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ALUMINUM COATED FERROUS MATERIAL

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3 Claims. (Cl. 29—196.2)

This invention relates to a method for producing composite metal articles having a ferrous metal base portion coated with aluminum or aluminum base alloys, the composite article produced thereby and the aluminum base coating alloys. More particularly this invention relates to a method for coating a ferrous metal base with aluminum or aluminum alloys which provides a coating characterized by a lustrous smooth appearance free from the presence of stains, the composite articles produced thereby and the aluminum base coating alloys.

This application is a divisional application of my copending application Serial Number 737,485, filed May 26, 1958,

Coatings of aluminum on ferrous metal products are highly desirable since the composites resulting in effect embody superior properties resident in each metal. To the strength and other desirable characteristics of the iron or steel core, the aluminum coating adds the more salient properties of resistance to corrosion and oxidation at both atmospheric and somewhat elevated temperatures, enhanced electrical conductivity, improvement in the brazing of aluminum to steel and a more attractive appearance.

In the production of aluminum coated ferrous metal articles one of the primary factors in regard to commercially acceptable results is the appearance of the coating. A lustrous smooth appearance similar to the color and texture of cast aluminum is a desirable characteristic in such aluminum coatings. When utilizing many aluminizing alloys the coatings may display a brown or tan stain, particularly if the ferrous article is quenched in water while the coating is still molten. Where the aluminum coated ferrous article is intended for ornamental purposes or for some other reason a stain free surface is desired, many aluminizing alloys may not be productive of satisfactory results.

In accordance with the prior art, beryllium has been added to aluminizing alloys to provide a clean bath surface and to prevent staining of the coating during air cooling. However, beryllium is very expensive and while the amount of beryllium added to the aluminizing alloy may be small, a continual replacement is required to maintain bright coatings. Thus the use of beryllium in aluminizing alloys is expensive.

Accordingly, it is an object of the present invention to provide a method of coating ferrous base metal to produce composite articles wherein the coating is characterized by a smooth appearance free or essentially free from any presence of staining.

It is a further object of this invention to provide an aluminum base alloy for coating ferrous base metal articles which provides a coating in the solid state or as-coated condition eminently suitable for ornamental or other purposes due to a lustrous smooth appearance and freedom from the presence of stains.

It is a still further object of the invention to provide aluminum alloy coated composite articles characterized by a lustrous smooth appearance and freedom from stains and relatively inexpensive aluminum base alloys for production thereof wherein conventional methods of hot dip coating may be employed.

Other objects and advantages of the invention will be apparent from the following detailed description thereof.

It has been discovered that the maintenance of a small but effective amount of magnesium in a molten coating bath of aluminum results in a coating exhibiting an appearance characterized by freedom from staining. When compared to the appearance of prior art commercially pure aluminum and aluminum alloy coatings, the freedom from staining of the coatings of the present invention is unique. Examples of prior art aluminum metal baths for coating ferrous base metal are commercially pure aluminum, aluminum-silicon alloys and an alloy consisting essentially of by weight from 1 to 6% silicon, at least one element selected from the group consisting of chromium, molybdenum and tungsten in amount from about 0.1 to 0.4%, the total not exceeding about 0.5%, at least one element selected from the group consisting of boron, titanium, vanadium and zirconium in amount from about 0.02 to about 0.20% boron and titanium, and from about 0.1 to about 0.25% vanadium and zirconium, the total of these last named elements not exceeding about 0.5%, 0.001 to 0.10% sodium, balance substantially all aluminum and impurities in normal amounts.

In general it has been found that amounts of magnesium from about 0.05 to 0.45% by weight are productive of satisfactory results wherein the production of an attractive relatively smooth stain free coating is the primary factor with regard to the intended purpose of the composite article. However, optimum results in regard to smoothness and freedom from staining are realized by amounts of magnesium from about 0.1 to 0.2% by weight of the total alloy bath. Beyond a magnesium content of about 0.45% there is a tendency for the oxide film to produce a wrinkled and poor surface texture to the coating. On the other hand, amounts below about 0.05% by weight magnesium do not provide sufficient resistance to staining.

Although the addition of magnesium to the aluminum alloy in accordance with this invention is primarily suited for ornamental purposes due to the freedom from staining obtained, it was found that there was a lack of any substantial adverse effect upon the ductility of the composites produced.

In accordance with this invention, the ferrous articles to be coated are first thoroughly cleaned by a suitable method, such as acid pickling, to remove oxide film or scale. They may then be rinsed, dryed and immersed in the coating bath with or without the use of a conventional flux. For large sections the use of flux may be used for further cleaning before immersion in the alloy bath. On the other hand, the articles with or without pickling, depending on the nature of the surface, may be pretreated by bright annealing in suitable apparatus in an inert or reducing atmosphere and then directly immersed in the molten coating bath without exposure to the atmosphere.

The bath temperature is maintained sufficiently high so that the alloys employed are completely molten. Of course, the particular bath temperature depends upon the coating alloy composition and the composition and nature of the ferrous article, and in regard to the alloys herein disclosed, temperatures generally of from 1280° to 1375° F. are recommended.

Since thickness of the Fe—Al interfacial layer increases with bath temperature, it is recommended that the lowest operating temperature consistent with good coating results be used to minimize cracking and spalling tendencies.

The time of immersion depends principally upon the composition of the molten bath, the composition and nature of the ferrous article and the temperature of the molten bath. The immersion time and also the bath temperature may be regulated to produce a composition suitable for the intended application. Extending the time of immersion tends to increase the thickness of the Fe—Al layer and, accordingly, the shortest immersion time consistent with satsifactory coverage is usually recommended.

The improved results obtained by the practice of this invention are more fully illustrated with reference to the examples below:

Panels of mild steel measuring 4" x 6" x .035" were degreased by furnace bluing then pickled in a 20% HCl solution at 170° F. for from 30 to 120 seconds. This was followed by dipping in an aqueous solution of Na_2SiF_6 plus $ZrCl_4$. Each specimen was then dipped for from 4 to 15 seconds in a molten bath of aluminum base alloy maintained at 1300° F. The compositions of the bath employed are indicated below. The coated specimens where then withdrawn and tapped lightly while in a vertical position to facilitate removal of the excess coating.

One aluminum coating bath was made up from approximately 10 pounds of commercially pure, i.e. 99.00% by weight minimum purity aluminum which was melted in an induction furnace. It is to be noted that during the course of operation either batch or continuous the molten aluminum bath gradually increases in iron content due to the fact of pickup of iron from the base metal. In order to represent this iron pickup which would be encountered in continued operation, 1.7% by weight iron was added to the melt. The amounts of magnesium as indicated in Table I below were then incrementally added to the melt and specimens immersed in each alloy. Table I indicates the appearance of these specimens.

TABLE I

Appearance of aluminized steel panels

Percent Mg. By Wt.	Color	Luster	Surface Texture
0.00	Light Tan	Dull	Slightly Rough.
0.01	Very Light Tan	do	Do.
0.05	Light	Dull to Bright	Do.
0.10	do	Bright	Smooth.
0.20	do	do	Do.
0.30	do	do	Do.
0.40	do	do	Do.
0.50	do	Fairly Bright	Rough and Wrinkled.
0.60	do	do	Wrinkled.
1.00	do	Dull	Very Wrinkled.

An aluminum base alloy bath was made up from approximately 10 pounds of an aluminum-2.5% by weight silicon alloy which was melted in an induction furnace and to which 1.7% by weight iron was added for reasons given above. The amounts of magnesium as indicated in Table II below were then incrementally added to the melt and specimens immersed in each alloy. Table II indicates the appearance of these specimens.

TABLE II

Appearance of aluminized steel panels

Percent Mg. By Wt.	Color	Luster	Surface Texture
0.00	Brown Spotted	Dull	Smooth.
0.05	Light	Bright	Do.
0.10	do	do	Do.
0.20	do	do	Do.
0.30	do	do	Do.
0.40	do	do	Slightly Wrinkled.
0.50	do	do	Wrinkled.
1.00	do	do	Wrinkled, Rough.

Another aluminum base alloy bath was made up from approximately 10 pounds of an aluminum-5% by weight silicon alloy which was melted in an induction furnace and to which 1.7% by weight iron was added for reasons given above. The amounts of magnesium as indicated in Table III below were then incrementally added to the melt and specimens immersed in each alloy. Table III indicated the appearance of these specimens.

TABLE III

Appearance of aluminized steel panels

Percent Mg. by Wt.	Color	Luster	Surface Texture
0.00	Brown	Dull	Smooth.
0.05	Light	Bright	Do.
0.10	do	do	Do.
0.20	do	do	Do.
0.30	do	do	Slightly Rough.
0.40	do	do	Do.
0.50	do	do	Rough, Wrinkled.
1.00	do	do	Very Rough, Wrinkled.

Another aluminum base alloy bath was made up from approximately 10 pounds of an aluminum base alloy consisting essentially of, by weight, 2.50% silicon, 0.10% chromium, 0.10% molybdenum, 0.05% titanium, 0.002% sodium, balance substantially all aluminum and impurities in normal amounts, which was melted in an induction furnace and to which 1.7% by weight iron was added for reasons given above. The amounts of magnesium as indicated in Table IV below were then incrementally added to the melt and specimens immersed in each alloy. Table IV indicates the appearance of these specimens.

TABLE IV

Appearance of aluminized steel panels

Percent Mg. By Wt.	Color	Luster	Surface Texture
0.00	Light Tan	Dull	Smooth.
0.05	Light	Bright	Do.
0.10	do	do	Do.
0.20	do	do	Do.
0.30	do	do	Slightly Wrinkled.
0.40	do	do	Do.
0.50	do	do	Wrinkled.
1.00	do	Bright at Center, Dull at edges.	Very Rough, Very Wrinkled.

It is readily seen from the results indicated above that the surfaces of the aluminized articles employing the principles of this invention were superior to those produced outside the teachings of this invention. More specifically, it will be noted that those coating baths containing magnesium in amounts above about 0.45% resulted in coatings which were wrinkled and, accordingly, unsatisfactory. Those coating baths containing magnesium contents below about 0.05% resulted in coatings characterized by tan or brown stain and thus were also unsatisfactory. While some of the samples having magnesium contents within the broad range of the invention exhibited slight wrinkling or slight roughness, the coatings produced were satisfactory from an appearance standpoint for many purposes.

As used herein the term "aluminum" is meant to cover high purity aluminum, commercial purity aluminum and aluminum base alloys.

It will be understood that various changes, omissions and additions may be made to this invention without departing from the spirit and scope thereof as set forth in the appended claims.

All percentages in the claims are by weight of the total coating bath.

What is claimed is:

1. A composite article characterized by a smooth surface free from stains comprising a base portion of a ferrous metal coated with an aluminum base alloy consisting essentially of from about 0.05 to 0.45% magnesium, balance substantially all aluminum and impurities in normal amounts.

2. A composite article characterized by a smooth surface free from stains comprising a base portion of ferrous metal coated with an aluminum base alloy consisting essentially of from about 2.5 to 5% silicon and from about 0.05 to 0.45% magnesium, balance substantially all aluminum and impurities in normal amounts.

3. A composite article characterized by a smooth surface free from stains comprising a base portion of ferrous metal coated with an aluminum base alloy consisting essentially of from about 1 to 6% silicon, at least one element selected from the group consisting of chromium, molybdenum and tungsten in amount from about 0.1 to about 0.4%, the total not exceeding about 0.5%, at least one element selected from the group consisting of boron, titanium, vanadium and zirconium in amount from about 0.02 to about 0.20% boron and titanium, and from about 0.1 to about 0.25% vanadium and zirconium, the total of these last named elements not exceeding about 0.5%, 0.001 to 0.10% sodium, 0.05 to 0.45% magnesium, balance substantially all aluminum and impurities in normal amounts.

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