Multiaxial fatigue fracture of the titanium compressor disks in low-cycle and gyga-cycle regimes.

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The fatigue fracture of disks in compressors of gas turbine engine (GTE) is a well-known phenomenon. As fractured GTE titanium compressor disk analysis indicates in most cases the fatigue fracture started near to disk-blade contact zone. It was shown that cyclic loading may initiate fatigue crack formation in LCF or GCF (in other words very-high-cycle-fatigue – VHCF) regimes depending on thickness of disk.

Fatigue failures of the disks under consideration took place earlier than it is predicted by the LCF criterion. Therefore a new numerical approach was developed to estimate and to compare predicted life durability of the disk for both LCF and GCF regimes. The finite element model of real titanium disk with shrouded blades was created and 3D stress-strain state was analyzed for multiaxial loading conditions taking into account centrifugal and aerodynamic loads, nonlinear contact loads and vibration loads. Life durability evaluations were found as a limit number of loading cycles for safety flight of the structure without in-flight failure in LCF regime (each cycle consists of take off, flight and landing). In addition the GCF fatigue regime due to observed high frequency axial vibrations of blades shroud ring was studied. Values of parameters for generalized criteria were determined by using known quite poor GCF experimental data for investigated material.

Though these life durability estimations are rather approximate they point onto possibility of fatigue development in considered structure elements for both cases of LCF (flight cycles) and GCF (high frequency low amplitude vibrations). The most serious danger may happen due to mutual action of mentioned mechanisms because they may develop almost simultaneously in one and the same place.

For LCF and GCF regimes fracture zones approximately coincide with those observed during flight service and situated near them. In both studied cases estimated durability is in the range of 20000 – 50000 flight loading cycles. It pointed out that alternative fatigue fracture mechanisms for in-service compressor disks can be switched on under considerations. The fractographic investigations of fractured disks also indicate that the nucleation of the initial fatigue crack arises according to GCF mechanism, but then it is developed according to LCF mechanism.

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