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SYNERGISM OF CREEP AND THERMAL CYCLIC BEHAVIOURON SUPERHEATER TUBE LOW ALLOY STEEL

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ABSTRACT

The application of superheater boiler tube includes a sequence of events such as fluctuating stress levels at constant temperature, fluctuating temperature levels at constant stress, and periods during which both stress and temperature are simultaneously fluctuating. Further, there is evidence to indicate that the thermal fatigue and creep processes interact to produce a synergistic response. Creep-thermal fatigue was generated by constant stress during hold periods at maximum temperature 5500°C and at minimum temperature 4200°C. The samples were left at different minimum holding periods separately, the first in the furnace and the latter in the air respectively. The results show that reduction elongation/ total strains increases with hold periods in the furnace at minimum temperature. However when the, specimens were hold at minimum temperature in the air, the results showed that increase elongation/ total strain with increase in hold periods. The observations suggest that crack nucleation may become predominantly a grain boundary process when simultaneous creep and thermal cyclic test is performed.

INTRODUCTION

There are several important high-performance application of current interest in which conditions persist that lead to combined creep and fatigue. For example, components in steam generating service are subjected to long periods of steady operation, interrupted by temperature and load cycles. In moderately high temperature environment (below the creep range), the cyclic nature of the loading causes fatigue damage which may be regarded as the sole function of the strain range and number cycles. In high temperature applications, however, where creep processes are activated, failure can occur even under steady load conditions (i.e. creep rupture) and the endurance of the material is influenced by both the elapsed time and the number of cycles of rapid strain variations.

The mechanism of fatigue and creep failure, separate into creep and fatigue components under the assumption that the time periods of constant or slowly changing strains (hold periods) are contributing to the creep damage, while the cycles of rapid strain changes cause the fatigue damage. There are two types of fatigue -creep interaction, which have been termed 'sequential' and 'simultaneous'(1). In the former category, the specimen experiences a complete period of fatigue or creep damage which is then followed by the other mode. In a simultaneous interaction, an element of fatigue (cycle dependent), and an element of creep (time dependent), occurs in each cycle(2).

The majority of high temperature fatigue tests are carried out isothermally for reasons of simplicity, although there is increasing interest in tests involving variable temperature to simulate service conditions (3).

In this paper, potential areas for synergism of creep and thermal cyclic process are considered. Examples from the author's laboratory are given to illustrate some of the areas where this synergism has led to understand the behavior of crack of creep and thermal cyclic process.

MATERIALS AND METHODS

Creep and thermal cycles were applied simultaneously on low alloy steel superheater tube specimens. The tests were conducted at maximum temperature 5500°C, with holding periods varied from 4, 7, and 10 minutes before cooling to minimum temperature 4200°C, holding for 1 minute at constant stress 33.33 kg/mm2 for 7 cycles. The samples were holded at minimum temperature separately in two different medium; in the furnace and in the air.