LOW CYCLE FATIGUE AND PREMATURE FAILURE OF NICKEL BASE SUPERALLOY

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The low cycle fatigue testing with hold time at top and bottom amplitude was performed at different temperatures to clarify the fatigue deformation behaviour of nickel base superalloy. The results showed that for identical fatigue testing condition the time to fracture expressed by number of cycles to fracture differed significantly. The fractography analysis of fracture surfaces supported by structure analysis at crack initiation sites was applied to investigate the primary crack initiation at the internal surface of bored hole in order to clarify the reason of premature failure of specimens. It was found that the total lifetime and number of cycles to failure were strongly dependent on structural state of alloy close to borehole surface. At early stages of cycling the titanium rich particles cleaving initiated cracks that further propagated under continuous cycling by intergranular mode until they reached critical size. The number of crack initiations located close to borehole surface controlled the fatigue life and rate of premature failure.

Key words : *nickel base superalloy, low cycle fatigue, trapezoidal stress cycle, fracture, structure*

1. Introduction

During the fatigue tests at elevated temperatures, when the extent of deformation $\Delta\varepsilon_t$ is constant during the fatigue cycle, the strain gradually increases or decreases with the growing number of cycles depending on testing and material conditions [1]. In general, the fatigue failure process associated with high-deformation strain cycle consists of the crack initiation stages (one or more cracks) and of its following propagation. Usually, the crack is initiated on the free surface and its growth occurs in three stages [2].

The creep-fatigue interactions may be examined, in dependence on the mode of stressing, as two specific cases. In the first case, subsequent consecutive interactions occur with the fatigue and creep stress components separated from each other in the process of loading. In the second case, one must consider simultaneous consecutive interactions with each element of each mechanism of failure acting in each individual strain cycle [3]. Simultaneous interactions are applied frequently at fatigue cycles controlled through constant deformation with holds introduced into the fatigue cycle either at tension or compression, or simultaneously.

In present paper the fatigue behaviour of nickel superalloy Udimet (U720Li) represented by the number of cycles to fracture and the corresponding premature fracture of the alloy under conditions of defined low cycle fatigue with short holds at top and bottom of cycle at various temperatures were investigated. The problem related to different service life of the alloy under the identical conditions of cyclic stress is analysed on the basis of failure nu-

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