

# Damage Resistance of Titanium Aluminide Evaluated

As part of the aviation safety goal to reduce the aircraft accident rate, NASA has undertaken studies to develop durable engine component materials. One of these materials,  $\gamma$ -TiAl, has superior high-temperature material properties. Its low density provides improved specific strength and creep resistance in comparison to currently used titanium alloys. However, this intermetallic is inherently brittle, and long life durability is a potential problem. Of particular concern is the material's sensitivity to defects, which may form during the manufacturing process or in service. To determine the sensitivity of TiAl to defects, a team consisting of GE Aircraft Engines, Precision Cast Parts, and NASA was formed. The work at the NASA Glenn Research Center at Lewis Field has concentrated on the fatigue response to specimens containing defects.

The overall objective of this work is to determine the influence of defects on the high cycle fatigue life of TiAl-simulated low-pressure turbine blades. Two types of defects have been introduced into the specimens: cracking from impact damage and casting porosity. For both types of defects, the cast-to-size fatigue specimens were fatigue tested at 650 °C and 100 Hz until failure.

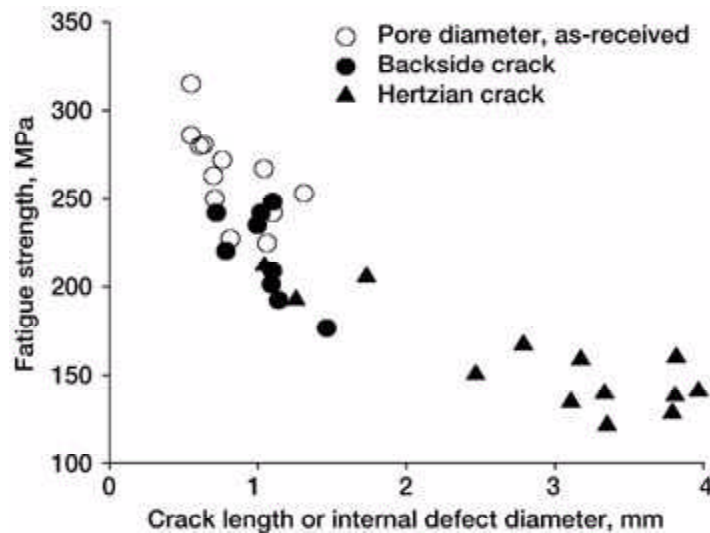
Impacting the specimens yielded two forms of cracks, dependent on the impact energy. At a high energy, hertzian cracks were dominant and often led to material being removed from the edge of the specimen. At lower impact energies, cracks formed on the backside of the specimen perpendicular to the specimen axis. Both types of cracks are described in reference 1.

Additional specimens, which were originally rejected because of nondestructive evaluation (NDE) indications, were fatigue tested to study the degradation in fatigue life due to the presence of the casting defects. Before testing, these specimens were reexamined using microfocus x-ray and computed tomography. Microfocus x-ray was successful in identifying 90 percent of the casting defects that caused failure and improved the detection capabilities over conventional radiography. Computed tomography, a time-consuming method, was only performed on two samples. This method gave cross-sectional information about the defects, which could be used to estimate the subsequent fatigue life.

Defect size played a large role in determining the critical fatigue loads. Increasing the defect size, regardless of whether the flaws resulted from casting porosity or from impact cracks, led to a decrease in the fatigue strength. Some of the severest impacts reduced the fatigue strength by almost a factor of three. The larger casting defects only reduced the fatigue strength by a maximum of 35 percent.

This information on the effects of defects in  $\gamma$ -TiAl will be used in several ways. First, it will help set accept-reject limits for castings at the foundry, and in some cases, depending on part cost and defect location, may indicate when casting repairs should be made. Second, it will help develop a damage-tolerant design and life-determination approach for

$\gamma$ , to make sure that  $\gamma$ -TiAl parts will have the necessary robustness to provide a long life in engine service. Third, it will help establish field inspection and repair limits for parts that develop damage in service.



*Decline in fatigue strength with increasing defect size.*

## References

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2. Lerch, B.A., et al.: Effect of Defects on the Fatigue Life of  $\gamma$ -TiAl. NASA/CP-1999-208915, Vol. II, HITEMP Review 1999, paper no. 30, pp. 1-11. (Available from NASA Glenn's Subsonic Systems Office.)

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