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METHOD OF FLOW-BRIGHTENING
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1

This invention relates to improvements in the method of manufacturing electrolytic tinplate and more particularly relates to improvements in flow-brightening electrolytic tinplate which reduce surface imperfections whereby tinplate having a bright mirror-like surface is produced.

In the present day, high speed production of electrolytic tinplate ferrous metal strip, such as black plate, is continuously passed through a long and complicated electroplating line at the high speed of 1,000 feet or more per minute. As the strip passes through the line, it is electroplated with tin. The amount of tin deposited on the strip is relatively small when compared to tinplate produced by the hot dip process and usually varies from about $\frac{1}{4}$ pound to 1 pound per base box. The tin plate leaving the electroplating cell has a dull or matte finish so that normally the electroplated tinplate is washed and passed through suitable flow-brightening apparatus. As the strip moves through this apparatus, the tin coating is heated to a temperature above its melting point so that the tin will flow and upon quenching will have a bright mirror-like surface. In practice, it is extremely difficult, if not impossible, to control accurately the temperature to which the tin is heated and while tin melts at about 449° F., the tin coating is heated up to an estimated temperature of about 500° F., or higher, in the flow-brightening zone. The molten tin is preferably immediately quenched and solidified. Various quenching mediums have been used; for example, palm oil has been used as a quenching liquid but the palm oil leaves a residual layer on the tinplate which is undesirable, especially when the tinplate is subsequently lacquered or treated in any manner which requires the removal of all foreign material. For various practical reasons, water is a highly desirable quenching liquid. It is readily available, inexpensive, and the strip can be easily dried to remove all of the water without leaving a residual deposit on the surface of the tinplate. For these reasons, the use of water as a quenching medium has been fairly widely accepted. Water does have the serious drawback in that it tends to produce surface blemishes on the tinplate. One type of surface blemish is commonly referred to as "quench lines." When such a sheet is examined under a light, it can be readily seen that these quench lines are present as the light is diffused and the area appears gray instead of appearing bright or mirror-like as it should appear.

Another type of surface blemish which is at times encountered when producing tinplate in the

2

mill is called "snow balls" which term is quite descriptive of the appearance of these surface blemishes. Both quench lines and snow balls are undesirable surface blemishes which are readily distinguishable from each other by one skilled in the art.

Accordingly, it is an object of this invention to provide an improved process of producing electrolytic tinplate which is relatively free of surface blemishes when water is used as a quenching medium.

Another object of the present invention is to produce flow-brightened electrolytic tinplate by quenching the molten tin in water without causing quench lines to appear on the surface.

It is also an object of the present invention to provide an improved process of producing flow-brightened electrolytic tinplate which is free from the surface blemish known as snow balls.

It has been found that reducing the temperature of the quench water does in turn reduce the quantity and frequency of occurrence of the phenomena known as "quench stains." To reduce or eliminate the quench stains, it is necessary to make a deliberate effort to maintain the temperature of the quench water relatively low. Normally, if no effort is made to maintain the temperature of the quench water low, the water will take up such a large quantity of heat from the surrounding atmosphere and from the relatively large quantity of tinplate passing through the quench bath that the water is maintained at a relatively high temperature; for example, 165° F., or higher. It has been found that if the temperature of the quench water is reduced to below about 135° F. the amount of quench stains is greatly reduced and if the quench water is reduced in temperature to about 100° F. the quench stains will be almost completely eliminated, especially for the lighter grades, such as $\frac{1}{4}$ and $\frac{1}{2}$ pound tinplate. Maintaining the quench water at about 100° F. does not entirely eliminate the quench stains.

Lowering the temperature of the quench water reduces quench stains but it has been found that in production in the mill, the phenomena known as "snow balls" appear. It has been found that reducing the quench water temperature to about 135° F. tends to increase the occurrence of snow balls and the snow balls are especially pronounced when the temperature is reduced to about 110°–115° F. or lower. Thus, lowering the temperature of the quench water reduces or substantially eliminates the quench stains but tends to produce snow balls.

3

It has been discovered that quench stains can be prevented by reducing the temperature of the quench water without producing snow balls if the molten tin coating from the flow-brightening zone is precooled before the tinplate is quenched in the relatively cool quench water. Precooling of the molten tin in a gaseous atmosphere without solidification of the tin followed by quenching in quench water at a temperature at about or below 135° F. greatly reduces the occurrence of quench stains. The quench stains can be entirely eliminated if the quench water is maintained at a temperature below about 125°-130° F. Preferably, quench water is maintained between about 100°-130° F. to eliminate the quench stains. This temperature range provides a certain amount of tolerance and for practical reasons it is not preferred to go below 100° F. as it is too difficult to maintain such a low temperature. These low temperatures will not produce snow balls when the strip is precooled.

These and other objects and advantages will become more readily apparent when considering the following detailed description, taken with the accompanying drawing in which there is schematically shown a portion of an electroplating line embodying the principles of the present invention.

Referring to the drawing, the strip S is moved from left to right through the electroplating line by any suitable means, such as the power-driven roll means usually employed for moving strip along a path in a steel mill. The rolls, hereinafter described when discussing the drawing, may be power-driven by any suitable means to move the strip along the line. As shown, the strip after leaving the electroplating apparatus (not shown) and having on one surface or on both surfaces a layer of protective tin, passes between a first pair of rolls 10 and 11. The strip S passes from rolls 10 and 11 down and through an aqueous rinsing bath 12 in tank 13. A pair of rotatable rolls 14 and 15 are provided in the tank 13 for holding the strip beneath the surface of the bath 12. The purpose of this bath is to remove any residual electroplating salts remaining on the surface of the strip and which would be detrimental to the flow-brightening operation. Preferably, the bath 12 is heated so that as the strip passes through the bath, it is preheated. The film of rinse water on the strip as it leaves the bath evaporates quite readily when the bath is at an elevated temperature close to its boiling point. The rinsed strip from tank 13 passes through a dryer 17 and then through a flow-brightening furnace 18 in which the tin coating is heated to above its fusion temperature. The particular type of heating means employed in the furnace 18 may be of any type heretofore employed. After the strip with the molten tin on its surfaces leaves the furnace 18, it passes through a precooler. The precooler 19 comprises a box or hood 20 having an inlet pipe 21 connected to a source of gas and an outlet pipe 22. The gas flows through inlet pipe 21 and through hood 19 in a direction countercurrent to the direction of strip travel and out pipe 22. The countercurrently flowing stream of gas cools the molten tin without disturbing the tin to thereby cause an uneven surface. Preferably, a non-oxidizing gas is used and the gas may be at ambient temperature or colder or hotter than ambient temperature as long as the temperature is below the melting temperature of tin. The colder the gas, the less volume of gas required.

4

If the gas is recycled, it should be cooled prior to reintroduction into the hood. After being pre-cooled and with the tin above its fusion temperature and molten, the strip S passes into a quench tank 23 in which there is a quench bath of water 24 which effects solidification of the tin coating. The wet strip passes from the quench tank 23 through a dryer 25 and then between a pair of rolls 26 to the usual coiler or other usual apparatus for handling the tinplated strip. Pre-cooling can not be done in a separate bath of water and obtain the same results.

Quench water is continuously supplied to the tank 23 through a pipe 27 which is connected through a valve 28 to a suitable source of quench water having a lower temperature than the water bath 24. An outlet pipe 29 is connected through a valve 30 to the tank 23 to conduct quench water from the tank to a sewer or other suitable place of disposal. Rotatable rolls 31 and 32 are mounted in tank 23 for holding strip S in the quench bath. Water is supplied to the tank at such a rate of flow and temperature as to maintain the temperature of the bath at about 135° F., or lower, so as to reduce the occurrence of quench stains on the surface of the tin. Preferably, the temperature is maintained below about 125° to 130° F. to eliminate quench stains. For practical reasons, the water is not normally maintained below 100° F. as the strip adds so much heat to the bath that a lower temperature is not economical.

Maintaining the quench water at the above mentioned temperatures without precooling the molten tin tends to produce snow balls on the surface of the tin. By using the stream of gas flowing through hood 20, it is possible to reduce or eliminate quench stains without producing snow balls when the quench water is maintained at these relatively low temperatures.

Alternatively, precooling of the strip may be effected by increasing the distance between the flow-brightening furnace 18 and the quench tank 23 so that an appreciable amount of cooling can be effected by the atmospheric air or other surrounding gaseous medium. For example, it has been found that if the distance is such that the strip travels for a period of about three seconds through the air, there is sufficient precooling so that the quench bath will solidify the tin without producing quench stains or snow balls. When the strip is travelling, for example, at 1200 feet per minute or 20 feet per second, the quench tank 23 would have to be about 60 feet away from the flow-brightening furnace 18 to provide a cooling period of three seconds. The time required, and, in turn, the distance between furnace 18 and tank 23 will depend on a number of factors, including the thickness of the coating and the base metal, and the temperature of the atmosphere. Similarly, the preferred gas temperature in hood 20 depends upon a number of factors and can be readily determined for any particular set of conditions. If the temperature of the quench water is as specified and some quench stains appear, then more precooling should be obtained by lowering the temperature of the gas, by increasing the rate of gas flow or by increasing the length of the precooling zone.

The quench water may contain relatively small amounts of materials which improve the appearance or quality of the solidified tin coating. Such materials will be used in such minute amounts as to not materially affect the quenching characteristics of the water quench bath.

5

In addition, the quench water may be agitated and streams of quench water may be applied against the strip to effect more rapid quenching of the molten tin.

The non-oxidizing gas may be any suitable gas which will not unduly oxidize the molten tin. For example, nitrogen, hydrogen, carbon monoxide and the like, or mixtures of gases may be used.

I claim:

1. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in a gaseous atmosphere without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature not above 135° F. and solidifying the tin coating in the quench bath.

2. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating by countercurrently flowing cooling gas along the surface of the tin coating without effecting solidification of the molten tin, and then passing the precooled strip through a bath of quench water having a temperature not above 135° F. and solidifying the tin coating in the quench bath without producing quench stains or snow balls.

3. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in gas at atmospheric temperature for a period of about three seconds without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature not above 135° F. and solidifying the tin coating in the quench bath.

4. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in an atmosphere of non-oxidizing gas without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature not above 135° F. and solidifying the tin coating in the quench bath.

5. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in a gaseous atmosphere without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature below 130° F. and solidifying the molten tin.

6

6. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightened zone and precooling the molten tin coating in a gaseous atmosphere without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature below 130° F. and above 100° F. and solidifying the molten tin.

7. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating by countercurrently flowing non-oxidizing gas along the surface of the tin coating without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature not above 135° F. and solidifying the tin coating in the quench bath.

8. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in a gaseous atmosphere of non-oxidizing gas without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature below 130° F. and solidifying the tin coating.

9. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in a gaseous atmosphere of non-oxidizing gas without effecting solidification of the tin coating, and then passing the precooled strip through a bath of quench water having a temperature below 130° F. and above 100° F. and solidifying the tin coating.

10. In the process of treating electrolytic tinplate strip in which the tinplate is passed through a flow-brightening zone and the tin coating melted, the steps comprising, passing the strip from the flow-brightening zone and precooling the molten tin coating in a non-oxidizing atmosphere at atmospheric temperature for a period of about three seconds, and then passing the precooled strip through a bath of quench water having a temperature below 130° F. and above 100° F. and solidifying the molten tin.

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