DAMAGE ACCUMULATION MODEL FOR LOW CYCLE FATIGUE UNDER MULTIAXIAL SEQUENTIAL LOADING

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1. Introduction

Machine and constructions elements often undergo multiaxial sequential cycle loading. Though fatigue life of materials has been studied for a long time and enough of experimental data has been accumulated, problem of multiaxial irregular loading low-cycle fatigue is still actual. Many attempts to describe fatigue damage process were made, which resulted in many developed models of damage accumulation. The most wide-spread is the conception of linear damage accumulation, offered by Miner. This approach is easy to use but it does not give adequate estimation of life in many cases. It is studied influence of sequential loading effects on the titanium alloys BT9 and BT1-0 fatigue damage and under tension-compression, torsion and 90° out-of-phase non-proportional loading.

2. Extend

The test results on low-cycle fatigue of titanium alloy BT9 and technically pure titan BT1-0 under biaxial loading are given. It is also determined that damage accumulation process for fully reversed pure torsional fatigue experiment is described in the best way by linear damage accumulation rule and has a nonlinear character for tension - compression. The paper shows that a deviation from linear damage accumulation law for tension - compression of both materials under «low - high» sequence loading is bigger in comparison with «high - low» sequence loading. It is obtained that a damage accumulation under «non-proportional - proportional» sequence loading is more intensive in comparison with «proportional – non-proportional» sequence loading.

Earlier in the paper [1] the criterion for multiaxial regular cycle loading was proposed. This criterion is based on the non-proportional strain parameter [2]. Analyzing calculation data one can see that during the application of the criterion [1] and the linear damage accumulation hypothesis the best correlation of the predicted and test data is obtained for alternating torsion. As a result, one can come to a conclusion about the linearity of damage accumulation process for a given loading type. The combined application of this criterion and damage curve approach by Manson and Halford [3] showed the high level of predicted and test data correlation for all the loading programmes except the alternating torsion. So the following modification of the Manson and Halford approach is proposed:

$$D_i = \left(n_i / N_i\right)^{\beta(\omega)},$$

where $\beta(\omega) = \left(\frac{N}{N_r}\right)^{\alpha} + \frac{2\omega}{\pi}\left[1 - \left(\frac{N}{N_r}\right)^{\alpha}\right]$; $\omega = arctg\left(\frac{\gamma_a}{\varepsilon_a} \cdot \frac{\varepsilon_{fs}}{\gamma_{fs}}\right)$ – strain path orientation angle, which determines the dominating type of the strain state.

3. Conclusion

Suggested method for metal alloys fatigue life estimation under irregular multiaxial low-cycle loading is based on damage curve approach.

Application boundaries of the proposed method for different deformation path have been analyzed. It is shown that the suggested method can be successfully used for fatigue life estimation of materials with different sensitivity to non-proportionality loading.

4. References

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