Patented Apr. 14, 1942

2,279,935

UNITED STATES PATENT OFFICE

2,279,935

VITREOUS ENAMEL COATED STEEL ARTICLE AND METHOD OF MAKING THE SAME

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No Drawing. Application October 7, 1939, Serial No. 298,506

4 Claims. (Cl. 29—148)

In the manufacture of vitreous enamel coated steel articles it is customary to form or draw sheets of steel to produce the shapes desired and to thereafter apply the vitreous enamel coatings. These coatings are then heated so that they are fused or sintered onto the steel articles. At this stage of the process, numerous difficulties frequently arise.

One of these difficulties is reboiling, this causing the formation, during the fusing or sintering of the coatings, of objectionable surface defects. This difficulty is commonly believed to be due to bubbles of gas which are released from the steel when it is heated during the firing of the coatings. These surface defects obviously mar the appearance of the finished articles.

Another difficulty frequently encountered is the formation of openings or depressions in the surfaces of the enamel coatings, these being known in the art as black specks, copper-heads and fish-scaling. The formation of these defects is not consistent, it apparently varying with the coating material and the time and temperature to which it is fired, these factors, in turn, differing among the various fabricating plants.

When the steel sheets used to form the articles are cold rolled steel, that is to say, steel heavily reduced by cold working from a hot rolled unfinished product, and when this steel is oxidized or unkilled, it has been found that reboiling difficulties are not generally encountered during the firing of vitreous enamel coatings on the articles, with the same degree of frequency as when the articles are made from steel sheets of oxidized or unkilled hot rolled steel, this being steel finished by hot rolling methods excepting for very slight cold rolling necessary to impart its temper.

However, it has been found that this greater freedom from reboiling exhibited by cold rolled oxidized steel depends upon the carbon and manganese contents of the steel. Thus, it has been found that steel containing .07 per cent carbon or more and .30 per cent manganese or more usually is not subject to this difficulty. Steel containing from .04 per cent to .06 per cent carbon and from .20 per cent to .30 per cent manganese may or may not be subject to this difficulty, depending on factors not known at the present time. Steel containing less than .04 per cent carbon and substantially less than .20 per cent manganese usually causes considerable trouble through reboiling and, if the manganese is less than .12 per cent, the difficulty is encountered to a most objectionable degree.

In other words, the lower the carbon and manganese contents of oxidized cold rolled steel, the more frequent and objectionable is reboiling during the fusing or sintering of vitreous enamel on an article made of the steel.

In spite of this greater reboiling tendency of cold rolled oxidized steel that is low in its content of carbon and manganese, there is a demand for the same for formation into products to be vitreous enamel coated. This is due to the greater freedom of such steel from warping during the firing of the coatings, and its greater softness and ductility which aids in deep stamping, spinning and other forming operations necessary to produce the various shapes.

With the foregoing in mind, the present invention is based on the discovery that the addition of titanium to molten steel which is cast as an oxidized unkilled steel and processed to cold rolled steel when solidified, results in a material which when formed into articles that are coated with vitreous enamel, is not subject to reboiling difficulties during the firing of the coatings.

It has been discovered that reboiling is positively prevented unless the carbon content of the steel is less than .03 per cent and the manganese is less than .06 per cent (by ladle analysis), and in this latter case, reboiling is so greatly reduced as not to produce appreciably harmful effects during firing of the vitreous enamel coatings on the steel.

The treatment of iron and steel with titanium for other purposes is of course old, but so far as is known, its peculiar effect in preventing or greatly reducing reboiling during vitreous enamel coating, when added to steel produced as an oxidized cold rolled steel of low carbon and manganese content, has hitherto been unknown. The peculiar effect of titanium in preventing reboiling is not, as might be thought, due to its well known deoxidizing power, because aluminum, an even stronger deoxidizer than titanium, does not prevent reboiling even when added in excessive amounts. As a matter of fact, the use of aluminum causes an increase in the reboiling tendency of cold rolled steel.

Although titanium possesses its peculiar effect when added to either the furnace, the ladle or the molds, and when added in any usual form, it is believed preferable to add it to the ladle in its commercial alloy form known as ferro-carbon-titanium.

It has been found that the amount of titanium that must be added to the molten steel depends on the carbon and manganese contents of the

same. Thus, steel analyzing in the ladle as containing from .07 per cent to .03 per cent carbon and from .30 per cent to .10 per cent manganese, requires about three pounds per ton of steel of the titanium alloy when this alloy contains 20 per cent titanium. In such a case, reboiling difficulties are completely eliminated. On the other hand, three and one-half pounds of such an alloy must be added for each ton of steel containing, when in the ladle, .03 per cent maximum carbon and from .06 per cent to .10 per cent manganese. If the carbon is as low as .03 per cent maximum, and if the manganese content is below .06 per cent, then at least three and one-half pounds of 20 per cent titanium alloy per ton of steel must be used and preferably five pounds per ton should be used. In the case of steel of such extremely low carbon and manganese contents reboiling difficulties are not entirely eliminated but they are so greatly reduced that they are no longer productive of material damage to the enamel coatings.

It is obvious from the above that the amounts of titanium added to steel to be cast without being killed and worked into a cold rolled product that is formed into articles which are coated with vitreous enamel, must be varied in accordance with the carbon and manganese content of the steel, if reboiling difficulties during firing of the enamel coatings are to be prevented.

A further important effect is obtained by the use of the titanium, namely, the formation of defects such as black specks, copper-heads and fish-scaling are retarded or entirely prevented regardless of the slight variations in enameling practice encountered in the case of the various fabricating plants. In other words, the steel is no longer particularly sensitive to plant practices.

It is to be understood that in all cases, the steel will have an analysis producing an oxidized cold rolled steel suitable for use in the manufacture of vitreous enamel coated steel articles. The steel will differ from the prior art steel provided for this purpose in that it will contain the titanium and will be effectively free from the difficulties encountered heretofore. This requires at least .50 pound of titanium per ton of steel.

We claim:

1. A method of producing vitreous enamel coated steel articles, which includes producing oxidized molten steel containing less than .07% carbon and less than .30% manganese, adding titanium thereto in amounts insufficient to kill said steel, solidifying said unkilled steel, producing cold rolled steel from said steel when it solidifies, producing the desired articles from said cold rolled steel and fusing vitreous enamel coatings on said articles.

2. A method of producing vitreous enamel coated steel articles, which includes producing oxidized molten steel containing less than .07% carbon and less than .30% manganese, adding titanium thereto in amounts insufficient to kill said steel, solidifying said unkilled steel, producing cold rolled steel from said steel when it solidifies, producing the desired articles from said cold rolled steel and fusing vitreous enamel coatings on said articles, said titanium being added to said molten steel to the amount of at least .50 pound per ton of said steel.

3. A method of producing vitreous enamel coated steel articles, which includes producing oxidized molten steel containing less than .07% carbon and less than .30% manganese, adding titanium thereto in amounts insufficient to kill said steel, solidifying said unkilled steel, producing cold rolled steel from said steel when it solidifies, producing the desired articles from said cold rolled steel and fusing vitreous enamel coatings on said articles, said titanium being added to said molten steel to the amount of at least .50 pound per ton of said steel, and being increased above said amount when the carbon and manganese contents of said steel are less than said percentages as required to retard or eliminate the formation of defects in said vitreous enamel coatings fused on said articles.

4. Cold rolled unkilled steel containing less than .07 per cent carbon and less than .30 per cent manganese and being otherwise of an analysis suiting it for working into articles requiring cold forming in their production, said steel containing at least .50 pound per ton of steel of titanium to materially retard reboiling or other similar harmful effects when vitreous enamel is fused on its surface.

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