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Kubick

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[54] **METHOD OF FORMING PROTECTIVE COATINGS ON FERROUS METAL AND THE RESULTING ARTICLE**

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[52] **U.S. Cl.** .....**29/195,** 29/196.2, 29/196.6, 117/69, 117/71 M, 117/93.1 PF, 117/105, 117/105.2

[51] **Int. Cl.**.....**B32b 15/00,** B32b 15/04

[58] **Field of Search**.....117/71 M, 69, 93.1 PF, 105, 117/105.2; 29/195, 196.2, 196.6

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[57] **ABSTRACT**

A composite comprising a ferrous metal substrate and three layers of specific materials is disclosed. The first layer is nickel aluminide, the second layer is a nickel-chromium alloy and the third layer is an aluminum oxide ceramic. A process for producing the composite is also disclosed which comprises depositing the layers in a specific order under controlled temperature conditions.

8 Claims, No Drawings

METHOD OF FORMING PROTECTIVE COATINGS ON FERROUS METAL AND THE RESULTING ARTICLE

BACKGROUND OF THE INVENTION

This invention relates to coated ferrous metal substrates. More particularly, it relates to coated materials suitable for the casting of molten aluminum.

Molds and cores which are useful in the permanent mold casting of various aluminum articles in addition to withstanding the temperatures of molten aluminum have to be insoluble in molten aluminum, have good heat transfer properties and leave a smooth finish to the cast article. One of the presently used methods is to use a tool steel coated with a parting compound which enables the cast aluminum article to be separated from the mold, however, after repeated casting, for example, in the order of 600 to 650 castings, the parting compound coating cracks and spans and has to be removed by sandblasting. Other materials such as cast iron which are generally less expensive are not suitable since the sandblasting yields an unsmooth finish. Refractory metal molds have been used but are difficult to machine, thus adding to the cost of the mold.

It is believed, therefore, that a composition that can withstand the temperatures of molten aluminum, has good heat transfer p operties, does not require expensive steels as a substrate, does not require repetitive sandblasting and allows separation of a smooth cast aluminum article is an advancement in the art.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide a new composite having a ferrous metal substrate that exhibits good heat transfer and is capable of withstanding elevated temperatures.

It is another object of this invention to provide a composite useful in casting molten aluminum.

It is a further object of this invention to provide a process for producing a composite having a ferrous metal substrate and a coating which is resistant to molten aluminum.

These and other objects are achieved in one embodiment of this invention by providing a composite comprising a ferrous metal substrate and a first layer of nickel aluminide metallurgically bonded to the substrate, a second layer of a nickel-chromium alloy mechanically bonded to the first layer and a third layer of an aluminum oxide mechanically bonded to the second layer.

In another embodiment of this invention the substrate is first heated to a specified temperature, depositing by flame spraying a coating of nickel aluminide to the substrate, heating the coating substrate to a specified temperature and depositing a coating of nickel-chromium alloy on said first coating, elevating the temperature of the material containing the first and second layers to a specified temperature, applying an aluminum oxide powder to the second layer and allowing the coated material containing the three layers to slowly cool in air to ambient temperature.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the above description of some of the aspects of the invention.

In general, any ferrous metal such as cast iron, carbon steels, and stainless steels can be used as substrates. Suitable substrates include the carbon and stainless steels such as the steels listed in Metals Handbook as 1010, 1020, 1030, 300 and 400 series of stainless steels.

The first layer which is metallurgically bonded to the substrate is essentially nickel aluminide. In the practice of this invention the substrate is heated to from about 275° F to about 325° F with about 300° F being preferred by flame spraying a nickel aluminide wire onto the heated surface of the substrate. A thickness of the first layer of from about 5 to 10 mils is preferred.

The temperature of the substrate containing the first layer is raised to a temperature of about 400° to 450° F and a second layer of an alloy containing about 19 percent to about 21 percent chromium and balance essentially nickel is applied by spraying an alloy powder onto the heated surface sufficiently to obtain a thickness of from about 5 to about 10 mils. Preferred alloys contain from about 19 percent to about 21 percent chromium with about 20 percent being preferred. Nichrome is a trade name for such alloys and is supplied by a variety of alloy producers. It is believed that this second layer achieves a well-bonded finished product which can withstand temperature cycling without cracking or spalling. Additionally, it is believed this second layer provides a barrier to the oxidation of the substrate.

After application of the second layer the material is raised to a temperature in excess of 600° F but below about 700° F and aluminum oxide ceramic powder containing from about 93 to about 95 percent by weight of aluminum oxide is deposited. Suitable ceramics are well known in the art. A typical example is aluminum oxide 94 percent, titanium dioxide 2.5 percent, silicon dioxide 2.0 percent, iron oxide (Fe_2O_3) 1.0 percent, other oxides balance. The thickness of the ceramic layer is from about 1 to about 3 mils. If the third layer is in excess of about 3 mils, there is a tendency of the coating to crack.

A cast iron substrate coated according to the process of this invention containing a first layer of nickel aluminide of about 5 mils thickness, a second layer of an alloy having 20 percent chromium and about 5 mil thick and a third layer of about 94 percent aluminum oxide ceramic of about 3 mils thickness was used for over 11,000 castings without any appreciable change in appearance.

While described in relationship to use in casting aluminum the composite is not so limited. The invention is useful in any application where the composite is subjected to cyclic temperatures up to about 700° C or where the composite is in contact with molten aluminum.

While there has been shown and described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that

various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A composite comprising a ferrous metal substrate, a first layer metallurgically bonded thereto of nickel aluminide, a second layer bonded to said first layer consisting essentially of from 19 to 21 percent by weight of chromium, balance nickel and a third layer of an aluminum oxide ceramic bonded to said second layer, said third layer less than 3 mils thickness.

2. A composite according to claim 1 wherein said first and second layer have a thickness of from about 5 to about 10 mils.

3. A composite according to claim 2 wherein said substrate is cast iron.

4. A composite according to claim 2 wherein said substrate is carbon steel.

5. A process comprising

a. heating a ferrous metal substrate to a temperature of from about 275° F to about 325° F,

b. depositing on said substrate a first coating layer of nickel aluminide by flame spraying nickel aluminide on said layer,

c. heating the resulting coated material to a second temperature of from about 400° F to about 450° F,

d. depositing on said first coating layer an alloy powder consisting essentially of from about 19 percent to about 21 percent by weight chromium to form a second layer of a nickel-chromium alloy,

e. heating said coated substrate having said first and second layers to a third temperature of about 600° F to about 700° F and

f. depositing sufficient aluminum oxide ceramic powder on said second layer to form a ceramic layer of about 1 to about 3 mils thickness.

6. A process according to claim 5 wherein said first temperature is about 300° F.

7. A process according to claim 6 wherein said second temperature is about 400° F.

8. A process according to claim 7 wherein said third temperature is about 600° F.

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