Technology Opportunity

High-Temperature Braided Seals

The National Aeronautics and Space Administration (NASA) seeks to transfer technology for high-temperature braided seals that have proven effective in sealing complex structures under severe operating conditions.

Potential Commercial Uses

Demonstrated Applications

- Compliant seals for advanced turbine vanes at temperatures over 1500 °F
- High-temperature seals for industrial tube applications

Potential Applications

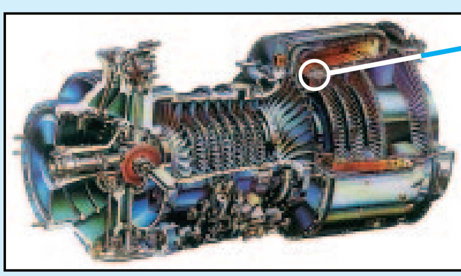
- Furnace doors
- Heat exchangers and recuperators
- Rocket casings and engine nozzles
- Combustor liners
- Two-dimensional turbine afterburner nozzles, aerospike nozzles for X-33 aircraft, and hypersonic engine nozzles
- Aerospace vehicle access doors
- Seals for continuous casting or molds
- Glass processing systems
- High-temperature joints requiring flexibility

Benefits

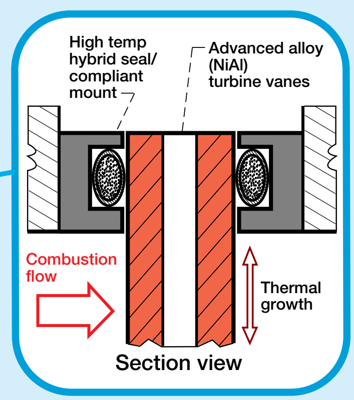
- High-temperature operation (1500 to over 2000 °F)
- Flexible: seals and conforms to complex geometries, providing O-ring-like flexibility
- Low leakage
- Field joint capability
- Relative thermal growth allowed between primary and support structures
- Hybrid design resists abrasion

GE Uses NASA Seals to Meet JTAGG Engine Goals

- GE application of NASA 1500 °F rope seals overcomes thermal shock failure of advanced NiAl blades in engine test
- Contributed to meeting JTAGG Phase 1 goals:
  + Reducing specific fuel consumption by 20%
  + Increasing power-to-weight by 40%
- Engine Team awarded 1995 Aviation Week & Space Technology Laureate Award



Schematic of vane seal hardware



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The Technology

Developed initially for the National AeroSpace Plane (NASP) project, the new braided rope seals under development at the NASA Lewis Research Center have potential for both industrial and aerospace applications. The seals are braided of emerging high-temperature ceramic and/or superalloy materials that can withstand the extreme temperatures (above 2000 ºF) of the next generation of commercial and military aircraft engines and of advanced industrial system applications.

Advanced metal and ceramic fibers are braided into low-leakage flexible seal structures capable of sealing complex geometries. The seals exhibit the following important properties: (1) they operate at high temperatures (1500 to over 2000 ºF), (2) they exhibit low leakage, (3) they resist mechanical scrubbing caused by differential thermal growth and acoustic loads, (4) they seal complex geometries, (5) they retain resilience after cycling, and (6) they support structural loads. These seals can be braided to any size possible with conventional braiding equipment. Sizes investigated to date include 1/16, 1/8, and 1/2 in.

NASA has developed unique facilities to evaluate the high-temperature flow and durability properties of the seals. The piston seal test fixture measures seal flow and durability at temperatures between 70 and 1500 ºF and pressures between 0 and 100 psig. At high temperatures, the durability of the test seals is investigated by reciprocating the piston within the stationary cylinder up to 0.3 in. The feasibility of the high-temperature braided seals have been demonstrated for several applications, including the turbine vane seal and the industrial tube seal.

Turbine Vane Seal—Aircraft engine turbine inlet temperatures and industrial system temperatures continue to climb to meet aggressive cycle thermal efficiency goals. Advanced material systems including monolithic and composite ceramics, intermetallic alloys (i.e., nickel aluminide), and carbon-carbon composites are being explored to meet the aggressive temperature, durability, and weight requirements. In incorporating these materials in the high-temperature locations in the system, designers must overcome materials issues such as differences in thermal expansion rates and lack of material ductility. NASA provided hybrid braided rope seals to GE to overcome thermal cracking of the advanced alloy vanes exposed to turbine heating rates. The NiAl vane and seal were implemented into a JTAGG engine demonstrator and successfully run for multiple cycles, meeting all performance criteria.

Industrial Tube Seal—In an industrial tube seal application, the seal serves as both a seal and a compliant mount, allowing relative thermal growth between the high-temperature, low-expansion rate primary structure and a higher expansion rate structural support, limiting thermal/structural loads. Both the all-ceramic and hybrid (ceramic core/superalloy sheath) seals met flow and durability goals under design preloads at temperatures up to 1300 ºF.

Options for Commercialization

NASA holds the following five patents for high-temperature seal technology, including the fiber preform technology described herein, and is seeking partnerships with industry to commercialize the technology:

- *High Temperature, Bellows Hybrid Seal* (U.S. Patent Number 5,332,239 issued July 26, 1994)
- *High Temperature, Flexible Fiber Preform Seal* (U.S. Patent Number 5,082,293 issued: January 21, 1992)
- *High Temperature, Flexible Pressure-Actuated Brush Seal* (U.S. Patent Number 5,076,590 issued December 31, 1991)
- *High Temperature, Flexible Thermal Barrier Seal* (U.S. Patent Number 5,014,917 issued May 14, 1991)
- *High Temperature Flexible Seal* (U.S. Patent Number 4,917,302 issued April 17, 1990)

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