United States Patent Office 3,794,511 Patented Feb. 26, 1974

3,794,511

COATING PROCESS FOR A SUPERALLOY ARTICLE

Sanford Baranow, Woodbridge, Conn., assignor to Avco Corporation, Stratford, Conn.

No Drawing. Continuation of abandoned application Ser. No. 686,852, Nov. 30, 1967. This application Oct. 22, 1971, Ser. No. 191,819

Int. Cl. C23c 9/02

U.S. Cl. 117—22 5 Claims

ABSTRACT OF THE DISCLOSURE

The coating of nickel- and cobalt-base alloy articles to improve both thermal fatigue and sulfidation resistance of said articles. The coating is applied by pack cementation in an inert or non-reactive atmosphere or in a vacuum, using as a pack powder an alloy of aluminum and one or more rare earth elements.

This is a continuation of application Ser. No. 686,852 filed Nov. 30, 1967, and now abandoned.

This invention relates to improvements in the properties of articles made of nickel-base or cobalt-base superalloys. More particularly, it relates to the coating of such articles by cementation in a powder pack consisting essentially of an alloy of aluminum and at least one rare earth element, the cementation being carried out in a non-reactive atmosphere. The rare earth element(s) alloyed with the aluminum are those exhibiting a relatively high vapor pressure and the powder composition is such that no melting occurs during the coating process.

The procedure: whereby articles are provided with an outer coating for the purpose of enhancing oxidation resistance or other properties involves diffusion of one or more elements into the article and are well known in the art.

Recent patents describing the application of such coatings to superalloys include the following: Wachtell et al., 3,073,015; Puyear et al., 3,079,276; and Puyear, 3,086,-160.

The disclosures of these patents are incorporated herein by reference, as representative of the prior art and for their definitions of superalloys and other terms in the art.

The present invention provides articles with enhanced thermal fatigue and sulfidation resistance, as compared with articles not treated in accordance with the invention, or with aluminized articles, i.e. articles provided with coatings of aluminum diffused into or alloyed with the surface layers of the article.

Briefly, the process of the invention involves the following:

Embedding articles to be coated in a mass of powdered aluminum—rare earth alloy;

Heating the article while so embedded to a temperature between 1500 and 1900° F.;

Maintaining the pack in a non-reactive atmosphere while it is heated for a desired time interval, usually between 2 and 8 hours;

Cooling the article; and

Recovering the coated article from the pack.

The invention will be better understood from the example which follows:

Articles made of Inco 713 Calloy, an alloy whose nominal composition is 13% Cr, 5.75% Al, 0.75% Ti, 4.5%

Mo, 2% Cb, 0.20% Zr, 0.012% B, balance Ni, except for small amounts of C, Mn and Si, were packed in coating powder alloy consisting of 60 weight percent Misch Metal and 40 weight percent aluminum.

The coating powder was obtained by crushing the alloy of Al and Misch Metal formed by vacuum melting the two ingredients. The retort was placed in a vacuum furnace and heated to 1750° F. and held at that temperature for 4 hours. The loosely adherent pack powder was brushed from the surface of the articles, after they had cooled to room temperature. Metallographic and microprobe examination of the resulting coating derived discloses an outer zone rich in Misch Metal overlaying a zone chiefly of Ni_2Al_3. Below the Ni_2Al_3 zone is a layer of NiAl under which is the article being coated. Comparative testing of these specimens and specimens which had been aluminized with no rare earth present showed a definite superiority of the rare earth aluminized articles, especially in resistance to sulfidation, as compared with the aluminized articles.

Similar improvements were obtained with articles made from high nickel and high cobalt alloys of the following nominal compositions:

	Sr	Co	Zr	Fe	Mo	W	Al	Sb	Ti	Ta	S	B	Ni
A	10		.10	1	4	2	6.5	1	1	2	.18	.2	Bal.
B	24.5	55		1		7.4					.5		10.5
C	5-30	15-65		0-10	3-15		Up to 5		Up to 3		Up to 0.5		10-80

or any of the alloys in U.S. Pat. 3,096,160, or any other of the nickel- or cobalt-base superalloys presently known in the art.

The coating powder used in the example is preferred, because Misch Metal is one of the least expensive sources of rare earths. Alloys or mixtures comprising between 55 and 73% Misch Metal, or cerium or lanthanum or other rare earth metals and between 45% and 27% Al are preferred to alloys containing higher percentages of Al, such as those described in U.S. Pat. 2,980,529, i.e., those containing 70–96% Al.

Instead of a vacuum furnace, the heating can be carried out in any controlled atmosphere furnace in which an inert atmosphere (argon, helium or other noble gas) or a non-reactive atmosphere (hydrogen) is provided and in which the temperature can be maintained at any desired value between 1500° F. and 2000° F.

When rare earth elements such as yttrium are alloyed with Al, the low vapor pressure of the rare earth element may be overcome by including a small amount of NH_4Cl or other volatile halide in the pack in order to effect transport and diffusion of the yttrium into the substrate.

What is claimed is:

1. A process for coating nickel-base superalloy articles to provide them with improved sulfidation resistance and improved thermal fatigue which comprises:

embedding said articles in a pack which consists essentially of particles of a powdered aluminum-rare earth alloy containing between 55 and 73% by weight of rare earth and between 45 and 27% by weight of aluminum;

heating said articles while so embedded to a temperature between 1500° F. and 1900° F. while maintaining said articles in a non-reactive atmosphere;

maintaining said temperature for between 2 and 8 hours and thereafter permitting said articles to cool;

and recovering the resultant coated superalloy articles each bearing a surface into which said rare earth-aluminum alloy has diffused;

the resulting superalloy articles comprising a superalloy base exhibiting a varying composition from the outer surface thereof to the inner core thereof as a result of said process, namely: a first zone adjacent

to the unaffected core of said articles consisting principally of NiAl and being integral with said superalloy article, a second zone consisting essentially of Ni_2Al_3 and disposed between said first zone and a third zone constituting the outer surface of the coated article, said third zone consisting essentially of an alloy of aluminum, rare earth and superalloy and being integral with said article.

2. The process of claim 1 wherein the powdered pack contains a substantial amount of a volatile halide.

3. The process of claim 2 wherein the volatile halide is ammonium chloride.

4. The process of claim 1 wherein the rare earth in said powdered alloy is supplied by Misch metal.

5. The process of claim 1 wherein the heating step is conducted while the article and the powder pack are in a vacuum furnace.

References Cited

UNITED STATES PATENTS

3,447,912	6/1969	Ortner et al.	75—138 X
3,096,160	7/1963	Puyear	117—22 X
3,079,276	2/1963	Puyear et al.	117—131 X
3,061,463	10/1962	Samuel	117—107.2 PX
3,073,015	1/1963	Wachtell et al.	117—107.2 PX
1,672,444	6/1928	Becket	117—131 X
1,899,569	2/1933	Howe	117—119 X
2,536,774	1/1951	Samuel	117—22
3,312,546	4/1967	Mayer et al.	117—107.2 P
2,809,887	10/1957	Runnalls	75—152 X
3,528,806	9/1970	Beghi et al.	75—138
1,091,057	3/1914	Gilson	117—131 X
2,885,283	5/1959	Schonfeld et al.	75—138 X
2,980,529	4/1961	Knapp et al.	75—58 X

FOREIGN PATENTS

9,097	10/1913	Great Britain	117—22

WILLIAM D. MARTIN, Primary Examiner

S. BECK, Assistant Examiner

U.S. Cl. X.R.

29—197; 117—107.2 P, 131