Introduction to Creep

R.W. Evans and B. Wilshire
(The Institute of Materials, London, 1993, 111 pages).
ISBN: 0-901462-64-0

Evans and Wilshire have compiled, in a brief format of about 100 pages, a rather comprehensive review of time-dependent deformation from a materials science perspective. The treatment is somewhat longer than that found in encyclopedic texts on mechanical behavior, but is considerably briefer than that found in texts devoted solely to high-temperature deformation.

The book is promoted as an introduction to creep, with the aim "...to provide a basis for further reading," and accomplishes that goal rather well from the standpoint of physical metallurgy for those persons having a background or introductory coursework in materials science/metallurgy. In several places, the authors point out the relevancy of creep to practical engineering design/failure problems, but there is little discussion of numerical analytical procedures pertinent to such problems, with one exception—the "Theta Project." The commonly used Larson Miller parameter, for example, is referenced only indirectly and never stated in a figure used to justify parametric plotting procedures.

With the emphasis of the text on rationalizing physical metallurgy and deformation mechanisms, there is little discussion of various empirical approaches used to handle creep rupture data and, in parallel, almost no discussion of analytical curve-fitting procedures for experimental data. Such treatments may not be pertinent to understanding the basic mechanisms of creep, but are certainly important in the analysis of creep data and its use in engineering applications. Neither alternative methods for handling stress dependence as a power series in log stress, nor the use of Garafalo's hyperbolic sine function in contrast to an exponential stress dependence, are mentioned. The authors cite only one reference in this regard, omitting the important work of Goldhoff and Hahn ("Correlation and Extrapolation of Creep-Rupture Data of Several Steels and Superalloys Using Time-Temperature Parameters" in *Time-Temperature Parameters for Creep-Rupture Analysis*, ASM, 1968) and Conway (*Stress-Rupture Parameters, Origin, Calculation and Use*, Gordon and Breach, 1969).

Taken as a text in high-temperature deformation of *materials*, the book discusses in an abbreviated manner the creep deformation of polymeric materials and mentions the elevated temperature behavior of ceramics. The strength of the discussion of creep mechanisms clearly lies in the treatment of the behavior of metallic materials, and that is done very well. In defense of the authors, the book is published by The Institute of Materials, and is most likely directed specifically at upper-division materials students. But without an introductory background in theory of crystalline defects, those persons may have some difficulty understanding major sections of the book.

Since the book seems directed to university/classroom use, some additional points may be in order. The mathematics used in the text involves only elementary differential equations, and is used to develop several fundamental equations. The authors have proposed a new approach to handling creep data—identified as the results of the Theta Project, to which about 20% of the text is devoted. The chapter dealing with that project does utilize some mathematical manipulation which, if understood, should provide the necessary background for examining other approaches to creep behavior not discussed in the text. The assumptions inherent in the Theta Concept focus on normalizing creep strain and time at various stress levels in order to examine primary (transient), secondary (steady state), and tertiary behavior in more detail. The proposed model is intriguing, and supporting experimental data for both a single-phase material (copper) and a polyphase alloy (1/4Cr 1/4Mo 1/4V steel) are shown.

Considering this work as a textbook, one might hope for more worked numerical examples. Only two simple examples are provided—in the body of the text and in an appendix containing four rather lengthy worked problems, one of which includes (linear) regression analysis. The approach taken is that of short texts providing an overview of the subject with minimum references and minimum development of analytical expressions. My experience is that, for U.S. students, using such a book as a text can create some difficulty since the students expect to find more detail and procedural steps in the mathematics. (In this case, the mathematics is not a difficulty.) Nevertheless, the authors are certainly well-known in their field and have published extensively, so, for someone who wants to examine a second treatment of a subject, and can look at issues from a broad-based background and prior exposure, there is much to be gained from such a text. I personally found it quite interesting and well-written. The authors do indeed comprehensively discuss experimental testing procedures, as well as the differences in those procedures for stress-rupture testing versus creep testing.

In summary, the text is especially appealing for its availability as a minimally priced treatment of a single subject area. Its strong point is a well-written discussion of basic microstructural mechanisms and the modeling of those mechanisms—Cobble creep, Herring-Nabarro creep, deformation maps—that control elevated temperature behavior of metallic materials. It is not a discussion of parametric fitting techniques and the use of the resulting equations in engineering design.

Reviewer: William T. Becker is an associate professor in materials science at the University of Tennessee-Knoxville. He has a general interest in all aspects of mechanical behavior, not only from a materials science perspective, but also from a macroscopic engineering applications perspective.

Ion Implantation in Diamond, Graphite, and Related Materials

M. S. Dresselhaus and R. Kalish
(Springer-Verlag, Berlin, 1992, 202 pages).
ISBN: 3-540-54956-0

This volume presents an integrated review of the studies on ion-beam irradiation of the many and very different carbon-based materials and analyzes the majority of the results published through 1990, along with some published in 1991. The review emphasizes both the physical (radiation damage) and chemical effects of ion implantation into diamond (natural crystals and CVD polycrystalline films), diamondlike a-C:H films, graphite, glassy carbon, carbon fibers, and also disordered carbon.

To integrate studies that often originated in different scientific communities, the authors begin with a two-chapter tutorial on the structure and properties of various carbon-based materials in the absence of irradiation and on the fundamentals of ion-solid interactions. These chapters provide a useful introduction to researchers in one area who are unfamiliar with the other. The description of analytical techniques based on ion beams and the discussion of the special characteristics of channeling in graphite-based materials is comprehensive, and essential for understanding the later discussions. This reviewer found the description of other analytical techniques (Chapter 5) too brief to help anyone not already knowledgeable in the particular area.

The discussions of implantation-induced modifications to graphite (Chapter 6) and graphite-related materials (Chapter 7) are extensive and present a coherent analysis of the state of knowledge relative to both lattice damage and impurity effects. The authors' suggestions of opportunities and the need for further studies enhance the value of this publication.

The book contains a thorough treatment of implantation into diamond and diamond-related materials that is especially valuable in view of current attempts to produce wide bandgap semiconducting CVD diamond films. This critical assessment of results obtained to date indicates that success in this area will require close control of experimental parameters and a thorough understanding of the many ion-beamed-induced structural modifications.

This volume presents a critical and integrated assessment of the literature. It appears that structural modifications are reasonably well-understood in terms of lattice damage and impurity effects. The effects on properties appear to be less well-defined. Further research on mechanical properties would seem to offer a fruitful area for study. The volume should be of value to graduate students entering this field of research, researchers in either carbon materials or implantation interested in expanding into the other area, and anyone desiring to become familiar with the state of the art in this field.

Reviewer: Carl J. McHargue is a professor of materials science and engineering and director, Center for Materials Processing, at the University of Tennessee-Knoxville. His research involves surface modification of ceramics using ion beams.

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