METHOD FOR COATING THE SUPERALLOYS


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Int. Cl. B21c 23/22; C221 1/10

U.S. Cl. 148—11.5

Claims

3,528,861

ABSTRACT OF THE DISCLOSURE

A method of coating the superalloys, particularly with an iron/chromium/aluminum/yttrium alloy, including cold-working and subsequent heat treatment of the coating to minimize the size of the intergranular precipitate and thereby prolong the useful life of the superalloy.

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to and shares a common assignee with a copending application entitled "Iron Base Coating for the Superalloys," Ser. No. 731,650, by F. P. Talboom, Jr. and J. Grafwallner.

BACKGROUND OF THE INVENTION

The present invention relates to improved methods of processing various alloys, particularly the nickel-base and cobalt-base superalloys, to provide a corrosion resistant coating thereon of long term durability.

In the copending application entitled "Iron Base Coating for the Superalloys," Ser. No. 731,650, mentioned previously, there is described a coating composition for the nickel-base and cobalt-base alloys which comprises iron, chromium, aluminum, and yttrium or a rare earth particularly at the composition, by weight, 20–50 percent chromium, 10–20 percent aluminum, 0.03–2 percent yttrium or rare earth balance iron. The present invention is particularly effective in eliminating the detrimental intergranular precipitate which has been found to occur during the deposition cycle of the coating process.

SUMMARY OF THE INVENTION

This invention describes an improved coating process for imparting long term corrosion resistance to various alloys, including the nickel-base and cobalt-base superalloys. In particular it contemplates, as part of a coating process, a cold-working/heat treatment sequence, to minimize the size and effect of any undesirable intergranular precipitate which may be formed in the deposition process.

In the preferred process the coated articles are cold-worked by shot peening, particularly glass bead blasting.

In the more preferred process, articles formed from the nickel-base and cobalt base alloys are coated with a composition comprising iron, chromium, aluminum and yttrium or a rare earth; heat treated following coating; cold-worked; and heat treated to effect recrystallization.

In the most preferred process, articles formed from the nickel-base and cobalt base superalloys are coated in a vacuum chamber to a thickness of 0.003–0.005 inch with a composition comprising, by weight, 25–29 percent chromium, 12–14 percent aluminum, 0.6–0.9 percent yttrium, balance iron; following coating, the articles are heated to about 1900° F. for 4 hours in a non-oxidizing atmosphere, and cooled; the coated surfaces are dry glass bead peened; and, following peening the coated parts are held at about 1975° F. for 4 hours in a non-oxidizing atmosphere.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention was developed primarily to increase the oxidation, sulfidation, erosion and thermal shock resistance of gas turbine blades and vanes formed of the nickel-base and cobalt-base superalloys. The superalloys will be understood to be those strong, high temperature materials which find particular utility in the very demanding environments. Representative of these alloys are those identified in the industry as follows:

Alloy: Composition (percent by weight)
IN 100........ 10 Cr, 15 Co, 4.5 Ti, 5.5 Al, 3 Mo, .17 C, .75 V, .075 Zr, .015 B, balance Ni
MAR–M200... 9 Cr, 10 Co, 2 Ti, 5 Al, 12.5 W, .15 C, 1 Nb, .05 Zr, .015 B, balance Ni
WI 52........ 21 Cr, 1.75 Fe, 11 W, 2(Nb+Ta), .45 C, balance Co
MAR–M302... 21.5 Cr, 1 Fe, 10 W, 9 Ta, .85 C, .25 Zr, balance Co

The characteristic of the typical superalloy is its basis as a nickel-chromium or cobalt-chromium solid solution with additions of aluminum, titanium and/or of refractory metals for strengthening, and carbon, boron and zirconium to promote creep-rupture ductility.

It has been discovered, as described in the copending application, that an alloy of the composition, by weight, 20–30 percent chromium, 10–20 percent aluminum, 0.03–2 percent yttrium/rare earth balance iron will provide long term corrosion protection to the superalloys when applied as a coating. However, the coating effectiveness has been found to be limited by the formation of an intergranular precipitate during the coating deposition cycle.

In accordance with the present invention the effect of the detrimental precipitate is eliminated with a corresponding increase in useful coating life by compressively stressing the coating through cold-working and subsequently heat treating the coating to cause recrystallization. This treatment, which is preferably performed utilizing shot peening or glass bead blasting, breaks up the precipitate into small particles which are more easily taken into solution by heat treatment and which are, in any event, more homogeneously distributed throughout the coating. Accordingly, exposure of the substrate to corrosive attack along the line of the intergranular precipitate is prevented.

In the preferred method of coating the nickel-base and cobalt-base turbine blades and vanes, the surfaces to be coated are first thoroughly cleaned free of all dirt, grease and other objectionable foreign matter, then conditioned by abrasive blasting followed by power flushing with clean water.

The coating is achieved by vapor deposition from a molten pool of the coating alloy in a vacuum chamber held at 10–4 Torr or better. The melt chemistry is preferably the following composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>.02</td>
<td>.005</td>
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<tr>
<td>Chromium</td>
<td>26–28</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>12.5–13.5</td>
<td></td>
</tr>
<tr>
<td>Yttrium</td>
<td>0.65–0.75</td>
<td></td>
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<tr>
<td>Phosphorus</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Sulfur</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>Other elements, total, max.</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

Iron Remainder
The parts are preheated in the vacuum chamber at 1750°F for 5 minutes before deposition is commenced and maintained at temperature during coating. Deposition time varies somewhat but is controlled to obtain the preferred coating thickness for the exterior of blades and vanes of 0.003–0.005, excluding diffused zone. Subsequent cooling to below 1000°F is accomplished in a non-oxidizing atmosphere at a rate equivalent to air cooling. Following coating, the parts are heated to 1900°F in vacuum; held at heat for 4 hours; and cooled in a non-oxidizing atmosphere at a rate equivalent to air cooling.

The coated surfaces are then dry glass bead peened using 0.007–0.011 inch diameter beads with an intensity equivalent to 15 N, the peening being conducted in accordance with the provisions of the Aerospace Materials Specifications AMS 2430E.

The post-peening heat treatment involves heating to 1975°F ±25°F in dry argon, dry hydrogen or vacuum, holding at heat for 4 hours, and cooling at a rate equivalent to air cooling.

Blades and vanes so processed exhibit a uniform coating having a thickness, excluding diffused zone, of 0.003–0.005 inch. The diffused zone for the nickel-base superalloys is 0.001–0.002 inch and for the cobalt-base alloys 0.005–0.0015 inch.

While the present invention has been described in connection with certain preferred embodiments, these will be understood to be illustrative only. Those modifications to the invention evident to those skilled in the art from the teachings herein will, in the true spirit of the invention, be embraced within the scope of the appended claims.

What is claimed is:

1. The method of imparting high temperature corrosion resistance to the nickel-base and cobalt-base alloys which comprises the steps of:
   coating the alloys with a composition consisting essentially of, by weight, 20–50 percent chromium, 10–20 percent aluminum, 0.03–2 percent selected from the group consisting of yttrium and the rare earth elements, balance iron;
   cold-working the coated surfaces to fracture any intergranular precipitates formed in the coating process;
   and
   heat treating the cold-worked alloys to effect recrystallization of the coating.

2. The method according to claim 1 wherein the coating consists essentially of, by weight, about 25–29 percent chromium, 12–14 percent aluminum, 0.6–0.9 yttrium, balance iron, to a thickness of at least 0.003 inch.

3. The method of imparting corrosion resistance to articles formed from the nickel-base and cobalt-base superalloys which comprises the steps of:
   coating the articles with a composition consisting essentially of, by weight, 20–50 percent chromium, 10–20 percent aluminum, 0.03–2 percent selected from the group consisting of yttrium and the rare earth elements, balance iron;
   heat treating the coated articles at about 1900°F;
   peening the coated surfaces; and
   heat treating the peened articles to effect recrystallization of the coating.

4. The method according to claim 3 wherein the recrystallization heat treatment is conducted at a temperature of about 1975°F.

5. The method according to claim 3 wherein the coating consists essentially of, by weight, about 25–29 percent chromium, 12–14 percent aluminum, 0.6–0.9 percent yttrium, balance iron to a thickness of 0.003–0.005 inch.

6. The method according to claim 5 wherein coating is accomplished by vapor deposition from a molten pool of the coating composition in a vacuum chamber.

7. In the processes wherein the high temperature alloys are coated with composition providing long term corrosion resistance thereto, the improvement which comprises:
   peening the surface of the coated alloy; and
   subsequently heat treating the alloy to effect recrystallization of the coating.

References Cited

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U.S. Cl. X.R.
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