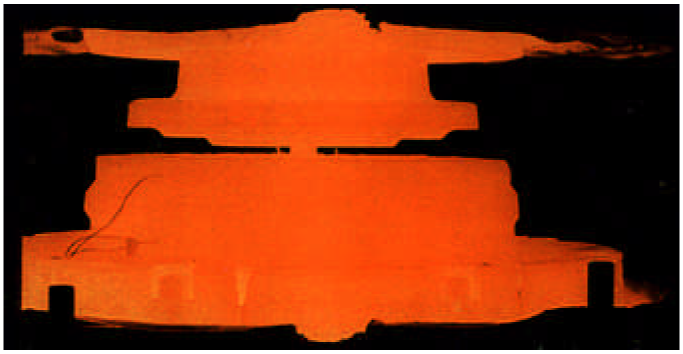
High-Temperature Compressor Material Development

The next generation of subsonic commercial aircraft will require engines with improved efficiency and greater durability at lower costs. To help achieve these goals, manufacturing technologies for the disks, airfoils, and impellers in the compressors of these advanced turbine engines are being developed by a team representing all four U.S. aircraft engine companies--GE Aircraft Engines, Pratt & Whitney, AlliedSignal Inc., and Allison Engine Company. This work is being funded by NASA's Advanced Subsonic Technology (AST) project.

For axial compressors, manufacturing technologies are being developed for advanced nickel-base superalloy disks with improved creep strength and slower crack growth rates. Statistically designed experiments are being employed to develop the optimal compaction, forging, and heat treatment of these advanced disk alloys for large and small turbine engines. For large turbine engines, emphasis will be directed at developing the manufacturing technologies for an advanced disk alloy developed under NASA's Enabling Propulsion Materials (EPM) program. A wide processing window will be needed because of the thick bores and large diameters of these disks. For small turbine engines, emphasis will be directed at optimizing the processing window of alloys specifically tailored for the more aggressive heat treatments obtainable in smaller disk sizes. The disk manufacturing technologies will be developed on subscale disks and verified on full-scale disks, with a goal of increasing the operating temperatures by as much as 200 F or extending life at current operating temperatures up to 2 times. Furthermore, the cost of manufacturing these advanced disk alloys should be no greater than that for current disk alloys.



Forging of nickel-base superalloy disk.

To realize increased operating temperatures in advanced axial compressors, researchers must also improve airfoil alloys since current forged airfoils will not meet the projected life requirements of future compressors. To overcome this deficiency, the AST engine team is also developing casting technologies for "razor" thin compressor airfoils. Cast nickel-base superalloy airfoils will match the enhanced temperature capability of the advanced disk alloys and at the same time reduce the cost of compressor airfoils once the casting process is developed and optimized.

Although the disk and airfoil effort will enable higher operating temperatures in axial compressors, many smaller turbine engines utilize a centrifugal compressor that is limited by the speed and temperature of the impeller. Current impellers, which use only a single alloy (titanium or superalloy), will not meet projected operating conditions for future designs. Instead, using a dual-alloy titanium impeller appears to be the only way future requirements can be met. In this part of the program, AlliedSignal and GE have formed a team to develop a dual-alloy titanium impeller for future commercial turbine engines. The impeller will use a high-temperature, creep-resistant titanium alloy in the airfoil section bonded to a high-strength, fatigue-resistant titanium alloy in the hub. As with the disk program, subscale impellers will be used to develop manufacturing technologies, such as the bonding process. After development is completed, a full-scale impeller will be produced and spin tested to prove the design.

Development and demonstration of all three technology items-disk, airfoil, and impeller-are scheduled to be completed by 2001. If successful, they will be available to all four U.S. engine companies at that time to help them maintain a competitive position in the global market.

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