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3,369,923

## METHOD OF PRODUCING HEAVY COATINGS BY CONTINUOUS GALVANIZING

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No Drawing. Filed Dec. 14, 1964, Ser. No. 418,316

6 Claims. (Cl. 117-51)

This invention relates to continuous galvanizing. More particularly, this invention relates to the production of heavy zinc coatings by a continuous galvanizing process.

Heavy zinc coated products such as highway guard rails require less frequent maintenance than thin coated products. Due to the increasing cost of regular maintenance the demand for heavily coated products has increased at an accelerating rate. Heavy coatings have hitherto been produced by hot dipping but with the accelerating demand hot dipping has been found too slow and too expensive.

Attempts have been made to produce heavy zinc coatings by continuous methods, but although continuous galvanizing is widely used for producing thin coatings, no successful continuous procedure for producing zinc coatings of greater than approximately 2.5 ounces of zinc per square foot of strip has hitherto been developed. As usually measured this amount of coating is actually distributed over two square feet (one on each side of the strip). So-called 4 ounce coatings, in particular, now much in demand for highway guard rail and culvert stock, have required the more expensive individual hot dipping.

It is an object of the present invention to provide a practical method of applying a heavy zinc coating by continuous galvanizing.

It is a further object of the present invention to provide a practical method of obtaining a 4 ounce per square foot of base metal zinc coating by continuous galvanizing.

Briefly, I have discovered that the above objects can be obtained by the correct combination of the following:

- (1) The degree of roughness of the strip surface.
- (2) The degree of fluidity of the molten zinc bath.
- (3) The adjustment and operation of the exit rolls.
- (4) The strip speed.
- (5) The temperature of the strip.
- (6) The manner of quenching after coating.

The first step in my novel process is roughening the strip surface prior to passing the strip into the coating pot. Preferably, the roughening takes place in a rolling operation.

After having been roughened, the strip may be treated with a flux, and then dried in a furnace at 350° F. or higher, or may be otherwise pre-treated to condition it for coating.

The strip is run from the heating furnace directly into the galvanizing bath. Preferably the strip is passed from the furnace into the bath through an enclosed hood if a protective atmosphere has been used. If the strip has been taken to an elevated temperature such as into the annealing range, it must be passed through a cooling zone in the heating furnace to bring it down to approximately the temperature of the bath. A temperature less than the temperature of the bath is preferable for the application of heavy galvanized coatings and may be as low as 350° F. The strip should enter the bath at a temperature no higher than 840° F.

820° F. has been found to be a satisfactory temperature for the bath. At this temperature, the fluidity of the bath is less than maximum, but is sufficiently high to prevent objectionable incipient crystallization. In some cases, the temperature of the bath may be reduced to

as low as 780° F., depending upon the exact melting point of the particular bath.

The fluidity of the bath may be further decreased by adding less than the usual addition of aluminum to the bath. I have found a range of .05% to .10% aluminum suitable for the practice of my invention. The addition of some aluminum is necessary to suppress the formation of a brittle iron-zinc alloy layer, but much less is necessary than in prior processes.

The strip should be passed through the coating bath at a speed of at least 100 feet per minute, in order to obtain the heavy coatings of the present invention. In general, the greater the speed which can be attained, the heavier the coating which will be produced.

The strip is passed out of the coating bath in a generally upward direction between two exit rolls partially submerged in the coating bath. The amount of coating deposited upon the strip is in part dependent upon the depth of the pool between the rolls. To obtain a deeper pool, more molten metal is pumped by the rolls into the pool in the nip of said rolls by increasing the peripheral speed of the rolls to a rate at least 10% greater than the speed of the strip. In other words, if the strip is passing out of the bath between the rolls at the minimum speed for this invention of 100 feet per minute, then the peripheral speed of rotation of the exit rolls in the same direction would be at least 110 feet per minute. Preferably, the speed of rotation of the exit rolls will be approximately 20%-40% greater than the speed of the strip. In no case, however, should the speed of rotation of the rolls be so great as to cause excessive agitation of the bath and thereby accelerate the formation of detrimental oxidation products which may contaminate the strip.

In order to obtain a satisfactory depth of pool the exit rolls should be supported in the molten bath so that only approximately a third of the roll is visible.

In order to still further increase the pumping action of the rolls, they are preferably provided with numerous grooves. The grooves, which may be U or V-shaped, should preferably be from 1/3 to 3/4 of an inch apart and from 1/32 to 1/8 inch deep and 1/32 to 1/8 inch wide. The grooves may be arranged parallel to each other in discrete rings or may be in a spiral pattern around the roll.

The exit rolls should be backed off until they just barely touch the coated strip. They should be sufficiently close to the strip to smooth the coating thereon but not to exert a significant wiping action on the strip.

After the coated strip has left the exit rolls, it should be cooled as soon as practicable by a cool gas quench, which may be an air blast, directed upwardly along the strip. The gas quench not only cools the coating but also acts, by virtue of being upwardly directed, to partially support the coating and prevent saglines or run-back. After the coated strip passes through the gas quench, it may also be cooled by a moist steam and air blast or a water and air blast also upwardly directed.

The resulting 4 ounce coating will be found to be smooth with an even pebble-like texture as compared with the smeary, uneven distribution of zinc on a 4 ounce hot-dipped product. Less zinc is used to obtain a continuously produced 4 ounce coating than a hot-dip 4 ounce coating because the distribution of zinc is more even. In a hot-dipped product a significant percentage of the zinc used is contained in the drip edge.

As a specific example of my invention for obtaining heavy coatings on strip material, I have shot blasted the rolls of the final finishing stand of a hot mill to produce a 700 to 900 micro-inch finish on said rolls. Nineteen and one-half inch wide strip after passing through these

roughened rolls was found to have a 175 to 250 micro-inch surface. The final gauge of the strip was .112".

After hot rolling the strip was passed through a pickler with just sufficient scale breaking to loosen the hot mill oxide but not sufficient to seriously affect the surface finish. No oil was used after pickling. The hot rolled surface of 175 to 250 micro-inches was somewhat flattened to a 125 to 225 micro-inch finish during pickling.

The pickled strip was next passed at 110 feet per minute into a Selas (radiation) furnace where it was exposed to a furnace temperature of 2500° F. for approximately 25 feet in a non-oxidizing atmosphere. From here the strip entered a 75 ft. holding zone, the temperature of the holding zone decreasing from about 1225° F. to about 1100° F. From here the strip entered a short high rate cooling zone held at 500° F. and then entered a 105 ft. controlled cooling zone where the furnace temperature decreased steadily along the zone in a protective atmosphere from 900° F. to 750° F. The strip passed directly from this section of the cooling zone at 110 feet per minute through a hood containing a protective atmosphere directly into the surface of a galvanizing bath. The last section of the cooling zone was controlled to provide a strip temperature into the coating bath of approximately 780° F.

After passing around a sinker roll the strip passed up out of the molten zinc bath at 110 ft. per minute between two exit rolls rotating in the same direction as the travel of the strip at a peripheral speed of approximately 130 feet per minute. Each of the exit rolls was submerged in the molten zinc so that only  $\frac{1}{3}$  of the diameter of the roll was visible and each had a series of V-grooves cut  $\frac{1}{2}$  inch apart,  $\frac{1}{16}$  inch deep and  $\frac{1}{16}$  inch wide, about the circumference of the roll across the face thereof. The rolls were adjusted to just barely touch the strip.

The zinc bath had an aluminum content of approximately 0.08%, and was maintained at approximately 820° F.

After passing between the exit rolls, the coated strip was subjected approximately 4 feet above the exit rolls to a quenching blast of air, on both sides of said strip, directed upwardly at an angle towards the strip. Above the air quench, and about 10 feet above the exit rolls, a blast of moist steam was directed upwardly at an angle toward the strip on both sides of said strip.

The strip was roller-leveled and then coiled, and upon examination was found to have an evenly applied, strongly adherent 4 ounce coating with an attractive pebble-like patterned surface. Guard rails were easily fabricated from this stock with no flaking or cracking of the zinc coating. The zinc coating was tight and adherent after fabrication, in contrast to a normal hot-dipped 4 ounce coating which often flakes.

As another specific example of my invention, a .112 inch gauge strip 19.5 inches in width was roughened to a 150 to 250 micro-inch finish on the last stand of a hot finishing train. The strip was then subjected to a pickling operation and coiled without oil. The resulting strip had a 125 to 225 micro-inch finish.

On the galvanizing line just prior to galvanizing, the strip was subjected to a second very light pickling, washed, repickled and rinsed. The strip was then immediately passed into a flux bath, contacted with an aqueous fluxing composition and then dried at 450° F. in a drying oven from which it passed directly into a galvanizing pot. The strip entered the surface of the bath at 100 feet per minute at a temperature of approximately 425° F. The temperature of the molten zinc was approximately 820° F. After passing down around two sinker rolls, the strip passed at 100 feet per minute upwardly out of the bath between two exit rolls rotating in the same direction as the strip at a peripheral speed of approximately 135 feet per minute. About five-eighths of the diameter of the rolls was submerged in the molten bath. Due to operating circumstances, this was the maximum depth to which the

rolls could be lowered. Spiral  $\frac{1}{16}$  x  $\frac{1}{16}$  inch V-grooves were cut  $\frac{1}{2}$  inch apart on the surface of the rolls. The rolls were adjusted to just barely touch the strip. The aluminum content in the bath was held at about .16%.

At 4 feet above the exit rolls the strip was subjected to an air quench with the air blast inclined upward.

An even 4 ounce zinc coating with a pleasing pebble-like surface and good adherence was produced, and the coated strip was fabricated into a guard rail without flaking of said coating.

While the examples given above have used hot rolled material the process of the invention may also be applied to cold reduced strip material which has been roughened to a 175 to 250 micro-inch finish in one of the last stands of a cold reduction mill. With respect to the second of the foregoing examples it would be necessary to batch anneal the cold reduced strip prior to the coating operation.

The strip had a pleasing appearance and the 4 ounce coating was adherent. No difficulty was encountered in fabricating the strip into guard rail.

I claim:

1. A method of producing heavy galvanized coatings on ferrous strip stock in a continuous process comprising:
  - (a) providing a rough surface upon the strip,
  - (b) passing the strip at a temperature between 350° F. and 820° F. continuously into a molten galvanizing bath held at a temperature of not greater than 840° F.,
  - (c) passing the strip through the molten bath at a rate of not less than 100 feet per minute,
  - (d) passing the strip in an upward direction from the molten bath between exit rolls,
  - (e) said rolls being partially submerged to a depth over the roll axes in the coating bath,
  - (f) said rolls being sufficiently close to the coated strip to smooth the coating without exerting a wiping action thereon,
  - (g) operating the exit rolls in the same direction as the strip at a peripheral speed at least 10% greater than the speed of the strip, and
  - (h) quenching the strip by upwardly directed gas blasts located above the surface of the bath.
2. A method of producing heavy galvanized coatings on ferrous strip stock in a continuous process comprising:
  - (a) providing a 125 to 300 micro-inch surface finish upon the strip,
  - (b) passing the strip at a temperature between 350° F. and 820° F. continuously into a molten galvanizing bath held at a temperature of not greater than 840° F.,
  - (c) said bath having an aluminum content no greater than .05 to .10%,
  - (d) passing the strip through the molten bath at a rate of 100 or more feet per minute,
  - (e) passing the strip in an upward direction from the molten bath between exit rolls having grooves spaced approximately  $\frac{1}{3}$  inch to  $\frac{3}{4}$  inch apart across their face,
  - (f) said grooves being approximately  $\frac{1}{32}$  to  $\frac{1}{8}$  inch wide and  $\frac{1}{32}$  to  $\frac{1}{8}$  inch deep,
  - (g) said rolls being submerged in the coating bath to a depth equal to five-eighths or more of the diameter of the roll,
  - (h) said rolls being adjusted to just touch the coated strip in order to smooth the coating without exerting a wiping action thereon,
  - (i) operating the exit rolls in the same direction as the strip at a peripheral speed at least 10% higher than the speed of the strip,
  - (j) quenching the strip by means of upwardly directed air blast located above the surface of the bath, and
  - (k) quenching the strip by means of upwardly directed steam blast above the air blasts.

3. A method of producing heavy galvanized coatings on ferrous strip stock in a continuous process comprising:

- (a) providing a 125 to 225 micro-inch surface finish upon the strip by passing the strip through roughened rolls,
- (b) passing the strip at a temperature between 700° F. and 800° F. continuously into a molten galvanizing bath held at a temperature of 820° F.,
- (c) said bath having an aluminum content no greater than .08%,
- (d) passing the strip through the molten bath at a rate of 110 feet per minute,
- (e) passing the strip in an upward direction from the molten bath between exit rolls having V-grooves spaced approximately 1/2 inch apart across their face,
- (f) said grooves being approximately 1/16 inch wide and 1/16 inch deep,
- (g) said rolls being submerged in the coating bath to a depth equal to two-thirds of the diameter of the roll,
- (h) said rolls being adjusted to just touch the coated strip,
- (i) operating the exit rolls in the same direction as the strip at a peripheral speed of 130 feet per minute,
- (j) quenching the strip by means of upwardly directed air blast located above the surface of the bath, and
- (k) quenching the strip by means of upwardly directed steam blast 10' above the surface of the bath.

4. A method of producing heavy galvanized coatings on ferrous strip stock in a continuous process comprising:

- (a) providing a 125 to 225 micro-inch surface finish upon the strip by passing the strip through roughened rolls,
- (b) passing the strip at a temperature of 350° F. continuously into a molten galvanizing bath held at a temperature of 820° F.,
- (c) passing the strip through the molten bath at a rate of 100 feet per minute,
- (d) passing the strip in an upward direction from the molten bath between exit rolls having V-grooves spaced approximately 1/2 inch apart across their face,
- (e) said grooves being approximately 1/16 inch wide and 1/16 inch deep,
- (f) said rolls being submerged in the coating bath to a depth equal to two-thirds of the diameter of the roll,
- (g) said rolls being adjusted to just touch the coated strip in order to smooth the coating without exerting a wiping action thereon,
- (h) operating the exit rolls in the same direction as the strip at a peripheral speed of 135 feet per minute, and
- (i) quenching the strip by means of upwardly directed air blast located above the surface of the bath.

5. A method of producing heavy galvanized coatings on ferrous strip stock in a continuous process comprising:

- (a) providing a 175 to 250 micro-inch surface finish upon the strip,
- (b) passing the strip at a temperature of 780° F. continuously into a molten galvanizing bath held at a temperature of 820° F.,

(c) passing the strip through the molten bath at a rate of 110 feet per minute,

- (d) passing the strip in an upward direction from the molten bath between exit rolls having V-grooves spaced approximately 1/2 inch apart across their face,
- (e) said grooves being approximately 1/16 inch wide and 1/16 inch deep,
- (f) said rolls being submerged in the coating bath to a depth equal to two-thirds of the diameter of the roll,
- (g) said rolls being adjusted to just touch the coated strip in order to smooth the coating without exerting a wiping action thereon,
- (h) operating the exit rolls in the same direction as the strip at a peripheral speed 20% greater than the speed of the strip, and
- (i) quenching the strip by means of upwardly directed air blast located 4' above the surface of the bath.

6. A method of producing heavy galvanized coatings on ferrous strip stock in a continuous process comprising:

- (a) providing at least a 125 to 300 micro-inch surface finish upon the strip,
- (b) controlling the temperature of the strip between 350° F. to 820° F. prior to entering the bath,
- (c) passing the strip continuously into a galvanizing bath held at a temperature of 780° F. to 820° F.,
- (d) said bath having an aluminum content between 0.05% to .10%,
- (e) passing the strip through the molten bath at a rate of at least 100 feet per minute,
- (f) passing the strip in an upward direction from the molten bath between exit rolls having V-grooves spaced approximately 1/3 to 3/4 inch apart across their face,
- (g) said grooves being approximately 1/32 to 1/8 inch wide and 1/32 to 1/8 inch deep,
- (h) said rolls being submerged in the coating bath so that substantially two-thirds of the diameter of the roll is below the surface of the bath,
- (i) said rolls being adjusted to just touch the coated strip in order to smooth the coating without exerting a wiping action thereon,
- (j) operating the exit rolls in the same direction as the strip at a peripheral speed of at least 10% greater than the speed of the strip, and
- (k) quenching the strip by means of upwardly directed gaseous blasts.

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