PROCESS FOR ENAMELLING WIRE

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References Cited

UNITED STATES PATENTS
2,215,996 9/1940 Benton.......................... 117/232 X
3,265,033 8/1966 Touze et al.......................... 118/61
3,369,922 2/1968 Surcek.............................. 117/132 A

Primary Examiner—Harry J. Gwinnell
Attorney, Agent, or Firm—Fleit & Jacobson

ABSTRACT

The wire is first heated and the hot wire is then passed through an applicator which applies a layer of enamel including a solvent to the wire. The wire is then passed through surroundings at a lower temperature than the wire itself, in which surroundings at least a major portion of the solvent on the wire evaporates. The wire is then passed through an oven where polymerization of the enamel takes place. Enamel coatings are obtainable of high quality at much higher speeds than by conventional methods.

9 Claims, 7 Drawing Figures
PROCESS FOR ENAMELLING WIRE

This application is a division of application Ser. No. 46,791, filed June 16, 1970, now U.S. Pat. No. 3,710,756, which is in turn a continuation-in-part of application Ser. No. 660,256, filed Aug. 14, 1967, now abandoned.

The invention relates to a process for the continuous coating, in particular the enameling, of wires especially electric wires. In such a process the wire is passed in a continuous manner through an applicator device for the coating of enamel (varnish, etc.) and through an oven for the drying and the polymerization of the coated layer.

Prior processes for this purpose evaporate the solvent from the enamel by heat directed from the outside towards the centre of the coated wire. As will be explained below, this feature results in slow production speeds and/or poor quality products.

It is an object to provide a process which produces enamelled wires in which the enamel is free from cracks and/or is more durable.

It is another object to provide a process which can be operated at very high speeds.

It is a further object of the invention to provide a process by which enameled wires of high quality can be obtained more economically.

The process according to the invention is characterised by the fact that the wires are hot when they first arrive at the applicator device and that the evaporation of the solvent takes place, for a major part, on the path of the wires outside the oven, by the flow of heat from the wire towards the outside.

Apparatus suitable for carrying out the process according to the invention includes preferably, a closed casing containing the enamel bath and the various die blocks fed by this bath, according to the features of my U.S. Pat. No. 3,412,709 granted Nov. 26, 1968.

The invention will be well understood with the aid of the following complementary description as well as the accompanying drawings, which complementary description and drawings are, of course, given merely by way of example.

In these drawings;

FIG. 1 illustrates in schematic perspective an enameling apparatus used according to a known process;

FIG. 2 illustrates in section the conditions of heat flow in the wire inside the oven during the drying of the enamel in the known process of FIG. 1;

FIG. 3 shows, in a view similar to FIG. 1, an embodiment of an apparatus for performing the process according to the invention;

FIG. 4 is a partial section through the oven of the embodiment shown in FIG. 3;

FIG. 5 shows, in a view similar to FIG. 2, the conditions of heat flow in the wire during the drying of the enamel in the process according to the invention, outside the oven;

FIG. 6 shows, in a view similar to FIG. 3, part of a modification of the apparatus shown in FIG. 3; and

FIG. 7 shows, schematically, other parts of the apparatus of FIG. 6.

The following description relates to an embodiment of the process according to the invention, applied to continuous enameling of copper wires.

First of all, the prior process used most frequently at present will be described.

In this process, the wire (FIG. 1), is moved continuously along a path forming several passes. This wire is passed successively through the die blocks 2, generally freely open, of an applicator 3, and successive passes are separated from each other by other passes, in one direction and then in the other, through an oven 4.

The wire enters at A and leaves at B, after passing around at least 2 rollers 5 and 6 (which can have grooves for the passage of the wires). The wire to be coated, when it arrives at the inlet in the applicator 3, is cold, because it is necessary to prevent this applicator from becoming heated, which would cause evaporation of the solvent from the bath. Thus, the wire 1, at the intake A, after having undergone, if necessary, annealing at 7, passes into a cooling bath 8. Similarly, after a first pass in the oven, the temperature of the wire at the inlet of the second die block 2 is arranged to remain moderate by cooling the wire between the oven and the applicator. This necessitates in particular that the speed of movement of the wire must remain rather low. This limitation of speed is a first disadvantage.

Another disadvantage resides in the fact that the cooling of the wire is required in all the outer portions of the oven, and the evaporation of the solvent from the layer of enamel, which is applied to the wire during each pass in the applicator, takes place solely by the action of the heat going from the outside towards the inside of the wire, as illustrated by the arrows of FIG. 2.

The calorific exchanges inside the enamel coating (represented by reference numeral 9, FIG. 2) thus take place from the periphery towards the center. Now, as the pass in the oven causes the evaporation of the solvent and the polymerization of the enamel at the same time, and since the peripheral layer tends to polymerize before the total removal of the solvent, the result is that:

on the one hand, this process gives rise, if the solvent is not entirely removed to a rapid ageing of the enamel, which thus loses, in time, its dielectric qualities;

and on the other hand, it gives rise to cracked enamel (micro-cracks), these cracks being caused by the solvent vapors which, in order to escape, burst through an already polymerized layer.

To avoid the latter disadvantage, there was previously no other solution than to carry out the polymerization at a relatively low temperature, and thus to reduce the speed of enameling, or to have, at the price of serious complications and considerable cumbersomeness, an oven comprising:

a low temperature zone for the evaporation, and,

a high temperature zone for the polymerization.

These means, valid for vertical ovens, such as that described in U.S. Pat. No. 3,265,033, are difficult to apply to horizontal ovens (excessive length of the oven resulting in excessive sag of the wire), and are relatively slow.

To avoid these disadvantages, by the process according to the present invention, maintains the wire hot outside the oven, that is, at a temperature hereinafter called "drying temperature" comprised between the temperature of the enamel when applied and the polymerization temperature of the enamel. The evaporation of the solvent can thus take place, for a major part, along a path outside the oven.

It is essential that the temperature of the wire be maintained between the two limits just mentioned. In
fact, if it were less than the lower limit, the exchange of heat during evaporation would take place from the exterior towards the interior as in the prior art processes. If, on the other hand, it reaches or exceeds the temperature of the polymerization oven, there would no longer be two successive steps of evaporation of the solvent and the polymerization of the enamel; consequently the quality of the enamel would be unfavorably affected.

Thus on the one hand, the role of the oven can be reduced to that of polymerization of the deposited substantially solvent-free enamel, which leads to the avoidance of cracks, and on the other hand, a higher speed can be used, since it is no longer necessary to cool the wire before its arrival at the die blocks 2.

It is then appropriate, preferably, to use a closed applicator, of the type described in the above-identified patent application, the bath being contained in this applicator in a closed container which only communicates with the outside through the die blocks 2 or the holes leading to these die blocks.

For example, if the polymerization temperature of the oven 4 is of the order of 500°C, the portions of the wire outside the oven can be maintained at temperatures of the order of 120° to 150°C, whereas the applicator itself, for example, at a temperature of the order of 50°C and preferably under pressure. As for the speed of translation of the wire, which can reach values of the order of 700 meters/min, even 900 meters/min (in particular for 9/100 mm wire), instead of about 80 meters/min as in the existing processes. Of course, these figures are given by way of example and are not to be regarded as limiting the scope of the invention.

In the Table below are shown the production speeds obtainable with various enamels by the method according to the invention compared with the conventional method. The wire was 9/100 mm diameter and the enamel was applied in a xylene/cresol based solvent.

<table>
<thead>
<tr>
<th>Enamel</th>
<th>Wire Speed m/min</th>
<th>Quality of Product</th>
<th>Wire Speed m/min</th>
<th>Quality of Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane</td>
<td>200</td>
<td>Difficult to maintain</td>
<td>850</td>
<td>Free of micro-cracks;</td>
</tr>
<tr>
<td>Polyester</td>
<td>100</td>
<td>product at these wire speeds</td>
<td>500</td>
<td>enamel flexible and durable</td>
</tr>
<tr>
<td>Oil-base</td>
<td>70</td>
<td></td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

FIGS. 3 and 4 show an apparatus which enables these process conditions to be fulfilled, with the same reference numerals as FIG. 1 for the same members.

The cooling device is eliminated and a heating device, such as an electrical resistance represented at 10, in the oven 4, is advantageously provided for annealing the wire.

It has been assumed in FIG. 3 that the wire intended to be heated by this resistance 10 could be moved away from or towards the resistance at will, for example by means of two pulleys 11 and 12 borne by pivoting rods 13 and 14.

In such an arrangement, a preliminary heating of the wire is thus ensured before the first coating, and the calories thus stored can be used to help the evaporation of solvent. For the other layers of the coating, the conditions will be the same, since during the corresponding passes, the wire will arrive hot at the applicator 3 and will also leave the applicator hot. In all these cases, the wire will be able to arrive at the oven with all or practically all of the solvent already evaporated in the space between the applicator and the oven. FIG. 5 shows the manner in which the thermal exchange takes place in the portions of the wire outside the oven. These portions are hotter than their surroundings, so that the thermal exchange takes place towards the outside of the wire, ensuring the free evaporation of the solvent. The result is that, in the oven, the polymerization will be able to take place properly without risk of cracks, since the solvent will have already evaporated.

 Needless to say, this evaporation can take place in the open air by using, for example, a fume hood or any sort of tunnel comprising suction means, placed upstream of the polymerization oven and completely independent of this oven.

In FIG. 6, there is shown an apparatus for carrying out a modification of the method described above and illustrated by FIG. 3, this apparatus including a fume hood H provided with an evacuation chimney C.

In order to avoid polluting the atmosphere by the vapor from the fume hood it can be burnt e.g., in an apparatus as shown in FIG. 7. This also permits the recovery of thermal energy from the solvent vapor. This burning step can be effected catalytically.

The apparatus for this purpose comprises, first of all, a suction device or fan 20 which, through the fume hood H, suck the solvent vapor at the outlet of the applicator 3, and directs this vapor to a heat-exchanger 21 where it is re-heated, and then through a conduit 22 towards a combustion chamber 23 in which its temperature is first of all raised by heating means such as resistances 24, before the vapor passes to the catalytic combustion device 25.

The burnt gas is sucked by a fan 26, and a first part (the larger part) is directed through the conduit 27 towards the polymerization oven 4, whereas the other part is rejected through a conduit 28 to the open air, after having served for the re-heating of the solvent vapor in the heat exchanger 21. The part of the burnt gas which is directed towards the polymerization oven follows the path indicated by arrows inside this oven (the oven operates, as can be seen, by radiation and by convection) and returns through a conduit 29 towards the combustion chamber 23, after mixing with the solvent vapor coming from the exchanger 21.

By modifying the operating conditions of the fans and by actuating regulating valves, in particular 30, 31 and 32 (placed respectively upstream of the fan 20 and downstream of the fan 26 in the conduits 27 and 28), all the possible adjustments of pressure (overpressure and underpressure) and discharge can be obtained.

The Table below shows the production speeds obtainable with various enamels by the method according to the invention compared with the conventional method. The wire was 9/100 mm diameter and the enamel was applied in a xylene/cresol based solvent.
It is clear from the foregoing that only burnt gas enters the polymerization oven or is rejected into the atmosphere, and this permits the recovery of heat energy from this gas.

It can be seen that, in each of the above embodiments, the entire length of the oven remains available for the polymerization. Moreover, it is then possible to increase the temperature in the oven as much as the construction of the oven permits. The speed of enameling will then be adapted to this temperature so that, finally, the enamel will reach the ideal temperature of polymerization. The distance between the applicator and the oven will be sufficient to permit the evaporation of the solvent before the wire enters the heating tunnel. Experience has shown that this distance can be small.

It is appropriate to add that the process according to the invention permits the use of enamel having a high solids content. The quantity of the solvent to be evaporated will thus be reduced, and accordingly, the distance between the applicator and the polymerization oven can be all the less. For example, a solids content of the order of 60 percent of the original total of enamel and solvent can be attained. It will also be apparent that the solvent may be a liquid vehicle in which the enamel or enamel-forming component is carried in suspension rather than in solution.

As a result, whatever embodiment is adopted, a process is provided by which wires can be enamelled under conditions which have numerous advantages with respect to previously known processes. In particular:

the possibility of high production speeds of the enamelled wire;

the possibility of eliminating micro-cracks and in any case of improving the quality of the finished product;

and the possibility of using an enamel having a high solids content.

In a general manner, while the above description discloses what are deemed to be practical and efficient embodiments of the present invention, the invention is not limited thereto, and there might be changes made without departing from the inventive concept as defined by the appended claims.

1 claim:

1. A process for continuously enamelling wire with a polymerizable enamel containing a solvent, comprising continuously moving said wire axially of itself at high speed and repeating cyclically the sequence of steps of heating the wire to a drying temperature between the temperature of the enamel at the time of its application and the polymerization temperature of the enamel;

then applying said enamel inside a closed applicator zone to the wire at said drying temperature;

then passing the wire through surroundings which are at a lower temperature than said drying temperature so that the direction of heat flow is from the wire towards the surroundings thereby ensuring the free evaporation of substantially all of the solvent without premature polymerization of the surface of the layer of enamel; and

then passing said wire through an oven at said polymerization temperature to polymerize said enamel layer thereby enabling high-speed production of the enamelled wire while avoiding micro-crack formation due to emission of residual solvent through the enamel.

2. A process according to claim 1 in which the polymerization temperature in the oven is of the order of 500°C, the wire outside the oven is at a temperature in the range of 120°C to 150°C, and the enamel is applied to the wire under pressure at a temperature of about 50°C.

3. A process according to claim 1, in which said moving of the wire axially is at a speed of at least 700 meters per minute.

4. A process according to claim 1, in which the enamel applied to the wire comprises at least 60 percent solids content.

5. A process according to claim 1, in which the wire is passed horizontally through said oven.

6. A process according to claim 1, including collecting the solvent vapors emitted upstream of the polymerization oven and burning said vapors.

7. A process according to claim 6, including burning said vapors catalytically.

8. A process according to claim 7, including recovering the heat generated by burning said vapors and directing it to provide at least part of the heat energy used in the process.

9. Enamelled wire produced by the process of claim 1.
UNIVERSAL STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,877,966
DATED : April 15, 1975
INVENTOR(S) : ROLAND A. GOYFFON

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

On the title page, under Foreign Application Priority Data, change the number of the prior French application from "66.73791" to -- 73,791 --.

Signed and Sealed this twenty-fourth Day of February 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

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Commissioner of Patents and Trademarks