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INFLUENCE OF RETENTIONS IN LOADING CYCLES ON HOT PARTS OF GTE IN SERVICE LIFE MONITORING

Calculation of the strength of gas turbine engine (GTE) main parts is an important and difficult task. The failure of these GTE main parts could lead to dramatic consequences. Increased safety factors lead to a decrease in GTE efficiency on the whole, and their reduction may not provide the required level of engine safety. Therefore, when assigning the safety factors, it is necessary to take into consideration the complex loading acting on the part. It becomes critical for calculating the residual lifetime of engine parts in service.

Currently, the calculations of GTE main parts for long-term strength and low-cycle fatigue are carried out separately [1]. So, their mutual influence, which, as experiments show, is of great importance, is not factored in. Taking into account the combined effect of two-component loading, it is advisable to consider a trapezoidal loading cycle [2], with retentions at maximum stresses (and temperatures), which reflects the actual operation of the gas turbine engine.

Using the method of linear summation of damage from long-term strength and low-cycle fatigue, the equation may be as follows:

$$\frac{\tau_{\Sigma}}{t_f} + \frac{N_{\Sigma}}{N_f} = 1 \quad (1)$$

where τ_{Σ} is total time of all retentions,
 N_{Σ} is the number of cycles to failure on a trapezoidal cycle,
 t_f is time to failure under continuous loading,
 N_f is the number of cycles to failure under a triangular loading cycle.

The solution of this damage summation equation makes it possible to determine the durability (lifetime) of the material. However, as shown by numerous studies [3, 4, 5], the direct use of formula (1) does not make it possible to obtain high accuracy in determining the lifetime of GTE hot parts.

Therefore, it is proposed to use the loading interruption factor as K_z , then formula (1) will be as follows:

$$\frac{\tau_{\Sigma}}{t_f \cdot (K_z)^m} + \frac{N_{\Sigma}}{N_f} = 1 \quad (2)$$

where m is the index of the long-term strength curve, and:

$$K_z = \frac{\sigma(t_f)}{\sigma[t_f(z)]} \quad (3)$$

where $\sigma(t_f)$ is material long-term strength limit, determined at a given temperature T and time to failure t_f under a single ($z=1$) loading according to the generally accepted model of long-term strength,
 $\sigma[t_f(z)]$ is material long-term strength limit under the temperature T and time to failure $t_f(z)$.

Model (3) gives good results when performing verification on some materials that are currently used to manufacture parts of the hot part of aircraft engines, in particular, for blades and disks. Therefore the accuracy of their residual lifetime calculation can be improved using this equation.

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