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(54) METHOD FOR TREATMENT OF GALVANIZED OR GALVANNEALED STEEL

(57) A method, comprising:
- providing a first roll, a second roll, and a nip between the first and second rolls;
- passing a substrate through the nip between the rolls at a predetermined line speed;
- supplying a coating liquid to the substrate in the nip, wherein the coating liquid has a predetermined contact angle with the substrate; and
- smoothing the coating liquid, via the nip, into a substantially uniform layer of liquid coating on the substrate,
- providing that the substrate is a galvanized or galvannealed steel strip;
- providing that a circumferential speed of a surface area of the rolls contacting the substrate substantially matches the line speed; and
- providing that the contact angle of the coating liquid with the substrate is smaller than 97°.

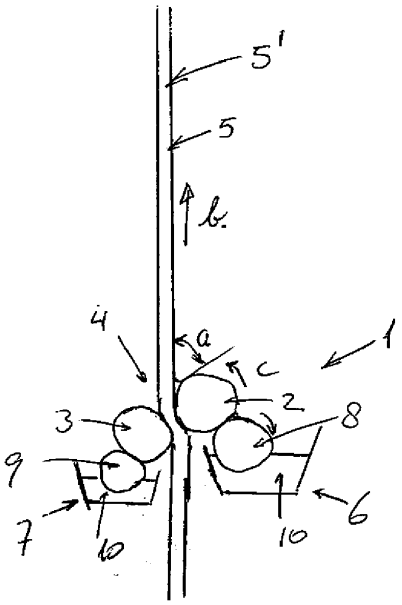

Fig. 1

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Description

[0001] The invention relates to a method, comprising:

- providing a first roll, a second roll, and a nip between the first and second rolls;
- passing a substrate through the nip between the rolls at a predetermined line speed;
- supplying a coating liquid to the substrate in the nip, wherein the coating liquid has a predetermined contact angle with the substrate; and
- smoothing the coating liquid, via the nip, into a substantially uniform layer of liquid coating on the substrate.

[0002] Such a method is known from WO 2016/200866.

[0003] According to WO2016/200866 so-called ribbing defects are often observed in conventional roll coating processes for liquid coatings, for example, when the coating liquid has a viscosity of about 0.1 mPa- S or greater. The defects may occur as a coating liquid passes through a nip between rolls and the viscous stress at a film split overcomes surface tension forces attempting to maintain a uniform curvature of the interface at the film split. WO2016/200866 teaches that the balance of viscous to surface tension forces can be described by a dimensionless capillary number defined by the equation $Ca = \mu U/\sigma$, wherein Ca is the capillary number, μ is a liquid viscosity, U is an average speed of the first and second rolls, and σ is the liquid surface tension. The ribbing defect may according to this document lead to a highly non-uniform coating as the liquid exits the nip. To address this problem it may be necessary to limit line speeds. Other problems are that it may reduce the coating efficiency, and increase the cost of production. Additionally according to WO2016/200866, as line speeds are increased it can lead to misting, for example, ejection of small droplets in the form of a mist as the ribs pass through the nip, which can be a concern for the health and safety of the factory environment.

[0004] The problem of the ribbing defect is a long-lasting one; reference can be made to the article "Ribbing Instability of a Two-roll Coater: Newtonian fluids" by J. Greener et al, published in Chem. Eng. Common, Vol. 5, pp. 73 - 83, published by Gordon and Breach, Science Publishers Inc. 1980, which already made an effort in understanding the physical background of the ribbing defect. Its physical background is however unruly and hard to understand, which explains that the authors of said article exhale in discussing the theory known at the time: "Why does the theory of Savage fit the data so well in the case of the roll rotating near a fixed plate? We are unable to offer an explanation for this."

[0005] There are indeed many factors that play a role in the emergence of the ribbing defect. Mention can be made of roll properties such as hardness, Young modulus, viscoelastic, roll layer thickness, compressibility, roll radius etc. Also properties of the applied coating liquid are of importance, such as density, surface tension, viscosity, viscoelasticity. And finally operating conditions such as roll speed, speed ratio, slip, the height of the nip between the rolls and the applied load, temperature etc. are all factors that influence the occurrence of the ribbing defect.

[0006] According to WO2016/200866 the ribbing defect is cured by arranging that the first roll comprises a thin metal shell and a resilient layer, the thin metal shell encases the resilient layer there beneath, and the thin metal shell is capable of deflecting in unison with the resilient layer such that the thin metal shell is elastically deformable at the nip when in contact with the second roll.

[0007] In the particular field of treating strips of galvanized or galvannealed steel the problems that are observed in WO2016/200866 equally apply, yet the solutions as taught by WO2016/200866 are unfit to be practiced in this heavy industrial environment.

[0008] It is therefore an object of the invention to counter the ribbing defect when treating a strip of galvanized or galvannealed steel with a coating liquid.

[0009] It is another object of the invention to be able to provide a galvanized or galvannealed steel with a coating liquid without reducing the line speed.

[0010] According to the invention a method and a galvanized or galvannealed steel substrate treated with a coating liquid is provided in accordance with one or more of the appended claims.

[0011] In a first aspect of the invention a method is proposed comprising the steps of

- providing a first roll, a second roll, and a nip between the first and second rolls;
- passing a substrate of galvanized or galvannealed steel through the nip between the rolls at a predetermined line speed; - providing that a circumferential speed of a surface area of the rolls contacting the substrate substantially matches the line speed;
- supplying a coating liquid to the substrate in the nip;
- smoothing the coating liquid, via the nip, into a substan-tially uniform layer of liquid coating on the substrate; and
- providing that the contact angle of the coating liquid with the substrate is smaller than 97°.

[0012] The inventors have found that particularly controlling said contact angle of the coating liquid with the substrate to remain below 97° plays a decisive role in the prevention of the ribbing defect when treating galvanized or galvannealed steel.

[0013] The mentioned 97° is an upper limit; more favourable results are achievable by providing that the contact angle of the coating liquid with the substrate is smaller than 93°, more preferably even smaller than 80°.

[0014] The treatment of the galvanized or galvannealed steel is carried out preferably by arranging that at least one of the rolls has a rubber cover and is used

as an applicator roll and that the coating liquid is applied to the substrate as a thin film of less than 6 μm, wherein the applicator roll has a circumferential speed which is directed opposite to the line speed of the substrate. This results into a very efficient and effective application of coating liquid without occurrence of the ribbing defect.

[0015] Preventing the ribbing defect can even further be promoted by arranging that an absolute value of the said circumferential speed of a surface area of the rolls contacting the substrate differs less than 10% from an absolute value of the line speed.

[0016] When the line speed and the circumferential speed of the applicator roll are in the same direction it is preferred that the circumferential speed of the surface area of the rolls contacting the substrate differs less than 10% up or down from the line speed.

[0017] Beneficially the coating liquid is provided onto the substrate in two steps, a first step wherein the coating liquid is prepalene, and a second step wherein the coating liquid is palbond. Prepalene and palbond are known chemical compositions marketed by the firm Henkel. Their application for treatment of metal surfaces is for instance known from US 5,591,275.

[0018] Optimal effects are achieved when the coating liquid in both steps is diluted to a solution of 20 - 40%, the remainder being water.

[0019] The result of the method of the invention is a galvanized or galvannealed steel treated with the coating liquid, wherein ribbing defects are effectively avoided.

[0020] The invention will hereinafter be further elucidated with reference to the drawing of an exemplary embodiment of an apparatus employing the method according to the invention that is not limiting as to the appended claims.

[0021] In the drawing:

- Figure 1 shows an apparatus employing the method according to the invention.

[0022] Figure 1 shows an apparatus 1 comprising a first roll 2, a second roll 3, and a nip 4 between the first and second rolls 2, 3. Through the nip 4 between the first roll 2 and the second roll 3 a substrate 5 in the form of a galvanized or galvannealed steel strip 5' moves with a predefined speed in the direction of arrow b. With the first roll 2 and the second roll 3 the steel strip 5' is coated on both sides with a coating liquid 10 that is stored in and retrieved from tanks 6, 7. Supporting or pick-up rolls 8, 9 are rotating within the tanks 6, 7 to pick up the coating liquid 10 from these tanks 6, 7. As these supporting rolls 8, 9 are in contact with the earlier mentioned first roll 2 and second roll 3 a transfer of the coating liquid 10 from the pick-up rolls 8, 9 to these latter rolls 2, 3 takes place. The applicator rolls 2, 3 can subsequently provide the coating liquid 10 to both sides of the metal strip 5'. It is of course also possible to arrange the apparatus 1 in a way that coating liquid 10 will be provided on only one side of the metal strip 5'. The way this can be implemented is entirely obvious for the skilled person, so it is unnecessary to provide a detailed description thereof.

[0023] With the action of the applicator rolls 2, 3 on the metal strip 5' a further smoothing of the coating liquid 10 which is passed on to the metal strip 5' in the nip 4, is arranged which results into a substantially uniform layer of liquid coating 10 on the metal strip 5.

[0024] Figure 1 shows that the applicator roll 2 is counter-rotating with a circumferential speed as symbolized with arrow C, and which is opposite in comparison with the movement direction of the metal strip 5' symbolized by the arrow b. Such a reverse operation is however only one possible option, another common option which is within the scope of the invention is that the roll 2 has a circumferential speed which is in the same direction as the movement direction b of the metal strip 5. Arrow c is then pointing in the opposite direction than is shown in the drawing.

[0025] In accordance with the invention the prevention of ribbing in the coating 10 that is provided on the surface of the metal strip 5' requires in combination that an absolute value of a circumferential speed of a surface area of the rolls 2, 3 contacting the substrate 5 or metal strip 5' substantially matches an absolute value of the line speed of the substrate 5 or metal strip 5', and that a contact angle of the coating liquid 10 with the substrate 5 or metal strip 5' is smaller than 97°. This contact angle is symbolized in the drawing with the letter 'a'. The results of the invention are supported by the following table summarizing experimental results.

Contact angle 'a'	Occurrence of ribbing
110°	Always visible ribbing
97°	Almost no visible ribbing
93°	No visible ribbing detected
80°	Never visible ribbing

In accordance with these results it is preferred that the contact angle of the coating liquid 10 with the substrate 5 or metal strip 5' is smaller than 93°, and even more preferably that the contact angle of the coating liquid 10 with the substrate 5 or metal strip 5' is smaller than 80°.

[0026] It is further found beneficial to promote the prevention of ribbing by arranging that at the side where ribbing is to be suppressed the concerning applicator roll 2, 3 on that side has a rubber cover and that the coating liquid 10 is applied to the substrate 5 or metal strip 5' as a thin film of less than 6 μm, wherein the applicator roll 2, 3 has a circumferential speed which is directed opposite to the line speed of the substrate 5 or metal strip 5', as is shown in figure 1 with the symbolizing arrows b and c.

[0027] It is further found that the requirement of the invention that an absolute value of a circumferential speed of a surface area of the rolls 2, 3 contacting the

substrate 5 or metal strip 5' substantially matches an absolute value of the line speed of the substrate 5 or metal strip 5', is met when the absolute value of the said circumferential speed of a surface area of the rolls 2, 3 contacting the substrate 5 or metal strip 5' differs less than 10% from the absolute value of the line speed of the substrate 5 or metal strip 5'.

[0028] Conversely, when the applicator rolls 2, 3 have a circumferential speed which have the same direction as the line speed of the substrate 5 or metal strip 5', this requirement still applies in that that said circumferential speed of the surface area of the rolls 2, 3 contacting the substrate 5 or metal strip 5' should differ less than 10% up or down from the line speed of the substrate 5 or metal strip 5'.

[0029] Although figure 1 shows the application of a coating liquid 10 in a single step, it is preferred with a view to achieve best results that the coating liquid is provided onto the metal strip 5 in two subsequent steps, a first step wherein the coating liquid is prepalene, and a second step wherein the coating liquid is palbond. Preferably the coating liquid in both steps is then diluted to a solution of 20 - 40%, the remainder being water.

[0030] Finally it is remarked that the invention is also embodied in a galvanized or galvannealed steel strip 5 treated with a coating liquid 10 as provided on the metal strip 5 in accordance with the method of the invention.

[0031] Although the invention has been discussed in the foregoing with reference to an exemplary embodiment of the method of the invention, the invention is not restricted to this particular embodiment which can be varied in many ways without departing from the invention. The discussed exemplary embodiment shall therefore not be used to construe the appended claims strictly in accordance therewith. On the contrary the embodiment is merely intended to explain the wording of the appended claims without intent to limit the claims to this exemplary embodiment. The scope of protection of the invention shall therefore be construed in accordance with the appended claims only, wherein a possible ambiguity in the wording of the claims shall be resolved using this exemplary embodiment.

Claims

1. A method, comprising:

- providing a first roll (2), a second roll (3), and a nip (4) between the first and second rolls (2, 3);
- passing a substrate (5) through the nip (4) between the rolls (2, 3) at a predetermined line speed;
- supplying a coating liquid (10) to the substrate (5) in the nip (4), wherein the coating liquid (10) has a predetermined contact angle (a) with the substrate (5); and
- smoothing the coating liquid (10), via the nip (4), into a substantially uniform layer of liquid coating (10) on the substrate (5),

characterized by

- providing that the substrate (5) is a galvanized or galvannealed steel strip (5');
- providing that an absolute value of a circumferential speed of a surface area of the rolls (2, 3) contacting the substrate (5) substantially matches an absolute value of the line speed of the substrate (5);
- providing that the contact angle (a) of the coating liquid (10) with the substrate (5) is smaller than 97°.

2. Method according to claim 1, **characterized by** providing that the contact angle (a) of the coating liquid (10) with the substrate (5) is smaller than 93°.

3. Method according to claim 1 or 2, **characterized by** providing that the contact angle (a) of the coating liquid (10) with the substrate (5) is smaller than 80°.

4. Method according to any one of the previous claims 1 - 3, **characterized by** providing that at least one of the rolls (2, 3) has a rubber cover and is used as an applicator roll and that the coating liquid (10) is applied to the substrate (5) as a thin film of less than 6 μm, wherein the applicator roll (2, 3) has a circumferential speed (c) which is directed opposite to the line speed (b) of the substrate (5).

5. Method according to claim 4, **characterized by** providing that an absolute value of the said circumferential speed of a surface area of the rolls (2, 3) contacting the substrate (5) differs less than 10% from an absolute value of the line speed (b) of the substrate (5).

6. Method according to any one of the previous claims 1 - 3, **characterized by** providing that at least one of the rolls (2, 3) has a rubber cover and is used as an applicator roll, wherein a circumferential speed of the applicator roll (2, 3) has the same direction as the line speed of the substrate (5), and that said circumferential speed of the surface area of the rolls (2, 3) contacting the substrate (5) differs less than 10% up or down from the line speed of the substrate (5).

7. Method according to any one of the previous claims 1 - 6, **characterized by** providing the coating liquid (10) onto the substrate (5) in two steps, a first step wherein the coating liquid is prepalene, and a second step wherein the coating liquid is palbond.

8. Method according to claim 7, **characterized in that**

the coating liquid (10) in both steps is diluted to a solution of 20 - 40%, the remainder being water.

9. Galvanized or galvannealed steel substrate treated with a coating liquid as provided on the substrate according to any one of the previous claims 1 - 8.

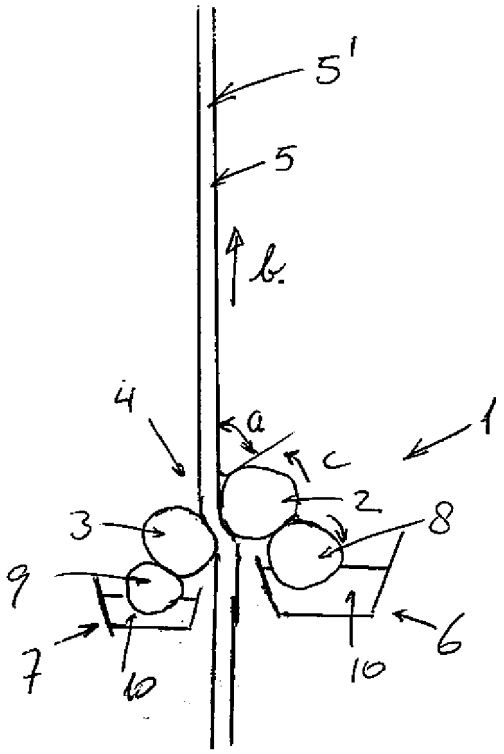

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 17 16 3995

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	* tables 1, 2 *	1-8	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 September 2017	Brisson, Olivier

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 16 3995

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12-09-2017

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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