Introduction

An increase in the efficiency of a power generating unit, in the rate of an industrial chemical process, or in the speed of supersonic aircraft, have in common an association with an increase in temperature. The technological advances, required to obtain such performance increases, are largely dependent upon the development of new materials and design methods for structures capable of withstanding the rigors of elevated temperature service. However, before these developments can be put into practice, it is necessary that the materials be thoroughly characterized with respect to resistance to stress, temperature, and environment, and that the reliability of associated design procedures be established. These are both formidable tasks of the utmost importance, especially where long-time service experience is lacking. Consider, for example, the problems associated with the design of a nuclear reactor component of a relatively new alloy which is expected to be in service at elevated temperatures for forty years or more. Such a design can be made reliable only after the response of the alloy for the service conditions has been quantified.

In addition to this trend toward higher operating temperatures there is also a trend toward more efficient and economical design. This latter goal can only be achieved through an understanding of the load-structure-stress-strain-temperature-environment-material interactions. Whereas in the past creep behavior at elevated temperatures may have been the principal consideration, experience has shown that, in fact, fatigue may often be the controlling factor. All aspects of the fatigue process are modified in the creep range. Mechanisms of crack initiation and growth, test methods, lifetime predictions, and design methods all are changed. In addition new factors are introduced such as thermal fatigue, thermal ratchetting, and stress relaxation. Each of these serves to make fatigue at elevated temperatures a very complex subject, but it is this very complexity which offers a challenge to researchers and design engineers concerned with creep-fatigue interaction.

The present volume is intended to provide a comprehensive overview of this subject, as well as to provide current research findings in four major subareas:

1. Mechanisms: The processes of crack initiation and growth leading to creep-fatigue failure.
2. Test Methods: The techniques for carrying out elevated temperature fatigue tests and for analyzing the resultant data.

3. Materials: A review of the alloys used in elevated temperature creep-fatigue design, together with the latest data on their properties.

4. Prediction Methods and Thermal Ratchetting: A review of current approaches to creep-fatigue lifetime predictions, including thermal ratchetting, and a consideration of code design procedures and emerging design philosophies.

It is expected that the information contained in this volume will be of use to metallurgists, materials test engineers, and designers who are concerned with this important problem. It is hoped that interaction between the various disciplines involved will be promoted, and that this volume will serve as an impetus for rapid advance in the field of fatigue at elevated temperatures.