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PATENT SPECIFICATION
DRAWINGS ATTACHED.

1,116,221

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COMPLETE SPECIFICATION.

Improvements relating to the Coating of Metals.

We, NATIONAL STEEL CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 2800, Grant Building, Pittsburgh 19, Pennsylvania, United States of America, (Assignee of JOHN THOMAS MAYHEW), 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:—

This invention is concerned with improvements in continuous-strip molten metal coating operations. In one of its more specific aspects, it is concerned with maintaining a controlled temperature differential in a continuous-strip hot-dip coating metal bath.

Continuous-strip galvanizing lines can be divided, for purposes of applying this invention, into two types — the preheat or "hot" strip type line which heats the strip in the line prior to coating in the galvanizing bath and the "cold" strip type line which heats the strip in the galvanizing bath. Preheat type lines include a number of process steps in a single line thereby reducing coil handling. They usually include an annealing or other type of heat treatment which may be combined with cleaning and other treatments, in addition to hot-dip coating, in a continuous-strip operation. The strip is preheated and adds at least a portion of the required heat to the bath whereas, with a "cold" type line, the strip takes heat from the bath.

The present invention can be useful in both hot strip and cold strip type lines but will be described in connection with preheat lines which at present are more common.

A persistent problem with preheat type lines which seriously limits line speed is

overheating of the bath. This causes thinning of galvanizing spelter, draping of the coating applied, and uneven, non-uniform coating surfaces. 45

There are other circumstances in hot-dip coating where the temperature of the bath must be above optimum coating temperature for the particular coating metal. 50

The present invention provides a continuous strip hot-dip metal coating process in which heat is continuously added to a molten bath of coating metal to obtain a coating metal temperature substantially above the melting temperature of the coating metal in a major portion of the metal bath and a portion of the molten bath of coating metal is cooled to maintain a zone of cooled coating metal having a temperature substantially lower than the major portion of the molten bath of coating metal, the process including the steps of moving metallic strip through the major portion of the molten coating metal bath and then through the zone of cooled coating metal, and controlling the coating weight of molten coating metal on the strip upon delivery from the zone of cooled coating metal. 55 60 65 70

The invention includes continuous strip hot-dip metal coating apparatus comprising hot-dip coating means including a coating bath for containing molten coating metal, means for introducing metallic strip into and for delivering metallic strip from the coating bath, means for heating the metallic strip before delivering the strip to the coating bath to a temperature above the melting temperature of the coating metal, coolant means in the molten coating metal, the coolant means being located to define a cooled zone of molten coating metal contiguous with the travel path of strip approaching delivery from the coating bath, means 75 80 85

[Price 4s. 6d.]

for providing fluid coolant for the coolant means, and means for controlling coating weight on the strip upon delivery from the coating bath.

- 5 The invention will be further described, by way of example, with reference to the accompanying drawings wherein:

Figure 1 is a schematic diagram of a continuous-strip galvanizing line constructed in accordance with the invention;

10 Figure 2 is a schematic diagram of portions of the continuous-strip galvanizing line, and

15 Figure 3 is another schematic diagram of portions of the continuous-strip galvanizing line.

Figure 1 schematically illustrates a preheat type line. Steel from coils 12 and 14 is formed into continuous strip 16 at a welder 18. A cleaning step is carried out at a strip treatment unit 20 and the strip may be heated or annealed in a furnace 22.

After cleaning and heat treatment, the strip is led through a transfer zone defined by a chute 24 which leads from the preheat portion of the line to a coating pot 26.

25 The atmosphere in the chute 24 is chosen to prevent oxidation of the surface of the steel strip by a protective atmosphere control 30 and venting provided, for example, at strip entry into the controlled atmosphere. A 20% to 80% hydrogen content atmosphere is maintained in the transfer zone with the percentage being selectable based on strip temperature available. Low-temperature strip ordinarily requires a higher hydrogen content atmosphere to prevent oxidation. If heat is available, the temperature of the strip and the temperature in the chute can be maintained high in order to save on hydrogen. In general, high strip temperature is desired both for heat treating and strip cleaning purposes.

30 The chute 24 can be insulated to maintain the heat of the strip during transfer. The chute 24 can also include heating means and heat control 32. The temperature of the strip can then be maintained at a particular level based on percentage of hydrogen in the chute atmosphere. Proper coordination of these values is necessary in order to obtain and maintain good coating adhesion with continuous-strip galvanizing lines of the preheat type.

35 In addition to the above atmosphere and heat control problems, efficient control of a preheat type line is extremely complex because of the combination of processes involved. Rarely are present lines able to use their entire cleaning, annealing or other heat treatment capacities and run at speeds of which the line is capable. In the past, the coating operation at the hot-dip coating pot has been the chief limiting factor on line speed and line capacity for continuous-

strip galvanizing lines of the preheat type. One problem has been overheating of the galvanizing spelter.

Spelter temperature is controlled largely by the strip temperature as introduced into the coating pot and the strip speed and gage, although heat can be added to the pot by supplemental heating units as described in the Cook U.S.A. Patent No. 2,647,305. The strip is usually above the melting temperature of the galvanizing spelter and the available strip heat is useful for a number of purposes. However, as strip gauge or line speed changes from a theoretical ideal at which pot temperature may be correct, the temperature of the galvanizing spelter varies. With increased efficiency in supplying heat for line processes, higher line speeds are available and the coating pot tends to run hot. It has not been possible to adopt existing lines to efficiently produce the various hot-dip galvanized products in demand today because of the various temperature requirements for optimum coating. The coating step itself has held down line capacity because uncoordinated control of different processes in the line has had a very detrimental effect on coating adhesion, finish,*and related matters.

One effect of hot spelter is a gritty finish on the galvanized steel strip. This is believed to be due to an increase in dissolved iron with increases in bath temperature. Hot spelter also causes fouling of coating weight control rolls, which further mars the galvanize coating finish and destroys coating uniformity. The present invention substantially eliminates the problem of gritty coating on strip, regardless of the type of coating weight control used, and substantially alleviates problems associated with fouling of coating weight control rolls. The usual marks caused by coating weight control rolls are also substantially reduced.

As referred to above, the preheat type lines have serious problems associated with changes in strip temperature, speed or gauge. Each change will vary pot temperature and affect coating weight control. These problems are believed to be associated with changes in bath viscosity; however, this subject has never been satisfactorily explored. And it need never be, since the problems stemming from changes in strip temperature, speed and gauge can be avoided by the present invention.

Ideally, galvanizing spelter should have a temperature around 840°F. to 860°F. in a preheat type line. When heavier coating is required, a temperature around 820°F. can be used. The galvanizing spelter referred to is conventional and can include low-percentage aluminum additions (about 0.1% to 0.3%) and small percentages of lead, antimony, cadmium, tin, and other

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impurities with the balance zinc (98%+). It has a melting temperature in the neighbourhood of 790°F. Therefore, galvanizing bath temperature should ordinarily be maintained above approximately 800°F. However, the galvanizing spelter in coating pots on today's preheat type lines readily builds up to temperatures of 900°F. to 960°F. and higher. Often, the line must be slowed down, stopped, or other major operational changes made because bath temperature goes above 960°F.

These problems can be avoided by controlling the temperature of molten spelter which forms the final coating on the strip. A cooled spelter zone is located in the galvanizing bath so as to deliver strip which is coated with spelter at the desired temperature for effective coating weight control and to produce coating smoothness. This feature can be accomplished by simplified controls without interruption of the normal operation of the line or concern for the preheating or other line processes.

Referring to Figure 2, the strip 34 enters the molten galvanizing bath 36 through the chute 38. After passage around a sink roll 40, the strip travels upwardly toward the coating weight control unit which include coating rolls 41 and 42. While approaching the coating weight control unit, the strip passes through a cooled spelter zone 44 shown in dotted lines. Here, spelter of the desired temperature is applied to the strip.

At times on conventional preheat type lines, the galvanizing bath temperature goes above 860°F. and can vary from approximately 900°F. to 960°F. and higher, depending upon the gauge of the strip, the speed of the line, etc. However, the temperature of coating metal in the cooled spelter zone 44 is readily controlled and can be accurately maintained at the ideal temperature required, such temperature being not more than 860°F. and not less than 800°F. as previously described, while the temperature of the remainder of the bath rises substantially above 860°F. The temperature regulator can be relatively simple and can be automated so that a simple control eliminates the complex problems of coordinating a plurality of processes and coating problems associated with changes in line speed, strip gauge and temperature.

Conduits, such as 46, 48, 52 and 54, are submerged in the molten galvanizing bath to create and maintain a zone of cooled spelter contiguous with the travel path of steel strip as it approaches exit from the molten galvanizing bath. Flow control of coolant, which can be water, in bath-submerged conduits and the number of conduits help to define the zone 44 and its properties.

The temperature of the coating metal

applied to the strip upon exit from the bath is controlled. This is the coating metal which determines strip surface and the coating metal to be controlled for proper weight. Such control is readily effected and the effect on heavy-gauge material is immediately apparent by casual inspection with the naked eye. Heavy-gauge galvanized strip produced with the galvanizing bath cooler has a bright, smooth, uniform galvanize coating. Similar product without benefit of the cooled spelter zone 44 has a gritty, non-uniform, dull surface.

Other objectionable aspects of high coating pot temperature are experienced when heavy-gauge material, such as guard rail stock, is being run. The heat input to the bath from the strip increases with the gauge. Pot temperature can go to 1000°F. and the coating is thinned. The problem is compounded by the usual requirement for heavy coating on heavy-gauge material. For example, overheating of the pot would indicate to the operator that the line should be slowed down. However, decreasing the line speed will decrease the quantity of coating metal applied to the strip, making it impossible to get the desired heavy coating.

For many years, guard rail stock was made on the old sheet pots rather than on continuous lines in order to get more coating metal on the product. With recent non-draping improvements (see United States Patent No. 3,104,981 to John T. Mayhew), guard rail stock and the like can be made on certain types of continuous-strip galvanizing lines. The product has been limited to a coating of around two and one-half ounces per square foot (total, both sides) produced at line speeds around fifty-five to seventy feet per minute. On the same type lines, using the present invention, line speeds around eighty-five feet per minute can produce stock having a coating weight of three to four ounces per square foot (total, both sides) and higher, with a cooled spelter zone maintained at 840°F. to 860°F.

By maintaining the cooled spelter zone at approximately 820°F., the coating on heavy stock can be increased further. At higher strip speeds, e.g. one hundred and thirty feet per minute, coatings of six ounces per square foot (total, both sides) can be readily obtained.

The problem of thin coating and running of the coating is not limited to heavy stock. Running or draping of the coating occurred in the past at substantially all coating thicknesses when the coating metal temperature exceeded 860°F. This draping effect can be observed more readily on lighter coating weights when a minimized-spangle treatment is applied. Markings on the strip which become apparent are commonly referred to as "tiger stripes". This

defect can be avoided by the present invention.

Similarly, the increase in line speed available is not limited to heavy gauge; increased line speeds are available at all gauges.

5 The invention finds special application when it is required to have a high strip temperature and a high bath temperature in order to produce the desired coating and, at the same time, it is desired to coat at optimum coating bath temperature and deliver strip from the bath near optimum coating temperature. An example of this is the alloy coating process described in the copending British Patent Application No. 25064/65 (Serial No. 1,116,222). Such unusual coating pot requirements can be accurately satisfied by the present invention.

20 Control of a cooled spelter zone can be exercised partially by controlling the quantity of fluid flow in individual conduits. Figure 3 schematically illustrates a frontal view of coating apparatus in which a fluid coolant conduit 56 employs a flow control valve 58. The conduit 56 is surrounded by a heat transfer and protective jacket 60 which is filled with lead 62. The lead becomes molten when the bath cooler is put into use and is a good heat conductor. The jacket 60 is a protection against accidental leakage where the coolant is a liquid such as water.

30 In practice, a plurality of conduits are used to define the zone and control the temperature of the cooled spelter. Varying heat exchange requirements are met primarily by varying the number of submerged conduits in use, since excessive flow of coolant through too limited a number of conduits will merely result in freezing of spelter on an exterior bath-contact surface of the conduit(s).

45 When control of fluid coolant flow is manual, the flow should be terminated when the line is stopped. Flow should be diminished when line speed is diminished or heat additions to the pot are otherwise reduced. However, the present system can be readily automated by continuous measurement of spelter zone temperature, e.g. by use of a continuous measurement temperature gauge such as 64 in Figure 3. Signals from the temperature gauge 64 to temperature control apparatus 66 can be used to control the flow valve 58 or a plurality of valves to maintain the desired temperature in the cooled spelter zone. With this arrangement, the coating operation, in a multiple-process continuous-strip line, can be standardized despite variations in other line processes or variations in the product being treated.

65 Whilst the invention has been described in its application to continuous-strip galvanizing, the invention may be useful in

other hot-dip metal coating baths such as tin or aluminum where situations similar to those described earlier are encountered.

WHAT WE CLAIM IS:—

1. A continuous strip hot-dip metal coating process in which heat is continuously added to a molten bath of coating metal to obtain a coating metal temperature substantially above the melting temperature of the coating metal in a major portion of the metal bath and a portion of the molten bath of coating metal is cooled to maintain a zone of cooled coating metal having a temperature substantially lower than the major portion of the molten bath of coating metal, the process including the steps of moving metallic strip through the major portion of the molten coating metal bath and then through the zone of cooled coating metal, and controlling the coating weight of molten coating metal on the strip upon delivery from the zone of cooled coating metal.

2. A coating process as claimed in claim 1 in which the strip is steel strip.

3. A coating process as claimed in claim 2 wherein the molten bath of coating metal comprises galvanizing spelter the major portion of which is heated to a temperature substantially above 860°F and the zone of cooled spelter is maintained in a temperature range between 800°F and 860°F, inclusive.

4. A coating process as claimed in claim 1, 2 or 3 wherein the cooled portion of the molten bath of coating metal is cooled by coolant means contacting the molten bath in the zone of cooled coating metal.

5. A coating process as claimed in claim 1, 2 or 3 wherein the portion of the molten bath of coating metal is cooled by coolant flow through conduit means submerged in the molten bath of coating metal.

6. A coating process as claimed in any of claims 1 to 5 in which heat is continuously added to the bath of coating metal by heating the strip to a temperature above the temperature of the major portion of the bath prior to entry of the strip into the bath.

7. A coating process as claimed in any of claims 1 to 6 in which the coating weight is controlled by means of coating rolls.

8. A continuous strip hot-dip metal coating processes substantially as herein described with reference to the accompanying drawings.

9. Metallic strip when metal coated by the process claimed in any of claims 1 to 8.

10. Galvanized flat rolled steel coated with a bright smooth-finish galvanized coating of substantially uniform coating weight on both surfaces of the base metal by the process claimed in any of claims 1 to 8, with total coating weight on both surfaces



defect can be avoided by the present invention.

Similarly, the increase in line speed available is not limited to heavy gauge; increased line speeds are available at all gauges.

The invention finds special application when it is required to have a high strip temperature and a high bath temperature in order to produce the desired coating and, at the same time, it is desired to coat at optimum coating bath temperature and deliver strip from the bath near optimum coating temperature. An example of this is the alloy coating process described in the copending British Patent Application No. 25064/65 (Serial No. 1,116,222). Such unusual coating pot requirements can be accurately satisfied by the present invention.

Control of a cooled spelter zone can be exercised partially by controlling the quantity of fluid flow in individual conduits. Figure 3 schematically illustrates a frontal view of coating apparatus in which a fluid coolant conduit 56 employs a flow control valve 58. The conduit 56 is surrounded by a heat transfer and protective jacket 60 which is filled with lead 62. The lead becomes molten when the bath cooler is put into use and is a good heat conductor. The jacket 60 is a protection against accidental leakage where the coolant is a liquid such as water.

In practice, a plurality of conduits are used to define the zone and control the temperature of the cooled spelter. Varying heat exchange requirements are met primarily by varying the number of submerged conduits in use, since excessive flow of coolant through too limited a number of conduits will merely result in freezing of spelter on an exterior bath-contact surface of the conduit(s).

When control of fluid coolant flow is manual, the flow should be terminated when the line is stopped. Flow should be diminished when line speed is diminished or heat additions to the pot are otherwise reduced. However, the present system can be readily automated by continuous measurement of spelter zone temperature, e.g. by use of a continuous measurement temperature gauge such as 64 in Figure 3. Signals from the temperature gauge 64 to temperature control apparatus 66 can be used to control the flow valve 58 or a plurality of valves to maintain the desired temperature in the cooled spelter zone. With this arrangement, the coating operation, in a multiple-process continuous-strip line, can be standardized despite variations in other line processes or variations in the product being treated.

Whilst the invention has been described in its application to continuous-strip galvanizing, the invention may be useful in

other hot-dip metal coating baths such as tin or aluminum where situations similar to those described earlier are encountered.

WHAT WE CLAIM IS:—

1. A continuous strip hot-dip metal coating process in which heat is continuously added to a molten bath of coating metal to obtain a coating metal temperature substantially above the melting temperature of the coating metal in a major portion of the metal bath and a portion of the molten bath of coating metal is cooled to maintain a zone of cooled coating metal having a temperature substantially lower than the major portion of the molten bath of coating metal, the process including the steps of moving metallic strip through the major portion of the molten coating metal bath and then through the zone of cooled coating metal, and controlling the coating weight of molten coating metal on the strip upon delivery from the zone of cooled coating metal.

2. A coating process as claimed in claim 1 in which the strip is steel strip.

3. A coating process as claimed in claim 2 wherein the molten bath of coating metal comprises galvanizing spelter the major portion of which is heated to a temperature substantially above 860°F and the zone of cooled spelter is maintained in a temperature range between 800°F and 860°F, inclusive.

4. A coating process as claimed in claim 1, 2 or 3 wherein the cooled portion of the molten bath of coating metal is cooled by coolant means contacting the molten bath in the zone of cooled coating metal.

5. A coating process as claimed in claim 1, 2 or 3 wherein the portion of the molten bath of coating metal is cooled by coolant flow through conduit means submerged in the molten bath of coating metal.

6. A coating process as claimed in any of claims 1 to 5 in which heat is continuously added to the bath of coating metal by heating the strip to a temperature above the temperature of the major portion of the bath prior to entry of the strip into the bath.

7. A coating process as claimed in any of claims 1 to 6 in which the coating weight is controlled by means of coating rolls.

8. A continuous strip hot-dip metal coating processes substantially as herein described with reference to the accompanying drawings.

9. Metallic strip when metal coated by the process claimed in any of claims 1 to 8.

10. Galvanized flat rolled steel coated with a bright smooth-finish galvanized coating of substantially uniform coating weight on both surfaces of the base metal by the process claimed in any of claims 1 to 8, with total coating weight on both surfaces

being in the range of three to six ounces of galvanized coating per square foot of base metal inclusive.

11. Continuous strip hot-dip metal coating apparatus comprising hot-dip coating means including a coating bath for containing molten coating metal, means for introducing metallic strip into and for delivering metallic strip from the coating bath, means for heating the metallic strip before delivering the strip to the coating bath to a temperature above the melting temperature of the coating metal, coolant means in the molten coating metal, the coolant means being located to define a cooled zone of molten coating metal contiguous with the travel path of strip approaching delivery from the coating bath, means for providing fluid coolant for the coolant means, and means for controlling coating weight on the strip upon delivery from the coating bath.

12. Coating apparatus as claimed in claim 11 wherein the coolant means include at least one conduit for fluid coolant flow submerged in the molten coating metal.

13. Coating apparatus as claimed in claim 11 or 12 wherein means are provided for controlling fluid coolant flow responsively to the temperature of the cooled zone of molten coating metal.

14. Coating apparatus as claimed in claim 11, 12 or 13 for coating steel strip wherein the molten coating metal is galvanizing spelter and the means for heating the steel strip includes means for preheating steel strip to a temperature above the melting temperature of galvanizing spelter before entry into the molten galvanizing bath.

15. Coating apparatus as claimed in any of claims 11 to 14 in which the coating weight control means comprise coating rolls.

16. Continuous strip hot-dip metal coating apparatus constructed substantially as herein described with reference to and as illustrated in Fig. 1 or Fig. 2 or Fig. 3 of the accompanying drawings.

17. Metallic strip when metal coated by the apparatus claimed in any of claims 11 to 16.

18. Galvanized flat rolled steel coated with a bright smooth-finish galvanized coating of substantially uniform coating weight on both surfaces of the base metal by the apparatus claimed in claim 14 with total coating weight on both surfaces being in the range of three to six ounces of galvanized coating per square foot of base metal inclusive.

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