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book reviews

HIGH-TEMPERATURE MATERIALS IN GAS TURBINES, Edited by P. R. Sahm and M. O. Speidel, Elsevier Scientific Publishing Company, 1974, $38.50.

REVIEWED BY D. A. WOODFORD[1]

This excellent book includes sixteen invited papers and short communications presented at a Symposium held in March, 1973, at Baden, Switzerland. The objective of the Symposium was to review the current status of research, development, and application of materials for stationary gas turbines. Four subject areas were emphasized:

1 Engineering of gas turbines and the key role of materials;
2 high-temperature materials used in, and developed for, gas turbines: review of development and properties;
3 critical properties of high-temperature gas turbine materials;
4 processing of high-temperature materials.

Although most of the contributors are from Europe, there are representatives from U. S. companies to establish a full-international participation, and many of the contributions are from recognized authorities in their fields.

The first section, dealing with the role of materials in engineering design, covers the extreme thermal and mechanical demands on materials in gas turbines. These necessitate design procedures to incorporate creep resistance, ductility, thermal fatigue resistance, and surface stability in highly oxidizing and corrosive environments.

The second section reviews the properties of currently used materials including high temperature titanium and iron based alloys and the real work horses of the gas turbine: the nickel and cobalt base superalloys. In this latter area, although as pointed out by R. F. Decker, there have been significant recent advances in controlled grain structures, dispersion hardening and superplastic processing, the next five years is likely to be a period of consolidation and improved understanding. There is a comprehensive review of the recent advances in understanding and controlling long-time phase stability. The area of eutectic and artificial composite superalloys is well covered. Eutectic composites are being studied intensively and new challenges have been identified since this book was prepared. However, the paper by P. R. Sahm gives a careful assessment of the problems and potentials of this new class of material. The special challenges associated with the use of ceramic parts in gas turbines are also well covered.

The critical properties of creep resistance, fatigue crack growth, thermal fatigue, and surface stability are included in the third section. The principals of alloying for improved creep resistance are now reasonably well known and are covered here. A case could be made for increased emphasis on primary creep deformation. This is the least understood and technologically most important stage for design analysis using constitutive equations relating creep strain accumulation to the local conditions of stress and temperature. Perhaps the most original contribution to this volume is the paper by M. O. Speidel on fatigue crack growth. In this paper, crack growth rate data for a wide variety of alloys are interpreted within a linear elastic fracture mechanics framework using the modulus of elasticity. This approach is developed to include thermal fatigue and creep crack growth. An excellent review by R. J. E. Glenny covers thermal fatigue, which is one of the most design limiting properties of blade and vane materials. It is becoming increasingly apparent that critical property evaluation must be considered in conjunction with surface and environmental effects. There is a full treatment of oxidation and hot corrosion and some recognition of the importance of the agressive environment in the fatigue papers. However, there is a clear need for an interdisciplinary approach here, particularly when considering the response of coatings and the need to develop thermal and mechanical compatability between substrate and coating in addition to the environmental protection.

The final section deals extensively with modern processing methods including directional solidification and powder metallurgy. Both papers in this section provide a solid background and review of the latest developments. However, there is much work still to be done and exciting prospects for further innovations.

The organizers of this conference and the editors of these proceedings are to be complimented on a well balanced and timely treatment of the development and application of high temperature materials. This is essential reading for both the materials people responsible for development and characterization and the design engineer. The gap between these two essential disciplines in gas turbine technology should become less noticeable as a result of this book.

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