METHOD OF GAS WIPING WIRE EMERGING FROM A HOT-DIP COATING BATH

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6 Claims

ABSTRACT OF THE DISCLOSURE

A gas jet is directed radially onto a wire in the axis of the jet to determine the thickness and smoothness of liquid coating on the wire. The quality of the coating achieved is markedly improved if the resulting downward component of the jet is confined by walls extending from the wire region down to the bath, to cause the wiping jet to fluctuate at a much lower frequency. Where the liquid coating is an oxidizable metal such as Zn or Al, it is also desirable to employ an inert or reducing gas, to further improve cost quality.

This application is a continuation-in-part application of U.S. application Ser. No. 804,636, filed Mar. 5, 1969, now abandoned, by applicants and assigned to the same assignee.

This invention is concerned with dip coating of wire, and particularly relates to a method for effecting improved control of the coatings as the wire emerges from the dipping bath. The invention is specifically concerned with an improved method and apparatus for providing smooth, uniform coatings on wire or tubular products by means of a gas knife.

In the dip coating of metal strands (strip, sheet, wire, etc.), it has long been the practice to employ the wiping action of a gas jet to below excesses coating metal from the surface of the strand. These gas wires were generally employed to augment the primary wiping control element, which in the case of wire was in the form of a circular die composed of asbestos or charcoal. Recently, metallic high dip coatings on sheet and strip have been controlled solely by means of straight edge gas knives or barriees. While these systems have in some cases been effective in controlling both the coating weight and smoothness, and have permitted appreciably higher strip speeds in comparison to mechanical wiping methods, the gas knife principle has not been satisfactorily applied to wire.

The effectiveness of gas wires on both flat strip and on wire is not only dependent on physical factors such as wiper fluid pressure at the impact point, liquid coat viscosity, strand velocity, etc., but is also dependent on the geometrical relationship between the strand and the wiper orifice. The geometrical difference between a wiper orifice which completely surrounds a strand (as necessitated in the case of wire wiping) introduces problems in wire, not ordinarily encountered in a straight-slot gas wire acting on flat strip, resulting in the occurrence of close spaced rings of heavy and light coatings. It has now been found that the above disadvantage of employing a circular knife can be overcome with the addition of confining walls, extending from the region of the wiper ring down to the bath, to form a closed-bottom chamber which is integral with the knife assembly. This addition changes the geometrical relationship involved in the gas barrier, so that the wiping ring becomes the orifice end of a closed end pipe resonator. As such, it becomes part of a vibrating system that has a markedly lower fundamental frequency of vibration than that of a free jet, thereby providing a smoothening effect on the close spaced irregularities.

It is therefore an object of this invention to provide a method and apparatus for controlling the coatings on wire by means of a gas knife.

It is another object of this invention to provide an improved gas knife which will provide smooth and uniform wire coatings.

It is a further object of this invention to provide a coating control method which permits the application of closely controlled hot-dip coatings at speeds greatly in excess of those presently employed.

Other objects and advantages will be more apparent from the following description and claims, read in conjunction with the accompanying drawing, in which:

The figure is a sectional view of a device for practicing the invention.

The invention will be described in its application to metallic hot-dip coating, although it will be apparent that the principles employed are equally applicable to other types of dip coating, in which, for example, the wire to be coated may be passed through (1) a molten resin, to provide a plastic coating; (2) through oil, to provide a protective lubricant; or (3) through paint.

Presently, metallic hot-dip coatings may be controlled on flat strip by passing the strip between opposed straight edge gas jets, the jets forming a gas barrier region for wiping the coating. While these systems are effective in controlling both coating weight and smoothness and have permitted strip speeds to be increased appreciably over those using roll wiping methods, the gas knife application of coatings to wire has not been entirely satisfactory. Since gas is a compressible fluid and since the lateral motion of the moving wire cannot be completely constrained, the exact location of the barrier region (the zone of most intense wiping) will fluctuate to some extent. In such prior art devices, the barrier region position changes rapidly and easily over a small distance, and the gas jets have generally surrounded the strand in such a manner that they were open in the direction of entry and exit of the strand. (See for example, U.S. Pat. Nos. 3,499,418 and 3,459,587.) In the case of a rapidly moving wire, the wire moves sufficiently between these changing barrier regions, so that these fluctuations (vibrations) in the zone of most intense wiping result in areas of heavy and light coatings. In the instant invention, these spaced rings of heavy and light coatings are substantially eliminated. When the gas jet impinges approximately perpendicularly (deviations of ±30° from the perpendicular are contemplated) on a centrally located wire, the flow is split into two component gas streams directed substantially along the length of the wire and in opposite directions. If the flow of one of these component gas streams is constrained by a closed chamber, the effective mass of the vibrating wiping system is significantly increased. As such, the wiping ring becomes part of a vibrating system with a much lower frequency of vibration than a "free" jet, thereby providing a smoothening effect on the close spaced irregularities.

A preferred embodiment of the device for performing the instant invention is shown in cross-section in the figure. The device consists of bushing 1, inserted in housing 2. Orifice opening 3 is adjustable controlled by the depth to which the bushing is inserted (screwed) into the housing. The lower end 4 of the bushing has an outside diameter somewhat less than that of the body of the bushing, to provide an equalizing chamber 5. Cylindrical screen 6 further improves gas distribution. Gas enters through
supply pipes, fills chamber, thus equalizing the pressure of the gas impinging around the perimeter of wire W, former a gas hood to wipe the coating liquid from the wire. Pipe 8 is connected to the bottom of the housing to provide closed chamber by either dipping below the surface of the bath or by interconnecting with bath container (not shown). In the preferred embodiment as illustrated in the figure, the pipe is connected to a bell of larger diameter 11 to provide chamber with an increased volume, thereby increasing the mass of the resonating system.

The instant method was satisfactorily employed in the hot dip galvanizing of steel wire. The heaviest galvanized wire coatings now produced by the hot dip method are coatings of about Class B (~2 oz./ft²) and Class C (~3 oz./ft²) coatings are now produced commercially only by electrolytic methods. The instant method, in addition to enabling the use of line speeds of up to 350 ft./min. provides uniform, controlled hot-dip galvanized coatings to be produced within the whole range of commercial coatings, i.e., from 0.1 to 3.0 oz./ft².

In application of this invention, the volume of the chamber should not be excessively large, otherwise extremely high amplitude oscillations will result with severe changes in wiping effectiveness, thus causing coating weight variations over the total length of the wire. As a practical matter, the choice of distance between the bath and wipe zone is also determined in part by factors such as bath temperature and permissible heat loss from the coating liquid as well as by mechanical factors such as spacing requirements for the pass line stabilizing rolls.

A variety of gases, such as air, steam, inert gases, and products of fuel combustion may be employed as the wiping fluid. With highly reactive coatings such as zinc or aluminum, it is preferable to use a non-oxidizing gas. Zinc, for example, oxidizes with the use of either air or steam. The oxidized particles increase the viscosity of the molten zinc and thereby impede its flow under the action of the gas knife. As a result, high viscosity material tends to build up in thick rings about the wire just below the region of maximum wiping. While detrimental effects of this nature can sometimes be alleviated by increasing the temperature of the coating liquid, it is preferable to use a non-oxidizing gas, since temperature increases may also increase the oxidation rate.

In hot-dip galvanizing employing an inert gas such as nitrogen, it is desirable, for both quality of coating and economy of gas usage, to vary both the pressure and orifice opening when producing different weight coatings. Therefore, for the lightest coating weight range (0.1 to 0.3 oz./ft²), wiping pressures of from 10 to 30 lb./in² should be maintained with orifice diameters of from 0.005 to .008 inch; the optimum orifice opening being directly proportional and the wiping pressure being inversely proportional to the desired coating weight. Thus, for coating weights of about 0.2 oz./ft², an orifice opening within the range of about 0.020-0.025 inches and a wiping pressure of from about 0.2 to 0.4 lb./in² was found preferable.

While the figure depicts an orifice directing the gas jet perpendicular to the wire, this angle may be varied within a range of about 30 degrees in either direction from the perpendicular. In the system illustrated, in which the wire emerges from the bath in a vertical direction, excellent results were obtained when the orifice was directed 15 degrees below the horizontal, in the direction of the bath. Similar principles would, of course, hold if the wire were to be withdrawn in a horizontal direction. Thus, it should be understood that for purposes of this invention, the term "substantially perpendicular" includes an impingement angle within ±30° of the perpendicular, i.e., an arc of 60°.

We claim:

1. In the method of coating a wire emerging from a bath of coating liquid, wherein the thickness and smoothness of the coating is controlled by means of a gas jet impinging substantially perpendicularly onto the surface of the wire circumferentially thereof and forming a gas barrier region around the wire in the region of gas impingement thereon; said jet dividing into two basic components, one directed toward and the other away from the bath; the improvement wherein said bath-directed component of the jet is confined to a closed zone, extending from said barrier region to the bath, whereby the gas in said bath-directed component is forced to reverse its direction and exit principally at said barrier region about the periphery of the wire.

2. The method of claim 1, wherein said wire emerges from the bath in a substantially vertically upward direction.

3. The method of claim 2, wherein said coating liquid is an oxidizable metal and said gas is a non-oxidizing gas.

4. The method of claim 3, wherein said oxidizable metal is selected from the group consisting of Al and Zn.

5. The method of claim 4, wherein said bath-directed component is confined by means of a closed chamber, integral with both a means for emitting said gas jet and said bath surface.

6. The method of claim 5, wherein said closed chamber is integral with said means for emitting said gas jet and a means for containing said bath.

References Cited

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U.S. Cl. X.R.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,404,400

October 1, 196

Park H. Miller, Jr.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 25, "3,369,229" should read -- 3,363,229 --

Column 3, line 32, "systme" should read -- system --. Column lines 59 to 63, equation (4) should appear as shown below:

\[ f(t) = \frac{K(f_{\text{max}}+f_{\text{min}})}{2} + \frac{(f_{\text{max}}-f_{\text{min}})t}{T} + \frac{2(f_{\text{max}}-f_{\text{min}})t^2}{T^2} \]

same column 9, line 68, "trans" should read -- trains --. Column 10, line 59, "timt" should read -- time --. Column 11, line 61, "inervse" should read -- inverse --. Column 12, line 23, "a" should read -- at --. Column 13, line 3, "filter" should read -- filters --; line 13, "aong" should read -- along --; line 26, "relationship" should read -- relationships --. Column 15, line 28,

\[ \frac{\alpha/2/2}{\sqrt{R_1C_1}} \]

should read \[ \frac{\sqrt{\alpha}}{2\pi R_1 C_1} \]

same column 15, line 29,

\[ \frac{\alpha/2/f}{\sqrt{Y}} \]

should read \[ \frac{\sqrt{\alpha}}{Y} \]

Column 16, line 18, "records" should read -- recorders --.

Signed and sealed this 10th day of March 1970.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
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