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PROCESS OF ENAMELING

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This invention relates to the art of enameling ferrous metal, and is particularly concerned with an enameling iron and a new and improved method of enameling such iron which prevents the formation of bubbles and similar imperfections in enamel coatings on ferrous metal articles.

The usual practice in coating ferrous sheet metal with enamel is as follows: A ferrous sheet metal article to be enameled is covered with enameling material either as a liquid or in a finely divided form, and the article is then placed in a suitable furnace where it is heated at about 1600° F. for a short period of time, for example from about three to five minutes, and until the enameling material has fused to form a layer, covering the surface of the metal. The article is then removed from the furnace and cooled to room temperature and a second layer of enameling material is placed on the article and it is then reheated to about 1500° F. The article is then allowed to cool, which step completes the enameling operation.

During the first heating, small bubbles form within or beneath the molten enamel layer and often rise thru it and break at the surface. This action is commonly referred to as the "primary boiling". Before the heating is completed these bubbles have ceased to form and hence the enamel layer is substantially smooth and quiet when the article is removed from the furnace. During the first 30 to 45 seconds of the second heating bubbles again form and often break thru the enamel. This action is commonly referred to as "reboiling" or "secondary boiling".

Many efforts have been made to prevent the primary and secondary boiling, but, so far as I am aware, little success has been attained by anyone prior to my invention. It is desirable that these "boilings" or the formation of bubbles should be avoided, since the bubbles cause a non-uniformity in the thickness of enamel and often cause thin spots in the enamel coating. Where a white finish coating of enamel is provided on the metal the bubbles resulting from boiling often cause black specks or discoloration of the finished enameled surface.

I have discovered that the boiling and reboiling action can be largely, if not entirely, overcome and have devised a method by which this result may be attained.

The metal ordinarily enameled is ferrous sheet metal containing carbon or carbides, or both. I have found that when such metal is so treated that deoxidation of the iron by carbon or carbides is prevented during the enameling operation and until the enameling material has formed a protective layer over the metal surfaces the amount of boiling and reboiling can be greatly reduced, if not actually eliminated entirely. Accordingly, my invention is based on this discovery and may be practiced in any one of several manners, including the protection of the metal by (*a*) providing the metal with a surface layer of substantially pure iron, (*b*) coating the metal with an air-excluding soluble silicate, such as sodium silicate, or (*c*) deeply pickling the metal. After the metal has been treated to protect it as aforesaid, it is covered with enameling material, heated for a suitable time at about 1600° F., cooled to room temperature, recoated with enameling material, and then reheated to about 1500° F., and finally cooled.

Generally speaking, the heating and cooling operations are similar to those heretofore used but, according to the present invention, are carried out on metal which has been protected as aforesaid.

In practicing my invention by the step of providing the article with a surface layer of substantially pure iron, I may proceed along either of two courses: The ferrous metal sheet or article is freed from grease and other impurities in the ordinary well known manner, and is then made the cathode in an electroplating bath, the electrolyte of which preferably consists of a normal solution of neutral ferrous sulphate. The anode may be of any suitable ferrous material. A current is used of a strength which will give a bright, firm, closely adherent, smooth plate of substantially pure iron on the article. The thus coated ferrous metal article, when enameled according to the ordinary practice, was found to exhibit substantially no tendency to boiling or reboiling during either of the two heatings, and the enameled layer was found to be of substantially uniform thickness and to be free from all occluded bubble spaces. Moreover, the enamel coating was tightly adherent and showed no tendency to flake or chip off.

Alternatively, the ferrous metal sheet or article may be heated in an oxidizing furnace between about 1000° F. and about 1200° F. until an oxide coating has been formed thereon; or, the article may be subjected to the action of steam at a temperature between about 1100° F. and about 1600° F.; or, if desired, oxidized sheets discharged from a normalizing furnace may be employed. These oxidized sheets or articles are then heated in a reducing furnace to reduce the oxide surface

layer to substantially carbon free iron. The sheets or articles to be enameled and having such a layer of carbon free iron on their surfaces are then subjected to the ordinary enameling operation described hereinabove.

It is also within the purview of my invention to provide an enameling sheet which has been rolled from an ingot in such a manner as to retain on the surface thereof the layer of substantially pure iron which is formed about the ingot during the initial steps in the cooling of the ingot after the same has been poured.

In practicing my method by using a soluble silicate, as above mentioned, the ferrous sheet metal article to be enameled is first cleaned in the usual manner, for example, by subjecting it to an alkali cleaning bath, rinsing it, acid pickling it, rinsing it again and dipping it into a neutralizing bath, after which it is immersed in a boiling 6% solution of a soluble silicate, for example, sodium silicate. After being subjected for about two minutes in this solution, it is then dried at about 250° F. Then the surfaces are covered with the enameling material and the article subjected to the usual enameling operation above mentioned. Substantially no boiling action was observed during the heatings and the enamel coating which resulted was of substantially uniform thickness and substantially free from discoloration of the enameled surface.

In practicing my invention by the method including the pickling step above mentioned, the ferrous metal article to be enameled is pickled preferably in concentrated hydro-chloric acid at a temperature of about 100° F. for about one and one-half hours. Then it is rinsed and the acid remaining thereon is neutralized in the ordinary manner. The article is then enameled in the ordinary manner, the amount of boiling being greatly reduced, although not to the extent attained by the other methods herein disclosed. I believe that pickling in concentrated hydrochloric acid removes a substantial amount of the surface carbides and to that extent decreases boiling but since the pickling does not effect the carbon, the boiling traceable to the carbon is not avoided.

I believe that the primary cause of boiling and reboiling is due to the oxidation of the iron in the surface portions of the ferrous article being enameled, which oxidation takes place between the time the article is placed in the first heating furnace and the time the enameling material melts. I believe that such iron oxide reacts with the iron carbides and carbon in the metal to produce a gas, probably carbon monoxide or carbon dioxide, which being liberated beneath the liquid enamel coating forms bubbles, some of which rise to the surface and break and others of which are entrapped in the enamel. At any rate, by protecting the metal from deoxidation or by the deoxidizing influences of carbides or carbon until the enameling material has melted and formed a protective layer thereon, the production of bubbles can be largely, if not entirely, avoided.

I have set forth several specific illustrations of my invention, so that those skilled in the art may be able to practice the same. The scope of my invention is defined in what is claimed.

What I claim is:

1. In the process of enameling ferrous sheet metal those steps comprising heating the metal in an oxidizing atmosphere to form a smooth, firm oxide scale thereon, heating the oxidized metal in a reducing atmosphere to remove the oxygen and provide a layer of carbon free iron on the base metal, thereafter working the metal to the desired texture and shape, and enameling directly to the prepared surface of the base metal whereby an improved bond results with an absence of reboiling.

2. The process of enameling which includes the steps of removing carbon and carbides from the surface film of ferrous sheet metal containing carbon and carbides by subjecting a surface of said metal to oxidizing and then reducing conditions, applying enameling material to said film, and heating said metal and enameling material to enameling temperatures.

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