Study on nonlinear multiaxial fatigue damage and reliability of TC4 titanium alloy for aeroengine blades

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Abstract

In order to study the fatigue damage and cycle life of TC4 titanium alloy for aero-engine blade under various load conditions, uniaxial fatigue, multi-stage loading and multiaxial fatigue tests were carried out on the titanium alloy sample. For uniaxial fatigue, the damage and life distribution of the alloy under different stress ratios and mean stresses were counted by axial fatigue test. In view of the shortcomings of the linear damage model, based on the Chaboche nonlinear damage model, the nonlinear damage evolution equation of TC4 titanium alloy was derived and the parameters were fitted. For multiple variable amplitude loadings, the calculation method of equivalent cycle number was deduced. The relationship between loading sequence and cumulative damage was studied. For multiaxial fatigue, the critical plane method combined with von Mises criterion was used to study the fatigue life distribution under various loading paths, and the results were verified by experiments. According to the simulation results of flow field of compressor blade under maximum continuous working condition, the stress time history of compressor blade was calculated. Based on the stress intensity interference model, the residual strength model of TC4 material was described. Combined with Poisson stochastic process, the reliability prediction of aero-engine compressor blade under maximum continuous working condition was completed. The results show that the fatigue damage and life distribution of TC4 titanium alloy for aeroengine blade under various conditions can be accurately predicted by the method proposed in this paper and the reliability of the blade can still be maintained above 0.9 after it works for 3000 hours under the maximum continuous working condition.

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