March 1974 B74-10002

NASA TECH BRIEF

Lewis Research Center

A New Nickel-Base Wrought Superalloy for Applications Up to 1033 K (1400°F)

A new nickel-base wrought superalloy has been formulated which has superior tensile strength combined with good ductility up to 1033 K (1400°F). The alloy, designated as NASA IIB-7, has properties of interest for jet engine parts such as compressor and turbine discs.

The alloy has a nominal composition in weight percent of: 0.13 carbon, 9.0 chromium, 9.0 cobalt, 2.0 molybdenum, 7.5 tungsten, 10.0 tantalum, 3.5 aluminum, 0.75 titanium, 0.02 boron, 0.10 zirconium, 0.50 vanadium, and 1.0 hafnium, with the balance nickel. Its calculated density is 9.03 g/cm^3 (0.327 lb/in^3). This alloy was melted from high purity raw materials and the cast ingots extruded at 1422 K (2100°F). The material was then hot rolled to 0.013 m (.05 in) diameter bar stock. The heat-treatment which developed outstanding properties in this alloy consisted of a partial solution heat-treatment followed by aging to produce a structure of a fine gamma prime precipitate reinforcing the gamma matrix containing coarser blocky gamma prime particles. Heat treatment consists of: holding for 16 hours at 1144 K (1600°F), then increasing the temperature to 1366 K (2000°F) and holding for one hour, oil quenching, and then aging for 16 hours at 1033 K (1400°F), and cooling.

The alloy, when tested in this condition, displayed the following average tensile properties:

Temperature		Ultimate Tensile Strength		Yield Strength		Elongation	Red. of Area
K	°F	MN/m^2	psi x 10^3	MN/m^2	psi x 10^3	%	%
293	75	2000	300	1720	250	9	13
922	1200	1800	260	1560	230	7	9
1033	1400	1400	210	1290	190	4	5

In stress rupture, the following average properties were determined:

Temperature		Stress		Life	Elongation	Red. of Area
K	°F	MN/m^2	psi x 10^3	hours	%	%
922	1200	1210	175	230	5	7
1033	1400	621	90	20	18	21

The alloy displays good phase stability. When exposed for 1500 hours at 1144 K (1600°F), sigma and mu phases did not form.

The alloy can also be processed by powder metallurgy. Prototype engine discs have been produced from pre-alloyed powder by hot isostatic pressing followed by cross rolling or forging.

Notes:

1. A similar alloy, IIB-11 (see Tech Brief 74-10003), but with 7% tantalum and 4.5% aluminum, has higher rupture strength from 1033 to 1253 K (1400 to 1800°F) but does not have as high tensile strength up to 1033 K (1400°F).
2. Further information is available in the following report:

   NASA CR-120934 (N72-26441), Development Study of Compositions for Advanced Wrought Nickel-Base Superalloys

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10002
3. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10002

Patent Status:

NASA has decided not to apply for a patent.

Source: W.B. Kent and H.L. Black
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under contract to
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(LEW-11827)

Category 04