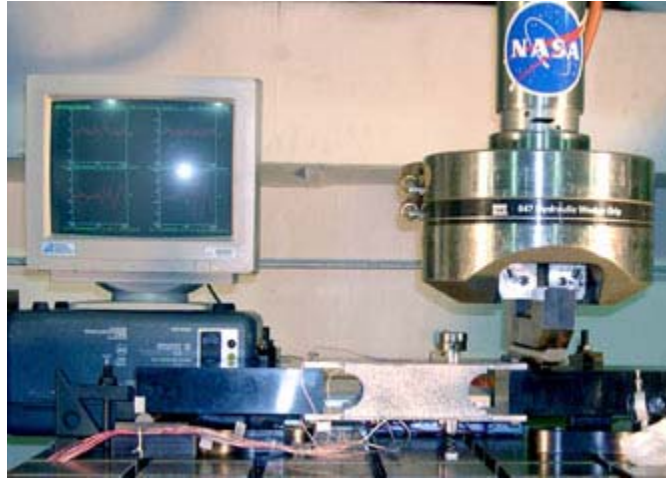


Titanium Aluminide Scramjet Inlet Flap Subelement Benchmark Tested



Benchmark test configuration for inlet flap subelement (object painted white with black speckles).

Long description of figure. Approximately 1-foot-long subelement sandwiched between two similarly sized black fixtures. The fixtures are supported by rollers at the extreme ends, and the right-side fixture is loaded from above by a large hydraulically gripped load bar.

A subelement-level ultimate strength test was completed successfully at the NASA Glenn Research Center (<http://www.nasa.gov/glenn/>) on a large gamma titanium aluminide (TiAl) inlet flap demonstration piece. The test subjected the part to prototypical stress conditions by using unique fixtures that allowed both loading and support points to be located remote to the part itself (see the photograph). The resulting configuration produced shear, moment, and the consequent stress topology proportional to the design point. The test was conducted at room temperature, a harsh condition for the material because of reduced available ductility. Still, the peak experimental load-carrying capability exceeded original predictions.

The lightweight TiAl subelement was designed with several complicated features and fabrication technologies to demonstrate full-scale manufacturing capability as a potential backstructure material for maintainable composite panel heat exchangers in the inlet, combustor, and nozzle section of a turbine-based combined-cycle propulsion system (refs. 1 and 2). The achievement of aggressive thrust-to-weight and long-life goals requires advanced materials such as TiAl for next-generation launch vehicles. This subelement was constructed with the high-strength, high-temperature alloy Gamma MET PX,¹ with a weight-reduction potential of approximately 40 percent in comparison to a baseline Inconel 718 configuration (ref. 2). It was a collaborative effort between NASA, Pratt & Whitney (<http://www.pratt-whitney.com>), Engineering Evaluation & Design

(<http://www.eeandd.com>), PLANSEE AG (<http://www.plansee.com>), and the Austrian Space Agency (<http://www.asaspace.at>).

The TiAl inlet flap was designed to satisfy many functional objectives. Structurally, it avoided complicated shapes, minimized the number of stress concentrations, and used one-pass brazing for sheet construction and local reinforcement at high-stress locations. During the benchmark test, sensors detected early cracking at less than the predicted failure load; it was theorized that a face-sheet-to-web braze began to peel at this level. The local separations resulting from the braze peeling allowed load shedding to stiffer adjacent regions of the structure. The loading ramp progressed with quite linear structural response and with continued crack detection until a peak load approximately 10 percent higher than predicted was reached, when the subelement fractured completely. This high load-carrying capacity demonstrated a significant TiAl material success.

The test was completed in-house at Glenn's Life Prediction Branch's (<http://www.grc.nasa.gov/WWW/LPB/>) Structural Benchmark Test Facility. It utilized a large 500-kN (110,000-lb) load frame with a fully digital data acquisition and control system. A four-sensor acoustic emissions system monitored crack detection and growth. Real-time strains were measured with eight strain gauges, and digital images of a random speckle pattern applied to the subelement were correlated after testing to produce full-field, through-the-thickness surface strain plots. Glenn's Advanced Metallics Branch (<http://www.grc.nasa.gov/WWW/AdvMet/webpage/>) personnel performed related sheet tensile, fatigue, and creep tests, and a number of realistic feature tests, including bond shear, stepped tensile, bolted clevis, and braze peel tests.

References

1. Draper, S.L., et al.: Advanced Metallic Materials for Turbine Based Combined Cycle Propulsion Systems. Presented at the JANNAF 39th Combustion Subcommittee, 27th Airbreathing Propulsion, 21st Propulsion Systems Hazards Committee, and 3rd Modeling and Simulation Subcommittee Joint Meeting, Dec. 2003. Available from Chemical Propulsion Information Agency (CPIA).
2. Doehnert, B., et al.: Final report for NASA Contract No. NAS3-01138 Task Order 11, FR-26186-1, Pratt & Whitney Space Propulsion, West Palm Beach, FL, Apr. 2004.

Find out more about this research:

NASA Glenn Research Center at <http://www.nasa.gov/glenn/>

Advanced Metallics Branch at <http://www.grc.nasa.gov/WWW/AdvMet/webpage/>

Life Prediction Branch at <http://www.grc.nasa.gov/WWW/LPB/>

Pratt & Whitney at <http://www.pratt-whitney.com/>

Engineering Evaluation & Design at <http://www.eeandd.com/>

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¹Gamma MET PX is a trademark of PLANSEE AG, Austria. Alloy composition is based on TNB alloys developed by GKSS Research Center, Germany.