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COATING FERROUS METALS WITH ALUMINUM

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1

Attempts to coat ferrous articles with molten aluminum have hitherto produced products having certain disadvantages, being deficient both in the adherence and in the ductility of the coating. The fundamental object of our invention is the provision of an improved ferrous article coated with aluminum.

It is an object of our invention to provide ferrous articles having aluminum coatings, the adherence of which to the base metal is superior to any hitherto produced.

It is an object of our invention to provide aluminum coated ferrous articles in which the aluminum coating is in itself more ductile, which factor coupled with adhesion, furnishes an article capable of withstanding much more severe bending, fabricating and drawing operations without loss or disruption of the coating.

It is an object of our invention to provide aluminum coated ferrous articles in which the coating has enhanced corrosion resistance.

It is a further object of the invention to provide a mode of control of the formation of alloys between the coating metal and the base metal, whereby the characteristics of the coating may be improved.

It is a further object of our invention to provide for the control of the appearance of modified aluminum coatings, as will be more fully explained hereinafter.

These and other objects of our invention which will be set forth hereinafter or will be apparent to one skilled in the art upon reading these specifications, we accomplish by that procedure and in those articles of which we shall now describe certain exemplary embodiments.

After intensive research we have found that the addition of proper quantities of silicon to the aluminum for molten coating operations exercises a marked effect upon the production of iron-aluminum alloys at the juncture of the base and coating metals, and greatly improves adhesion. Microscopic examination shows that the silicon changes the type of the alloy formed. The new alloy not only is itself more ductile, but enables the production of a much more adherent coating.

Repeated tests have shown, however, that silicon has only a minor and relatively unimportant effect upon adherence up to around 7.5% of silicon in the coating. At this point the improvement becomes marked and the rate of improvement greatly accelerated. The range of silicon content in which we ordinarily work is from about 7.5% to 9.5% by weight of the coating.

2

There is a silicon-aluminum eutectic at around 11.65% and our investigations have shown that the improved adherence continues even up to as high as 25% silicon. Over the entire range there is a falling off in appearance which is more marked at the higher silicon values. By this we mean that the spangle and luster characteristic of ordinary aluminum coated ferrous articles changes or disappears. Above around 16% there appears a depressed spangle boundary which harms the appearance of the coating for some applications. Above around 18% the melting point is already as high as that of pure aluminum and the practical problems of applying the coating are greatly multiplied.

The theory of the improvement produced by the addition of silicon is not fully worked out. We have shown that the form of the alloy layers is greatly altered. The amount of the so-called iron-aluminum alloy formed next to the ferrous base is known to have an important effect upon adhesion. The silicon forms a practical way of suppressing the alloy formation to the point where adherence is significantly improved. The aluminum layer now consists of two phases and is probably a mixture of a eutectic of some aluminum-silicon compound with a solid solution of silicon in aluminum.

In coating the ferrous article, including of course strip and sheet, they are first thoroughly cleaned by any suitable method and then dipped in a bath of the molten aluminum and silicon. Proper precautions are observed at the entrance and exit ends of the bath. We prefer to operate in accordance with the process teachings of the Sendzimir Patent No. 2,110,893, wherein the scale free articles such as sheet or strip are first passed through an oxidizing furnace to burn off any combustible material and form on the surfaces a thin, controlled coating of oxide which may vary from straw to blue and even into gray. The strip or sheet is next passed into a reducing furnace where, under the influence of a reducing atmosphere, the thin coating of oxide is converted back to the metal. The result is a thoroughly cleaned piece with a surface very receptive to molten coatings. Preferably the iron, mild steel, or other ferrous metal is annealed in the reducing furnace to increase its workability and drawability. Without re-exposing the surfaces of the articles to the air, they are passed into the molten coating bath. With the treated articles and the entrance end of the bath both protected by a reducing or non-oxidizing atmosphere, it is not necessary to use a flux.

We have indicated above that the addition of silicon in the preferred amounts somewhat changes the appearance of the coated article by diminishing lustre and by modifying the size and type of spangle. This is not a disadvantage in many uses where protection and corrosion resistance or heat resistance, rather than appearance, are the primary requisites, or in instances where the coated articles are to be painted, lacquered, or enameled.

We have found however that the addition of magnesium will bring back the spangle and lustre to a large extent. We have been unable to find that the magnesium in the proper amounts adversely affects the adherence, or alters the alloy formation as controlled by the silicon. In commercial operations we prefer to employ between about 2 to 2.5% magnesium. More or less may be used; but we have found that below 1% the improvement in lustre and spangle is relatively little, while an increase much above 2.5% has an adverse effect upon adherence and appearance.

Our tests indicate that both silicon and magnesium improve the corrosion resistance of the coated article in certain types of service.

While the mixture of molten coating metals in the coating bath may be formed in any way desired, we have found it most convenient to feed the bath with pigs or pieces of a preformed alloy of aluminum with silicon, or aluminum with silicon and magnesium.

Modifications in our invention may be made without departing from the spirit of it.

Having thus described our invention, what we

claim is new and desire to secure by Letters Patent, is:

1. A process of producing aluminum coated ferrous articles characterized by enchanced ductility and adherence of the coating, which comprises forming an alloy of aluminum and silicon of the order of substantially 7.5 to 9.5% and magnesium of the order of substantially 2 to 2.5%, melting said alloy, thoroughly cleaning said ferrous articles and dipping said ferrous articles in said molten alloy.

2. A process of making aluminum coated ferrous articles which comprises thoroughly cleaning said articles and dipping them beneath the surface of a bath of molten aluminum, while controlling the formation of iron aluminum alloy by maintaining in said bath silicon at least in an amount equal substantially to 7.5% and controlling the spangle and the lustre by maintaining in said bath magnesium at least in an amount equal substantially to 1%.

3. A hot dipped ferrous article coated with an aluminum alloy, the said coating comprising a thin layer located next the ferrous article and comprising a iron-silicon-aluminum-magnesium alloy, and a substantially thicker external layer of high aluminum content and containing also silicon from substantially 7.5 to substantially 9.5%, and magnesium from substantially 2.0 to 2.5%, the said ferrous article being characterized by ductility and high adherence of said coating.

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