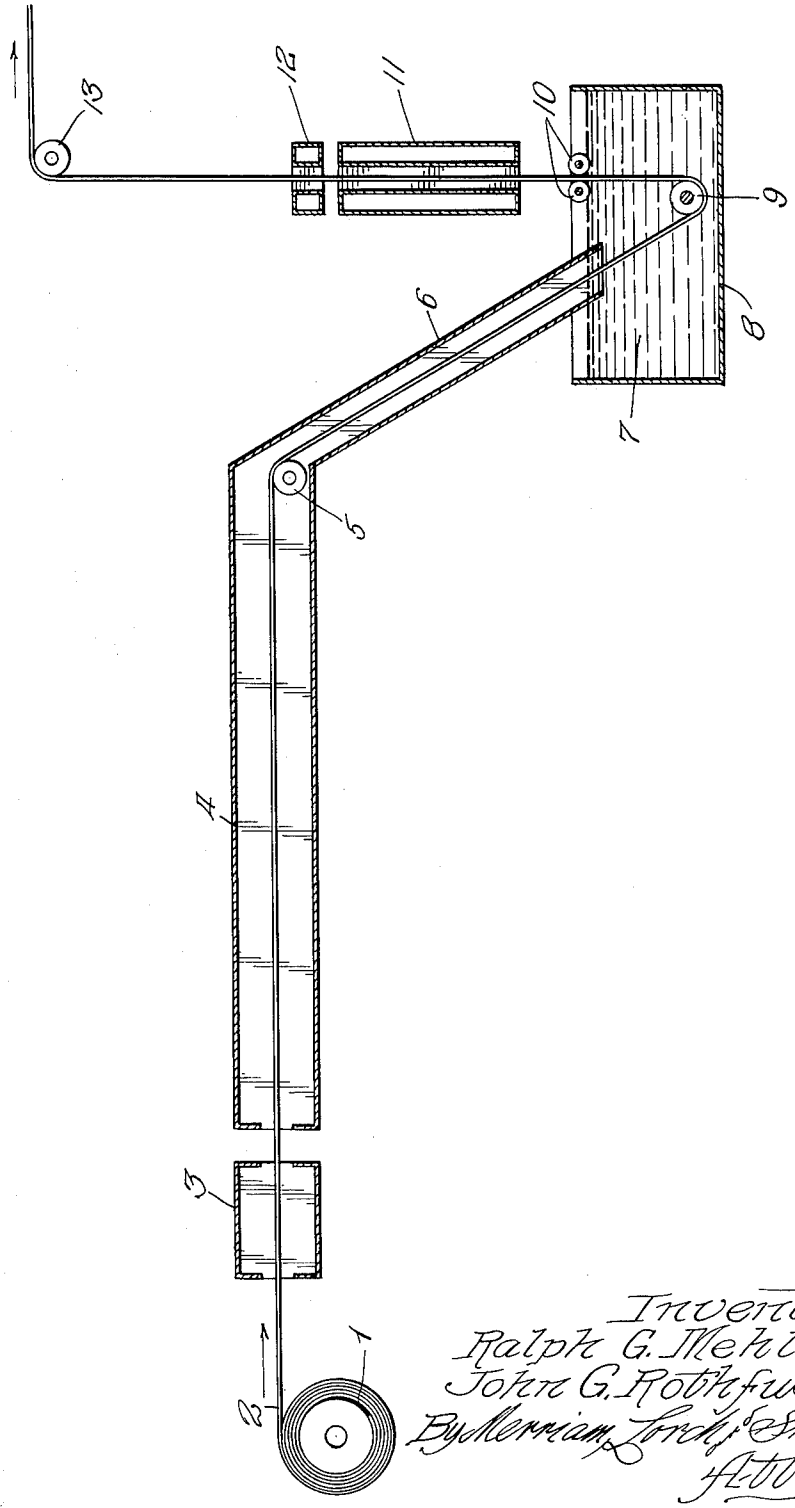
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GALVANIZING PROCESS

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Inventors:
Ralph G. Mehler,
John G. Rothfuss,
By Merriam, Lorch & Smith,
Attys.

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GALVANIZING PROCESS

Ralph G. Mehler, Chicago, Ill., and John G. Rothfuss, Cedar Lake, Ind., assignors to Inland Steel Company, Chicago, Ill., a corporation of Delaware

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This invention relates to a process for continuously galvanizing ferrous metal products in strand or continuous strip form, and more particularly it relates to a continuous process for the production of galvanized strip or strand having a surface which is suitable for receiving a surface finish such as paint, lacquer, and the like without further treatment.

The well-known hot-dip method of galvanizing ferrous articles has come into widespread use, particularly in the several continuous versions thereof, which by reason of the superior product produced and the lower cost of operation have largely displaced the older batch types of operation. The typical product from the hot-dip continuous galvanizing line is bright and shiny, with large, well-defined spangles. Although such a product is acceptable for many uses in this condition, it cannot usually be covered with a surface finish such as paint, lacquer, enamel or the like, when such a coating is desired, without special preparation of the zinc coating. Depending on the smoothness of the finish desired, this preparation may consist of natural weathering of the coating over an extended period of time, rapid multi-step chemical treatment, or the use of specially-formulated priming paints. All of these methods, however, markedly increase the expense incurred in producing a painted article fabricated of the usual types of galvanized sheet metal.

The process of this invention yields a galvanized product which can be painted or otherwise coated with a variety of surface finish coatings without any special preparation other than that customarily given to any metallic surface prior to painting. Moreover, the coating produced by the process of this invention is highly adherent to the base metal, permitting various forming operations such as bending, shaping and drawing to be performed without causing peeling or flaking of the protective zinc coating. The surface of the product is uniformly smooth and non-spangled, with a pleasing grey to grey-white frost lustered appearance. The product possesses a number of advantages over the conventional forms of galvanized strip. Thus, the adherence of paint or other surface coatings to the product produced by the process of this invention is at least equal, if not superior, to that of any other galvanized product which has been especially prepared for painting. The absence of spangles eliminates the problem of spangle relief, i.e., spangles having depressed boundaries which show through any coating applied to the surface. The uniformly smooth surface enables the material to be used for panel work without any metal finishing operation such as sandblasting. The product may also be coated, without special preparation, with the synthetic plastic coatings now coming into increasing use. As further advantages of the product, it has been noted that it is more readily welded and soldered than is ordinary galvanized material, and in addition exhibits greater resistance to heat.

The invention will be better understood from the following detailed description thereof, and from the accompanying drawing which is a schematic representation of apparatus suitable for carrying out the process of the invention.

The improved product is made by a hot-dip continuous galvanizing process which incorporates a heat treating step at the point where the strip leaves the dipping-pot with a molten coating of zinc. The strip is passed through a

furnace in which it is heated to an elevated temperature above about 850° F. for a time sufficient to cause alloying to take place to a controlled extent between the zinc in the coating and the iron in the sheet metal. It has been determined that a product having the above-described advantageous properties is obtained if the alloying proceeds to an extent such that the zinc layer on the surface of the strip contains from about 4% to about 20% by weight of iron, and preferably from about 7% to about 12%. This concentration of iron in the surface alloy is characteristic of a satisfactory product, and can readly be determined in a number of ways well known to those skilled in the art, such as, for example, by X-ray spectroscopic analysis of the surface layer or by chemical methods involving dissolution of the surface layer in an acid bath followed by conventional quantitative analysis of the acid solution.

The heating time required for obtaining the desired alloying on the surface of the strip depends inversely on the temperature to which the strip is heated, i.e., a relatively low temperature requires a relatively long time and vice versa. Because of the speed with which the strip moves through the typical modern galvanizing line, it is difficult to measure with any degree of exactness the temperature which the strip reaches in the heat-treating zone. As approximate guides to the proper operation of the process of the invention, however, the following approximate time and temperature relationships may be set forth. Since the zinc layer must be kept molten, the lowest feasible strip temperature which can be used is one somewhat above the melting point of the zinc coating, that is, in the vicinity of 850° F. At this temperature, satisfactory alloying may take from about 40 seconds to about 120 seconds or more, depending on several other factors such as the gauge of the base metal and the quantity of coating metal applied thereto per unit of area. If the length of the heating zone is kept to a reasonable figure, for example, not more than about 15 feet, the heating times indicated for a temperature of about 850° F. restrict the speed of the line to about 7–20 feet per minute, which is too slow for economical operation. For this reason temperatures as low as 850° F. are not preferred, and as the temperature is increased substantially above 850° F. the time at temperature is decreased substantially below 40 seconds.

Within the preferred temperature range of about 1000° F. to about 1300° F. the heating times are on the order of about 6 to 10 seconds, permitting line speeds of about 100–150 feet per minute, which speeds are well within the capabilities of most modern galvanizing lines and which lead to the economical operation thereof.

The upper limit for the range of temperatures to which the strip can be heated in the heating zone is established by the requirement that the zinc coating be kept from vaporizing and by the difficulty in control occasioned by the shortened heating periods required. At temperatures of about 1500° F. and above, the permissible heating time rapidly drops below about 4 seconds, making control of the process difficult.

Two factors which have already been mentioned as affecting the amount of heating required for successful operation of this process are the thickness (i.e., the gauge) of the strip and the quantity of zinc coating applied per unit of area. Relatively thick strip requires additional heating because of the greater quantity of metal which must be brought to temperature. Likewise, a heavy coating of zinc requires additional heating since alloying must proceed through the entire thickness of the coating in order to reach the surface. The time-temperature relationships indicated above were established for strip of about 14–24 gauge which has been coated to an extent of about 0.5–1.5 oz. (preferably 0.7–0.9 oz.) of zinc

per square foot of strip. If the strip gauge and/or the coating weight varies from the above, more or less heating may be required as will be apparent to those skilled in the art.

Although, as indicated, the iron content of the surface alloy is the ultimate criterion of product quality (other than actual or simulated use of the final product), it has been found that the color of the finished strip correlates well with the surface iron content and can be used for controlling the process on a routine basis. Strip having the preferred surface iron content of about 7–12% has a uniform dull medium grey color. As the iron content drops to about 4% and below, the color passes through various shades of grey to light grey and grey-white and ultimately takes on the shiny appearance of conventional galvanized material. Thus if the color of the product is too light, or shiny to any degree, more heating is indicated in order to increase the extent of alloy formation. Such increased heating may be supplied either by decreasing the speed of the line, other factors remaining constant, or by increasing the temperature or the length of the heating zone. Since, however, the latter two variables are relatively inflexible, it will in most cases be found most convenient to control the heating step by adjusting the speed of the line.

Similarly, if the product is too dark, approaching black in color, or if an iron powder tends to form on the surface, the heating has been excessive and must be reduced, either by increasing the speed of the line or by decreasing the temperature of the heating zone.

In order that the coating of zinc produced by the process of this invention have good adherence to the base metal, such that the galvanized material may be sharply bent, formed, or drawn without loss of the protective zinc coating by peeling or flaking, it is essential that the molten zinc bath contain a small amount of aluminum, in the range of from about 0.05% to about 0.2% by weight, and preferably from about 0.13% to about 0.18%. In addition, the molten zinc bath may also contain minor amounts of other metals, such as lead, commonly used in the production of conventional spangled galvanized strip to provide nuclei for spangling. While such additional metals are not required in the present process, neither is their presence in small amounts detrimental. Thus the same bath can be used in the line to produce conventional spangled galvanized material or the non-spangled strip of the invention, as desired, by merely including or excluding the additional heat-treating step described herein.

The type of furnace used as the heat-treating zone in the process of the invention is not critical to the successful operation thereof. Thus any conventional furnace adapted or adaptable for use in the continuous heat-treatment of metals can be used, as will be apparent to those skilled in the art. Any convenient method of heating the furnace can be used, such as by burning liquid or gaseous fuels fired either directly into the furnace or in radiant tubes, or by induction heating. A suitable furnace for use with gaseous or liquid fuels comprises a simple box-like structure lined with an insulating material surrounding the moving strip. A number of jet burners suitably positioned in the sides of the furnace heat both sides of the strip as it passes through. The only precaution to be observed is that the jets should not be allowed to impinge too closely on the surface of the strip in order to avoid disturbing the molten coating thereon, and also to avoid localized hot spots.

Regardless of the heating method employed, it is preferred that heat-treatment of the strip be carried out in the presence of an oxidizing atmosphere, such as air or other oxygen-containing gas. Although the process of the invention is operative if a non-oxidizing atmosphere is used, the formation of the desired iron-zinc alloy may in some cases be inhibited or retarded. For this reason and in further view of the fact that an oxidizing atmosphere is readily supplied in the furnace by merely providing openings through which air may enter, the use of other than an oxidizing atmosphere is not recommended. In supplying air to the furnace, however, care should be taken to avoid excessive rates of flow which might diminish the heating capacity of the furnace to the point where the strip receives insufficient heating. Suitable modifications of the furnace for regulating the flow of air therethrough, such as dampers and the like, will be apparent to those skilled in the art.

The furnace is preferably positioned in the line as close as possible to the dipping-pot so that the heat-treatment of the strip is initiated before the molten coating thereon has had time to cool and harden. The object of the heat-treatment is to permit diffusion of iron in the specified proportions from the strip into the zinc coating to form the desired alloy. In order to permit this diffusion, the layer of zinc must be kept in a molten condition during the heat-treatment. It is therefore advantageous to prevent, insofar as possible, any cooling of the coating in the interval from the dipping-pot to the furnace as a matter of process economy. Furthermore, remelting the coating on galvanized strip that has been allowed to harden may have a detrimental effect on the quality of the product. The adherence of the coating to the base metal may be adversely affected and in some cases powdering of the coating may be observed.

After leaving the heating zone, the strip must be cooled in order to solidify the molten coating thereon. Artificial cooling, as opposed to natural cooling by contact with the atmosphere, is not required for the successful operation of the herein-described process, except possibly in the case of the heavier gauge materials which by reason of their considerable retained heat may continue to alloy, with adverse effects, for some time after leaving the heating zone. In such cases, it may be desirable to provide some cooling means, such as a cold air stream or a spray of water, for rapidly cooling the strip below the freezing point of the coating. Otherwise, satisfactory cooling of the strip may be effected by causing it to travel a sufficient distance in contact with the atomsphere to permit solidification of the coating.

It is, of course, well known that ferrous strip must be given a preparatory treatment prior to galvanizing in order to remove scale and other surface impurities and to condition the surface so that a firm bond between the same and the coating can be established. Any of the pretreatments suitable for use in the production of conventional galvanized products can be used in the process of this invention. Preferred among these, however, is the method which involves pre-heating the strip in an oxidizing atmosphere to form a thin coating of metal oxide, reducing the oxide to form a reduced metal layer, and then passing the strip into the dipping-pot while protecting the reduced surface by means for a non-oxidizing atmosphere. A suitable process of this type is described in detail in U.S. Patent No. 2,110,898, issued March 15, 1938.

The process of the invention may be carried out by means of apparatus set forth schematically in the accompanying drawing. As shown in the FIGURE, steel strip 2 fed from coil 1 passes through oxidizing furnace 3 in which the strip is heated under oxidizing conditions to produce thereon a thin, uniform oxide coating. The strip then passes over reducing roller 5 through furnace 4 containing a reducing atmosphere, in which the oxide coating produced in furnace 3 is reduced to a tightly adhering layer of base metal free of oxides and other impurities. A hood or spout 6 leads from reducing furnace 4 to a point below the surface of the molten zinc 7 containing about 0.05–0.2% of aluminum in pot 8. By extending below the surface of the molten zinc in this manner spout 6 forms an effective seal against the entry into furnace 4 of oxidizing gases which would tend to destroy the film of reduced metal on the strip. The strip passes out of spout 6, through the dipping pot, around sinker roll 9,

and through coating rolls 10 which are used to control the thickness of the zinc coating on the strip, then through alloying furnace 11 which may be fired in any convenient manner. In furnace 11 the strip is heated to the proper temperature for producing the desired alloying, as previously described. Leaving alloying furnace 11, the strip passes through an optional cooling vessel 12 in which the strip is cooled by means of a stream of cold air or the like or a fine spray of water for solidifying the molten coating of zinc thereon. The strip then passes over roller 13 and proceeds to a coiling operation (not shown).

The process as described above in conjunction with the drawing is conventional up to the point where the coated strip leaves the dipping pot 8. Although the general method described is preferred, it will be obvious that any other suitable method for preparing and coating the strip with zinc may be used.

From the foregoing description it will be apparent that the process of this invention is readily adaptable to existing in-line galvanizing plants without major modifications of the equipment. Moreover, the same line can be used to produce both the heat-treated, non-spangled type of product as well as the conventional spangled product with practically no down-time necessary for converting from one type of product to the other. Thus, if the non-spangled variety is to be produced the heat-treating furnace is fired up; if the spangled product is desired, the heat-treatment is omitted. In either case, all the other operating variables remain essentially constant. It can therefore be seen that the process of this invention yields a product having the advantageous properties already discussed while maintaining the economies resulting from high-speed continuous processing.

Various changes and modifications of the invention can be made and, to the extent that such variations incorporate the spirit of this invention, they are intended to be included within the scope of the appended claims.

What is claimed is:

1. A continuous process for producing flat galvanized ferrous strip having a uniformly smooth, non-spangled, adherent, galvanized coating containing about 4–20 wt. percent iron and readily susceptible to painting, said process comprising:

dipping a continuous heated ferrous base strip, having a thickness of about 14 to 24 gauge, in a bath of molten zinc containing about 0.05–0.2 wt. percent aluminum, and coating said base strip with about 0.5–1.5 oz. of said zinc per square foot of strip;

passing said continuous strip through a furnace, after coating, to heat said strip to a strip temperature substantially above 850° F. but below about 1500° F. for more than about 4 seconds but substantially less than 40 seconds;

and then cooling said strip,

2. A process as recited in claim 1 wherein:

said strip is heated, after coating, to a strip temperature of from about 1000° F. to 1300° F. for about 6 to 10 seconds.

3. A process as recited in claim 1 wherein:

said heating is performed immediately after said coating and before the molten coating has a chance to harden.

4. A process as recited in claim 1 wherein:

said heating is performed in an oxidizing atmosphere.

5. A process as recited in claim 1 wherein:

said base strip is coated with about 0.7–0.9 oz. of said zinc per square foot of strip.

6. A process as recited in claim 1 wherein:

said base strip is coated in a bath of molten zinc containing about 0.13–0.18 wt. percent aluminum.

7. A continuous process for producing flat galvanized ferrous strip having a uniformly smooth, non-spangled, adherent, galvanized coating with a dull, medium gray color and containing about 7–12 wt. percent iron and readily susceptible to painting, said process comprising:

dipping a continuous heated ferrous base strip, having a thickness of about 14 to 24 gauge, in a bath of molten zinc containing about 0.13–0.18 wt. percent aluminum, and coating said base strip with about 0.7–0.9 oz. of said zinc per square foot of strip;

passing said continuous strip through a furnace, after coating, to heat said strip to a strip temperature of from about 1000° F. to 1300° F. for about 6 to 10 seconds;

and then cooling said strip.

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