FATIGUE LIFE AND FRACTURE OF METAL ALLOYS AT ELEVATED TEMPERATURE

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ABSTRACT

Constructional elements are often exposed during operation to fatigue loads in high temperature conditions. Cracking of metal alloys at elevated temperature is different than at ambient temperature. The degradation processes of the material under these conditions are not fully investigated. Uncontrolled loss of durability may lead to costly failures, standstills on process lines, and sometimes even to the death of those nearby when a structural component cracks. This is why information about how long and under what loading and temperature conditions a structural component can work safely is important. The fatigue damage accumulation models of materials working under low-cycle loading conditions at elevated temperatures presented in the literature are modified functions formulated to estimate material's fatigue life at room temperature. Due to the low number of functioning fatigue criteria in this scope, there is a justified need to create new models that will provide a more accurate description of the material cracking process, thus enabling calculation of fatigue life with greater accuracy. That is also why it was undertaken in this paper to create a new fatigue damage accumulation model that will make it possible to determine the number of cycles until failure of material working under conditions of fatigue loads of constant amplitude at elevated temperature with engineering accuracy.

On the basis of own research and observation of material behavior at elevated temperature due to the cyclic loading and the results of experimental studies in the literature, a model for estimating the fatigue life of metallic materials was proposed. The undoubted advantage of the proposed model, in comparison to other functioning criteria in this field, is the small number of experimental data necessary to identify constants. In the proposed model, to calculate the number of cycles to failure is required only knowledge of the course of one fatigue characteristic - deformation curve of fatigue life at room temperature and the recrystallization temperature of the material. This model assumes that permanent slip bands are the site of crack nucleation and defect formation, where crack initiation is the result of the accumulation of this damage. In this case, damage is induced by the action of the stress vector's normal component. The presented law of damage accumulation induced by plastic strains under elevated temperature conditions was linked to the stress-based damage accumulation function Ψ_p, the value of which is dependent on the value of normal stresses σ_n, damage state variable ω_n on the physical plane and temperature T. The increment of the damage state variable on the physical plane $d\omega_n$, caused by the development of plastic strains at elevated temperature T, was made dependent on the increment of plastic shear strains $d\gamma_n^p$ on the same plane.

An undoubted advantage of the model is its capability of accounting for loading history in the fatigue damage accumulation process. This is done when determining stress or strain tensor components depending on the method of effecting force (force/displacement).

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