends of the frame members is represented by an equation which corresponds essentially to the inverse of the Ramberg-Osgood representation. The methods proposed in this study are incorporated into the computer program and several results are produced.

80-2072

Dynamic Snap-Through Buckling of a Timoshenko Two Bar Frame under a Suddenly Applied Load

A.N. Kounadis

National Tech. Univ., Athens, 42, 28th October Ave., Athens 147, Greece, Z. angew Math. Mech., 59 (10), pp 523-531 (1979) 3 figs, 2 tables, 33 refs

Key Words: Frames, Timoshenko theory, Dynamic buckling

A variational methodology for investigating the dynamic stability of frames subjected to a suddenly applied load of constant magnitude and infinite duration is developed and successfully demonstrated through a simple two-bar frame. A criterion for dynamic stability is presented on the basis of which dynamic snap-through loads are established. Using Timoshenko's beam theory the individual and coupling effects of various parameters (i.e. cross-sectional shape, loading, eccentricity, slenderness ratio and moment of inertia ratio of the two bars) on the dynamic and static snap-through load are fully assessed.

PANELS

80-2073

Large Amplitude Supersonic Flutter of Panels with Ends Elastically Restrained Against Rotation

K.S. Rao and G.V. Rao

Structural Engrg. Div., Vikram Sarabhai Space Center, Trivandrum-695022, India, Computers Struc., 11 (3), pp 197-201 (Mar 1980) 3 figs, 4 tables, 13 refs

Key Words: Panels, Flutter, Aircraft

Nonlinear supersonic flutter of panels of simply supported, clamped and partially restrained against rotation end conditions is studied using a unified approach. The effects of large deflection and inplane forces on flutter boundary are included. An eight element solution based on convergence study is presented.

PLATES

(Also see Nos. 2016, 2146)

80-2074

Finite Element Analysis of a Dynamically Loaded Flat Laminated Plate

D.W. Pillasch

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 109 pp (1979)

UM 8009131

Key Words: Plates, Layered materials, Finite element technique

A finite element structural model has been developed for the dynamic analysis of laminated, thick plates. The model uses quadrilateral elements to represent the shape of the plate and the elements are stacked in the thickness direction to represent various material layers. This analysis allows for orthotropic, elastic plastic or elastic viscoplastic material properties. Non-linear strain displacement relations are used to represent large transverse plate deflection. A finite difference technique is used to perform the numerical time integration.

80-2075

Large Deflection and Large-Amplitude Free Vibrations of Laminated Composite-Material Plates

J.N. Reddy and W.C. Chao

School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73019, Rept. No. OU-AMNE-80-7

Key Words: Plates, Layered materials, Composite materials, Finite element technique, Transverse shear deformation effects, Natural frequencies

Finite-element analysis of the large-deflection theory including transverse shear, governing moderately thick, laminated anisotropic composite plates is presented. Linear and quadratic rectangular elements with five degrees of freedom (three displacements, and two shear rotations) per node are employed to analyze rectangular plates subjected to various loadings and edge conditions. Numerical results for bending deflections, stresses, and natural frequencies are presented showing the parametric effects of plate aspect ratio, side-to-thickness ratio, orientation of layers, and anisotropy.

80-2076

Acoustic Scattering from a Submerged Plate. I. One Reinforcing Rib

B.L. Woolley
Naval Ocean Systems Center, San Diego, CA 92152,
J. Acoust. Soc. Amer., 67 (5), pp 1642-1653 (May 1980) 13 figs, 15 refs

Key Words: Acoustic scattering, Plates, Reinforced plates, Submerged structures

Theoretical calculations of the backscattering of a plane sound wave by a rib stiffened Timoshenko-Mindlin plate are presented. An exact solution is compared with two saddle point integral approximations. One saddle point integral approximation takes into account the near coalescence of the leaky wave pole and the saddle point. Mass loading of the rib and different rib constraints are discussed. The range of validity of the model is also given.

80-2077

Acoustic Scattering from a Submerged Plate. II. Finite Number of Reinforcing Ribs

B.L. Woolley
Naval Ocean Systems Center, San Diego, CA, 92152,
J. Acoust. Soc. Amer., 67 (5), pp 1654-1658 (May 1980) 7 figs, 3 refs

Key Words: Acoustic scattering, Plates, Reinforced plates, Submerged structures

Theoretical calculations of the backscattering of a plane sound wave by a rib stiffened Timoshenko-Mindlin plate are presented. Equations are derived for the calculation of the influence of *N* arbitrarily situated, arbitrarily loaded ribs on the amplitude of the reflected wave. Calculated results for two, nine, ten, and an infinite number of equally spaced ribs are given.

80-2078

Transverse Vibrations of Clamped Rectangular Plates of Generalized Orthotropy Subjected to In-Plane Forces

P.A.A. Laura and L.E. Luisoni
Inst. of Applied Mechanics, Base Naval Puerto Belgrano, Argentina,
J. Mech. Des., Trans. ASME, 102 (2), pp 399-404 (Apr 1980) 6 figs, 1 table, 14 refs

Key Words: Plates, Rectangular plates, Flexural vibration, Variational methods

A very simple solution of the title problem is obtained by using simple polynomials and a variational method. Free and forced vibrations of the structural element are analyzed in a unified manner. The algorithmic procedure can be implemented in a microcomputer. The problem is of particular interest in certain filamentary plates as well as of obliquely stiffened plates.

80-2079

Moderately Large Amplitude Plate Vibration Modes

J.C. Kennedy, Jr.
Applied Dynamics and Acoustics Section, Battelle Columbus Labs., Columbus, OH,
J. Mech. Des., Trans. ASME, 102 (2), pp 405-411 (Apr 1980) 6 figs, 7 refs

Key Words: Plates, Rectangular plates, Large amplitudes, Vibration frequencies

The influence of moderately large amplitudes on the frequency of vibration for the fundamental mode and some higher modes of the simply supported rectangular plate is established. Plate equations that are valid for the moderately large motions are programmed for solution on the analog computer. The effect of eliminating in-plane motions and accelerations on the system response is quantitatively established. It is shown that frequency ratio versus amplitude ratio is aspect ratio dependent and the study shows how simplifying assumptions made in some previous studies affect this dependence.

80-2080

Nonlinear Dynamic Analysis of Orthotropic Circular Plates

T. Nath and R.S. Alwar
Applied Mechanics Dept., Indian Inst. of Tech., Delhi

Hauzhas, New Delhi - 110029, India, Intl. J. Solids Struc., 16 (5), pp 433-443 (1980) 7 figs, 15 refs

Key Words: Plates, Circular plates, Nonlinear theories

In the present investigation an analytical technique using Chebyshev series has been used to study the nonlinear dynamic response of orthotropic circular plates for both clamped as well as simply supported edge conditions. The influence of orthotropic parameter β on the large amplitude response of circular plates, under three types of dynamic loadings namely, step function, sinusoidal and *N* shaped pulse, has been studied.

80-2081

Effect of Secondary Terms on Axisymmetric Vibration of Circular Plates

A.P. Gupta and N. Mishra
Dept. of Mathematics, Univ. of Roorkee, Roorkee-247672, UP, India, J. Engr. Math., 14 (2), pp 101-106 (Apr 1980) 1 fig, 5 refs

Key Words: Plates, Circular plates, Flexural vibration

Free transverse vibration of a circular plate is considered by assuming the displacement components as an infinite series in the thickness coordinate. The analysis is done by retaining only the first two terms in each series. The equations of motion are derived by Hamilton's energy principle and the solutions are obtained in terms of Bessel functions. Numerical results are compared with the classical and shear theories which are particular cases of the present theory.

80-2082

Transient Dynamic Large Deflection Analysis of Elastic Viscoplastic Plates by the Finite Element Method

M.T.E. Tuomala and M.J. Mikkola
Dept. of Civil Engrg., Helsinki Univ. of Tech., 02150 Espoo 15, Finland, Intl. J. Mech. Sci., 22 (3), pp 151-166 (1980) 15 figs, 28 refs

Key Words: Plates, Viscoplastic properties, Transient response, Finite element technique

The transient response of plates subjected to impulsive loads is analyzed by the finite element method taking into account the influences of geometry changes and material nonlinearities due to plasticity and strain rate sensitivity. The equations of motion are derived using the principle of virtual work in total lagrangian formulation. For plates the large deflection theory by von Kármán and the theory including the effect of transverse shear strain by Mindlin are employed. Time integration of the nonlinear system of finite element equations is effected using central difference and Newmark schemes. Numerical examples include beams and circular and rectangular plates. Comparisons are made to available experimental, analytical, and numerical results.

80-2083

Dynamic Large Deflection Analysis of Plates Using Mixed Finite Elements

H.U. Akay
Dept. of Civil Engrg., Middle East Technical Univ., Ankara, Turkey, Computers Struc., 11 (1-2), pp 1-11 (Feb 1980) 9 figs, 4 tables, 27 refs

Key Words: Plates, Large amplitudes, Finite element technique

A four-node isoparametric mixed quadrilateral element is developed for large deflection dynamic analysis of plates. Dynamic von Karman plate equations are modified to include the effect of transverse shear deformations as in Reissner plate theory. Finite element equations of motion are obtained via a mixed-Galerkin approach with three moment and three displacement components as dependent variables. Resulting nonlinear time dependent equations are solved by using Newmark's step-by-step direct integration algorithm in conjunction with Picard type successive iterations within each time step.

80-2084

Vibration Characteristics of Slip Plates at High Frequencies

R. Buckingham and D. Kimball
Canadian Astronautics Ltd., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 183-186, 6 figs, 4 refs

Key Words: Plates, Vibration measurement, Measurement techniques, High frequencies

The purpose of this paper is to describe high frequency vibration characteristics of slip plates - using analytical methods and test data - in order to understand their behavior and fundamental limitations. Several types of structural modes are considered. The axial and in-plane shearing modes of the slip plate/adapter/armature system at frequencies above 100 Hz are observed.

SHELLS

80-2085

The Free Vibration Equations, Natural Frequencies and Modal Characteristics of Closed Circular Cylindrical Shells

T. Koga and K. Komatsu

National Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-569T, 45 pp (Apr 1979)

N80-16373/6

Key Words: Shells, Cylindrical shells, Natural frequencies, Mode shapes

The relative accuracies of the representative classical theories of thin shells are examined. The order of magnitude comparison of terms involved in the governing equations for the free vibrations of a circular cylindrical shell is the method utilized.

80-2086

Axisymmetric Free Vibration of a Submerged Spherical Shell

C.A. Felippa and T.L. Geers

Lockheed Palo Alto Research Lab., Palo Alto, CA 94304, J. Acoust. Soc. Amer., 67 (5), pp 1427-1431 (May 1980) 5 figs, 5 refs

Key Words: Shells, Spherical shells, Free vibration, Axisymmetric vibrations, Submerged structures

A study of the title problem shows how complete solutions for this classical configuration are readily obtained from simple polynomial expressions. Numerical results in graphical form are presented for a steel shell submerged in water as functions of a parameter related to the shell's thickness-to-radius ratio.

PIPES AND TUBES

80-2087

Vortex-Excited Cross-Flow Vibrations of a Single Cylindrical Tube

O.M. Griffin

Naval Research Lab., Washington, D.C. 20375, J. Pressure Vessel Tech., Trans. ASME, 102 (2), pp 158-166 (May 1980) 9 figs, 4 tables, 30 refs

Key Words: Tubes, Fluid-induced excitation, Vortex-induced vibration

The cross-flow vibrations of a single tube are considered for incident flows of air and water. Recent experimental measurements of the resonant response of and fluid dynamic forces on circular cylinders as a result of vortex shedding at subcritical Reynolds numbers are presented, and different approaches to measuring and characterizing the fluid forces are compared.

80-2088

Prevention and Cure of Flow-Induced Vibration Problems in Tubular Heat Exchangers

F.L. Eisinger

Foster Wheeler Energy Corp., Livingston, NJ 07039, J. Pressure Vessel Tech., Trans. ASME, 102 (2), pp 138-145 (May 1980) 9 figs, 1 table, 26 refs

Key Words: Heat exchangers, Tubes, Fluid-induced excitation, Vibration control

Various methods for predicting and solving tube and acoustic vibration problems in heat exchangers in cross flow are presented: the use of stability diagrams comprising in-service experience of heat exchangers, for a general multispan tube model; a method of selecting efficient baffle configurations for prevention of acoustic vibration, a new method of fin barriers, an alternative to conventional baffling; a new method of enhancing the vibration resistance of a tube bank based on the use of a helical spacer. These methods, singly or in combination, can be used to design against flow-induced vibration.

80-2089

Cures Given for Reciprocating Compressor Pulsation

W.F. Schula

Conoco, Inc., Ponca City, OK, Oil Gas J., 78 (14), pp 68-76 (April 7, 1980) 7 figs

Key Words: Compressors, Pipes (tubes), Pulse excitation

Steps to be taken in the detection of pulsation induced piping vibration, allowable pulsation, pulsation caused by piping supports, and the elimination of pulsation are discussed.

80-2090
Seismic Response of Buried Pipelines
A.I.M.O. Hindy
Ph.D. Thesis, Univ. of Western Ontario, Canada (1979)

Key Words: Pipelines, Underground structures, Seismic response, Interaction: soil-structure

The seismic response of buried pipelines to ground shaking is investigated theoretically considering dynamic soil-pipe interaction. Both discrete and continuum models are employed with soil reactions derived from static and dynamic continuum theories. The pipe motion is analyzed as a deterministic response to traveling waves as well as random vibration. The axial and bending stresses are calculated and compared with those obtained under the often-used assumption that the pipe closely follows the motion of the ground.

80-2091
Time History Input Development for the Seismic Analysis of Piping Systems
C.-W. Lin
Westinghouse Electric Corp., Pittsburgh, PA 15230, J. Pressure Vessel Tech., Trans. ASME, 102 (2), pp 212-218 (May 1980) 17 figs, 1 table, 5 refs

Key Words: Piping systems, Seismic response, Statistical analysis

The results of a study conducted to establish statistical relationships on 22 earthquakes are reported. These earthquakes are those used in establishing the design ground response spectra specified in Regulatory Guide 1.60. The statistical properties studied include the autocorrelation functions, crosscorrelation functions, coherence functions, and acceleration motion distribution. A set of criteria is recommended for the generation of the synthesized time histories so that analysis of the piping systems can be realistically and correctly conducted.

80-2092
Seismic Analysis and Design of Buried Pipelines (Seismic Vulnerability, Behavior and Design of Underground Piping Systems)
L.R.-L. Wang
Rept. No. NSF/RA-790272, 17 pp (Aug 1979)
PB80-141260

Key Words: Pipelines, Underground structures, Seismic response, Earthquake response

Analysis procedures and design criteria for buried pipeline systems to resist earthquakes are described. To evaluate the adequacy of existing systems and improve the design of future systems, 'Simplified Analysis' and 'Quasi-static Analysis' approaches are presented for use in computing pipe strains and relative joint displacements due to seismic ground shaking. Related parameters to fulfill analysis requirements are described. Both active and passive design procedures and considerations to reduce seismic damage of buried pipelines are presented.

DUCTS

(Also see No. 2037)

80-2093
Transmission of Sound Through Nonuniform Circular Ducts with Compressible Mean Flows
A.H. Nayfeh, B.S. Shaker, and J.E. Kaiser
Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, AIAA J., 18 (5), pp 515-525 (May 1980) 9 figs, 1 table, 31 refs

Key Words: Ducts, Acoustic linings, Elastic waves, Wave propagation

An acoustic theory is developed to determine the sound transmission and attenuation through an infinite hardwalled or lined circular duct carrying compressible, sheared mean flows and having a variable cross section. The technique is based on solving for the envelopes of the quasiparallel acoustic modes that exist in the duct instead of solving for the actual wave, thereby reducing the computation time and the round-off error encountered in purely numerical techniques. A number of test cases that demonstrate the flexibility of the program are included.

80-2094
Applications of Velocity Potential Function to Acoustic Duct Propagation Using Finite Elements
K.J. Baumeister and R.K. Majjigi
NASA Lewis Research Center, Cleveland, OH, AIAA J., 18 (5), pp 509-514 (May 1980) 9 figs, 19 refs

Key Words: Ducts, Elastic wave propagation, Finite element technique

A finite element velocity potential program has been developed to study acoustic wave propagation in complex geometries. For irrotational flows, relatively low sound frequencies, and plane wave input, the finite element solutions show significant effects of inlet curvature and flow gradients on the attenuation of a given acoustic liner in a realistic variable area turbofan inlet.

80-2095

Reciprocity Principle in Duct Acoustics

Y.-C. Cho
Lewis Research Center, NASA, Cleveland, OH 44135,
J. Acoust. Soc. Amer., 67 (5), pp 1421-1426 (May 1980) 7 figs, 10 refs

Key Words: Sound propagation, Ducts, Modal analysis, Reciprocity principle

Various reciprocity relations in duct acoustics have been derived on the basis of the spatial reciprocity principle implied in Green's functions for linear waves. The derivation includes the reciprocity relations between mode conversion coefficients for reflection and transmission in nonuniform ducts, and the relation between the radiation of a mode from an arbitrarily terminated duct and the absorption of an externally incident plane wave by the duct.

80-2096

Acoustic Momentum and Energy Theorems for Piecewise Uniform Ducts

W. Möhring
Max-Planck-Institut f. Strömungsforschung, Böttingerstrasse 4-8, D 3400 Göttingen, Federal Republic of Germany,
J. Acoust. Soc. Amer., 67 (5), pp 1463-1471 (May 1980) 5 figs, 19 refs

Key Words: Sound propagation, Ducts

The problem of sound propagation in a constant-area duct with compliant walls is studied, including a uniform mean flow.

80-2097

Propagation of Waves in Rectangular Ducts with Sinusoidal Undulations

A.-M. Nusayr
Dept. of Mathematics, Yarmouk Univ., Irbid, Jordan,
J. Acoust. Soc. Amer., 67 (5), pp 1472-1476 (May 1980) 1 table, 6 refs

Key Words: Ducts, Rectangular ducts, Variable cross section, Sound propagation

The method of multiple scales is employed to analyze the wave propagation in a rectangular hard-walled duct whose walls have weak periodic undulations.

BUILDING COMPONENTS

(Also see No. 2125)

80-2098

Dynamic Analysis of Shear Walls and Discretely Connected Panel Structures Using a Super Finite Element Technique

H.-P. Huttelmaier
Ph.D. Thesis, Concordia Univ., Canada (1979)

Key Words: Walls, Panels, Seismic response, Substructuring methods, Finite element technique, Computer programs

The aim of this research is the development of a versatile substructuring technique for dynamic analysis, applicable to shear wall-type structures. Intended applications are precast panel structures and their seismic response. The theoretical background for dynamic substructuring is reviewed, followed by the development of a substructuring scheme which is described as a multilevel super-finite element technique, based on a series of static condensations.

ELECTRIC COMPONENTS

MOTORS

(See No. 2161)

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 1988, 1989, 1990, 1992, 1993, 1995, 2021, 2022, 2036, 2047, 2076, 2077, 2094, 2095, 2096, 2097, 2132, 2137, 2158)

80-2099

Resonant Scattering of Elastic Waves from Spherical Solid Inclusions

L. Flax and H. Überall
Naval Research Lab., Washington, D.C. 20375, J. Acoust. Soc. Amer., 67 (5), pp 1432-1442 (May 1980) 6 figs, 1 table, 20 refs

Key Words: Elastic waves, Wave diffraction

The resonances of solid inclusions, exemplified by iron or lucite spheres imbedded in an aluminum matrix, are found numerically in the individual normal-mode scattering amplitudes, and are interpreted in terms of phase-matched circumferential waves. Dispersion curves for the phase velocities of the latter are obtained, exhibiting two families of waves of different type. Finally, the connection of these waves with the Stonely waves on the boundary between two flat half-spaces is noted in high-frequency limit.

80-2100
Sound Propagation in a Wedge-Shaped Ocean with a Penetrable Bottom
F.B. Jensen and W.A. Kuperman
SACLANT ASW Research Center, La Spezia, Italy, J. Acoust. Soc. Amer., 67 (5), pp 1564-1566 (May 1980) 4 figs, 1 table, 7 refs

Key Words: Underwater sound, Sound propagation

Modal cutoff during up-slope propagation in a wedge-shaped ocean is studied using the parabolic equation model; theoretical results are compared with some model tank experiments.

80-2101
Noise Reduction in Machinery. Fundamental Possibilities and Attainable Effects (Geräuschminderung an Maschinen und Anlagen. Prinzipielle Möglichkeiten, erreichbare Wirkungen)
U. Bernhardt and R. Westphal
Universität Hanover, Hanover, Germany, VDI Z., 122 (7), pp 273-278 (1980) 9 figs, 4 tables, 12 refs
(In German)

Key Words: Machinery noise, Noise reduction, Noise generation, Noise propagation

Noise reduction techniques based on an understanding of noise generation and noise propagation is presented.

80-2102
Low Frequency Gas Turbine Noise
J.R. Newman and K.I. McEwan
British Gas, 326 High Holborn, London, UK, J. Engr. Power, Trans. ASME, 102 (2), pp 476-481 (Apr 1980) 5 figs, 5 tables, 8 refs

Key Words: Silencers, Turbines, Noise reduction, Low frequencies

Low frequency turbine noise problems were investigated and then resolved by aerodynamic modifications and a silencer extension.

80-2103
Some Effects of Motion and Plane Reflecting Surfaces on the Radiation from Acoustic Sources
D.L. Lansing
NASA Langley Research Center, Hampton, VA, Noise Control Engr., 14 (2), pp 54-65 (Mar/Apr 1980) 20 figs, 12 refs

Key Words: Noise measurement, Helicopter rotors

The radiation properties of acoustic monopole and dipole sources in a free field and in the presence of an absorptive plane surface are detailed. The kinematic effects of translation and rotation on source radiation are discussed, along with the key equations underlying these concepts. Measurements of sound from an acoustic monopole in motion and the characteristics of helicopter rotor and propeller noise serve as illustrations of the practical application of theory.

80-2104
***Controlling* Industrial and Environmental Test Laboratory Noise Pollution**
C.L. Meteer
Space-Tronics, Inc., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 169-172

Key Words: Industrial facilities, Noise reduction

Two methods for industrial noise control are discussed. They are reduction of noise at the source and alteration of the sound transmission path from the source to the receiver.

80-2105

Quilted Noise Absorber/Barriers for Industrial Noise Control

E.W. Stone and S.J. Stahovic

Noise Control Associates, Inc., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 179-182

Key Words: Industrial facilities, Noise reduction, Noise barriers, Acoustic absorption

Noise abatement applications requiring a 10 dBA to 15 dBA reduction by means of a quilted noise absorber/barrier are described.

SHOCK EXCITATION

(Also see Nos. 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2006, 2008, 2090, 2091, 2092, 2131, 2167, 2175)

80-2106

Periodic Vibration and Impact Characteristics of a Nonlinear System with Collision

T. Fujita and S. Hattori

Inst. of Industrial Science, Univ. of Tokyo, Tokyo, Japan, Bull. JSME, 23 (117), pp 409-418 (Mar 1980) 13 figs, 7 refs

Key Words: Nonlinear systems, Harmonic response, Impact response (mechanical)

The analytical and experimental studies of impact characteristics, such as force of restitution, impulse, a coefficient of restitution and contact time, in the harmonic resonance of a nonlinear system with collision subjected to a sinusoidal excitation are described. The system consists of an oscillator and reflectors at both sides.

80-2107

Statistical Analysis of the Response of Nonlinear Systems Subjected to Earthquakes

R. Riddell and N.M. Newmark

Dept. of Civil Engrg., Illinois Univ. at Urbana-Champaign, IL, Rept. No. UILU-ENG-79-2016, 312 pp (Aug 1979)
PB80-134810

Key Words: Nonlinear systems, Statistical analysis, Seismic excitation, Earthquake response

The dynamic response of single degree of freedom nonlinear systems subjected to earthquake motions is considered with the purpose of deriving factors for constructing inelastic design spectra, and of evaluating the effect of damping combined with inelastic behavior and the influence of the type of material nonlinearity on inelastic response.

80-2108

Identification of One-Dimensional Model for a Soil-Layered-Bedrock System During an Earthquake

M. Tomizawa

Dept. of Architectural Engrg., Science Univ. of Tokyo, Noda City, Japan, Intl. J. Earthquake Engr. Struc. Dynam., 8 (3), pp 251-265 (May/June 1980) 7 figs, 2 tables, 15 refs

Key Words: Seismic excitation, Ground motion, Statistical analysis, System identification techniques

The propriety of adopting a multi-degree-of-freedom lumped mass-spring-dampers system driven by white noise support excitation as a one-dimensional model for a soil-layer-bedrock system during an earthquake is investigated by means of statistical system identification of the model with noisy measuement of the earthquake ground velocity.

80-2109

Seismic Torsional Provisions for Dynamic Eccentricity

W.K. Tso and K.M. Dempsey

Dept. of Civil Engrg. and Engrg. Mechanics, McMaster Univ., Hamilton, Ontario, Canada, Intl. J. Earthquake Engr. Struc. Dynam., 8 (3), pp 275-289 (May/June 1980) 17 figs, 13 refs

Key Words: Buildings, Seismic design, Torsional response, Seismic response spectra, Standards and codes, Earthquake response

A study is made of the dynamic torsional response of a single mass partially symmetric system to ground excitation. Using the response spectrum technique, the torsional response and dynamic eccentricity are determined as functions of the eccentricity of the system and its uncoupled frequency ratio. It is shown that the dynamic eccentricity can best be expressed as a bilinear function of eccentricity.

80-2110

EASY-ACLS Dynamic Analysis. Volume I. Component Mathematical Models

M.K. Wahi, G.S. Duleba, J.R. Kilner, and P.R. Perkins
Airplane Development, Boeing Aerospace Co., Seattle, WA, Rept. No. AFFDL-TR-79-31-5-VOL-1, 246 pp (Sept 1978)
AD-A080 634/9

Key Words: Air cushion landing systems, Structural members, Computer programs

Mathematical models were developed for a variety of Air Cushion Landing System components which include aircraft flight model components, wind, engine and air flow components, inelastic-elastic-trunk and cushion, air bag skid and arresting gear model components etc. The models were developed for utilization in the EASY-ACLS dynamic analysis computer program simulation.

80-2111

EASY-ACLS Dynamic Analysis. Volume III. Description of Simulations

M.K. Wahi, P.R. Perkins, G.S. Duleba, and J.R. Kilner
Military Airplane Development, Boeing Aerospace Co., Seattle, WA, Rept. No. AFFDL-TR-79-3105-VOL-3, 354 pp (Sept 1979)
AD-A080 489/8

Key Words: Air cushion landing systems, Landing, Simulation

The development, results, and conclusions of EASY Air Cushion Landing Systems dynamic simulations are described. These consist of free flight, drop test, landing approach-touchdown-slideout, and takeoff roll-rotation-climbout of the Jindivik RPV and the XC-8A. Also included as examples are an air bag skid simulation and an arresting gear simulation.

80-2112

Seismic Wave Analysis of Underground Nuclear Explosions

R. Butler, L.J. Ruff, R.S. Hart, and G.R. Mellman
Sierra Geophysics Inc., Arcadia, CA, Rept. No. SGI-R-79-011, 81 pp (Nov 1979)
AD-A079 615/1

Key Words: Nuclear explosions, Underground explosions, Time domain method, Seismic waves, Wave propagation

An application of the methods of time domain seismology to the observed short period P-waves from underground explosions is presented. Goals were to obtain better estimates of the variation of short period seismic attenuation across the continental United States, evaluate the influence of different source regions on teleseismic P-wave amplitudes and waveforms, quantify the concepts of station/receiver transparency, and develop the initial states of a waveform inversion technique for both source discrimination and source description applications.

VIBRATION EXCITATION

80-2113

Nonlinear Oscillations and Boundary-Value Problems for Hamiltonian Systems

F.H. Clarke and I. Ekeland
Mathematics Research Center, Wisconsin Univ., Madison, WI, Rept. No. MRS-TSR-2001, 26 pp (Sept 1979)
AD-A079 736/5

Key Words: Boundary value problems, Hamiltonian functions, Periodic response

A particular class of motions of interest for Hamilton's differential equations are the periodic ones, which correspond to oscillations (vibrations) of the underlying physical system; the absence of such motions is usually associated with resonance phenomena. Conditions on the Hamiltonian function H which guarantee the existence of periodic orbits, as well as other more general types of motions are given.

80-2114

A New Method of Determining Regions of Instability of a System with Parametric Excitations

T. Kotera
Faculty of Engrg., Kobe Univ., Rokko-dai, Nada, Japan, Bull. JSME, 23 (117), pp 419-424 (Mar 1980) 5 figs, 9 refs

Key Words: Vibrating structures, Parametric excitation, Variable material properties, Stability

Vibrations of a system with periodically variable coefficients are treated and a new method of determining regions of instability is presented. A solution of such a system is introduced according to Lyapunov's theorem.

80-2115

Vibration Analysis of Continuous Systems by Dynamic Discretization

B. Downs
Dept. of Mech. Engrg., Loughborough Univ. of Tech., Loughborough, Leicestershire, UK, J. Mech. Des., Trans. ASME, 102 (2), pp 391-398 (Apr 1980) 3 figs, 5 tables, 17 refs

Key Words: Continuous beams, Beams, Transverse shear deformation effects, Rotatory inertia effects, Lumped parameter methods, Vibration response

An equivalent mass matrix may be defined, for a segment of a continuous system, as one which retains precisely the dynamic properties of the original segment in discretized form. Dynamic Discretization, which makes use of a particular form of Stodola iteration, progressively generates the equivalent mass matrix in ascending powers of frequency squared, while simultaneously generating deformation functions in a similar power series. The method is quasi-static and readily copes with shear deformation, rotary inertia and quite complex segment geometry. Accurate vibration analysis in terms of frequencies, mode shapes and corresponding stress distributions is achieved using an extremely coarse system subdivision for a variety of geometries.

80-2116

Proximity Spectra of Oscillators under Random Excitation

S.F. Masri
Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA 90007, J. Mech. Des., Trans. ASME, 102 (2), pp 329-337 (Apr 1980) 13 figs, 20 refs

Key Words: Random excitation, Oscillators, Mean square response

The transient mean-square response of an uncoupled two-degree-of-freedom system under spatially correlated non-stationary random excitation is determined. The excitation is modulated white noise with an intensity function that resembles the envelopes of typical earthquakes.

80-2117

Multi-Harmonic Response in the Regions of Instability of Harmonic Solution in Multi-Degree-of-Freedom Non-Linear Systems

W. Szemplińska-Stupnicka and J. Bajkowski
Institute of Fundamental Technological Research, Polish Academy of Sciences, 00-049 Warsaw, Swietokrzyska 21, Poland, Intl. J. Nonlin. Mech., 15 (1), pp 1-11 (1980) 7 figs, 15 refs

Key Words: Vibrating structures, Harmonic excitation

New results on the response of the multi-degree-of-freedom non-linear vibrating systems subject to harmonic excitation are presented. New combination type regions of instability of harmonic solution of the first order have been found theoretically and by the aid of an analog computer.

80-2118

Stability of Modes for a Class of Non-Linear Planar Oscillators

G. Pecelli and E.S. Thomas
Dept. of Mathematics, Hunter College, The City Univ. of New York, NY 10021, Intl. J. Nonlin. Mech., 15 (1), pp 57-70 (1980) 13 figs, 14 refs

Key Words: Vibration response, Non linear theories, Oscillators

Stability properties of some periodic orbits of a class of planar oscillators realized by a mass attached to two supports by identical cubic non-linear springs are studied. For some configurations the analysis is complete, while for other configurations there are infinitely many 'energy zones of stability' as the energy of the system tends to a critical value.

80-2119

Sensible Display of Power Spectral Density Information

W.D. Everett
Pacific Missile Test Center, Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 200-206, 4 figs

Key Words: Graphic methods, Random vibration, Power spectra

Reasons for graphically displaying random vibration Power Spectral Density (PSD) data in a linear rather than logarithmic format are presented. In the paper the author identifies some of the errors that the logarithmic formatting promotes; proposes a rationale for determining a linear format; and requests that random vibration analysis community adopt some uniform format, incorporating linear scales, for PSD presentation.

80-2120

Accurate Reduction of Stiffness and Mass Matrices for Vibration Analysis and a Rationale for Selecting Master Degrees of Freedom

B. Downs
Dept. of Mech. Engrg., Loughborough Univ. of Tech., Loughborough, Leicestershire, UK, J. Mech. Des., Trans. ASME, 102 (2), pp 412-416 (Apr 1980) 5 figs, 1 table, 15 refs

Key Words: Eigenvalue problems, Matrix reduction method, Vibration response

A method is described which permits the reduction of stiffness and mass matrices on to selected degrees of freedom, while accurately retaining, up to a certain cut-off frequency, the dynamic characteristics of the original matrices. The validity of the method is demonstrated by obtaining identical results, for the reduction of a simple system, with those derived from a rigorous solution.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 2049, 2173)

80-2121

A Simulation Method for the Torsional Vibration Waveform of a Crankshaft with a Rubber Damper

K. Wakabayashi, T. Nikura, and A. Yamamoto
Kokushikan Univ., Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 21-31, 15 figs, 4 tables, 7 refs

Key Words: Dampers, Elastomeric dampers, Crankshafts, Torsional vibration

A simulation method of torsional vibration waveform of a crankshaft with a rubber damper using transition matrices is described, in which the dynamic characteristics of the rubber are considered. The rubber part of the damper is replaced with a Voigt model. The empirical formulae, in which the dynamic stiffness and the damping are related to strain rate by experimental work, are adopted, in order to decide the representative values of the stiffness and the damping for one cycle.

80-2122

A Study on Damping Capacity of a Jointed Cantilever Beam (2nd Report: Comparison between Theoretical and Experimental Values)

N. Nishiwaki, M. Masuko, Y. Ito, and I. Okumura
Tokyo Univ. of Agriculture and Tech., Koganei-City, Tokyo, Japan, Bull. JSME, 23 (117), pp 469-475 (Mar 1980) 11 figs, 2 refs

Key Words: Damping, Machine tools, Beams, Cantilever beams

Relationships between the slip ratio and the damping capacity of the damping joint in large machine tools have been theoretically investigated, considering the first and second modes of vibration of the jointed cantilever beams used in the previous study. A comparison between the experimental and the theoretical values confirmed that the damping capacity of a jointed cantilever beam can be estimated by the proposed method.

80-2123

Vibrations of Immiscible Liquids with an Application to a New Damper of Satellite Booms (Schwingungen nichtmischbarer Flüssigkeiten mit Anwendung auf einen neuen Dämpfer f. Satellitenausleger)

H.F. Bauer
Fachbereich Luft u. Raumfahrttechnik, Hochschule der Bundeswehr München, Munich, Germany, Ing. Arch., 49 (2), pp 119-136 (1980) 9 figs, 9 refs
(In German)

Key Words: Dampers, Hydraulic dampers, Spacecraft antennas, Test models

The dissipation of energy in satellite antennas and booms is increased through a liquid damper consisting of a small

liquid container at the tip of the boom, filled with two immiscible liquids. The theory of liquid motion in an arbitrary annular cylindrical sector container is derived. The mathematical-mechanical model for a circular cylinder container is presented and introduced into the beam equation. Theoretical and experimental results exhibit the effectiveness of such a satellite boom damper.

80-2124

A Method of Damping Synthesis from Substructure Tests

L. Jezequel

Dept. of Mech. Engrg., Ecole Centrale de Lyon, Lyon, France, J. Mech. Des., Trans. ASME, 102 (2), pp 286 294 (Apr 1980) 6 figs, 3 tables, 15 refs

Key Words: Substructuring methods, Modal synthesis, Damping

A modal synthesis technique which uses two types of normal modes and a new orthogonalization of measured modes based on the Ritz-Galerkin method is proposed. A real damping synthesis in the case of damped plate assembly is given.

80-2125

Vibration of Composite Structures

C W. Bert

School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Okalahoma, Norman, OK 73019, Rept. No. OU-AMNE-80-6

Key Words: Damping coefficients, Stiffness coefficients, Composite materials, Beams, Bars, Rings, Panels, Shells

The topics of dynamic stiffness and damping of composite materials, beams and curved bars and rings, flat panels, and cylindrically curved panels and shells are surveyed, concluding with some suggestions for future research.

80-2126

On the Damping of a Vibrating Grid in a Viscous Medium: the Possible Basis for an Electrostatic Viscometer

M I. Morrell, M. Sahraoui-Tahar, and P.V.E. McClintock

Dept. of Physics, Univ. of Lancaster, Lancaster, UK, J. Phys. E. (Sci. Instr.), 13 (3), pp 350-354 (Mar 1980) 5 figs, 10 refs

Key Words: Viscometers, Vibrating structures, Measuring instruments

The damping of a tightly stretched circular nickel grid vibrating at a few kHz in air, in gaseous ^{4}He, in liquid HeI and in liquid HeII is investigated.

FATIGUE

(Also see Nos. 2014, 2034, 2059, 2060, 2148)

80-2127

The Hypothesis of Shear Stress Intensity-Elaboration and Experimental Basis for a New Strength Hypothesis for Vibrating Loads (Schubspannungsintensitatshypothese - Erweiterung und experimentalle Abstützung einer neuen Festigkeitshypothese für schwingende Beanspruchung)

H. Zenner, R. Heidenreich, and I. Richter

Industrieanlagen - Betriebsgesellschaft mbH, Ottobrunn, Germany, Konstruktion, 32 (4), pp 143-152 (Apr 1980) 12 figs, 1 table, 39 refs

(In German)

Key Words: Fatigue life, Steel, Computer programs

The application of shear stress intensity hypothesis for the calculation of fatigue life of ductile materials under complex multiaxial loads is investigated for other types of loads. In addition to the effect of a phase shift between normal and shear stress, the effect of various frequencies and nonsinusoidal excitation-time processes for the heat treatable 34 Cr 4 steel is examined. The spheroidal graphite iron GGG-60 was also investigated.

80-2128

Design and Operation of Multi-Specimen Fully Reversed Fatigue Systems for Advanced Composite Materials

G Waring, K E Hofer, Jr., I Brown, and R.E. Trabocco

IIT Research Inst., Chicago, IL 60616, Exptl. Mech.,

20 (5), pp 153-161 (May 1980) 11 figs, 2 tables, 24 refs

Key Words: Composite materials, Fatigue tests

An experimental system is described designed to investigate the static compressive strengths of high-strength graphite/epoxy composite sandwich structures with various defects, after exposure to combined moisture-saturation and elevated-temperature in the presence of fatigue stress cycling.

ELASTICITY AND PLASTICITY

80-2129

Dynamic Deformation Processes of Elastic-Plastic Systems

K. Gröger, J. Nečas, and L. Trávniček
Zentralinstitut f. Math. u. Mech. d. Akad. d. Wissenschafrten d. DDR, DDR 108 Berlin, P. Mohren str. 39, Z. angew. Math. Mech., 59 (10), pp 567-572 (1979)

Key Words: Elastic plastic properties, Dynamic response

The behavior of elastic-plastic systems is described by models that make use of internal state variables and internal forces. It is proved an existence-uniqueness result with respect to displacements, strains, stresses, internal state variables and internal forces, and it is shown that these values depend continuously on initial values and external forces.

80-2130

Dynamic Shakedown in Elastic-Plastic Bodies

G. Ceradini
Faculty of Engrg., Univ. of Rome, Italy, ASCE J. Engr. Mech. Div., 106 (EM3), pp 481-499 (June 1980) 3 figs, 23 refs

Key Words: Dynamic shakedown, Elastic plastic properties

Definition and methods for determining the safety factor for dynamic shakedown are examined; in the case of periodic actions, linear and nonlinear programming procedures can be formulated. The influence of damping is also considered. The paper is a review of the basic work done in this field.

80-2131

Dynamic Response of an Elastic-Viscoplastic System in Modal Co-Ordinates

P. Likkunaprasit, S. Widartawan, and P. Karasudhi
Dept. of Civil Engrg., Chulalongkorn Univ., Bangkok, Thailand, Intl. J. Earthquake Engr. Struc. Dynam., 8 (3), pp 237-250 (May/June 1980) 9 figs, 2 tables, 22 refs

Key Words: Elastic properties, Viscoplastic properties, Buildings, Multi-story buildings, Seismic response

A dynamic analysis of elastic-viscoplastic systems, incorporating the modal coordinate transformation technique, is presented. The formulation results in uncoupled incremental equations of motion with respect to the modal coordinates. The elastic-viscoplastic model adopted allows the analysis not to involve yielding regions and loading/unloading processes. An implicit Runge-Kutta scheme together with the Newton-Raphson method are used to solve the non-linear constitutive equations.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see Nos. 2019, 2084, 2126, 2160, 2172)

80-2132

The Helmholtz Resonator as a High-Power Deep-Submergence Source for Frequencies Below 500 Hz

T.A. Henriquez and A.M. Young
Naval Research Lab., Underwater Sound Reference Detachment, P.O. Box 8337, Orlando, FL 32856, J. Acoust. Soc. Amer., 67 (5), pp 1555-1558 (May 1980) 8 figs, 2 refs

Key Words: Helmholz resonators, Underwater sound

The use of the Helmholtz resonator in low-frequency underwater acoustic applications is discussed. Specific design parameters and their effect on acoustic performance are addressed. A design example is used in the analysis.

80-2133

Ultrasonic Spectrum Analysis Using Frequency-Tracked Gated rf Pulses

J.H. Cantrell, Jr. and J.S. Heyman

NASA-Langley Research Center, Hampton, VA 23665, J. Acoust. Soc. Amer., 67 (5), pp 1623-1628 (May 1980) 7 figs, 14 refs

Key Words: Spectrum analysis, Ultrasonic techniques

A new method of ultrasonic frequency analysis is introduced which employs frequency-tracked gated rf drive pulses rather than shock-excited broadband spikes to generate the ultrasonic waveform and eliminates problems associated with finite pulse widths of conventional methods.

80-2134

Holographic Interferometric Metrology. Part 1: Displacement Measurement: The Quantitative Basis System. (Holografisch-Interferometrische Messtechnik. Teil 1: Verschiebungsmessung: Das quantitative Basis System)

H. Kohler

FH Giessen-Friedberg, Fachbereich MND, Wiesenstr. 14, D-6300 Giessen 1, Germany, Techn. Messen TM, 47 (1), pp 59-69 (Feb 1980) 10 figs, 14 refs

(In German)

Key Words: Interferometers, Holographic techniques, Measurement techniques, Vibration measurement

In this three-part article the holographic interferometric techniques are evaluated. The techniques produce visible interference fringes which can be used to measure the three vectors due to rotation, translation and/or loading of the object. The vibration measurement relies heavily on the time average method but, for comparison, it is extended to real-time and pulse techniques.

80-2135

Holographic-Interferometric Metrology. Part 2: Displacement Measurement: Methods and Examples (Holografisch-Interferometrische Messtechnik. Teil 2: Verschiebungsmessung: Abgeleitete Verfahren und Biespiele)

H. Kohler

FH Giessen-Friedberg, Fachbereich MND, Wiesenstr. 14, D-6300 Giessen 1, Germany, Techn. Messen-TM, 47 (3), pp 83-92 (Mar 1980) 15 figs, 3 tables, 46 refs

(In German)

Key Words: Interferometers, Holographic techniques, Measurement techniques, Vibration measurement

In this three-part article the holographic interferometric techniques are evaluated. The techniques produce visible interference fringes which can be used to measure the three vectors due to rotation, *translation and/or loading of the* object. The vibration measurement relies heavily on the time average method but, for comparison, it is extended to real-time and pulse techniques.

80-2136

Holographic-Interferometric Metrology. Part 3: Vibration Measurement (Holografisch-Interferometrische Messtechnik. Teil 3: Schwingungsmessung)

H. Kohler

FH Giessen-Friedberg, Fachbereich MND, Wiesenstr. 14, D-6300 Giessen 1, Germany, Techn. Messen. TM, 47 (4), pp 147-153 (Apr 1980) 7 figs, 19 refs

(In German)

Key Words: Interferometers, Holographic techniques, Measurement techniques, Vibration measurement

In this three-part article the holographic interferometric techniques are evaluated. The techniques produce visible interference fringes which can be used to measure the three vectors due to rotation, translation and/or loading of the object. The vibration measurement relies heavily on the time average method but, for comparison, it is extended to real-time and pulse techniques.

80-2137

An Investigation of the Close Proximity Vehicle Noise Survey Method

F. Augusztinovicz and B. Buna

Research Inst. for Road Transport, 1502 Budapest, Pf. 107, Hungary, Noise Control Engr., 14 (2), pp 79-87 (Mar/Apr 1980) 13 figs, 1 table, 11 refs

Key Words: Motor vehicle noise, Noise measurement, Measurement techniques, Measuring instruments

A close proximity surveying method for simple, short and repeatable measurements for everyday control of noise emission of vehicles was developed by ISO. This method is examined and it was found that although the measurements are carried out in the near field of one of the major noise sources of the automobile, meaningful results could be obtained.

80-2138

Development of an Exterior Sound Level Measurement Procedure for Light Motor Vehicles - SAE J986

R.K. Hillquist

General Motors Proving Ground, SAE Paper No. 800440, 10 pp, 3 figs, 7 refs

Key Words: Measurement techniques, Noise measurement, Acoustic emission, Cars, Trucks, Standards and codes

The history of the development of SAE Standard J986 "Sound Level for Passenger Cars and Light Trucks" and its subsequent revisions is presented. The major issues considered and the rationale for the compromises and decisions made in this development process are discussed. This standard has been a major factor in the measurement and regulation of light motor vehicle sound emissions since its first approval in 1967.

80 2139

Modal Analysis of Gas Turbine Buckets Using a Digital Test System

H.A. Nied

Gas Turbine Div., General Electric Co., Schenectady, NY, J. Engr. Power, Trans. ASME, 102 (2), pp 357-368 (Apr 1980) 25 figs, 2 tables, 14 refs

Key Words: Turbine components, Modal analysis, Fourier analysis, Digital techniques

A modal analysis was conducted on gas turbine buckets using a digital Fourier analyzer. This digital test/computer system measures a set of frequency response functions for broadband impulse excitation at successive locations on the bucket airfoil. From the set of frequency response functions, the analyzer computes the modal parameters used to determine the natural frequencies, critical damping ratio and mode shapes of the turbine buckets.

80-2140

Theory of Guided Acoustic Waves in Piezoelectric Solids

S. Datta

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 78 pp (1979)
UM 8009012

Key Words: Transducers, Piezoelectric transducers, Elastic waves, Piezoelectricity

A non-iterative variational technique for solving the acoustic field equations is applied to three different boundary conditions; namely, a free surface, an edge and a surface with periodic discontinuities. A perturbation approach to surface wave scattering by periodic discontinuities is also developed and used to obtain both the elastic and the piezoelectric scatter matrix of a single electrode in a periodic array directly from the material parameters of the substrate and the electrodes. This scatter matrix accurately predicts the response of surface wave filters, transducers and reflectors.

80-2141

Theory of the Vibrating Capacitor for Displacement Measurement

B.L. Weszicha and R.E. Miles

Univ. of Leeds, Leeds LS2 9JT, UK, J. Phys. E. (Sci. Instr.), 13 (4), pp 406-408 (Apr 1980) 3 figs, 1 table, 3 refs

Key Words: Transducers, Displacement transducers, Measuring instruments, Vibration measurement

The equation of state for the vibrating capacitor has been solved for the case of a decaying vibration with $\omega RC \ll 1$. If the equilibrium separation of the capacitor plates is d_0 and the amplitude of vibration is d_1, the solution was shown to be valid for d_1/d_0 values of up to 0·64 by comparison with experimental data obtained using a continuous wave signal. Amplitude nonlinearity is evident for large values of d_1/d_0, the deviation from linearity at $d_1/d_0 = 0{\cdot}1$ being 2%.

DYNAMIC TESTS

80-2142

The Vibration Test Unit Control and Computer System

R.O. Coupland and A.J. Nintzel

Wyle Labs., Colorado Springs, CO, Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 207-211, 4 figs

Key Words: Test equipment and instrumentation, Interaction: rail-vehicle, Railroad trains, Suspension systems (vehicles), Natural frequencies, Computer simulation

The Vibration Test Unit (VTU) is described, which is designed to vibrate a railcar to simulate the action of track/

train dynamics using a hydraulic shaker system. Studies of suspension characteristics, rock and roll tendencies of rail vehicles, component and vehicle natural frequencies, ride comfort, lading responses, and simulation of full scale vehicle loads can be achieved on the VTU.

80-2143

Servo Hydraulics Vibration to 2,000 HZ

L.D. Isley

Ling Electronics, Inc., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12 14, 1980, Philadelphia, PA, pp 110-112, 5 figs

Key Words: Vibration tests, Test equipment and instrumentation, High frequencies

Technology for high frequency vibration is presented and two successful applications are analyzed, using fully operational servo hydraulic systems capable of providing sine or random testing to 2,000 Hz.

80-2144

Construction of a Large High Intensity Reverberation Facility

O.H. Moore, Jr.

General Dynamics Convair Div., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 162-164, 7 figs

Key Words: Test facilities, Acoustic tests, Missiles

A high intensity acoustic noise testing facility for a 22-ft long cruise missile for over 1,000 hours exposure is described.

80 2145

A Low Cost Pneumatic Vibration System

W. Silver, E. Szymkowiak, and H. Caruso

Westinghouse Electric Corp., Baltimore, MD, Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 97-100, 9 figs, 3 refs

Key Words: Vibrators (machinery), Vibration tests, Test equipment and instrumentation

A modulated pneumatic vibrator for vibration test screening is described. It produces the continuous broadband excitation required for effective screening at very low cost and with a high degree of safety.

80-2146

Head to Head vs Single Ended Shaker Excitation for Flat Plate Fixtures

E. Szymkowiak, W. Silver, and H. Caruso

Westinghouse Electric Corp., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 187-189, 4 figs, 3 refs

Key Words: Testing techniques, Shakers, Plates

This presentation discusses the most basic constraints of horizontal fixtures with both single ended and head to head excitation. Particular emphasis is placed on the maximum length with a reasonably flat frequency response. The paper describes simple experiments which demonstrate the limitations.

80-2147

Algorithms for Decoupling Vibratory Modes (Algorithmes de Decouplage Modes Vibratoires)

Centre Technique des Industries Mecaniques, Senlis, France, Rept. No. CETIM-1-1E-24-0, 81 pp (Feb 1979)

N80-17788

(In French)

Key Words: Test equipment and instrumentation, Normal modes

An algorithmic study of the decoupling of vibratory modes on a SAVIEM test rig is presented. Inconclusive results from the study are examined including a lack of accuracy in frequency measurement at the experimental stage, an insufficient number of measurement points, a highly nonlinear response to amplitude variations at the test rig, and the lack of an acceptable data smoothing procedure.

80-2148

Fatigue Strength Testing Employed for Evaluation and Acceptance of Jet-Engine Instrumentation Probes

E.C. Armentrout

Lewis Research Center, NASA, Cleveland, OH, Rept. No. NASA-TM-81402; E-313, 25 pp (1980)

N80-17422

Key Words: Test equipment and instrumentation, Fatigue tests, Jet engines

The fatigue type testing performed on instrumentation rakes and probes intended for use in the air flow passages of jet engines during full scale engine tests is outlined. A discussion of each type of test performed, the results that may be derived and means of inspection is included.

80-2149

Motorcycle Test-Rig with Multiaxial Load Input for a Service Like Simulation (Motorradprufstand zur wirklichkeitsnahen Simulation von Fahrbetriebsbeanspruchungen)

E. Alschweig and S. Angerer

Kirchweg 5, 6109 Mühltal 3, Automobiletech. Z., 82 (3), pp 135-137 (Mar 1980) 4 figs

(In German)

Key Words: Test stands, Motorcycles, Fatigue tests

A multiaxial test rig for fatigue testing of motorcycles is described. The loads are applied in the longitudinal, side, and vertical directions of each wheel.

80-2150

Development of a Taped Random Vibration Technique for Acceptance Testing

G. Hirschberger, J.J. Popolo, J. Devitt, and R. Pokallus

Grumman Aerospace Corp., Bethpage, NY, Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 101-109, 9 figs, 2 tables

Key Words: Random excitation, Testing techniques

A technique for utilizing an audio tape deck to produce random force excitation is evaluated. A detailed procedure is presented delineating the steps required to construct a synthetic random tape and to employ this tape to conduct random vibration acceptance tests.

80-2151

Criteria for Accelerated Random Vibration Tests

R.G. Lambert

Aircraft Equipment Div., General Electric Co., Life Cycle Problems and Environmental Technology, Proc. of the 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA, pp 71-75, 4 figs, 2 tables, 3 refs

Key Words: Vibration tests, Random vibration, Testing techniques

The criteria for selecting the form of the input vibration level-duration relationship and assigning values to the parameters of laboratory accelerated test environments is presented.

80-2152

Dynamic Wave Propagation in a Single Lap Joint

L.W. Zachary and C.P. Burger

Dept. of Engrg., Science and Mechanics, Iowa State Univ., Ames, IA 50011, Exptl. Mech., 20 (5), pp 162-166 (May 1980) 4 figs, 12 refs

Key Words: Impact tests, Wave propagation, Joints (junctions), Photoelastic analysis

Dynamic photoelasticity was used to study the stresses when an impulse wave propagates through a single lap joint. Color photographs were used to simplify identification of the photoelastic fringe orders.

DIAGNOSTICS

80-2153

An Analytic Model for Ball Bearing Vibrations to Predict Vibration Response to Distributed Defects

L.D. Meyer, F.F. Ahlgren, and B. Weichbrodt

Corporate Research and Development, General Electric Co., Schenectady, NY, J. Mech. Des., Trans. ASME, 102 (2), pp 205-210 (Apr 1980) 9 figs, 1 table, 3 refs

Key Words: Bearings, Ball bearings, Diagnostic techniques, Alignment, Lagrange equations

An analytic method for predicting the spectral character of vibrations generated by an important class of defects in ball bearings is described. This family of bearing problems comprises those operating modes in which the magnitude of the ball-race contact force varies continuously and periodically as the bearing rotates. Defects of this type include race misalignment and off-sized rolling elements. The analytic technique is based on solving Lagrangian equations for the time-varying displacement of the bearing race in response to the rotating system of ball forces.

80-2154

Application of Data Dependent Systems to Diagnostic Vibration Analysis

S.M. Pandit, H. Suzuki, and C.H. Kahng

Mechanical Engrg. - Engrg. Mechanics Dept., Michigan Technological Univ., Houghton, MI 49931, J. Mech. Des., Trans. ASME, 102 (2), pp 233-241 (Apr 1980) 10 figs, 2 tables, 11 refs

Key Words: Diagnostic techniques, Monitoring techniques, Data dependent systems, Tools

Application of Data Dependent Systems (DDS) is proposed for diagnostic monitoring of vibrations. It is exemplified by monitoring tool wear via tool holder vibrations in a turning operation. Finite element analysis confirms and elucidates the physical significance of DDS results.

80-2155

The Analysis and Mechanism of Engine 'Crank Rumble'

S.A. Andrews and D. Anderton

British Leyland Cars, Birmingham, UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 99-109, 8 figs, 13 refs

Key Words: Engine noise, Failure analysis

An investigation of crank rumble in a petrol engine is described in which noise, vibration and cylinder pressure development were measured.

80-2156

Identification of Bearing Defects by Spectral Analysis

J.I. Taylor

Gardinier Inc., Tampa, FL, J. Mech. Des., Trans. ASME, 102 (2), pp 119-204 (Apr 1980) 6 figs, 1 table

Key Words: Bearings, Diagnostic techniques, Spectrum analysis

This paper describes procedures for identifying defects in antifriction bearings from analyses of the low frequencies (up to 2,000 Hz) generated by the moving parts in the bearing. Defects on bearing raceways, the cage, or rolling elements, as well as excessive clearance, turning on the shaft and loose housing, cause unique vibration signals. A unique signal is also generated when bearings need lubrication. The spectrum shape, frequency, amplitude, and sum and difference frequencies are useful in identifying combinations of defects and their size. Information as to whether the bearing is in a thrust or radial loaded condition is presented.

80-2157

Detection and Analysis of Near Surface Defects by Ultrasound

J. Zimper, A. Erhard, E. Mundry, and H. Wüstenberg

Bundesanstalt f. Materialprufung, Unter den Eichen 87, 1000 Berlin 45, Germany, Techn. Messen TM, 47 (3), pp 107-111 (Mar 1980) 8 figs, 13 refs (In German)

Key Words: Holographic techniques, Acoustic holography, Measuring instruments, Diagnostic techniques

A method for the detection of near surface defects by use of creeping longitudinal-wave probes is presented. The creeping waves are more independent from disturbance factors as surface roughness, liquid drops or drops of welding material. Several techniques for the analysis of detected surface defects are used. They are: the acoustical holography in shadow-technique, focusing probes in tandem-technique and the so called scattering technique.

80-2158

The Reflection of Ultrasonic Pulses from Surfaces

N.F. Haines and D.B. Langston

Berkeley Nuclear Labs., Berkeley, Gloucestershire, UK, GL13 9PB, J. Acoust. Soc. Amer., 67 (5), pp 1443-1454 (May 1980) 25 figs, 7 refs

Key Words: Ultrasonic techniques, Testing techniques, Failure analysis

A diffraction-model is developed which successfully accounts for the experimentally observed reflections of ultrasonic pulses from a variety of surfaces. The equations describing reflection in the frequency domain essentially predict the complex frequency spectra of pulses reflected from surfaces of various geometries: by Fourier transforming them, expressions describing the actual pulse waveforms reflected from the surfaces have been obtained. The predicted effects of surface roughness, size, shape, and defect orientation on both the reflected pulse waveform and its frequency spectrum are confirmed by experiment.

80-2159

Tracking Down Problems in Centrifugal Pumps

S. Yedidiah

Worthington Pump Corp., East Orange, NJ, Mach. Des., 52 (10), pp 94-100 (May 8, 1980) 5 figs

Key Words: Pumps, Centrifugal pumps, Diagnostic techniques, Failure detection

A method for identifying the underlying cause of centrifugal pump failures is presented. Among the most common sources of problems are air in the liquid, high temperatures, vibration, and damaged pump parts.

MONITORING

(Also see No. 2154)

80 2160

Engine Analyzer Makes Key Predictive-Maintenance Tool

W.W. Graham

Mobil Oil Corp., Chickasha, OK, Oil Gas J., 78 (10), pp 75-80 (Mar 10, 1980) 19 figs

Key Words: Monitoring techniques, Vibration analyzers, Reciprocating engines

A program based on two types of analyzers, the maintenance analyzer and a performance analyzer, is described. The maintenance analyzer has three methods of detecting problems in reciprocating machinery. Its basic components are the crank angle transducer, the signal conditioner, and the oscilloscope. It can show the vibration pattern of the working components of power cylinders or of compressor cylinders while in operation; and an ignition pattern to check the functioning of the ignition system of each cylinder. Performance analyzer performs all the functions of the maintenance analyzer plus pressure-volume and determination of indication horsepower.

80-2161

Signature Analysis for Mechanical Systems via Dynamic Data System (DDS) Monitoring Technique

S.M. Wu, T.H. Tobin, Jr., and M.C. Chow

Dept. of Mechanical Engrg., University of Wisconsin, Madison, WI, J. Mech. Des., Trans. ASME, 102 (2), pp 217-221 (Apr 1980) 7 figs, 7 refs

Key Words: Monitoring techniques, Dynamic Data System technique, Signature analysis, Statistical analysis, Motors

A new modeling technique called Dynamic Data System (DDS) is introduced for signature analysis. A one-horsepower electric motor experiment is used to demonstrate the methodology. The 'normal' operation is simulated by idling runs and eccentric loads representing the 'defective' operations. A DDS Monitoring Technique, by employing statistical quality control theory, is developed to monitor the operations of imposed electric motor defects.

80-2162

Time Domain Analysis of Machinery Vibration Signals Using Digital Techniques

G.D. Xistris, G.K. Boast, and T.S. Sankar

Dept. of Mechanical Engrg., Concordia Univ., Montreal, Canada, J. Mech. Des., Trans. ASME, 102 (2), pp 211-216 (Apr 1980) 10 figs, 20 refs

Key Words: Monitoring techniques, Signal processing techniques, Time domain method, Machinery vibration, Internal combustion engines

The design and implementation of a general purpose processing system to analyze machinery vibration signals in the time domain are presented. The system comprises a data acquisition stage, where analog signals having a maximum frequency content up to 4 kHz and a dynamic range up to 72 dB, are converted into digital form and a processing stage, where modular software algorithms are employed to perform specific operations in an interactive environment. Processing capabilities encompass scaling, integration and the computation of statistical parameters such as means, RMS, standard deviation, maximum and minimum values. The performance of the system in processing acceleration signals from a 3 HP, 14,000 RPM internal combustion engine is demonstrated and the different application aspects of such a facility in the machinery maintenance field are outlined.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see Nos. 2082, 2083, 2106, 2113, 2114, 2115 2116, 2117, 2118, 2119, 2120, 2131)

80-2163

Normal Mode Uncoupling of Systems with Time Varying Stiffness

M. Benton and A. Seireg
Engrg. R & D Div., E.I. DuPont, Wilmington, DE 19898, J. Mech. Des., Trans. ASME, 102 (2), pp 379-383 (Apr 1980) 3 figs, 1 table, 8 refs

Key Words: Time-dependent parameters, Stiffness coefficients, Parametric vibrations, Multi-degree of freedom systems, Gears, Normal modes

This paper investigates the conditions for transforming coupled systems with time-varying stiffness to normal mode coordintes. The stability regions are determined from the normal mode equations and the effect of model damping on the width of these regions is investigated. An approximate method for uncoupling is also presented which can be used to give good practical solutions in situations where the theoretical necessary conditions are not met. The proposed method can provide a simple and effective tool for the analysis of parametric vibrations for systems with any number of degrees of freedom as in the case of high speed gear trains.

80-2164

The Application of Ritz Averaging Method to Determining the Response of Systems with Time Varying Stiffness to Harmonic Excitation

M. Benton and A. Seireg
Engrg. R & D Div., E.I. DuPont, Wilmington, DE 19898, J. Mech. Des., Trans. ASME, 102 (2), pp 384-390 (Apr 1980) 3 figs, 1 table, 9 refs

Key Words: Time-dependent parameters, Stiffness coefficients, Parametric vibrations, Harmonic excitation, Ritz method, Gears

Parametric vibrations occur in many mechanical systems such as gears where the stiffness variation and external excitations generally occur at integer multiples of the rotational speed. This paper describes a procedure based on the Ritz Averaging Method for developing closed form solutions for the response of such systems to harmonic excitations.

80-2165

Approximate Dynamic Analysis of Crossflow Heat Exchanger by the Method of Weighted Residuals

H. Terasaka, H. Kanoh, and M. Masubuchi
Inst. for Atomic Energy, Tokyo Shibaura Electric Works, Japan, Bull. JSME, 23 (117), pp 423-438 (Mar 1980) 6 figs, 7 refs

Key Words: Heat exchangers, Approximation methods, Method of weighted residuals

Approximate lumped parameter models by the method of Weighted Residuals (MWR) are given for a cross flow heat exchanger and compared favorably with the Finite Difference Method (FDM). Two kinds of weighting functions are considered: trial function itself and delta function. Several numerical examples show that the FDM model must be a considerably higher order to secure the same accuracy as the MWR model to simulate the static and dynamic characteristics.

MODELING TECHNIQUES

(Also see Nos. 1982, 2069, 2074, 2169)

80-2166

Modeling and Experimental Analysis of a Fluidic Generator

C.F. Tacey, F.E. Verrier, L.R. Wood, L.D. Mitchell, and H.A. Kurstedt
Engrg. Dept., E.I. DuPont de Nemours and Co., Inc., Wilmington, DE 19898, J. Mech. Des., Trans. ASME, 102 (2), pp 222-232 (Apr 1980) 15 figs, 6 tables, 28 refs

Key Words: Electric power plants, Lumped parameter method

The mechanical portion of a fluidic generator, a device that converts air flow into electrical power, is modeled for its dynamic characteristics so that optimization of the power output may be attained through mechanical system modification. A regression analysis is carried out on experimentally obtained data to allow specific definition of defects in the analytic model. A lumped parameter mechanical network is

used to model the system. Structural inertia, stiffness, viscous damping, and internal structural damping models are used to model a corrugated diaphragm, a connecting rod, coupling nuts, and a cantilever laminated reed. Special attention is given to the modeling of the corrugated diaphragm laminated reed.

STATISTICAL METHODS

(Also see No. 2107)

80-2167

Statistical Analysis of the Response of Non-Linear Systems Subjected to Earthquakes

R. Riddell

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 312 pp (1979)

UM 8009144

Key Words: Statistical analysis, Nonlinear systems, Single degree of freedom systems, Seismic response

The dynamic response of single degree of freedom nonlinear systems subjected to earthquake excitations is considered with the purpose of reviewing previous recommendations for deriving inelastic design spectra, and to evaluate the effect of damping combined with nonlinear behavior and the influence of the type of material nonlinearity on inelastic response.

PARAMETER IDENTIFICATION

(Also see Nos. 2026, 2027, 2028, 2108)

80-2168

A New and Simplified Approach to Synchronous Machine Modeling and Parameter Identification Techniques

R.F.-H. Chu

Ph.D. Thesis, Univ. of Pennsylvania, 232 pp (1979)

UM 8009391

Key Words: Parameter identification technique, Synchronous motors

A new and simplified approach to synchronous machine modeling and parameter identification techniques is presented. The Park's classical model with one damper winding in each rotor axis is employed. Four simple experiments are designed to determine the values of the required parameters. Also presented is a simple scheme to measure the rotor angle, the direct and quadrature axis quantities. This scheme was employed and proves to provide consistent results.

80-2169

Parameter Estimation in Structural Dynamics Models

D.R. Martinez

Ph.D. Thesis, Univ. of California, Los Angeles, 294 pp (1979)

UM 8008900

Key Words: Parameter identification technique

A method is presented for the estimation of parameters in structural dynamics models. A detailed development of the filter and transformation equations is presented, followed by a discussion of the measurement noise characteristics for the practical case, as well as the simulated data used in the numerical study. Results are given for the several cases of an example problem, demonstrating the effectiveness of the method.

COMPUTER PROGRAMS

(Also see Nos. 2110, 2127)

80-2170

Nondestructive Evaluation of Airport Pavements. Volume III. Operation Manual for MLGPAV Program at TCC

D. Yang

Yang and Assoc., NY, Rept. No. FAA/RD-78/154-3, 48 pp (Sept 1979)

AD-A079 591/4

Key Words: Computer programs, Airports, Pavements, Nondestructive tests

Sensitivity analysis of aircraft parameters on functional pavement design is the primary goal of the MLGPAV program at the Transportation Computer Center (TCC) in Washington, D.C. The program is an integrated system which is data independent based on defined mathematical models and operational logic. The input data is divided into job and universal default inputs.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

80-2171

Noise and Vibration of Engines and Transmissions

Proceedings of a Conference held in July 1979 at the Cranfield Institute of Technology, Cranfield, UK. Sponsored by the Institution of Mechanical Engineers, Automobile Div., U.S. Distribution: SAE, $31.00.

Key Words: Power transmission systems, Engine noise, Engine vibration, Proceedings

Eighteen papers presented at this conference ranged from the fundamentals of vibration and noise generation to the practical assessment of techniques for the reduction of noise. Individual papers are abstracted in the appropriate sections of this issue of the DIGEST.

80-2172

Life Cycle Problems and Environmental Technology

Proc. of 26th Technical Meeting of the Institute of Environmental Sciences, May 12-14, 1980, Philadelphia, PA

Key Words: Testing techniques, Electronic test equipment, Environmental effects, Proceedings

The papers listed in these proceedings were presented at the meeting at six in-depth seminars on key life cycle issues, entitled: Critical Need for Environmental Integration: Specification, Design and Test; The Challenge of Environmental Test Tailoring for Electronic Hardware; Emerging Technology in Environmental Testing and Measurement; Contamination Control in Industry and Bioscience; Environmental Strategy and Economic Balance: Planning and Management to Cope with Today's Environmental Regulation; and The Growing Conflict between Energy Demands and Environmental Regulation. Individual papers pertinent to shock, vibration and noise technology are abstracted in the appropriate sections of this issue of the SHOCK AND VIBRATION DIGEST.

80-2173

Damping Effects in Aerospace Structures

Conf. Proc., Meeting of the AGARD Structures and Materials Panel (48th), 2-3 Apr 79, Williamsburg, VA, Rept. No. AGARD-CP-277, 200 pp (Oct 1979)
AD-A080 451/8

Key Words: Spacecraft, Damping effects, Composite structures, Joints (junctions), Elasticity theory, Proceedings

The objective of the Specialists' Meeting was to make available pertinent information and reliable rules to account for the effects of structural damping on problems of elastic stability. The most general aspects of structural damping were covered; physical roots, mathematical formulation, damping characteristics of aerospace structural components, effects on dynamic response, investigation of damping in composites and effects in joints.

TUTORIALS AND REVIEWS

(Also see No. 2009)

80-2174

Fundamental Knowledge of Gear Noise - A Survey

D.B. Welbourn
Wolfson Cambridge Industrial Unit, Univ. of Cambridge, UK, Noise and Vibration of Engines and Transmissions, Conf. Proc., Cranfield Inst. of Tech., Cranfield, UK, July 1979, Sponsored by IME, Automobile Div., pp 9-14, 6 figs, 34 refs

Key Words: Reviews, Gear noise

Since Opitz reviewed the problem of noise in gears in 1969, much fundamental work has been published. The importance of transmission error and its results are now clearly understood thanks to the work of Niemann and Baethge. The successful computer modeling by J.D. Smith of gear trains to include manufacturing tooth errors has brought clarity into the field of gear box dynamics and their effects on noise. The literature is reviewed.

80-2175

Shock in Solids: Army Materials Research and Applications

R. Shea and J.F. Mescall
Dept. of the Army, Army Materials and Mechanics

Research Center, Watertown, MA 02172, Shock Vib. Dig., 12 (5), pp 7-18 (May 1980) 12 figs, 3 refs

Key Words: Reviews, Shock response

The Army Materials and Mechanics Research Center and its assigned mission of managing and conducting the Army's technology base programs in structural materials and solid mechanics are discussed. The dynamic behavior of materials, especially to shock, forms an important part of these research efforts. Existing codes for predicting the shock response of solids are discussed as well as failure mechanisms and current research efforts - both experimental and numerical. The most recent work in this area is surveyed.

80-2176

Cross-Flow-Induced Instabilities of Circular Cylinders

S.S. Chen

Argonne National Lab., Argonne, IL, Shock Vib. Dig., 12 (5), pp 21-31 (May 1980) 4 figs, 6 refs

Key Words: Reviews, Cylinders, Fluid-induced excitation

Dynamic instability of circular cylinder arrays subjected to cross flow is reviewed. Instability mechanisms, different types of instability, mathematical models, empirical correlations for the critical flow velocity, and effects of various system parameters are discussed.

BIBLIOGRAPHIES

80-2177

Aircraft Sonic Boom: Effects on Buildings (Citations from the NTIS Data Base)

G.E. Habercom, Jr.

NTIS, Springfield, VA, Rept. No. PB80-806334, 82 pp (Mar 1980)

Key Words: Bibliographies, Buildings, Structural members, Sonic boom

Research findings are cited on the effects of sonic booms on buildings, structural components, forms, windows, and walls. Test-house investigations are included, along with damage analysis and vibration response. Documentation is made on residential buildings. Other topics contained in the volume range from theory to failure analysis.

AUTHOR INDEX

TECHNICAL NOTES

M. Kothari and A.C. Rao
Dynamic Synthesis of a Timing Device with Pulse Loading
J. Mech. Engrg. Sci., 21 (6), pp 453-455 (Dec 1979) 2 tables, 5 refs

P.T.D. Spanos
Formulation of Stochastic Linearization for Symmetric or Asymmetric M.D.O.F. Nonlinear Systems
J. Appl. Mech., Trans. ASME, 47 (1), pp 209-211 (Mar 1980) 2 figs, 6 refs

E.H. Dowell
Bounds on Modal Damping by a Component Modes Method Using Lagrange Multipliers
J. Appl. Mech., Trans. ASME, 47 (1), pp 211-213 (Mar 1980) 2 figs, 1 table, 6 refs

M. Tajuddin and K.S. Sarma
Torsional Vibrations of Poroelastic Cylinders
J. Appl. Mech., Trans. ASME, 47 (1), pp 214-216 (Mar 1980) 3 figs, 3 refs

R.C. Shieh
Effects of Strain-Hardening on Dynamic Responses of Elastic Viscoplastic Frames
J. Appl. Mech., Trans. ASME, 47 (1), pp 192-194 (Mar 1980) 1 fig, 7 refs

R.C. Higgins
The Utilization of Zero-Crossed Statistics for Signal Detection
J. Acoust. Soc. Amer., 67 (5), pp 1818-1820 (May 1980) 4 figs, 11 refs

N. Aoshima
New Method of Measuring Reverberation Time by Fourier Transforms
J. Acoust. Soc. Amer., 67 (5), pp 1816-1817 (May 1980) 3 figs, 1 ref

A. Hamad and A. Seireg
Simulation of Whirl Interaction in Pinion-Gear Systems Supported on Oil Film Bearings
J. Engr. Power, Trans. ASME, 102 (2), pp 508-510 (Apr 1980) 4 figs, 4 refs

CALENDAR

SEPTEMBER 1980

2-4 International Conference on Vibrations in Rotating Machinery [IMechE] Cambridge, England *(Mr. A.J. Tugwell, Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1H 9JJ, UK)*

8-11 Off-Highway Meeting and Exposition [SAE] MECCA, Milwaukee, WI *(SAE Hq.)*

14-16 ASME Petroleum Division Conference and Workshop [ASME] Denver, CO *(ASME Hq.)*

28-Oct 1 Design Engineering Technical Conference [ASME] Beverly Hills, CA *(ASME Hq.)*

OCTOBER 1980

Stapp Car Crash Conference [SAE] Detroit, MI *(SAE Hq.)*

6-8 Computational Methods in Nonlinear Structural and Solid Mechanics [George Washington University & NASA Langley Research Center] Washington, D.C. *(Professor A.K. Noor, The George Washington University, NASA Langley Research Center, MS246, Hampton, VA 23665 - (804) 827-2897)*

14-15 Textile Engineering Technical Conference [ASME] Atlanta, GA *(ASME Hq.)*

21-23 51st Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, D.C.] San Diego, CA *(Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, D.C. 20375)*

27-31 ASCE Annual Convention & Exposition [ASCE] Hollywood, FL *(ASCE Hq.)*

28-30 Eastern Design Engineering Show [ASME] New York, NY *(ASME Hq.)*

NOVEMBER 1980

16-21 ASME Winter Annual Meeting [ASME] Chicago, IL *(ASME Hq.)*

18-21 Acoustical Society of America, Fall Meeting [ASA] Los Angeles, CA *(ASA Hq.)*

DECEMBER 1980

Aerospace Meeting [SAE] San Diego, CA *(SAE Hq.)*

8-10 INTER-NOISE 80 [International Institute of Noise Control Engineering] Miami, FL *(INTER-NOISE 80, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603)*

9-11 Western Design Engineering Show [ASME] Anaheim, CA *(ASME Hq.)*

MARCH 1981

8-12 26th International Gas Turbine Conference and Exhibit [ASME] Houston, TX *(ASME Hq.)*

21-Apr 1 Lubrication Symposium [ASME] San Francisco, CA *(ASME Hq.)*

APRIL 1981

6-8 22nd Structures, Structural Dynamics, and Materials Conference [AIAA, ASME, ASCE, AHS] Atlanta, Georgia *(AIAA, ASME, ASCE, AHS Hqs.)*

MAY 1981

4-7 Institute of Environmental Sciences' 27th Annu Technical Meeting [IES] Los Angeles, CA *(IES, 940 East Northwest Highway, Mt. Prospect, IL 60056)*

JUNE 1981

1-4 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hq.)*

22-24 Applied Mechanics Conference [ASME] Boulder, CO *(ASME Hq.)*

SEPTEMBER 1981

20-23 Design Engineering Technical Conference [ASME] Hartford, CT *(ASME Hq.)*

OCTOBER 1981

Eastern Design Engineering Show [ASME] New York, NY *(ASME Hq.)*

4-7 International Lubrication Conference [ASME - ASLE] New Orleans, LA *(ASME Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

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