NASA TECH BRIEF

Tungsten Fiber-Reinforced Nickel Superalloy with Greatly Increased Strength at 2000°F

Fiber-reinforced metals have been investigated extensively in recent years. One of the promising composite types being studied is refractory metal fiber-reinforced superalloys. An area of application under study for these particular composites is in advanced gas turbines where operating temperatures may exceed 2000°F. A tungsten fiber-reinforced nickel-base superalloy has now been developed which has a 1000-hour strength of 37,000 psi at 2000°F. This is equivalent to the 1000-hour strength of the best previously developed similar composite, and is six times as strong as commercially available nickel superalloys. The strength to density ratio of the composite is also greater and therefore can be considered for applications where reduced weight rather than greater strength is desired.

Previous work has shown that the properties of fiber-reinforced materials are greatly affected by the fiber-matrix reaction. Fiber composites with excellent properties can be produced by controlling the reaction between fiber and matrix. The strength of the composite is determined by the retained strength of the fiber; adverse fiber-matrix reaction can substantially reduce fiber strength. Accordingly, one of the efforts being made to improve the strength of composites is to develop stronger fibers. The stronger the fiber, the stronger the composite for a given degree of fiber-matrix reaction. One of the fibers recently developed was tungsten with 2 weight percent thorium oxide, which was combined with a nickel-base superalloy matrix to produce this new and stronger composite.

Matrix composition, fabrication technique and fiber diameter were selected to minimize fiber-matrix reaction and preserve composite strength. The fibers are 0.015-inch in diameter and specially drawn for high strength. The matrix composition in weight percent is: nickel 56, tungsten 25, chromium 15, titanium 2, and aluminum 2. The composite is prepared by slip-casting a powdered superalloy-water slurry into an array of fibers. The dried slip casting is consolidated by pressing and heating. Fiber content can be varied from zero to 80 volume percent to achieve the desired reinforcement. The 70 volume percent unidirectional-oriented fiber composite has a 100-hour rupture strength of 49,000 psi at 2000°F, and a 1000-hour strength of 37,000 psi at 2,000°F.

Notes:

1. The first refractory-alloy-fiber reinforced superalloy developed (announced in NASA Tech Brief 68-10369) used commercially available (lamp filament) tungsten fibers containing 1 weight percent thorium oxide. This composite has a 100-hour rupture strength of 35,000 psi at 2000°F, and a 1000-hour rupture strength of 26,000 psi at 2000°F. The stress-density value for rupture in 100 hours at 2000°F is 60,000 inches.
2. These composites may be used in place of superalloys where higher strength or greater strength to density ratios are advantageous, and will permit higher operating temperatures in particular applications.
3. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

(continued overleaf)

Reference:
NASA-TN-D-5575 (N70-18962), Preliminary Evaluation of Tungsten Alloy Fiber-Nickel Base Alloy Composites for Turbojet Engine Applications

4. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B70-10183

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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