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Book Reviews

Computer-Aided Engineering Applications, PVP-Vol. 126, eds., A. W. Filstrup III, F. L. Cho and R. F. Jones, 1987, Bk. No. G00372, 80 pp., $24.00, Mem. $12.00.

This volume contains twelve technical papers presented at the 1987 Fifth National Congress on Pressure Vessels and Piping. The papers were developed by the Computer Technology Committee of the Pressure Vessels and Piping Division of ASME for sessions titled, "Expert Systems in Engineering Applications" and "Engineering Applications of Microcomputers."

Seven papers are in the Expert Systems in Engineering Applications sessions. Ye-Sho Chen and James M. Pruett propose a cost-effective integration of an expert system with decision support systems. This integration provides a workstation-based environment for the user with integrated data base, model base, and expertise base. The approach is applied to a total quality control environment. Albert Koval describes an innovative all-digital image production facility of the near future that will use expert systems, expert databases, intelligent machine control, and large-scale simulation via Cray-class supercomputers to accomplish the actual production. This production facility will produce higher quality products than are now possible with an increase of productivity of one to two orders of magnitude. Casaba G. Ranganath describes the effective use of database management to provide the best chance to extend the life of operating lives of nuclear power plants. The intelligent collection and use of many databases can lead to the development of operational strategies for the remainder of plant life. Tianduo Li and Chi Chen describe an expert supervisory control system under development that is being built by adding an expert system to a conventional computerized supervisory control system. This system is to act as a group of experts working on site at a fossil fuel power plant. F. L. (Bill) Cho introduces a reliability model technique to assess risks in equipment in industrial plants. He describes the effort required to develop a pilot application of this expert system technique in the surveillance and maintenance programs for monitoring the operation of an auxiliary feedwater system for a nuclear power plant. William M. Turpin describes four case histories that used software products on microcomputers to develop actual expert system applications. Mitchell D. Horton discusses the advantages to CAE users of comand-driven interfaces of data between application software rather than source code-driven interfaces. He describes the implementation of a command-driven interface that retrieves finite element model data from a relational database and subsequently writes data to an IGES file.

Five papers are in the Engineering Applications of Microcomputers session. Wai K. Ho and Kenneth D. Blakely describe stress and vibration applications of finite element analyses performed on Apple Macintosh and IBM PC computers. These applications show the range of solutions that can be produced on these microcomputers. Mike Chainyk describes the use of heat transfer finite element software coupled with user-generated coding to simulate the behavior of a particular flow field on an IBM PC. Stephen C. Mitchell describes how recent advances in both personal computers and software have made finite element analysis available as a design tool to smaller companies with as few as one or two engineers. He shows how one company converted from a time-sharing analysis system to an in-house system. Brian H. Alsop tells how his organization has found that the BASIC programming language is a cost-effective language for personal computer program development. He shows that code program development is 3 to 30 times faster than using FORTRAN on the PC. Krishna S. Raichur discusses the recent increase in the use of personal computers for engineering applications and explores heat transfer analyses on personal computers.

Alvin W. Filstrup, III

Thermal Stress, Material Deformation, and Thermo-Mechanical Fatigue, ASME Special Publication PVP-Vol. 123, ASME, New York, 1987.

Problems of thermo-mechanical fatigue are encountered in the gas turbine, pressure vessel and piping, and railroad industries, among others. If life prediction methods are to be successful under thermo-mechanical fatigue conditions, their form should reflect the dominant damage mechanism operative in the alloys of interest and must be based on constitutive equations that characterize material response accurately. In the analysis of structure or component behavior, both the constitutive equations and the life prediction methodology should be coupled. This volume addresses some of these important issues. First, the problem of isothermal fatigue and thermo-mechanical fatigue life prediction is considered. Second, the constitutive response of materials under temperature strain cycling conditions is studied. Third, analyses of structural response with experiments and finite element methods are reported. An overview of the papers is given here.

F. A. Leckie summarizes the damage mechanisms at high temperature. He shows that creep life predictions based on the micro-mechanism approach alone are not necessarily sufficient to predict creep lives. The need for further work in bridging the gap between micro-mechanical models and phenomenological models is emphasized.

G. L. Halford and J. Saltsman provide insight into parameters (total strain range, Ostergen's work approach and inelastic strain range) used in life predictions under thermo-mechanical fatigue conditions. The inelastic strain range is found to provide successful correlations. They emphasize the need for incorporating time (and/or strain rate) and temperature effects in the coefficients of these parameters. These coefficients are dependent on the material stress-strain response, among other factors.

Characterization of thermo-mechanical fatigue crack growth under complex temperature-strain histories is needed. M. L. Heil, T. Nicholas and G. K. Haritos report crack growth results under in-phase, out-of-phase and diamond-type (clockwise and counterclockwise paths) temperature-strain histories. The isothermal crack growth rates at (T_{max} of the cycle) are highest among the cases considered. A crack growth model that summed fatigue and creep crack growth rates predicts the results successfully.

Microstructural examination of damage mechanisms operative under thermo-mechanical fatigue conditions provides insight into the form of the life prediction models. S. Majumdar identifies the regimes of cavity-induced crack growth and transgranular crack growth in out-of-phase and in-phase thermo-mechanical fatigue tests. Fatigue and creep damage growth equations accurately predict the results, including the cases of hold times.

Creep-fatigue life evaluation of several austenitic stainless steels at 550°C under different hold time conditions is examined by K. Aoto, Y. Wada and R. Komine. A linear creep-fatigue damage summation is used and lives are predicted within a factor of 5 for most cases. In a separate paper Y. Wada, Y. Kawakami, and K. Aoto predict lives using a statistical approach utilizing 95 percent confidence limits of the low-cycle fatigue. This approach also gives successful results even for different strain rates and hold times.

The characterization of material response under strain-softening conditions has important applications and has been observed in low-alloy steels. J. L. Handrock, D. L. Marriott and J. F. Stubbins analyze softening by allowing the stresses to decrease with accumulated plastic strain in their model. The rate of softening at several strain ranges was predicted satisfactorily.

The development of constitutive equations at high temperature is an area where further developments are needed in determination of the micro-mechanical damage mechanisms and in linking experiments directly to model constants. The paper by D. N. Robinson, S. F. Duffy, and J. R. Ellis presents a unified viscoplastic theory applicable to metal-matrix composites. The model accounts for the transverse anisotropy, creep, relaxation and thermal recovery behavior at high temperatures. Tension and torsion tests which allow the model constants to be determined are suggested.

The paper by V. G. Ramaswamy, D. C. Stouffer, R. H. VanStone and J. H. Laflen models Rene 80 under isothermal and thermo-mechanical fatigue loading conditions. This paper introduces a static recovery term in which the saturated back stress decreases with decreasing stress. This feature is incorporated to predict the long time creep data. Experimental isothermal data, creep strains at several stress levels and thermo-mechanical fatigue response are predicted satisfactorily.

The two-part paper by D. Slavik and Huseyin Sehitoglu introduces a constitutive model that reflects the microstructural deformation mechanisms such as plasticity and power law creep in the flow rule of the unified model. This procedure allows simulation of strain rate sensitivity over a wide range of strain rates and temperatures. Strain aging and thermal recovery effects are accurately predicted. The model predicts the thermo-mechanical fatigue response satisfactorily.

Structural components subjected to net section load and thermal fluxes exhibit thermal ratcheting, reversed plasticity and shakedown behavior. In the paper by R. Swindeman and D. Robinson, thermal ratcheting rates were found to be most sensitive to the maximum temperature in the cycle, among other factors. High temperature holds in the cycle resulted in recovery of yield strength and an accompanying increase in ratcheting rates.

Finite element analysis of a gas turbine nozzle was performed by S. Aksoy, Y. Peng and H. M. Armstrong. The analysis revealed tensile and compressive holds during the mission cycles. Therefore, the need for a life prediction model incorporating hold time effects is evident. Their analysis used a linear summation of fatigue and creep damage and found that both contributed to failure.

Life prediction for furnace tubes operating in the creep range and subjected to cyclic thermal stresses is addressed by R. Seshadri. It was found that cyclic thermal gradients across the wall can reduce tube life. This was incorporated into the analysis through a creep magnification factor, which was found to be between 1 and 2.

H. H. Ziada analyzed the plastic strain concentration factor of a hole in a core-barrel of a reactor subjected to thermal loading. A 3-D finite element analysis was performed. The strain concentration factor for nominal strains greater than 0.3 percent decreased to a value below that of the elastic level. The maximum stress concentration occurred below the surface, where the hydrostatic stresses were higher.

The problem of thermo-mechanical fatigue is a complex one, incorporating creep-fatigue-environmental effects in a synergistic manner. Further research work into potential damage and deformation mechanisms operative under thermo-mechanical fatigue is needed. Current developments in life prediction should also be translated into simpler design rules such that designers and engineers could readily incorporate them in their life prediction methodologies.

Huseyin Sehitoglu

S. Y. Zamrik

Recent Advances in Structural Dynamics, ASME Special Publications PVP-Vol. 124, ASME, New York, 1987.

The subject of structural dynamics has been of intense study in the last three decades. Most advances have been made in various areas and applied to the design of aerospace, civil, mechanical, nuclear, and ocean structures. Extensive studies are being continued to enhance understanding of structural behaviors, develop new/improved analytical and experimental techniques, and provide more reliable and economical design guidelines.

This volume contains twenty-three papers and covers a wide variety of topics, including stress and bucking analysis, limit analysis, optimal design, crack propagation, blast and fragmentation, and nonlinear vibration. The structural compnents considered include beams, plates, shells, piping systems, and pressure vessel attachments and supports. The analysis methods presented cover nonlinear analysis, finite element method, boundary integral method, and novel experimental techniques.

The paper by E. G. Berak and J. C. Gerdeen presents a finite element technique for calculating the bounds of the limit load multiplier for rigid perfectly plastic structures obeying the von Mises yield criterion. This new method is based on variational principle and satisfies all limit analysis theorems, and thus generates true upper and lower bounds.

R. L. Citerley discusses an efficient solution procedure for the analysis of a shell of revolution with imperfect geometry subjected to nonaxisymmetric loads with both geometric and material nonlinearity.