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PROCESS FOR ALUMINIZING METAL

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ABSTRACT OF THE DISCLOSURE

An improved process is disclosed for aluminizing metal articles whereby the article is coated with a metal hydride prior to immersion in the molten aluminum bath. The metal hydride decomposes at a temperature between 150° C. and 950° C.

The present invention relates to an improved method of coating metals with aluminum base alloys. More particularly, the present invention relates to the hot dip method of coating metals in particular, ferrous base metals, with aluminum base alloys.

Various methods have been used in the past for aluminizing ferrous metals. A method which has been found quite practical is the so-called hot dip process. This method has been used extensively in industry for coating various ferrous metal articles, in particular, for example, in the coating of ferrous metal wire, strip, sheet or the like, such as plain carbon or alloy steel, with various aluminum base alloys.

The hot dip method, briefly, comprises immersing the ferrous metal article in a molten bath of the aluminum base alloy for a period of time sufficient to coat the ferrous metal article with the desired thickness of aluminum base alloy.

A particular problem associated with the hot dip method is the interference of aluminum oxide as a specimen is introduced into the aluminum melt. The oxide tends to lay onto the specimen surface and prevent wetting of the specimen by the molten aluminum.

Various methods have been proposed to overcome this problem but all of these methods are characterized by one or more disadvantageous aspects. For example, it is conventional in the melt preparation to skim the molten aluminum immediately prior to the introduction of the specimen into the molten bath. This skimming simply comprises removing or moving back any excessive surface oxidation. However, the surface oxide rapidly grows back and it is not possible by this method to completely prevent the adherence of aluminum oxide on the specimen surface.

Accordingly, it is an object of the present invention to provide an improved process for coating metal articles with aluminum base alloys.

It is a further object of the present invention to provide an improved hot dip process for coating ferrous metal articles with aluminum base alloys.

It is a further object of the present invention to provide an improved process as aforesaid which eliminates the disadvantageous interference of aluminum oxide as the specimen is introduced into the aluminum melt.

It is a still further object of the present invention to provide an improved process as aforesaid which overcomes the aforementioned disadvantages simply and conveniently.

Further objects and advantages of the present invention will appear hereinafter.

In accordance with the present invention it has now been found that the foregoing objects and advantages may be readily accomplished and an improved process for aluminizing a metal article with an aluminum base alloy provided. The process of the present invention comprises:

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providing a molten bath of an aluminum base alloy; coating a metal article with a material which decomposes at a temperature between 150° C. and 950° C.; and immersing said coated metal article into said molten bath for a period of time sufficient to decompose said coating and aluminize said metal article with said aluminum base alloy. The preferred metal article is naturally a ferrous base metal and the preferred decomposable coating therefor is a metal hydride, optimally zirconium hydride.

When the ferrous metal article is coated with, for example, zirconium hydride, the zirconium hydride coating effectively prevents the surface oxide of the melt from coming into direct contact with the ferrous metal article on initial introduction into the melt. The aluminum oxide which has laid against the object over the zirconium hydride is pushed away from the specimen as the zirconium hydride decomposes. In the case of zirconium hydride this compound decomposes with the evolution of hydrogen which effectively pushes the aluminum oxide away from the surface of the ferrous base metal. In addition, the hydrogen tends to purify the ferrous base metal surface by eliminating oxygen as water, carbon as methane and sulphur as hydrogen sulfide. The zirconium metal resulting from the dissociation of zirconium hydride is then free to act as an active metal, i.e., a getter, which in turn actively removes such adsorbed gases as oxygen and nitrogen and therefore contributes to the maximum wetting of the object with the aluminum base alloy.

There are other advantages of the present invention. For example, conventionally the preparation of the basis metal, i.e., the ferrous metal to be aluminized, is most extensive and critical. It is not uncommon to sand blast, vapor degrease, acid pickle, wash and neutralize the ferrous metal to be aluminized. Once these steps have been meticulously accomplished, every effort is then necessary to avoid surface contamination of any type, such as fingerprints, dust or further oxidation. In fact, most ferrous base alloys will rapidly form oxide coats under these super-clean conditions when exposed to normal atmosphere. Thus, the time delay between surface preparation and final aluminizing is quite critical in conventional processes.

Inherently, the present invention minimizes the critical nature of the time delay between surface preparation and final aluminizing and allows considerably more flexibility in the overall process. In accordance with the present process surface pre-treatment is still a preferred procedure; however, the subsequent handling and time delay between the surface preparation and the final aluminizing is considerably less significant than in accordance with prior practices. For example, the zirconium hydride decomposes and mechanically pushes back oxide films which may have adhered to the surface of the basis metal on introduction into the melt, and in addition forms hydrogen gas and zirconium metal both of which are very strong reducing agents and have a very substantial cleaning action on the basis metal. The basis metal is cleaned in its most advantageous position and time, i.e., when it can be immediately exposed to the aluminum or the aluminum alloy with no further opportunity to be oxidized or contaminated through handling. Thus it can be seen that the "in situ" cleansing is a considerable advantage of the present invention.

The process of the present invention is particularly suitable to the aluminizing of ferrous base metals, but is fully applicable to other metals, such as copper base alloys, for example, brass.

Exemplificative ferrous base metals include, for example, 1020 mild steel, high carbon (1% carbon) and stainless steels, series 300 and series 400. The term ferrous base metal is used in its conventional sense to mean metals whose major constituent is iron.

It is an additional and highly significant advantage of the present invention that the instant process far more effectively aluminizes ferrous metals of the stainless steel series. These metals have been historically difficult to aluminize since aluminum will not effectively reduce chromium oxides even though it will readily reduce iron oxide. In accordance with the present process the zirconium and/or hydrogen, for example, both very strong reducing agents, will effectively reduce these other oxides peculiar to the stainless steels.

The molten bath is naturally an aluminum base alloy, i.e., a molten bath whose major constituent is aluminum. Exemplificative alloys include, but are not limited to high purity aluminum and aluminum alloys containing, for example, silicon, chromium, molybdenum, tungsten, boron, etc. The most common aluminizing bath is an aluminum alloy containing from 1 to 6 percent silicon, preferably 2 to 3 percent silicon. The addition of the silicon assists in the application of the coating; however, once applied the benefits derived are primarily characteristic of aluminum itself.

The molten bath is, naturally, maintained in the molten condition with the temperature of the bath normally varying from the liquidus temperature of the particular aluminum base alloy to about 1000° C. Naturally, a great many variables must be considered in deciding on a particular temperature, e.g., basic thermodynamics relative to the mass of molten metal, the mass of the object to be aluminized, and the nature of the desired coating.

The particular manner of covering the ferrous base metal with a decomposable material used to cover the ferrous metal article must decompose in the temperature range of from 150° C. to 950° C. Preferably the material should decompose in the temperature range of from 200 to 950° C. and be of such a nature that the decomposition thereof will not be excessively fast or excessively slow. The preferred decomposable materials are the metal hydrides and in particular zirconium, calcium, magnesium and lithium hydride. Other operative materials include but are not limited to hydrides of titanium, hafnium, niobium, tantalum, thorium, uranium and yttrium. In addition, mixed or complex metal hydrides may be used, such as lithium-aluminum hydride and also the alkali borohydrides, such as NaBH_4 , KBH_4 , PbBH_4 , CsBH_4 , and others.

The thickness of the decomposable covering is not especially critical, it being necessary only that the covering be substantially uniformly applied to the surface of the metal. In general, however, thicknesses of 0.005 inch or more are used.

The time of immersion should be sufficient to allow for decomposition of the covering and coating of the article with the aluminum alloy. In general, at least 30 seconds should be allowed with the actual times depending on (1) the nature of the covering and (2) the thickness of the coating desired. Preferably immersion times from 30 seconds to 15 minutes are used, and optimally less than 3 minutes.

The following is a representative detailed procedure applicable to the hot dip method for coating a mild steel. Naturally many variations from this procedure may be readily tolerated; however, this procedure is given to illustrate the detailed operation of the present invention.

EXAMPLE

A 1020 mild steel specimen 4" x 3/4" x 3/16" was sand blasted and immersed for ten minutes in a pickle solution comprising a 10 percent hydrochloric acid solution maintained at room temperature. The object was immediately removed and the excess pickle solution shaken free. The object was then dried thoroughly.

The zirconium hydride was made into a slurry using isopropyl alcohol as a vehicle using 25 grams of 5 micron ZrH_2 per 100 ml. of isopropyl alcohol. The zirconium hydride tends to settle out to the bottom of the slurry and

hence a stirring action is required. The slurry was painted onto the object with a paint brush in a thickness of 0.010 inch and the object dried. The object was then lowered in a molten aluminum bath consisting of high purity aluminum maintained at a temperature from 600 to 950° C. The object was kept under the melt surface until obvious hydrogen evolution, i.e., dissociation, had ceased and for an additional period of time to provide the desired aluminum coating thickness.

In a series of experiments it was found that between 60 and 90 seconds immersion time at a melt temperature of about 785° C. produced a uniform cladding of aluminum with a thickness of 0.002" to 0.003" in addition to a uniform interfacial layer of iron-aluminum compound ranging up to 0.007" for a total affected surface of 0.009" to 0.010" thickness.

In all cases there was obtained a uniform aluminized coating pleasing to the eye, fully bonded through alloying and fully effective as a protector against oxidation of the basis metal. Further, the specimens were suitable for further treatment which would effect a marked increase in the protective quality of the surface film on aluminum through, for example, anodic oxidation of the metal.

EXAMPLE

In a manner after the previous example, the following hydrides substituted for zirconium hydride produce an excellent aluminized article attaining the advantages of the present invention: calcium hydride; magnesium hydride; and lithium hydride.

This invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency are intended to be embraced therein.

What is claimed is:

1. A process for aluminizing a metal article which comprises: providing a molten bath of an aluminum base alloy; coating a metal article with a composition consisting essentially of a metal hydride which decomposes at a temperature of from 150° C. to 950° C.; drying the coated metal article and immersing said coated metal article into said molten bath.

2. A process for aluminizing a metal article which comprises: providing a molten bath of an aluminum base alloy; coating a ferrous metal with a composition consisting essentially of a metal hydride which decomposes at a temperature from 150° C. to 950° C.; drying the coated ferrous metal and immersing said coated ferrous metal in said molten bath for a period of time sufficient to decompose said coating and aluminize said ferrous metal with said aluminum base alloy.

3. A process for aluminizing a metal article which comprises: providing a molten bath of an aluminum base alloy maintained at a temperature from the liquidus temperature of the aluminum base alloy to 1000° C.; coating a ferrous metal with a composition consisting essentially of a metal hydride which decomposes at a temperature of from 150 to 950° C.; drying the coated ferrous metal and immersing said coated ferrous metal into said molten bath for at least 30 seconds.

4. A process according to claim 3 wherein said aluminum base alloy is high purity aluminum.

5. A process according to claim 3 wherein said aluminum base alloy contains from 1 to 6 percent silicon.

6. A process according to claim 3 wherein said immersion time is from 30 seconds to 15 minutes.

7. A process according to claim 3 wherein said immersion time is from 30 seconds to 3 minutes.

8. A process according to claim 3 wherein said metal hydride is zirconium hydride.

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9. A process according to claim 3 wherein said metal hydride is calcium hydride.
 10. A process according to claim 3 wherein said metal hydride is magnesium hydride.
 11. A process according to claim 3 wherein said metal hydride is lithium hydride.

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