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[72] Inventors **Melvin H. Brown**
Leechburg;
Maurice W. Wei, Lower Burrell, both of Pa.

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[73] Assignee **Aluminum Company of America**
Pittsburgh, Pa.

[54] METHOD OF MANUFACTURING ALUMINUM COATED FERROUS BASE ARTICLES

6 Claims, No Drawings

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[50] **Field of Search** ..... 117/51, 114 C; 148/23

[56] **References Cited**

UNITED STATES PATENTS

2,073,783	3/1937	Corkery	117/51 X
2,266,060	12/1941	Miller	148/23
2,291,399	7/1942	Miller	148/23
2,731,362	1/1956	Brondyke	117/51

Primary Examiner—Alfred L. Leavitt
Assistant Examiner—J. R. Batten, Jr.
Attorney—Arnold B. Silverman

ABSTRACT: A process for coating a ferrous metal article with aluminum including cleaning the ferrous article, applying to the surface of the ferrous article a flux of about 0.125 to 4% aqueous solution of an organic aromatic carboxylic acid having one carboxyl group and a phenolic hydroxyl group, drying the ferrous article and subsequently applying molten aluminum to the ferrous article. The coating process wherein the acid is salicylic acid or 5-chlorosalicylic acid employed in concentrations of about 1 to 4%. Applying the flux to the ferrous metal article surface by immersion of the article in a flux bath having a temperature of about 100 to 212° F. for a period of about 1 to 2 minutes.

METHOD OF MANUFACTURING ALUMINUM COATED FERROUS BASE ARTICLES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a process for coating a ferrous metal article with aluminum and more specifically relates to the use of an aqueous solution of an organic aromatic carboxylic acid as a flux bath.

2. Description of the Prior Art

It has been known that desirable properties may be provided to a ferrous article by coating the same with aluminum. Such coated articles not only provide improved resistance to oxidation and acid attack, but also reduce the likelihood of other forms of corrosion. In addition, such coatings provide increased electrical conductivity, reflectivity and an attractive surface appearance.

There are numerous known systems for applying an aluminum coating to a ferrous article. Among the known systems are hot dipping, electroplating, spraying, cladding and casting of aluminum around the steel article.

In general known systems provide for a preliminary cleaning of the ferrous article. This is generally followed by fluxing and application of the molten aluminum, with appropriate intermediate rinsing and drying steps. See U.S. Pat. No. 2,738,289.

The cleaning stages may consist of an initial grit blasting to remove scale and rust. It has been conventional to subsequently remove grease and oils from the surface of the ferrous articles by an organic solvent, an alkaline cleaner or a vapor degrease. Subsequent to degreasing, it has been known to treat the ferrous surface by acid pickling to remove oxidation products. This is generally accomplished by means of a strong acid, such as hydrochloric or sulfuric acids.

After the pickling operation, the ferrous surface is then conventionally rinsed and dried. An appropriate flux is then applied to the cleaned ferrous article surface in order to promote good bonding between the aluminum and the ferrous metal. Effective fluxing is essential to obtaining a uniformly bonded smooth aluminum coating on the ferrous article. Various materials have been employed in known fluxes. The use of molten salt baths are disclosed in U.S. Pat. Nos. 2,544,671 and 2,569,097. Various acid and alkaline materials have also been employed as fluxing materials.

One problem frequently resulting from use of an ineffective flux material is that the aluminum coating is not effectively and uniformly bonded to the ferrous article. Also, improper fluxing has been known to contribute to the production of a rough aluminum coating surface appearance which is aesthetically undesirable. Also, inadequate flux coverage on the ferrous article may result in regions of discoloration which will produce areas of brown staining on the aluminized ferrous article which will render the article unacceptable for most purposes. These problems become particularly acute with respect to articles having an irregular configuration as uniformity is more difficult to attain with respect to such articles.

It has been known that some fluxes suitable for use with some ferrous materials, such as mild steel, cannot be effectively employed with other ferrous materials, such as cast iron. The use of such limited purpose materials makes it more difficult for one to establish flexibility in a system which is to be employed to coat various types of ferrous articles.

SUMMARY OF THE INVENTION

The process of this invention employs a unique flux composition which is adapted to provide uniform, effective protection against oxidation, uniformly strong bonding of the aluminum coating to the ferrous article and a smooth aesthetically pleasing coating surface. After conventional surface cleaning of the ferrous article, the ferrous article is immersed in a flux bath of about 0.125 to 4 percent aqueous solution of an organic aromatic carboxylic acid having one carboxyl group and a phenolic hydroxyl group. The article is subsequently dried and the molten aluminum is applied.

In the preferred forms the acid employed is salicylic acid or 5-chlorosalicylic acid. The preferred acid concentrations are about 1 to 4 percent. The flux bath is provided at a temperature of about 100° to 212° F. and preferably about 160° to 212° F. The ferrous article is immersed in the bath for a period of 1 to 2 minutes.

After the article is removed from the flux bath, it is dried and subsequently molten aluminum is applied to the surface of the ferrous article as by immersion of the article in a molten aluminum bath maintained at a temperature of about 1,250° to 1,400° F. for a period of 1 to 2 minutes.

It is an object of this invention to provide a flux solution for use in coating a ferrous article with a uniformly bonded aluminum coating having a smooth surface texture.

It is another object of this invention to provide a method of hot dip aluminizing employing a flux which is adapted to effectively provide protection against oxidation and provide uniform coating characteristics with respect to molten aluminum.

It is another object of this invention to provide a process of aluminizing ferrous articles which process is adapted to be employed with a broad range of ferrous materials.

These and other objects of the invention will be more fully understood from the following description of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The process of this invention contemplates the coating of a broad range of ferrous materials, including mild steel and cast iron, with aluminum. By way of preliminary treatment, the ferrous article will preferably be cleaned in a conventional manner. Depending upon the condition of the material and type of material, it may be desirable to first grit blast the article to remove scale and rust. This may be followed by a conventional degreasing step employing conventional means such as solvent degreasing, vapor degreasing or an alkaline cleaner. After the vapor degreasing, the specimen may be pickled in a suitable acid such as hydrochloric or sulfuric acid. The pickling operation may be accelerated by employing a pickling solution at an elevated temperature.

After the cleaning operations, the article is then rinsed with water, which is preferably hot water, to remove all of the undesired residual materials and provide a uniformly cleaned oxide-free ferrous surface. As the clean ferrous article will, unless protected, deteriorate through oxidation and other corrosion it is important that the article be promptly protected with the flux treatment. The flux employed in this invention comprises an aqueous solution of about 0.125 to 4 percent of an organic aromatic carboxylic acid having one carboxyl group and a phenolic hydroxyl group. This flux may be most conveniently applied by immersion of the ferrous article into the flux bath. The flux bath is preferably maintained at a temperature of 100° to 212° F. The period of immersion of the ferrous article in the flux bath is preferably about 1 to 2 minutes, with longer immersion times in this range being preferred when the lower recited temperatures are used. The flux produces a uniform oxide resistant film or coating on the ferrous article which protects the clean surface of the ferrous article and provides a surface which may be continuously uniformly wetted by molten aluminum.

The preferred organic aromatic carboxylic acids of this invention are salicylic acid and 5-chlorosalicylic acid. The preferred range of concentration of these acids is about 1 to 4 percent. With a concentration under about 1 percent the maximum benefits of this invention are not obtained. When the concentrations of these acids exceed 4 percent, the solubility of the acid is exceeded and excess chemical material tends to accumulate on the surface of the flux bath. This tends to impede the efficiency of the operation.

It has been found that these acids provide superior oxide protection yielding excellent uniform coating. In addition, the resultant aluminum coating has a desired, aesthetically pleasing smooth surface free from oxide discoloration.

Subsequent to removal of the article from the flux bath, it is dried prior to application of the molten aluminum. This drying is preferably effected at a temperature of about 300° to 400° F.

The protected cleansed surface of the ferrous article is now in proper condition for application of the molten aluminum. This application is preferably effected through hot dip aluminizing, i.e., immersion of the ferrous article in a molten aluminum bath. It is preferred that the molten aluminum be at a temperature of about 1,250° to 1,400° F. and that the ferrous article be immersed in the molten aluminum bath for a period of 1 to 2 minutes. This provides for adequate time to effect the desired bonding of aluminum in the desired coating thickness, while avoiding excess formation of the relatively brittle aluminum-ferrous intermetallic compound.

After withdrawal of the coated ferrous article from the molten aluminum bath, conventional means may be employed to remove any excess aluminum on the article.

In order to verify the effectiveness of the flux treatment of this invention, several tests were performed.

EXAMPLE 1

Several cast iron articles were first grit blasted to remove scale and rust. They were then immersed in a pickling solution of 20 percent concentration hydrochloric acid at 180° F. for 1 minute. The specimens were then removed and rinsed in hot water and immersed in a 3 percent salicylic acid solution. After a 1 minute immersion period, the specimens were air dried. The cast iron articles were then immersed in a molten aluminum bath at 1,400° for 1 minute. Upon withdrawal of the specimens the excess aluminum was removed. A metallographic examination of the articles revealed excellent bonding of the aluminum to the cast iron and a smooth aesthetically pleasing surface appearance.

EXAMPLE 2

Example 1 was repeated with a group of mild steel articles being divided into three groups. Three different flux baths having a salicylic acid concentration of 1 percent, 3 percent and 4 percent, respectively, were employed. One group of mild steel articles was immersed in each flux bath. After completion of the aluminizing process, a metallographic examination of the articles revealed excellent bonding and a smooth aesthetically pleasing surface appearance.

EXAMPLE 3

Example 1 was repeated with mild steel articles employing a 0.125 percent 5-chlorosalicylic acid flux. The specimens revealed excellent bonding and the desired smooth coating.

EXAMPLE 4

A group of mild steel articles were treated in accordance with the procedure outlined in example 1 except that the flux bath contained salicylic acid in a concentration of 0.25 percent. The quality of the resultant aluminum coated articles was equal to that resulting from the tests of example 1.

It will be appreciated that the process of the present affords a single flux material which may be effectively employed with a broad range of ferrous materials. Uniform oxide formation resistant protection and excellent aluminum wetting and bonding properties are provided. In addition, the desired smooth aesthetically pleasing coating surface characteristic is obtained.

In addition to the foregoing advantages, the process of this invention produces a desirable bright surface appearance and the resultant article yields superior durability when the ferrous article is deformed after coating, as by bending.

Whereas particular embodiments of the invention have been described above for purposes of illustration, it will be evident to those skilled in the art that numerous variations of the details may be made without departing from the invention as defined in the appended claims.

We claim:

1. A process for coating a ferrous metal article with aluminum, comprising
   - cleaning the surface of said ferrous article,
   - applying to the surface of said ferrous article a flux of about 0.125 to 4 percent aqueous solution of an organic aromatic carboxyl acid having one carboxyl group and a phenolic hydroxyl group,
   - drying said ferrous article, and
   - subsequently applying molten aluminum to said ferrous article.

2. The process of claim 1 including
   - after cleaning said ferrous article rinsing said article with water,
   - applying said flux through immersion of said ferrous article in a bath of said flux at a temperature of about 100° to 212° F. for a period of about 1 to 2 minutes, and
   - maintaining said flux bath at an acid concentration of about 1 to 4 percent.

3. The process of claim 2 including
   - said organic aromatic carboxyl acid is salicylic acid.

4. The process of claim 2 including
   - said organic aromatic carboxylic acid is 5-chlorosalicylic acid.

5. The process of claim 2 including
   - subsequent to applying said flux but prior to applying said molten aluminum to said ferrous article drying said ferrous article at about 300° to 400° F., and
   - applying said molten aluminum to said ferrous article by immersion of said ferrous article in a molten aluminum bath for a period of about 1 to 2 minutes at a temperature of about 1,250° to 1,400° F.

6. The process of claim 5 including
   - maintaining said flux bath at a temperature of about 160° to 212° F. during the period of ferrous article immersion therein.

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