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NASA TECH BRIEF

Marshall Space Flight Center

High-Strength Alloy With Resistance to Hydrogen-Environment Embrittlement

Materials exposed to hydrogen under high pressures must be resistant to hydrogen-environment embrittlement. When this resistance is low, hydrogen diffuses through a material and makes it brittle. This is the characteristic of high-strength nickel and chromium alloys. On the other hand, low-strength materials, such as copper, aluminum, and their alloys, as well as some stainless steels have a high resistance to hydrogen-environment embrittlement. High-strength alloys which are highly resistant to hydrogen-environment embrittlement have not been available.

Recent tests on the high-strength Incoloy 903 have indicated that it may be highly resistant to hydrogen-environment embrittlement. The alloy is a precipitation-hardened, high-strength, and low-thermal-expansion material. It is iron-based and contains nickel and chromium at lower levels than the high-strength alloys. Its composition is as follows:

Element	Weight (Percent)
Nickel	38
Cobalt	15
Aluminum	0.7
Titanium	1.4
Columbium	3.0
Boron	0.005
Iron	Balance

Incoloy 903 is readily welded and brazed and has good oxidation resistance to 915 K (1200° F). The alloy is strengthened by a low-temperature anneal at 1100 K (1500° F) which is followed by doubling aging at 985 to 880 K (1325° to 1150° F). Its elastic modulus is constant between room temperature and 915 K, and its fracture toughness is 6.9×10^8 N/m (10^5 psi).

For the tests, Incoloy 903 was heat treated and machined into smooth and notched tensile specimens. These specimens were tested in 48.3×10^6 N/m^2 (7000 psi) hydrogen and helium environments at room temperature. Results have indicated that there was no reduction of notched or smooth strength and therefore no hydrogen-environment embrittlement.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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Code AT01
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Patent status:

NASA has decided not to apply for a patent.

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