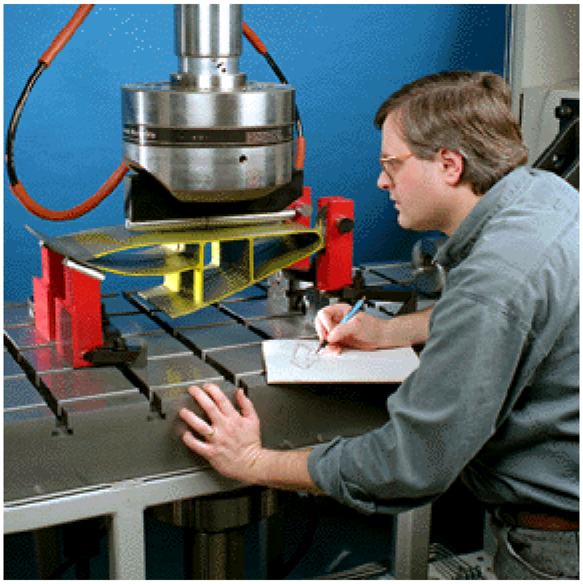
Enabling Propulsion Materials (EPM) Structural Component Successfully Tested Under Pseudo-Operating Conditions*

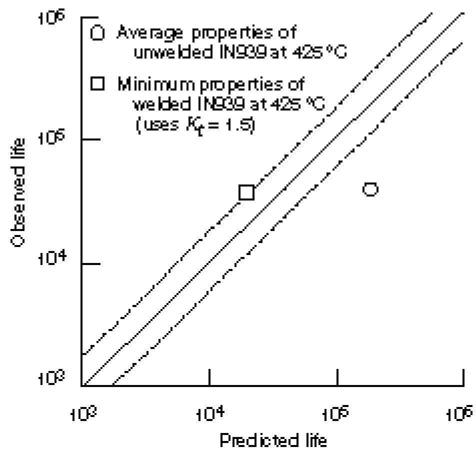
A fabrication feasibility demonstration component for the Enabling Propulsion Materials (EPM) program was evaluated under prototypical engine loading conditions at the Structural Benchmark Test Facility at the NASA Lewis Research Center. The purpose for this test was to verify EPM casting, joining, coating, and life-prediction methods. Electron beam welding techniques developed in the EPM program were used to join two large superalloy cast sections of an exhaust nozzle flap to fabricate the demonstration component. After the joints were inspected, the component was coated with an oxidation-resistant barrier coating and was sent to Lewis for testing.

The special test fixture shown in the photo (the Structural Benchmark Test Facility) was designed and built at Lewis to produce a biaxial bending condition similar to the loading condition this part would encounter during engine operation. Several finite element analyses were conducted to validate the mechanical test method. A floating furnace was then designed to provide prototypical thermal profiles in the component. An isothermal low-cycle fatigue test was used to evaluate the component at a cyclic load of 13 kN (maximum) to 1 kN (minimum) at a frequency of 1 Hz. Component failure was defined as a 30-percent increase in the component's compliance. On the basis of this definition, the low-cycle fatigue life of this component would be 35,000 cycles.



Mechanical loading fixture with demo component, loading ram, universal support pivots, and sliding rockers. Failure initiated in the weld at the location of the highest stress. Local temperature, 425 °C; loading, -1 to -13 kN at 1 Hz; pressure equivalent, 110 *kN/m² (maximum).*

As predicted, a fatigue crack began in the high stress location of the welded joint, and the local temperature at the failure site was 425 °C. On the basis of several lifing methods that were developed for conventional superalloys, the predicted life of the component was 18,000 cycles. As shown in the graph, using average material properties (see the circle on the graph) would give a very nonconservative (128,000 cycles) life prediction that is more representative of an unwelded component. To account for the welded joint and its unknown properties, minimum parent material properties and a K_t of 1.5 were used as knockdown factors. With these knockdown factors, the predicted life of the welded component was 18,000 cycles (see the square on the graph). Lewis' life prediction method was within a factor of 2 of the actual demo component life.



Life prediction of demo component showing predicted life for welded and unwelded component. Component life, 35,000 cycles; stress concentration factor, K_t, 1.5.

*Because of Limited Exclusive Rights restrictions, specifics on test conditions, material details, and engine operation conditions have been omitted.

Lewis contact: Dr. Paul A. Bartolotta, (216) 433-3338, SMBart@popserve.grc.nasa.gov
Author: Dr. Paul A. Bartolotta
Headquarters program office: OA