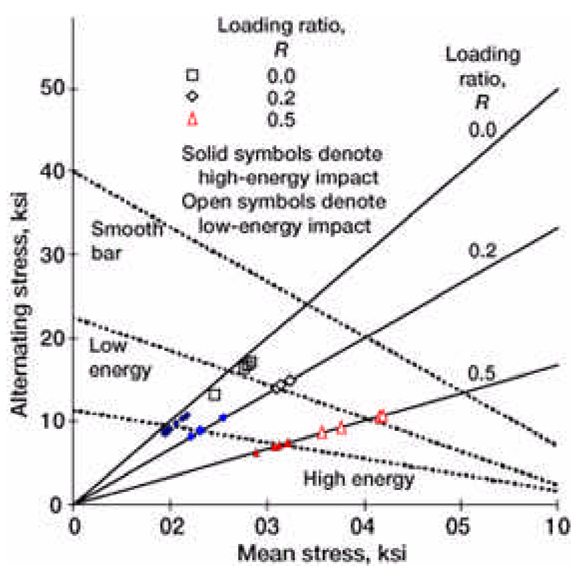
Resistance of Titanium Aluminide to Domestic Object Damage Assessed

A team consisting of GE Aircraft Engines, Precision Cast Parts, Oremet, and Chromalloy were awarded a NASA-sponsored Aerospace Industry Technology Program (AITP) to develop a design and manufacturing capability that will lead to the engine test demonstration and eventual implementation of a ?-Ti-47Al-2Nb-2Cr (at. %) titanium aluminide (TiAl) low-pressure turbine blade into commercial service. One of the main technical risks of implementing TiAl low-pressure turbine blades is the poor impact resistance of TiAl in comparison to the currently used nickel-based superalloy. The impact resistance of TiAl is being investigated at the NASA Lewis Research Center as part of the Aerospace Industry Technology Program and the Advanced High Temperature Engine Materials Program (HITEMP).

The overall objective of this work is to determine the influence of impact damage on the high cycle fatigue life of TiAl-simulated low-pressure turbine blades. To this end, impact specimens were cast to size in a dog-bone configuration and given a typical processing sequence followed by an exposure to 650 °C for 20 hours to simulate embrittlement at service conditions. Then, the specimens were impacted at 260 °C under a 69-MPa load. Steel projectiles with diameters 1.6 and 3.2 mm were used to impact the specimens at 90 °C to the leading edge. Two different impact energies (0.74 and 1.5 joules) were used to simulate fairly severe domestic object damage on a low-pressure turbine blade.



Goodman diagram for g*-TiAl specimens tested at 650 °C.*

Fatigue tests were performed at 650 °C and at a frequency of 100 Hz. In addition, three different loading ratios, *R*, were used to assess the effect of mean stresses. As expected, the specimens impacted at the higher energy levels failed at lower fatigue stresses because of the larger "defect" associated with the impact. Both energy levels resulted in fatigue strengths that were significantly lower, yet predictable, than for the smooth bars (i.e., nonimpacted specimens). In addition, a Goodman mean stress approach could be used to accurately model the fatigue data for all impacted specimens.

The industry-NASA team is using the results of this study to minimize the technical risks associated with impact issues. The actual damage tolerable for a low-pressure turbine blade application will be determined by a combination of fatigue testing and consideration of actual engine conditions. The current evaluations indicate that Ti-47Al-2Nb-2Cr possesses the level of damage tolerance required for implementation into service.

Bibliography

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