NASA TECH BRIEF

Improved Method of Producing Oxide-Dispersion-Strengthened Alloys

The problem:

To develop an improved method for producing wrought alloys consisting of one or more ductile matrix metals (e.g., copper) and a uniformly dispersed phase of a refractory metal oxide, or oxides (e.g., Al_2O_3). Since the introduction of the SAP (dispersion-strengthened, sintered aluminum powder) method in 1948, considerable effort has been expended to produce other dispersion-strengthened alloys incorporating a ductile metal as a matrix. The dispersed refractory oxide generally tends to improve the mechanical properties of the matrix metal with respect to resistance to creep, yield strength, and high-temperature stability. In previous methods of preparing alloys of this type, however, it was difficult to obtain uniform dispersions of sufficiently small-sized particles of the refractory oxide in the matrix metal. As a consequence, some of the favorable properties (e.g., electrical conductivity and ductility) of the matrix metal would be degraded when the alloys were prepared by these methods.

The solution:

Dispersion-strengthened alloys having the required properties are produced by a process in which the refractory particles (dispersoid) are reduced in size below that of the particles previously obtainable economically on a commercial scale. The refractory particles which appear in the wrought alloys are in the form of flakes less than 100 to 500 angstroms thick. These are fine enough to ensure the desired strength characteristics without appreciable degradation of the other characteristics of the alloys. The components used to make the alloys consist of a matrix metal (such as one of the following: copper, nickel, cobalt, iron, molybdenum, tungsten, titanium, zirconium, niobium, tantalum, or any of their alloys) and a dispersoid metal, which has a greater affinity for oxygen than the particular matrix metal chosen for the alloy. Examples of appropriate dispersoid metals are aluminum, beryllium, thorium, titanium, zirconium, hafnium, yttrium, and chromium. It is important to note that a given metal can function either as a matrix metal or a dispersoid metal, depending on the other metal used in the combination. Furthermore, the dispersoid metal must be soluble to the extent of at least 0.5 atom percent in the matrix metal at room temperature.

How it's done:

An example of an alloy produced by the improved method is one containing copper as the matrix metal and aluminum oxide (Al_2O_3) as the dispersoid. The powder used to make the wrought alloy consists of copper and aluminum in solution. This alloy powder contains 2.5 to 16.0 atom percent of aluminum (which is to be converted in part to the refractory Al_2O_3 dispersoid) and a balance of copper, which serves as the matrix metal. This powder is suspended in ethanol, and the suspension is subjected to comminution at room temperature to convert the powdered material to flakes having a thickness preferably no greater than 0.5 micron and length and width dimensions of 1 to 10 microns. In the comminution process, the powder particles are oxidized to provide flakes consisting of aluminum oxide film patches surrounded by copper oxide regions in a copper matrix. The flakes, after separation from the ethanol and drying, are placed in a container which can either be evacuated or filled with an inert gas. The temperature of the container is raised to about 600° to 850°C, and the flakes are kept in this environment to allow the copper oxides to dis-

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solve and react with the dissolved aluminum in the flakes. In this step of the process, the oxygen released from the copper oxides is diffused in depth to effect internal oxidation of the aluminum. This step can be completed in less than 1 hour, depending on the temperature control, to ensure that the matrix copper is entirely free of oxygen. The resultant product, containing a fine dispersion of the hard refractory aluminum oxide in a ductile copper matrix, is compacted and heated to a working temperature in the inert environment. The compact may then be extruded or otherwise hot-worked to a wrought alloy form.

Notes:

1. In one modification of the method, the flakes (from the comminution step) are placed in a reducing atmosphere, e.g., hydrogen, to free the matrix copper oxide of oxygen, thus eliminating the internal oxidation step (release of oxygen from the copper oxide to convert a chemically equivalent amount of aluminum to aluminum oxide).
2. A further advantage of the alloys produced by this method is that a significant amount of the reducing metal (aluminum cited in the example) is left in solution, thereby increasing the corrosion resistance of the alloys.
3. Inquiries may be directed to:

   Technology Utilization Officer
   NASA Headquarters
   Washington, D.C. 20546
   Reference: B69-10536

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act 42 U.S.C. 2457 (f), to the Massachusetts Institute of Technology, Cambridge, Mass. 02139.

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