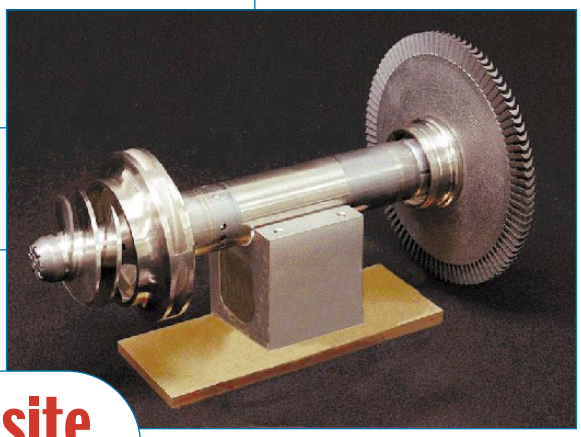

Ceramic Matrix Composite Turbine Disks

Using rugged, durable ceramic composites instead of metals in turbomachinery could dramatically improve rocket engines of the future. Engineers at NASA's Marshall Space Flight Center in Huntsville, Ala., are investigating the use of ceramic composites in rocket engine turbines to increase safety and reduce costs of operating reusable launch vehicles.

Major rocket engine manufacturers list improved turbines as one of their greatest needs. A turbine in a typical rocket engine is a metallic disk with separately attached blades. It provides power to the pumps that pressurize the engine propellants.

At the Marshall Center, engineers are testing a bladed disk—called a "blisk"—made of ceramic composite material. This material appears to tolerate extreme heat and vibration much better than traditional nickel-alloy turbines. The material used in the blisk is a weave of continuous carbon fibers reinforced by a silicon carbide matrix, or binding substance, deposited between the fibers. The ceramic matrix composite is similar in construction to multiple layers of cloth filled with an extremely strong starch.

An engineered, composite material offers many advantages. One intriguing characteristic is its ability to withstand damage. In extensive testing, the ceramic blisk continued to perform normally despite a crack in one of the blades. After detecting a fracture in the blade, engineers ran the ceramic turbine through millions of cycles that demonstrated its durability under stress.

The ceramic blisk also can withstand temperatures of 2,000 degrees Fahrenheit (1,093 degrees Celsius), considerably higher than the 1,200 degrees F (649 degrees C) tolerated by nickel-alloy turbines. The more heat the spinning turbine can withstand as it provides power to the engine, the less fuel it requires. The increased engine efficiency allows for heavier payloads or boosts to higher orbits. Additionally, since the composite blisk is only about one-fourth the weight of the metal discs, the weight saved in the blisk can be used to increase the weight of the payload.

The Marshall Center has tested the blisk in a rocket engine turbopump—a turbine-powered pump—dozens of times, accumulating a wealth of data to predict the life of ceramic matrix composites in rocket engines. It was tested at 25,000 revolutions per minute—about 10 times the average rpm of a car engine. The blisk used in testing is 7.6 inches (19 centimeters) in diameter and about 3/4 inch (2 centimeters) thick and was manufactured by Honeywell Advanced Composites Inc. of Newark, Del.

NASA's Glenn Research Center in Cleveland, Ohio, and the University of Alabama in Huntsville are also partnering with the Marshall Center in the ceramic composite activity.

These same materials could also make better industrial equipment and power-utility generators.

The ceramic blisk is one of many technology development activities at the Marshall Center aimed at improving the safety and reliability and reducing the cost of space transportation.