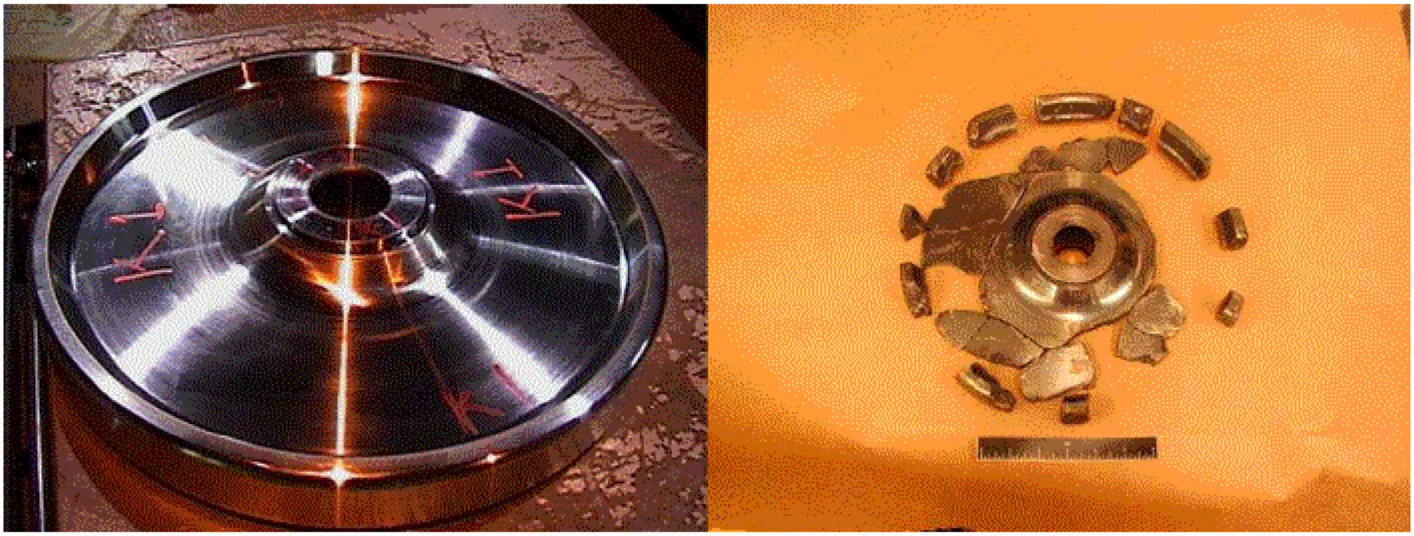
Superalloy Disk With Dual-Grain Structure Spin Tested

Advanced nickel-base disk alloys for future gas turbine engines will require greater temperature capability than current alloys, but they must also continue to deliver safe, reliable operation. An advanced, nickel-base disk alloy, designated Alloy 10, was selected for evaluation in NASA's Ultra Safe Propulsion Project. Early studies on small test specimens showed that heat treatments that produced a fine grain microstructure promoted high strength and long fatigue life in the bore of a disk, whereas heat treatments that produced a coarse grain microstructure promoted optimal creep and crack growth resistance in the rim of a disk. On the basis of these results, the optimal combination of performance and safety might be achieved by utilizing a heat-treatment technology that could produce a fine grain bore and coarse grain rim in a nickel-base disk.

Alloy 10 disks that were given a dual microstructure heat treatment (DMHT) were obtained from NASA's Ultra-Efficient Engine Technology (UEET) Program for preliminary evaluation. Data on small test specimens machined from a DMHT disk were encouraging. However, the benefit of the dual grain structure on the performance and reliability of the entire disk still needed to be demonstrated. For this reason, a high-temperature spin test of a DMHT disk was run at 20 000 rpm and 1500 °F at the Balancing Company of Dayton, Ohio, under the direction of NASA Glenn Research Center personnel. The results of that test showed that the DMHT disk exhibited significantly lower crack growth than a disk with a fine grain microstructure. In addition, the results of these tests could be accurately predicted using a two-dimensional, axisymmetric finite element analysis of the DMHT disk. Although the first spin test demonstrated a significant performance advantage associated with the DMHT technology, a second spin test on the DMHT disk was run to determine burst margin. The disk burst in the web at a very high speed, over 39 000 rpm, in line with the predicted location and speed. Furthermore, significant growth of the disk was observed before failure, in line with predictions, clearly demonstrating the reliability and safety of the DMHT technology.



DMHT disk before and after burst testing.

Although successful spin testing in Ultra Safe's Nickel Disk Program represents a significant milestone for DMHT technology, realistic engine operation will require repeated loading of a DMHT nickel disk. For this reason, a cyclic spin test study of DMHT nickel disk technology has been proposed to start in fiscal year 2003 under NASA's Aviation Safety Program. The goal of this program will be to determine the fatigue failure mechanism in DMHT nickel disks, thereby demonstrating the reliability and safety of DMHT technology under repetitive loading conditions encountered in realistic engine operation.

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Programs/Projects: Ultra Safe, UEET, AvSP