Study on the effects of vibration loads on thermal fatigue durability of materials

Bychkov N.G., Nozhnitsky Yu.A., Avrutsky V.V., Pershin A.V., Khamidullin A.Sh.
P.I. Baranov Central Institute of Aviation Motors

Details of the hot path of gas turbine engines (GTE) in operation are experiencing low and high frequency loads, with the powerful heat fluxes leading to the appearance of significant thermal stresses on the blades and disks of turbines. CIAM's methods for studying thermal fatigue of materials and thermocyclic durability of full-scale parts of GTE (including those with ceramic coatings) with their high-frequency heating with a given irregularity [1] are widely used in the industry. However, the effect of additional vibration loads imposed on part\detail while operation on thermal fatigue of high-temperature alloys remains unexplored.

To carry out such research the CIAM has developed the unique P926 test rig (Figure 1) allowing simultaneous independent axial loading of a standard cylindrical specimen with thermal stresses and fatigue loads of various levels. The specimen is rigidly fixed between the membranes and is heated by electric current. The vibration-loading unit contains piezo elements and a variable mass disk. Figure 2 presents the results of a study on the influence of vibration loads on the thermal fatigue durability of ZhS6U alloy at maximum cycle temperature of 1000 °C. In case of two-frequency non-isothermal loading of the specimen, the summarized damage at the time of fracture was significantly lower than 1 and valued to 0.53.

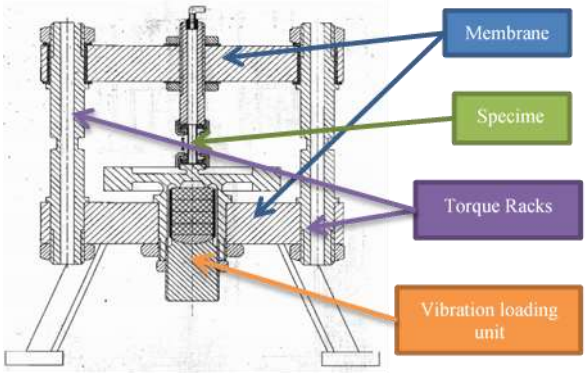

Figure 1. P926 test rig allowing independent axial cyclic loading at various levels in combination with thermal stresses

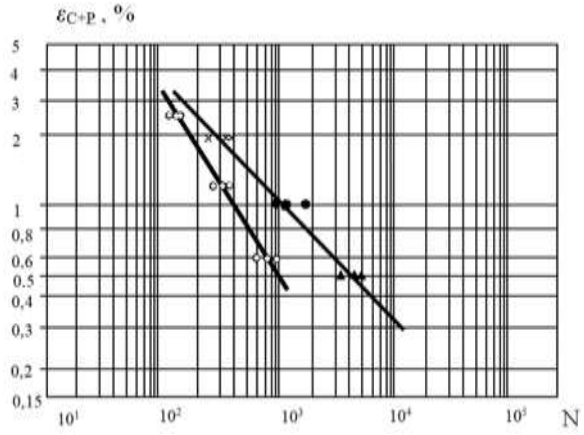

Figure 2. Influence of vibration loads on the thermal fatigue durability of ZhS6U alloy: × - 2 % ; ● - 1%, ▲ - 0,5 %; ○ – with imposed vibration.

Due to revealed significant effect of fatigue loads on thermal fatigue durability, it is necessary to conduct a set of similar studies for currently used and perspective materials under simultaneous thermal cycling and vibration loading in order to perform a reliable prediction of the service life of hot GTE unit.

Keywords: