

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in Hot-Dip Metal Coating Processes and Apparatus

5 We, NATIONAL STEEL CORPORATION, a Corporation organised under the laws of the State of Delaware, United States of America, of 2800, Grant Building, Pittsburgh, Pennsylvania 15219, United States of America, (Assignee of GEORGE PAUL ROSS), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention is concerned with the hot-dip coating of continuous metallic strip and in its more specific aspects, with control of coating bath temperature in continuous strip hot-dip coating processes.

15 In hot-dip metal coating of continuous steel strip, temperature of the strip entering the bath is a determinant factor of the coating bath temperature maintained. In the preheat type of continuous strip hot-dip galvanizing line, for example, gas fired or induction heaters are utilized for initial melting of galvanizing spelter, but they do not control bath temperatures during galvanizing operations. The strip entering the bath adds all but a minor fraction of the total heat added to the coating bath. However, temperature of the strip entering the bath is generally determined by processes other than coating, such as in-line heat treatment. As a result, the temperature of the bath can vary widely from optimum coating metal temperature. For example, bath temperatures between 950°F. and 1000°F., and higher can exist because of in-line heat treatment of the strip, strip temperature requirements for alloying of galvanizing spelter with a steel base, or for other reasons, whereas a temperature between 820°F. to 880°F., preferably around 860°F. is considered optimum for galvanizing coating metal application and coating weight control.

40 One method practised in an attempt to control bath temperature includes use of forced [Price 4s. 6d.]

45 air drafts on the bath to increase heat radiation losses. A more effective method is described in co-pending British Patent Application No. 25063/65 (Serial No. 1,116,221) and British Patent Application No. 25064/65 (Serial No. 1,116,222). These patent applications relate to the control of metal temperature in the vicinity of strip exiting from a coating bath, and specifically describe the use of bath submerged conduits for temperature control. While such submerged conduits have been successful and effective in overcoming the above problem, they are difficult to handle and maintain.

50 The present invention provides a continuous strip hot-dip metal coating process wherein the temperature of a hot-dip metal coating bath having an upper surface exposed to a gaseous atmosphere is controlled by confining a liquid coolant within a trough arrangement partially submerged beneath the exposed upper surface of the hot-dip metal coating bath, and controlling the rate of flow of liquid coolant into the trough arrangement to control the temperature of molten metal in the hot-dip metal coating bath, the liquid coolant having a vaporization temperature lower than the temperature of molten metal in the hot-dip metal coating bath.

65 The invention includes a hot-dip metal coating bath having, for the purpose of controlling molten metal temperature in the bath, apparatus comprising a trough arrangement disposed in the bath so as to be partially submerged below an exposed upper surface portion of the molten metal coating bath and to confine a liquid coolant and means for supplying liquid coolant to the trough arrangement, and for controlling the rate of flow of liquid coolant into the trough arrangement.

80 The present invention will be further described, by way of example, with reference to the accompanying drawings, in which:

85 Fig. 1 is a schematic view partially in section, of a continuous strip hot-dip coating line

constructed in accordance with the invention,

Fig. 2 is an enlarged side view of a portion of the apparatus of Fig. 1,

Fig. 3 is a perspective view of an open trough of the apparatus, and

Fig. 4 is a front view of the apparatus of Fig. 2.

Referring to Fig. 1, steel is supplied from coils 8 and 10 to form continuous strip 12 by successively welding a trailing end of one coil to the leading end of the next coil. While in continuous form a number of operations are performed on the line. For example, the strip is cleaned in a cleaning unit 14 and is then heated, annealed, or otherwise heat treated in a heating unit 16. Any of these operations can affect line speed, but usually the heating step is determinant of line speed and, in turn, affects coating bath temperature.

After heat treatment, the strip travels through an atmosphere-controlled chute 20 into a coating pot 22. The chute 20 includes supplemental means 21 for maintaining the temperature of the strip at a desired level. The reducing capacity of the atmosphere in the chute 20 has an effect on the temperature required in the chute to prevent oxidation of the strip.

Under ideal conditions the strip would enter the bath slightly above the desired coating metal temperature so as to add sufficient heat to the bath to make up for radiation losses and the like. However, with changing line speeds, changing strip dimensions, and changes in required heat treatments, it is seldom possible to maintain these ideal conditions even on sustained runs of the same material. Also when it is desired to produce a product involving alloying a portion or all of the coating metal with the base metal, the temperature of the bath can be 100°, or more, above an ideal temperature for controlling coating weight.

The strip 12 travels through coating metal 24 in the pot 22 around a submerged sink roll 26 and vertically upwardly from the sink roll 26 into a coating weight control zone 28 at the exit side of the bath. Coating temperature control means are located contiguous to the coating weight control zone 28 at the exit side of the bath. After passing through the coating weight control zone 28, the strip travels upwardly around a top roll 34, then downwardly around a roll 36 and along the processing line, for washing, marking, etc., towards a coiling roll 40.

With a line producing dull coat galvanized strip, for example, the bath temperature may be at 950°F to 1000°F, or higher. When it is desired to produce regular galvanized strip, the temperature of the coating metal on the strip 12 during passage through the coating weight control zone 28 should be between 820°F. and 860°F. for optimum coating weight control. It is also desired to consistently maintain this temperature for better control of

the coating weight. As set forth above, it is difficult to maintain a desired temperature with the various processes being performed on the line, especially when rapidly shifting from one product to another, such as from dull coat to regular galvanized strip, without substantial loss of time or product due to coating metal temperature problems. Efficient temperature control of the coating metal applied to the strip before entry into the coating weight control zone makes possible efficient maintenance of desired temperature and provides for rapid control of the coating metal temperature when shifting the line from one product to another.

Referring to Fig. 2, the coating weight control zone 28 is shown in dotted lines since coating rolls, located at the surface of the bath, may be used, or gas barrier type of coating weight control, located a short distance above the surface of the bath as described in British Patent No. 1,071,572, may be used within the scope of the present invention. Control of the coating metal temperature results in smoother coating and better coating weight control with both mechanical contact coating weight control and with gas barrier type coating weight control.

Open troughs 40 and 42 are suitably positioned contiguous to the coating weight control zone 28 and parallel to the strip 12, as shown in Figs. 1 and 2. One of the troughs is shown in more detail in Fig. 3. Each open trough includes peripheral side walls including elongated walls 44, 46 and end walls 48, 50. Rails 52, 53 along the upper elongated side periphery of the open troughs are provided for support of the troughs along the rim of the coating pot. The rails 52, 53 are interconnected by bracing crossbars 54, 55 with apertures 56, 57 for securing the open troughs in position and for adjustment of position to be described later. Each trough is open at its upper and lower surfaces. The peripheral side walls 44, 46, 48 and 50 can be formed from steel, or other material having a melting temperature significantly above the melting temperature of the hot-dip coating material.

The lower edges of the peripheral walls of the troughs 40 and 42 are immersed below the upper surface of the coating metal bath 24 which is exposed to a gaseous atmosphere, e.g. air. The open troughs 40, 42 confine layers 58, 60 (see Fig. 2) of a liquid coolant, such as water, on the exposed upper surface of the coating bath and having a boiling point below the temperature of the molten metal 24. The liquid coolant within the troughs 40, 42 is in direct contact with the bath, extracts heat from the bath, and controls the temperature of a portion of the coating metal bath at its exit side. Baffle means can be used in the bath to further define a controlled temperature zone if desired.

While two coolant troughs are shown in Figs. 1 and 2, the number of troughs can be

varied as required. Positioning of the troughs, as well as shape of the troughs, can also be selected otherwise than as shown to carry out desired objectives.

5 In the frontal view of Fig. 4, the trough 42 is shown supported by the coating pot. Its elongated dimension is substantially parallel to the strip and its lower periphery is immersed beneath the bath surface sufficiently to accom-

10 modate minor changes in bath level encountered in practice. Threaded bolt means 61 and 62 can be used to secure the trough in position and adjust height or level of the trough as required.

15 Liquid coolant is supplied to the trough through a conduit 64 under control of a valve 66. Heat removal is increased by increasing coolant flow into the trough.

20 Coolant flow can be regulated manually or can be regulated automatically by apparatus as shown schematically in Figs. 2 and 4. A thermal sensor 68, or a plurality of such sensors, is positioned to measure temperature in the portion or portions of the bath to be tem-

25 perature controlled. Temperature readings by the sensor 68 are compared with a preselected desired temperature by a temperature control unit 70 which delivers an output for opening and closing the valve 66 to regulate the rate of flow of coolant as required. Individual elements used for carrying out such automatic control are well known in the art.

30 Heat exchange is increased by increasing the rate of flow of coolant into a trough and thereby increasing the amount of coolant to be raised to vaporization temperature. However, coolant flow into a single trough should not be increased so as to cause freezing of coating metal to a substantial depth below the

35 bottom of the trough. Efficient heat exchange takes place with a thin solidified layer of coating metal in the bottom of a trough. As heat exchange requirements increase, freezing of metal to a substantial depth below the bottom

40 of a trough should be avoided by adding another cooling trough. More efficient heat exchange is maintained and possible contact between solidified metal and the strip being coated is avoided. Also, the troughs can be

45 put into use and withdrawn from use more rapidly in this way.

50 For cleaning purposes, and for removal of a trough, the cooling water flow can be stopped and water in the trough allowed to evaporate

55 completely permitting melting of the thin solidified layer of metal in the trough. Cleaning requirements vary depending on the pot and line operation; return of metal from the trough to the coating bath need only be practiced if it appears that dross or undesired impurities are accumulating in the trough.

60 With direct contact cooling troughs positioned at the exit side of the bath, a portion of the bath contiguous to the coating weight control zone can be maintained at a preselected

temperature varying by 15 to 30 degrees from other portions of the bath, such as the heated strip entry side of the bath. The over-all temperature of the bath can also be lowered or controlled. In practice, water is ordinarily used as the liquid coolant. The amount of water flow required varies with the type of run being conducted. as a representative example, desired coating metal temperature when galvanizing steel strip having a thickness of 0.092" and a width of 30" has been maintained by using a single cooling trough with water flow approximately two gallons per minute.

Other coolants and modifications of the structure shown in the accompanying drawings can be resorted to within the scope of the invention.

WHAT WE CLAIM IS:—

1. A continuous strip hot-dip metal coating process wherein the temperature of a hot-dip metal coating bath having an upper surface exposed to a gaseous atmosphere is controlled by confining a liquid coolant within a trough arrangement partially submerged beneath the exposed upper surface of the hot-dip metal coating bath, and controlling the rate of flow of liquid coolant into the trough arrangement to control the temperature of molten metal in the hot-dip metal coating bath, the liquid coolant having vaporization temperature lower than the temperature of molten metal in the hot-dip metal coating bath.

2. A metal coating process as claimed in claim 1 in which the trough arrangement has an open bottom to enable the coolant to make direct contact with the metal in the bath.

3. A metal coating process as claimed in claim 2 in which the continuous metallic strip is submerged beneath the exposed upper surface of the molten metal coating bath while travelling longitudinally of itself between a strip-entry side and a strip-exit side of the coating bath, and in which the open bottom of the trough arrangement is immersed beneath the exposed upper surface of the coating bath at the strip-exit side of the bath adjacent to strip travelling out of coating bath to control the temperature of the molten metal at the strip-exit side of the coating bath.

4. A metal coating process as claimed in claim 1, 2 or 3 in which the strip is continuous steel strip and the coating bath is a galvanizing bath.

5. A metal coating process as claimed in claims 3 and 4 in which the continuous steel strip has a temperature substantially above 860°F. at the strip-entry side of the bath tending to raise the temperature of the galvanizing bath substantially above 860°F., and water is added to the trough arrangement, the flow of water being controlled to maintain the temperature of the galvanizing metal at the strip-exit side of the coating bath at about 860°F.

6. A metal coating process as claimed in claim 3 or 5 in which the temperature of the



varied as required. Positioning of the troughs, as well as shape of the troughs, can also be selected otherwise than as shown to carry out desired objectives.

In the frontal view of Fig. 4, the trough 42 is shown supported by the coating pot. Its elongated dimension is substantially parallel to the strip and its lower periphery is immersed beneath the bath surface sufficiently to accommodate minor changes in bath level encountered in practice. Threaded bolt means 61 and 62 can be used to secure the trough in position and adjust height or level of the trough as required.

Liquid coolant is supplied to the trough through a conduit 64 under control of a valve 66. Heat removal is increased by increasing coolant flow into the trough.

Coolant flow can be regulated manually or can be regulated automatically by apparatus as shown schematically in Figs. 2 and 4. A thermal sensor 68, or a plurality of such sensors, is positioned to measure temperature in the portion or portions of the bath to be temperature controlled. Temperature readings by the sensor 68 are compared with a preselected desired temperature by a temperature control unit 70 which delivers an output for opening and closing the valve 66 to regulate the rate of flow of coolant as required. Individual elements used for carrying out such automatic control are well known in the art.

Heat exchange is increased by increasing the rate of flow of coolant into a trough and thereby increasing the amount of coolant to be raised to vaporization temperature. However, coolant flow into a single trough should not be increased so as to cause freezing of coating metal to a substantial depth below the bottom of the trough. Efficient heat exchange takes place with a thin solidified layer of coating metal in the bottom of a trough. As heat exchange requirements increase, freezing of metal to a substantial depth below the bottom of a trough should be avoided by adding another cooling trough. More efficient heat exchange is maintained and possible contact between solidified metal and the strip being coated is avoided. Also, the troughs can be put into use and withdrawn from use more rapidly in this way.

For cleaning purposes, and for removal of a trough, the cooling water flow can be stopped and water in the trough allowed to evaporate completely permitting melting of the thin solidified layer of metal in the trough. Cleaning requirements vary depending on the pot and line operation; return of metal from the trough to the coating bath need only be practiced if it appears that dross or undesired impurities are accumulating in the trough.

With direct contact cooling troughs positioned at the exit side of the bath, a portion of the bath contiguous to the coating weight control zone can be maintained at a preselected

temperature varying by 15 to 30 degrees from other portions of the bath, such as the heated strip entry side of the bath. The over-all temperature of the bath can also be lowered or controlled. In practice, water is ordinarily used as the liquid coolant. The amount of water flow required varies with the type of run being conducted. as a representative example, desired coating metal temperature when galvanizing steel strip having a thickness of 0.092" and a width of 30" has been maintained by using a single cooling trough with water flow approximately two gallons per minute.

Other coolants and modifications of the structure shown in the accompanying drawings can be resorted to within the scope of the invention.

WHAT WE CLAIM IS:—

1. A continuous strip hot-dip metal coating process wherein the temperature of a hot-dip metal coating bath having an upper surface exposed to a gaseous atmosphere is controlled by confining a liquid coolant within a trough arrangement partially submerged beneath the exposed upper surface of the hot-dip metal coating bath, and controlling the rate of flow of liquid coolant into the trough arrangement to control the temperature of molten metal in the hot-dip metal coating bath, the liquid coolant having vaporization temperature lower than the temperature of molten metal in the hot-dip metal coating bath.

2. A metal coating process as claimed in claim 1 in which the trough arrangement has an open bottom to enable the coolant to make direct contact with the metal in the bath.

3. A metal coating process as claimed in claim 2 in which the continuous metallic strip is submerged beneath the exposed upper surface of the molten metal coating bath while travelling longitudinally of itself between a strip-entry side and a strip-exit side of the coating bath, and in which the open bottom of the trough arrangement is immersed beneath the exposed upper surface of the coating bath at the strip-exit side of the bath adjacent to strip travelling out of coating bath to control the temperature of the molten metal at the strip-exit side of the coating bath.

4. A metal coating process as claimed in claim 1, 2 or 3 in which the strip is continuous steel strip and the coating bath is a galvanizing bath.

5. A metal coating process as claimed in claims 3 and 4 in which the continuous steel strip has a temperature substantially above 860°F. at the strip-entry side of the bath tending to raise the temperature of the galvanizing bath substantially above 860°F., and water is added to the trough arrangement, the flow of water being controlled to maintain the temperature of the galvanizing metal at the strip-exit side of the coating bath at about 860°F.

6. A metal coating process as claimed in claim 3 or 5 in which the temperature of the



- molten metal at the strip-exit side of the coating bath is sensed and compared with the desired temperature of the molten metal at the strip-exit side of the coating bath, and the flow of liquid coolant into the trough arrangement is automatically controlled in response to such comparison.
- 5 7. A continuous strip hot-dip metal coating process substantially as herein described with reference to the accompanying drawings.
- 10 8. Metallic strip when coated by the process claimed in any of claims 1 to 6.
- 15 9. A hot-dip metal coating bath having, for the purpose of controlling molten metal temperature in the bath, apparatus comprising a trough arrangement disposed in the bath so as to be partially submerged below an exposed upper surface portion of the molten metal coating bath and to confine a liquid coolant and means for supplying liquid coolant to the trough arrangement and for controlling the rate of flow of liquid coolant into the trough arrangement.
- 20 10. A coating bath as claimed in claim 9 in which the trough arrangement comprises at least one trough having an open bottom and having peripheral side walls whose bottom edges are arranged below the upper surface level of the molten metal coating bath to define a confined area for receiving the liquid coolant.
- 25 11. A coating bath as claimed in claim 9 or 10 further including means for sensing bath temperature and generating a signal for responsive control of liquid coolant flow into the open trough arrangement.
- 30 12. A hot-dip metal coating bath, constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.
- 35 13. Metal strip when coated by a hot-dip molten metal coating bath as claimed in any of claims 9 to 12.
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