NASA TECH BRIEF
Marshall Space Flight Center

Metallic Composites as High-Temperature Fasteners

Composites, as the name implies, are combinations of two or more materials, usually with combined properties superior to either material by itself. The technique of incorporating one of the composite components with directional ordering to provide added strength has been extensively used with fiber-polymer composites. A similar technique can be used with metallic alloys.

Metallic composites can be fabricated in a one-step casting process in which a eutectic mixture of the metals is directionally solidified. These phase-reinforced eutectic alloys have superior high-temperature mechanical properties. Because of their superior characteristics, such as microstructural stability, shear strength, creep-rupture strength, and fatigue resistance, they are excellent materials for high-temperature fasteners.

Prototype bolts and rivets have been made from directionally solidified, eutectic alloys of Ni_3Al-Ni_3Cb and (Co,Cr,Al)-$(Cr,Co)_7C_3$. The former is lamellar ordered or reinforced and the latter a fibrous reinforced eutectic composite.

The Ni_3Al-Ni_3Cb alloy consists of sheet-like dispersions of Ni_3Cb within an Ni_3Al matrix. The reinforcing Ni_3Cb phase makes up about 44% of the volume of the alloy. The alloy melts at 1279° C and has a density of 8.5 g/cm^3. It is a high-modulus material with a tensile strength and creep-rupture strength markedly superior to conventional superalloys.

Fasteners of the nickel-aluminum-columbium eutectic have been fabricated by casting, grinding, and creep forming. The bolts have high-temperature (538° C) transverse shear strengths as high as 609×10^6 N/m^2 (88.3×10^3 psi) and longitudinal shear strengths as high as 262×10^6 N/m^2 (38.0×10^3 psi).

The reinforced composite (Co,Cr,Al)-$(Cr,Co)_7C_3$has a fibrous microstructure in which the reinforcing phase $(Cr,Co)_7C_3$ is 26% of the volume. The matrix is a solid solution of cobalt and chromium with aluminum added to improve the oxidation resistance. The eutectic melts at 1297° C and has a density of 8 g/cm^3.

This alloy is not as strong as the Ni_3Al-Ni_3Cb eutectic, but is more easily grown, 50 cm/hr as compared to 2 cm/hr, and is more oxidation-resistant. The cobalt-chromium-carbon alloy is stronger than conventional nickel-base superalloys and has a high elastic modulus. Bolts of this material have exhibited transverse shear strengths of 559×10^6 N/m^2 (81×10^3 psi) and longitudinal shear strengths of 297×10^6 N/m^2 (43×10^3 psi) at 538° C.

Both Ni_3Al-Ni_3Cb and (Co,Cr,Al)-$(Cr,Co)_7C_3$ show promise as high-temperature fastener materials. The transverse shear strengths are higher than those reported for dispersion-strengthened metals (e.g., TD NiCr). Furthermore, both materials may be used in the manufacture of fasteners by all three methods tested: grinding, creep-forming, and casting.

Note:

Further information is available on the fabrication, properties, and testing of these fasteners. Requests for further information may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Code A&PS-TU
Marshall Space Flight Center, Alabama 35812
Reference: B73-10081

Patent status:

NASA has decided not to apply for a patent.

Source: F. D. George of
United Aircraft Corp.
under contract to
Marshall Space Flight Center
(MFS-22438)

Category 04