NICKEL BASE ALLOY

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Abstract

A nickel base superalloy for use at temperatures of 2000° F (1093° C) to 2200° F (1205° C) as a stator vane material in advanced gas turbine engines. The alloy has a nominal composition in weight percent of 16 tungsten, 7 aluminum, 1 molybdenum, 2 columbium, 0.3 zirconium, 0.2 carbon and the balance nickel.
NICKEL BASE ALLOY

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be manufactured or used by or for the Government without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention is concerned with an improved alloy having a superior combination of physical and mechanical properties at elevated temperatures for use in advance turbine applications. The invention is particularly directed to a nickel base alloy having ultra high strength at 2000° F to 2200° F.

High temperature superalloys are required to meet the demands imposed by the high turbine inlet-gas temperatures of newer aircraft turbine engines. Of all the hot engine components, the stator vanes are particularly limited by material capability because they are subject to the maximum gas temperatures in the engine cycle.

Various materials have been suggested for use at these elevated temperatures. Among these are a series of refractory metals, cobalt and nickel base superalloys, and dispersion strengthened alloys.

The refractory metals have been undesirable for gas turbine components because of their high density and cost, low oxidation and impact resistance, and processing difficulties. Conventional highly alloyed cast nickel-base alloys drop off sharply in strength above approximately 2000° F (1095° C) because the γ' phase, upon which these alloys primarily depend for high temperature strength, agglomerates or goes into solution above this temperature.

Cobalt-base alloys usually have higher strength above 2000° F than nickel-base alloys, and these alloys have been suggested for use in stator vane applications. However, existing cobalt-base alloys are undesirable because of their high density. Certain of the stronger cobalt-base alloys lack sufficient strength at high stress levels and have poor oxidation resistance. Moreover, the cobalt-base alloys are quite costly.

Dispersion strengthened alloys of nickel and cobalt are suitable for operating at about 2200° F. However, the load carrying capabilities of the dispersion strengthened alloys are limited. Also, certain of these materials exhibit anisotropic properties which may be undesirable in many applications. Dispersion strengthened materials require elaborate and complex processing procedures which must be closely controlled. Costs of dispersion strengthened materials are very high, and handling of the material may represent a problem because many of the dispersion strengthened alloys utilize radioactive dispersoids. Scrap recycling and alloy disposal of these materials then becomes a problem.

A nickel-base alloy series described in U.S. Pat. No. 3,620,718 has been utilized for turbine applications in the 2000° to 2200° F temperature range. While this material is satisfactory around 2000° F, it has become necessary to use a lower density material having higher strength around the upper temperatures of the range.

SUMMARY OF THE INVENTION

A need for a material having improved strength in the 2000° F to 2200° F range has been met by nickel base superalloys of the present invention. The nominal composi-
TABLE 1.-continued

PROPERTIES OF NICKEL BASE ALLOYS

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>PROVED</th>
<th>Pat. #3,620,718</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness: Rockwell A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>As cast</td>
<td>66.6</td>
<td>67.5</td>
</tr>
<tr>
<td>Aged</td>
<td>66.7</td>
<td>66.5</td>
</tr>
</tbody>
</table>

Tensile and stress-rupture data were obtained in air without protective coatings using a hydraulically operated tensile testing machine. The improved alloy has a substantially higher ultimate strength at 2200°F than that of the alloy U.S. Pat. No. 3,620,718. The tensile ductility was the same for both alloys. Also the long time stress-rupture specimens were used to measure density by displacement of water. The density of the improved alloy was less than that of the patented alloy.

A Charpy impact tester was used to measure impact strength at room temperature. Specimens were tested in both the as-cast and aged conditions. Oversize cast bars were aged by exposure for 100 hours at 1800°F followed by 500 hours at 1600°F, machined to standard impact specimen dimensions, and tested at room temperatures. Compared to typical cast commercial nickel- and cobalt-base alloys the impact strength of the improved alloy is two to four times as great.

Hardness readings were taken on flat ground as-cast surfaces. Bars that had been heat treated were ground and tested in a similar manner. Both alloys have similar hardness in both the as-cast and aged conditions.

Although the present invention has been described in conjunction with the preferred embodiment, it will be understood that modifications and variations may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

What is claimed is:

1. A nickel-base alloy adapted for use at elevated temperatures between about 2000°F and about 2200°F consisting essentially of from 15-17 percent tungsten, from 6.8-7.2 percent aluminum, from 0.8-1.8 percent molybdenum, from 1.8-2.2 percent columbium, from 0.2-0.4 percent zirconium, from 0.15-0.20 percent carbon, and the balance nickel.

2. A nickel-base alloy as claimed in claim 1 including about one percent molybdenum.

3. A nickel-base alloy as claimed in claim 1 including about 0.3 percent zirconium.

4. A nickel-base alloy as claimed in claim 3 including about 1 percent molybdenum.

5. A nickel base alloy about 16 percent tungsten, about 7 percent aluminum, about 2 percent columbium, about 0.2 percent carbon, about 1 percent molybdenum, and about 0.3 percent zirconium.