Introduction

The origin of interest in the subject of fatigue at high temperature is far from academic. High temperature is becoming a way of life with more and more of our engineering structures, and the means for accounting for the many effects which high temperature introduces must find its way into design criteria. Information generated on this subject can be applied in many areas in our advancing technology. Examples include the aircraft gas turbine, diesel engine, steam turbine, nuclear reactor, land-based gas turbine, and many other important applications. In each of these cases it is the design objective to provide reliable performance with a minimum of down time and cost of repair. Fatigue is encountered in these applications in several ways. One source is vibration as a consequence of rotation, or of fluid motion, and failure may result after a large number of stress cycles. Another source of fatigue is a consequence of start and stop operation, and is identified generally as thermal or low-cycle fatigue. Here strain is the controlling variable, induced mostly by temperature effects, such as thermal mismatch, temperature transients, etc.

In conjunction with these effects, high temperature introduces a number of complications. Included are:

(*a*) Gaseous or liquid environments introduce surface reactions which interact strongly with fatigue cracks to accelerate crack initiation, growth, and failure.

(*b*) Long hold-time periods between cycles introduce creep effects which interact with fatigue, often by changing the mode of crack propagation from the more ductile transgranular mode to the more brittle intergranular type.

(*c*) The material may change its properties with long times at temperature due to aging and phase instability effects or to creep damaging mechanisms.

(*d*) Thermal cycling introduces complications regarding predictions of stresses and strains and uncertainty regarding the interaction of temperature cycling and strain cycling.

These complications serve as a basis for identifying problem areas for fatigue investigation. It is clear that many disciplines are involved here, including those of the surface chemist, metallurgist, and mechanical engineer. In the papers that are included in this Special Technical Publication some of these problem areas are brought into focus. Particular attention is given to the effect of hold time, that is, where the strain is held constant for fixed intervals of time during the cyclic strain program.

It will become apparent, in reading over these papers, that testing technique is an important element in elevated temperature fatigue studies. Control of atmosphere, measurement of strain, control of the test to follow some predetermined strain-time program, and temperature control are some of the special areas where much attention has been given. Some insight into the current state of the art of mechanical testing is provided in close examination of the several papers.

On behalf of the E-9 Committee on Fatigue, I would like to thank the many authors for their willingness to contribute to this symposium. It is only through their efforts that this publication has come into being.

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