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METHOD OF GALVANIZING EMPLOYING ROLLS
OF AN AIR HARDENING DIE STEEL
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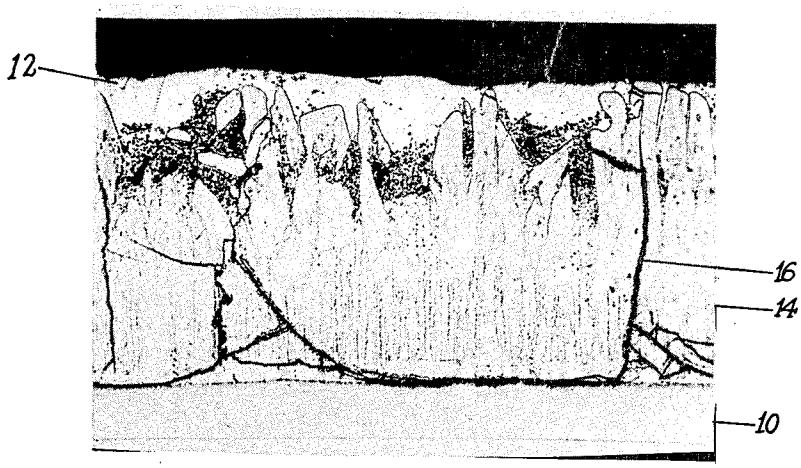


Fig. 1

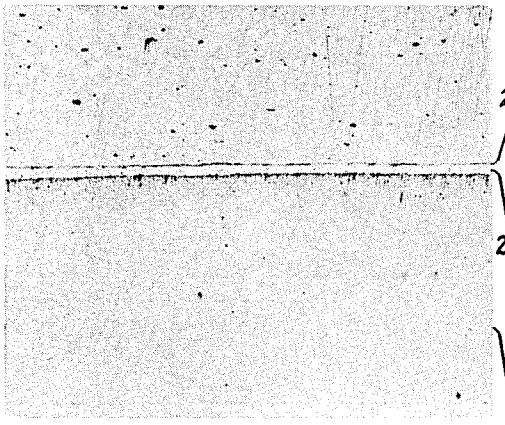


Fig. 2

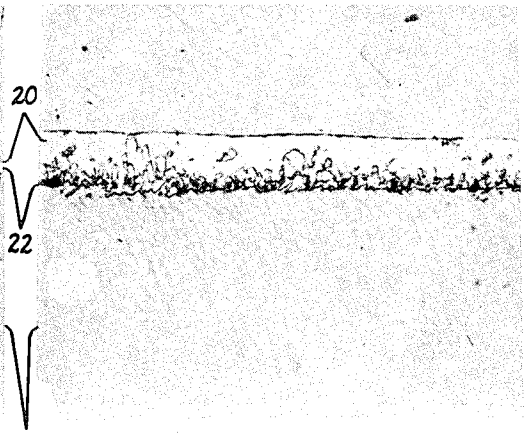


Fig. 3

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METHOD OF GALVANIZING EMPLOYING ROLLS OF AN AIR HARDENING DIE STEEL

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Int. Cl. C23c 1/02

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ABSTRACT OF THE DISCLOSURE

Method of galvanizing ferrous strand utilizing rolls of an air hardening die steel. In galvanizing apparatus, sinker, stabilizer and exit rolls subjected to molten zinc consisting of an air hardening die steel which is wettable by molten zinc and substantially resistant to formation of iron-zinc alloy.

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of application Ser. No. 481,865 filed Aug. 23, 1965, now abandoned, in the name of Paul E. Schnedler and entitled "Coating Method."

BACKGROUND OF THE INVENTION

This invention relates to the continuous coating of ferrous strand-like material with molten zinc and more particularly to a new alloy steel roll for such a coating operation. It will be understood that the term "strand" as used hereinafter in this application will refer generally to ferrous materials adapted to be coated in a continuous galvanizing operation. As such, the term includes strip, sheet, wire, tubing, or other forms of ferrous material.

According to the prior art, the ferrous strand has its surface prepared in various ways to insure receptivity of the molten coating metal. After this preliminary preparation the strand is passed into a bath of molten zinc and under a pot or sinker roll, then, optionally past one or more stabilizer rolls. As the strand is withdrawn from the zinc bath, exit rolls or coating rolls are often used for the purpose of smoothing out the coating and to control the coating weight within a desirable range.

Exit rolls are normally made of steel having a carbon content in the range of 0.01 to 0.30 and are normally used in the annealed condition. Such a material will alloy rapidly with the molten zinc of the coating bath forming a thick, easily removable iron-zinc alloy which has greater volume than the original iron. In the case of exit rolls, a skillful operator uses the known characteristics of this iron-zinc alloy in order to maintain the shape or, if necessary, to change the shape of the exit rolls in order to suit his needs. That is, in order to increase the roll diameter at a given point, he allows the alloy to form, and conversely, in order to decrease the diameter of the roll at a given point he removes the alloy with a scraping tool.

It will be recognized that great skill is required on the part of the operator in order to properly control the size and shape of the exit rolls. Furthermore, even the best operator will often err when the width or thickness of the material being coated is changed. For example, when it becomes necessary to change width of strip being coated from 36 inches to 48 inches, it is necessary for the operator to remove enough iron-zinc alloy from the exit rolls on each side of the existing strip so as to make the entire roll face a true cylinder. Since he has no means of measuring the amount of material removed (or left on the exit roll) he often is forced to operate under conditions which do not produce prime product. Likewise if the strip wanders off the center-line of the exit rolls, one edge of the strip contacts roll surfaces which are not conditioned in the same way as the rest of the roll surface, resulting in a non-uniform application of zinc. It is also known that the scraping operation removes the iron of the exit roll which has alloyed with the zinc. Applicant has observed that the conventional exit roll in normal operation will lose on the order of ¼ inch of its diameter in a week due to the constant alloying action and subsequent dressing and shaping of the roll. Depending upon the particular machine, the normal size of the exit rolls may be 6 to 12 inches in diameter.

In addition, the passage of the strip between a pair of exit rolls, particularly in the case where the rolls are driven at a speed different from that of the strip passing between them, causes great amounts of wear and removal of alloy at the areas of contact thereby resulting in roll surfaces which are no longer true cylinders. Finally, it is customary to form grooves in the surface of the exit rolls. These grooves are helpful as is well known in the art for oxide control and control of the weight of coating material applied to the strand. Like the surface of the exit roll, these grooves tend to alloy and fill up progressively, thereby changing the coating weight applied to the strand. The operator, just as he scrapes the surface of the roll, will customarily clean out these grooves by means of a grooving tool. Once again he is depending entirely upon his own judgment, skill and experience to determine the amount of grooving which is necessary in order to apply a desired thickness or weight of coating material.

Pot or sinker rolls as well as stabilizer rolls operate completely below the surface of the molten zinc. Therefore, they cannot be repaired or maintained unless the operation is stopped and they are raised from the bath. For this reason, the rolls should be as inert to the influences of the operation as possible. They must resist dimensional growth due to alloy formation as well as roughening or spalling which occurs when the alloy layer sloughs off, and wearing due to abrasion with the strip.

Since sinker rolls and stabilizer rolls are located under the bath surface and cannot therefore be shaped by the operator, other materials such as Type 316 stainless steel have been used. Even this stainless dissolves in zinc more rapidly than the material of this invention and, since it is a stable austenitic steel, it cannot be hardened to provide the wear resistance provided by the material of this invention.

SUMMARY OF THE INVENTION

In its broadest aspects, the invention of this application resides in the discovery that a particular steel alloy can be used for exit rolls, stabilizer rolls and sinker rolls in a strand galvanizing operation to achieve great economies and superior results.

It is a primary object of this invention to provide a coating method and rolls for use therewith which are dimensionally stable and which do not require continual maintenance by the operator.

Another object of the invention is the provision of a coating method and exit rolls therefor which will permit the application of more uniform zinc coatings without continual shaping by the operator.

Another object of the invention is to provide a stabilizer or sinker roll which will be dimensionally stable, will resist solution in molten zinc and have adequate wear resistance so that it can operate without maintenance for extended periods of time.

Still a further object of this invention is to provide rolls for use in molten zinc which are chemically and dimensionally stable, and wettable but resistant to the formation of an iron-zinc alloy.

Still a further object of the invention is the provision of an exit roll for a galvanizing operation which has longer life between re-machining operations, and longer ultimate life.

It will be understood that the formation of an iron-zinc alloy on the rolls during the coating step, and the subsequent scraping of this alloy from the exit rolls results in an increased dross formation, both in the bath and deposited on the strip, with the consequent reduction in quality and yield. It is therefore another object of this invention to reduce the formation of such dross on the surface of the coating bath and on the coated strip.

Still a further object of the invention is to provide a coating method and exit roll therefor which, by eliminating the necessity for scraping or shaping by the operator, permits substantially automatic control of the operation, thereby giving much greater control over the coating weight and thickness. This is particularly important in view of the increasing use of galvanized steels in products which previously have been made from uncoated steel, these new products often requiring improved characteristics of the coated surface.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a photomicrograph of the cross-section of the surface layers of conventional exit roll material submerged in a typical zinc galvanizing bath maintained at 850° F. for one hour.

FIG. 2 is a photomicrograph at the same magnification as FIG. 1 but showing a sectional view of the surface layers of a sample roll according to this application subjected to the same conditions as the exit roll of FIG. 1.

FIG. 3 is a photomicrograph of a portion of FIG. 2 at a much magnification.

DESCRIPTION ON THE PREFERRED EMBODIMENT

The invention relates to the use of a specific steel in three specific applications in strip galvanizing—exit rolls, stabilizer rolls, and sinker rolls. The sinker roll or pot roll is a smooth idle roll submerged in the bath which holds the strip below the surface of the zinc. Stabilizer rolls are smooth idler rolls ordinarily used in coating lines using air knife or jet finishing. One or more stabilizer rolls are positioned just below the surface of the zinc bath as the strip is about to exit from the pot. Ordinarily there is one stabilizer roll located on the opposite side of the strip from the sinker roll. The stabilizer roll damps any vibration in the strip and holds the strip flat as it passes between the air knives so that the sharp gaseous jet will have a flat strip properly positioned for optimum finishing. Exit rolls are located at the surface of the bath to smooth and control the molten coating.

Briefly considered, the crux of this invention resides in the provision of an exit roll, stabilizer or a sinker roll consisting essentially of an alloy steel which is wettable by molten zinc and yet is chemically stable so as to severally limit the formation of an iron-zinc alloy and which is dimensionally stable with respect to the exposure to the ordinary operating temperatures and hard enough to maintain its original size and shape in the presence of the abrasion of the strip passing over the rolls.

More specifically, it has been found that some types of alloy steels possess extremely high resistance to alloying with zinc and which are highly resistant to warpage at the operating temperatures normally encountered. Hardness of the alloy in the annealed condition is considerably greater than that of the conventional rolls, and the rolls of this invention can be further hardened so that the rate of wear due to strip abrasion is very low. This combination of properties now makes it possible to produce and use rolls which are dimensionally stable, which are chemically stable, and which resist change in shape due to differential wear.

The preferred rolls of this invention will consist essentially of an chromium-molybdenum-vanadium steel, ordinarily classified as an air hardening die steel.

Experimentation has indicated that an alloy steel having a composition within the following range is entirely satisfactory.

	Percent
Chromium	5–10
Molybdenum	0.5–2.0
Vanadium	0.5–1.5
Silicon	0.5–1.5
Carbon	0.20–0.60
Manganese	.20–.80

Within the above set forth range, the preferred analysis of the rolls of this invention will be approximately 7.5% chromium, 1.0% molybdenum, 1.0% vanadium, 1.0% silicon, 0.40% carbon and 0.35% manganese. Manganese does not seem to add must to the peculiar properties desired in this invention but an amount in this range is required in alloys of this type for known purposes.

As indicated above, it is desirable that the exit roll of this invention have dimensional stability. That is achieved by making the roll as hard as possible without causing susceptibility to cracking or excessive machining cost. By way of example, exit rolls within the composition range set forth above and having a Brinell hardness in the range of 200–550 have been found entirely satisfactory. This may be compared with conventional exit rolls which have a Brinell hardness of about 100.

The rolls of this invention may be heat treated by austenitizing at about 1900° F. and air cooling to produce a martensitic structure. Before using hardened rolls they should be tempered at a minimum temperature in excess of the coating temperature and up to approximately 1200° F. This will minimize warpage and distortion in operation and reduce susceptibility to cracking. After heat treatment, the hardness will be Brinell 300–550.

Since the alloy described above is relatively expensive, it may be desirable to produce the novel rolls according to this invention by alternate methods. This may be done by beginning with a mild steel roll and depositing the desired alloy on its surface by arc welding or any other suitable process. The deposited surface layer should be built up to a thickness of from about 1/16 inch to about ½ inch. In the case of exit rolls which are to be grooved according to conventional practice, the thickness of the surface layer should be near the upper end of the range set forth. The rolls may also be formed by centrifugal casting procedures wherein a laminated roll may be cast with the desired alloy forming the surface.

The rolls of this invention have been tried in actual practice and have been found to be superior to known rolls. However, laboratory immersion tests were made in order to determine the alloying rate of the material and to facilitate study of the undisturbed alloy layer. This was necessary to explain the unexpected good performance of the rolls of this invention.

FIGS. 1 through 3 show the results of a laboratory test to show the wettability and resistance to alloying of the rolls of this invention. Two test rolls, each three quarter inches in diameter by two inches long were made up, one formed of the alloy described in this application and the other of a conventional roll material with approximately 0.25% carbon. Both rolls were cleaned, prefluxed in zinc-ammonium chloride and immersed for one hour in a zinc bath containing .12% aluminum and maintained at 850° F.

In FIG. 1, a portion of the test roll is indicated at the reference numeral **10**, while the unalloyed or free zinc is the light material at the top of the figure indicated at the reference numeral **12**. Between the roll **10** and free zinc layer **12** is the iron-zinc alloy indicated at the reference numeral **14**.

While not intending to be bound by theory, applicant believes from a study of the photomicrograph of FIG. 1 that the conventional roll material when subjected to immersion in a galvanizing bath forms a very thick,

hard, brittle alloy layer. The combination of hardness and thickness apparently causes stresses resulting in the visible cracks of FIG. 1 indicated at **16**. This of course makes the alloy easily removed. Measurements of the alloy layer of the test roll shown in FIG. 1 indicate that the thickness of the alloy is approximately .0098 inch.

In FIG. 2, the test roll formed of the alloy of this invention is indicated at **18**. The free zinc layer, not clearly visible in FIG. 1 is indicated at **20** while the intermediate iron-zinc alloy is indicated at **22**.

The structure of this alloy and free zinc is more clearly shown in FIG. 3. (FIGS. 1 and 2 are taken at a magnification of 200×, while FIG. 3 is a magnification of 1000×.) It will readily be observed that the alloy layer is extremely small in relation to the free zinc. Actual measurements of this test roll showed an alloy layer .0003 inch thick. This is a thickness about 1/33 that of the test roll of conventional material.

Additional test rolls similar to those shown in FIGS. 1 and 2 were maintained in the zinc bath for a period of 24 hours. The test roll of conventional material increased in size from .750 inch to .779 inch in one hour, and after twenty-four hours attained a diameter of .800 inch. By way of comparison, the test roll of the alloy of this invention maintained a relatively uniform size between .748 and .753 inch during the entire twenty-four hour period.

By way of brief summary, the rolls described above do not form an easily-removed iron-zinc alloy as do conventional rolls and therefore retain their shape, size and surface texture for a relatively long period of time. Consequently, the coating applied to the strip is more uniform and free from dross or other surface defects. The greatly increased hardness reduces the rate of wear and in conjunction with the lower alloying rate allows the rolls to be used for substantially longer periods of time before remachining, and also permits a much longer ultimate roll life. These rolls lose ony about .020 inch in a week's continuous operation compared to a normal .250 inch. The elimination of the necessity for an operator to shape the exit roll during operation makes it possible for these rolls to be used in conjunction with an automatic coating weight sensing device, whereby substantially automatic control of the operation may be obtained.

The operation of the coating line, including the steps of surface preparation, temperature or other conditions of the bath, do not form a part of the instant invention per se. As will be apparent from considering the above description, this invention is concerned strictly with the provision of improved rolls for a galvanizing operation and a method of using these rolls.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a method of coating a ferrous strand with molten zinc including the steps of preparing the surface of the strand to insure receptivity to the molten zinc and passing said strand into a bath of molten zinc, the improvement which comprises the step of passing said strand through said bath with at least one surface thereof in contact with an alloy steel roll, said roll having a Brinell hardness in the range of from 200 to 550 said alloy steel being wettable by molten zinc and substantially resistant to the formation of an iron-zinc alloy and including substantially 5 to 10% chromium, 0.5 to 2% molybdenum, 0.5 to 1.5% vanadium, 0.5 to 1.5% silicon, 0.20 to 0.60% carbon, and 0.20 to 0.80% manganese, the balance substantially iron.

2. The method of claim **1**, wherein said alloy steel is heat treated to a hardness of Brinell 300–550 by austenitizing at a temperature above 1900° F., air cooling to produce a martensitic structure and tempering.

3. The method claimed in claim **1**, wherein said alloy steel includes substantially 7.5% chromium, 1% molybdenum, 1% vanadium, 1% silicon, 0.40% carbon, and 0.35% manganese.

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