NASA TECH BRIEF

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Grinding as an Approach to the Production of High-Strength, Dispersion-Strengthened Nickel-Base Alloys

The problem:

To develop dispersion-strengthened nickel-thoria alloys with outstanding properties from mechanically comminuted and blended powders. To date, the only nickel-base dispersion-strengthened products which have good high temperature strength have been produced by chemical processes.

The solution:

Previous efforts to make dispersion-strengthened products by a mechanical approach had very little success. Work at NASA has indicated that the main reason for this was that the surface of the fine matrix powder was contaminated during milling with large amounts of impurity oxide. The impurity oxide promoted undesirable agglomeration of the intentionally added stable oxide (thoria) during subsequent processing.

Undesired impurity oxides can be removed by a particular method (developed by NASA) of cleaning the ball-milled powdered blends. This method involves heating thin shapes of partially-compacted milled powder blends in hydrogen to carefully controlled temperature schedules to simultaneously clean and densify them. After further processing, the resulting alloy specimens possess substantially better strength than the best comparable commercial products produced by chemical methods. The mechanical comminution and blending process permits a high degree of flexibility in choice of materials, and may also prove to have a cost advantage over chemical processes.

How it's done:

Two material compositions have been produced: (1) 4.0 volume percent thoria in nickel; and (2) 0.5 weight percent zirconium and 4.0 volume percent thoria in nickel. Nickel, or nickel with 0.5 weight percent zirconium hydride, was ball-milled with added grinding agents for five days to particle sizes ranging from 0.02 to 0.04 microns. Four volume percent of colloidal (0.005 to 0.015 micron) thoria was then added and the mixture ball-milled for another 24 hours to achieve a random blend. The powder slurry (powder plus liquid grinding agents) was passed through screens, and partially dried and compacted. The compacted slabs were then cleaned by heating in hydrogen to a carefully controlled temperature schedule. (See NASA Technical Memorandum X-52228.) The cleaned sintered slabs were finally roll-worked in such a way as to promote high temperature strength. The resulting sheet material specimens had 2000°F tensile strengths ranging from 16,000 to over 20,000 psi. (Comparable chemically produced commercial sheet products have tensile strengths at 2000°F of 14,000 to 16,000 psi.) These new alloys can also be produced in bar stock or wire form.

Notes:

1. Dispersion-strengthened materials may ultimately be substituted for superalloy sheet in very high temperature use (above 1800°F). Specific applications would be for advanced gas turbine components such as turbine vanes, burner cans, and after-burner liners. Other applications could be for heat exchangers, honeycomb structures, high temperature fasteners, furnace trays, furnace liners, high temperature tubing, heat shields, electronic parts and other equipment for use in the 1800°F to 2400°F temperature range.
2. This technique, using ball-milled powders, should permit production of even higher strength nickel

(continued overleaf)

matrix products and alloys of many other material compositions. It can probably (with some refinements) be scaled up for commercial production of materials such as refractory metals, nickel and cobalt base superalloys, stainless steels, and nonferrous metals.

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)

   Reference: NASA-TN-D-5421(N69-38074),
   Dispersion-Strengthened Nickel Produced
   from Ultrafine Comminuted Powders

4. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B70-10185

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

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