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High Strength Nickel Base Alloy, WAZ-16, for Applications Up to 2200°F

This alloy product is a high strength, high temperature nickel base material with a higher incipient melting temperature than all known nickel base alloys. It retains a high level of useful strength up to temperatures of 1477 K (2200°F) and above. It is microstructurally stable and has high impact resistance both before and after prolonged thermal exposure. This alloy has higher strength at temperatures between 1366 and 1477 K (2000 and 2200°F) (both long and short time) than all known superalloys.

The NASA WAZ-16 alloy is unique among high temperature alloy systems in several ways. It contains relatively few alloying constitutents, being composed of 16W, 7Al, 2Cb, 2Mo, 0.5Zr, 0.2C and balance Ni (weight percent), and a low content of expensive and rare metals (for example, no chromium or expensive alloying elements such as Ta or Hf which are present in many high temperature nickel base alloys). It has the highest strength of all cast nickel-base alloys in the 1366 to 1477 K (2000 to 2200°F) temperature range. For example, its tensile strength at 1477 K (2200°F) is three times that of the strongest known commercial cast nickel base alloys; 186 MN/m^2 vs 35-69 MN/m^2 (27,000 psi vs 5,000-10,000 psi).

Refractory metals, such as tungsten and molybdenum, are an alternative for applications at these high temperatures, but are very heavy and have extremely poor oxidation resistance. These factors pose many problems in the application of such refractory metals since satisfactory coatings for long time service at these high temperatures simply do not exist. Other alternatives are dispersion-strengthened nickel and cobalt base alloys, which are costly to fabricate and whose strength properties are sensitive to fabrication variables. WAZ-16, on the other hand, is a relatively cheap cast alloy. No heat treatments are needed to develop its outstanding properties. Being a nickel-base alloy, it has substantially higher oxidation resistance than refractory metals.

WAZ-16 is particularly desirable for use where high strength at high temperature, high incipient melting temperature, high impact and wear resistance, and low cost are of concern. These applications include heat treating furnace fixtures, jet engine components, and turbine ground power generating system components. In particular, the turbine stator vanes are prime candidates because of (1) their exposure, in most turbine engines, to non-uniform gas temperature distribution which can cause localized failures if the incipient melting point is exceeded, (2) the need for strength at high temperature (the stator vanes see the highest temperature in the gas turbine cycle), (3) the need for high impact resistance (carbon particles can be extremely erosive to stator vanes), and (4) the need for low cost (the alloy can easily be investment cast to any blade shape at relatively low cost compared to the cost involved in making dispersion strengthened (TD-NiCr) vanes).

The unique aspects of this alloying concept involve the simultaneous achievement of the largest volume fraction of gamma prime of any nickel base alloy and the highest incipient melting point of any nickel base alloy. This was accomplished by three factors:

1. Maximizing the aluminum content to increase the principal high temperature strengthening phase (gamma prime).
2. Making tungsten the major alloying constituent (tungsten increases the melting point of nickel to a greater degree than other metal additions).
3. Keeping the number of alloying constitutents substantially lower than all other commercial high temperature nickel base alloys.

This approach results in a 75% gamma prime content and a 1574 K (2375°F) incipient melting temperature. The maximum gamma prime content in other known commercial nickel base systems is approximately 60%. The incipient melting temperature of other nickel base alloys ranges between 1477 and 1533 K (2200 and 2300°F).

In summary, WAZ-16 alloy represents a unique alloying concept that results in an alloy that (1) has a very high incipient melting temperature as well as very great high temperature strength, (2) is low cost, (3) has higher impact resistance than all known superalloys, (4) has a long service life capability under stress up to temperatures

(continued overleaf)

of 1477 K (2200°F) and above, (5) does not require unique fabrication techniques, and (6) is readily castable to shape.

Notes:

1. Further information is available in the following report:
   NASA TN-D-7648 (N74-26025), A Nickel-Base Alloy, NASA WAZ-16, with Potential for Gas Turbine Stator Vane Application
   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: B74-10082
2. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B74-10082

Patent Status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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