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[54] **REMOVAL OF EXCESS MOLTEN METAL COATINGS BY GAS BLAST WITHOUT RIPPLE FORMATIONS ON COATED SURFACES**
11 Claims, 3 Drawing Figs.

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C23c 1/02
 [50] Field of Search **117/102 M,**
102 L, 114, 114 A, 114 B, 114 C; 118/63; 15/345,
346, 306.1

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ABSTRACT: An improvement in the method of controlling a metal material in a hot-dip metal plating process jetting at least one stream of compressed gas toward the metal plating coating on the surface of the sheet metal material drawn out of a hot-dip bath before said plating coating has solidified. The stream of compressed gas when it collides with the coated sheet metal material forms an upwardly flowing branch stream of gas. The improvement lies in directing at least one stream of ripple eliminating gas at a pressure at least substantially equal to the pressure of the first mentioned stream of compressed gas downwardly and toward the metal plating coating on the surface of the sheet material from a point above the point at which said first mentioned stream of gas is directed at the surface of the sheet material and at a point ahead of, with respect to the direction of advance of the sheet material, the point at which the metal plating coating solidifies and sufficiently close to the point at which the first mentioned stream of gas collides with said sheet material to cancel the upwardly flowing branch stream of gas. The stream of ripple eliminating gas prevents formation of ripple patterns on the plated surface of the sheet material.

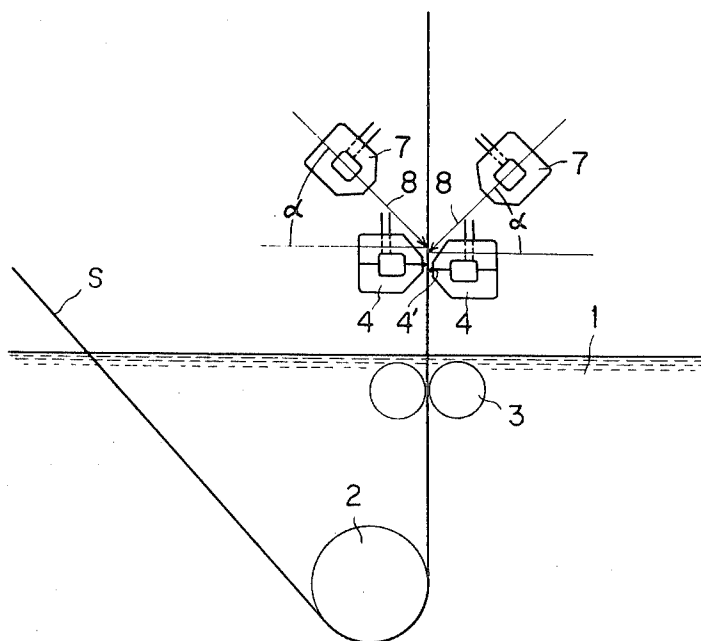


FIG. 1

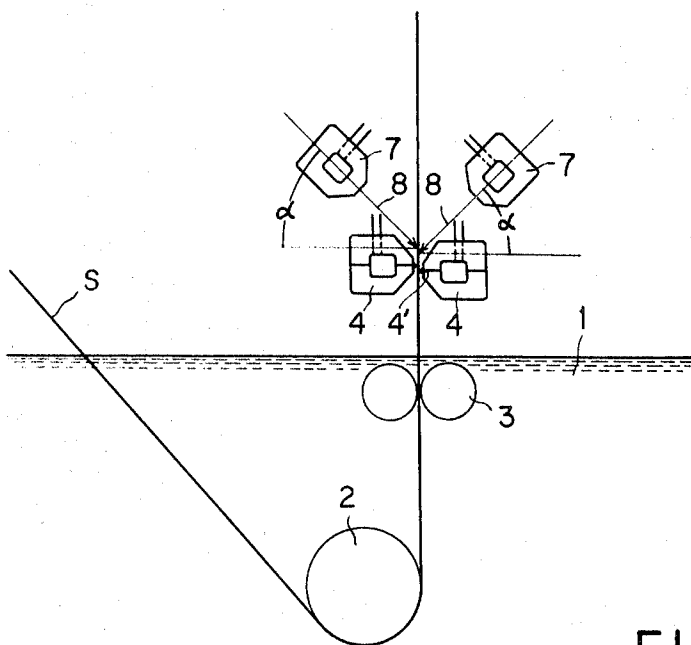


FIG. 2

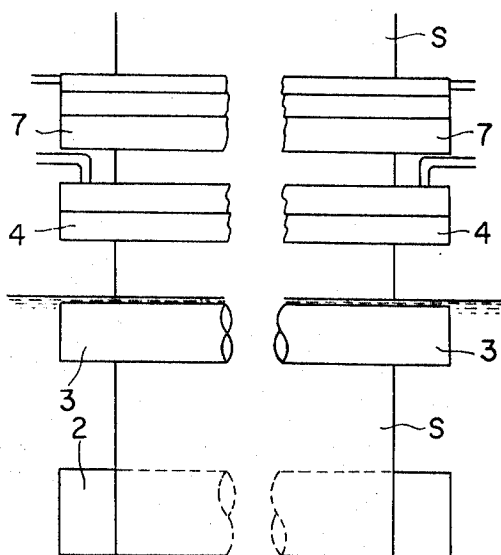
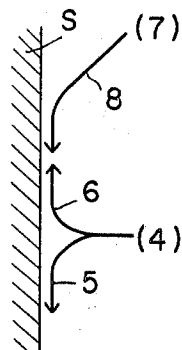


FIG. 3



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REMOVAL OF EXCESS MOLTEN METAL COATINGS BY GAS BLAST WITHOUT RIPLE FORMATIONS ON COATED SURFACES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a continuous melt-plating process, wherein there is adopted a so-called gas wiping system for controlling a plating deposit by jetting a compressed gas onto the fluid surface of a plating metal just after plating.

2. Description of the Prior Art

Generally, the continuous melt-plating process using the gas wiping system has such excellent features as (1) it gives a great uniformity of plating, (2) the fluctuation of the plating thickness in the direction of the width of the plate is small and the corrosion resistance is high and (3) plating finishing rolls are not required and the difficulties involved in exchanging them can be eliminated. Therefore, the continuous melt-plating process using the gas wiping system should take the place of the conventional plating deposit adjusting process carried out by using plating finishing rolls.

According to this gas wiping process, immediately after a band-shaped metal plate has been passed through and dipped in a molten metal plating bath, such as zinc, and is pulled out of the plating bath and moved upward, and, particularly where the coating, for instance a zinc coating, layer deposited on the surface of this band-shaped metal plate still remains in a fluid state, a flow of high temperature compressed gas is jetted onto the surface of the band-shaped metal plate in a parallel to the width direction of said metal plate through a jetting nozzle which directs the jet downward at an angle of inclination substantially at right angles to a normal to this metal plate so that the excess part of the zinc coating layer deposited on the surface of the above-mentioned band-shaped metal plate is wiped off.

In this case, the high temperature compressed gas is jetted through a slit in the front surface of the jetting nozzle which is positioned very close to the surface of the band-shaped metal plate.

This gas wiping process has many excellent advantages as described above. However, when producing a thinly plated product by elevating the pressure of the compressed wiping gas for adjusting the thickness of the plating deposit, ripplelike striped luster specks are often produced in the metal plating layer. Depending on the variations of the velocity of the plate passing through the plating bath and other conditions, the formation of such specks has also been found in other cases than thin plating.

The formation of such ripples in the metal plating layer is an urgent problem which must be solved to improve the appearance and anticorrosion property of the product.

SUMMARY OF THE INVENTION

The present invention provides an improved process for eliminating the striped luster specks in a metal plating layer which are produced when the gas wiping process is used so that a smooth plated product, which is excellent from the standpoint of anticorrosion and appearance can be produced.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings are schematic views showing an embodiment of the process of the present invention.

FIG. 1 is a side view of an apparatus used in the process of the present invention.

FIG. 2 is an elevation of the same wherein the central part is omitted.

FIG. 3 is an explanatory view showing the principle of multistage blowing of a compressed gas.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As a result of various experiments and research by the inventor of the present invention with a view to understanding the phenomenon of the production of striped luster specks in the metal plating layer in the above-described gas wiping process, it has been confirmed that the production of such striped patterns is due to the following phenomenon. When the high temperature compressed gas jetted onto the plated surface to control the plating deposit collides with the band-shaped metal plate (though there is a part of the gas which does not collide but turns near the plate depending on the gas particles, all the gas shall be assumed to collide for the purposes of the following discussion), there are formed branch streams in two directions substantially parallel to the surface of the metal plate, one stream advancing upward from the point of collision and the other advancing downward from the same point and particularly the stream advancing upward (in the same direction as the band-shaped metal advances) from the point of collision acts on the surface of the plating metal layer being wiped so that it is a fixed thickness and remaining in a fluid state to form ripple-shaped specks thereon.

The fact that the formation of ripples in the gas wiping process has a tendency to increase particularly when the pressure of the compressed gas for use in wiping off and excess plating deposit is elevated to make the deposit thinner further strengthens the conclusion that the formation of ripples is caused by the upward branch stream of the wiping compressed gas, advancing upward along the surface of the band-shaped metal plate, produced when the wiping compressed gas collides with the plated surface of the metal plate after being jetted. Therefore, the inventor of the present invention has carried out various experiments to eliminate ripples and has discovered that it is difficult to eliminate these ripples by only such measures as varying the angle of the wiping gas jetting nozzle, the clearance between the nozzle and the band-shaped metal plate, the distance from the surface of the plating bath to the compressed gas jetting point and the composition and pressure of the wiping gas. Even in an experiment, wherein the jetting nozzle was inclined considerably downward toward the surface of the plating bath, as the blowing angle of the jetting nozzle was considered to be particularly effective, a satisfactory result could not be obtained by the sole use of the wiping gas jetting nozzle.

As a result of further experiments carried out to discover an effective measure to erase ripples by other means, it was discovered that if a compressed gas having a pressure substantially equal to or higher than the pressure of the compressed gas jetted to wipe off the excess plating deposit is directed toward the upward branch stream of the said wiping compressed gas, which advances upwardly along the plated surface of the metal plate, said upward branch stream being produced when the said wiping compressed gas collides with the plated surface of the metal plate after being jetted, ripples can be effectively eliminated.

The present invention relates to a gas wiping process in which excess material in a plating layer deposited on the surface of a continuous metallic material is wiped off by jetting a high temperature stream of compressed gas at a pressure of 0.05 to 5 kg./cm.² gauge onto the continuous metallic material dipped and passed through a molten plating bath, such as zinc, zinc alloy, aluminum, or tin, immediately after the material is pulled out of the said plating bath metallic moved upward at a point at which the coating metal deposited on the surface of the metallic material still remains in a fluid state. The stream of gas is directed in a direction parallel to the width direction of the metallic material at an angle of 3 to 45 degrees downward to a normal to said metallic material, through a jetting nozzle having a slit with a width of 0.3 to 3 mm., while keeping the clearance between the jetting nozzle tip and the surface of the metallic material about 3 to 20 mm. or preferably about 5 to 15 mm. A further stream of compressed

gas having a pressure substantially equal to or higher than the pressure of the compressed gas jetted against the metallic material for wiping the excess plating material is directed toward the upward branch stream of the compressed gas, advancing upwardly along the surface of the metallic material, and which is produced when the compressed gas collides with the plated surface of the metallic material after being jetted.

The present invention will now be explained in detail with reference to the drawings.

In FIGS. 1 and 2, the numeral 1 represents, for example, a molten zinc plating bath below the surface of which are provided a deflector roll 2 and pinch rolls 3 to guide a metallic material to be plated, which is prepared with a surface condition adapted to be plated as, for example, a wide band-shaped steel strip S. The steel strip S is subjected to plating while it passes through the plating bath 1, and then it advances upward vertically from the plating bath 1. Two nozzles 4 are provided, one on each side of the strip, for jetting streams of high temperature compressed gas (combustion gas at about 600° C.) against opposite sides of the strip, said nozzles being directed substantially vertically to the plated surface of the steel strip S (within an angular range of 3 to 45 degrees downward to a normal to the steel strip plate surface) in any proper position along the strip where it is pulled out of the bath 1 within a range in which the zinc plating metal coating layer deposited on the steel strip S surface is still at a high temperature and is in a fluid state.

A jetting slit 4' at the tip of each jetting nozzle 4 is so arranged that its length is parallel to the width direction of the steel strip S. The clearance between the tip of this slit 4' and the surface of the steel strip S is kept usually within 5 to 15 mm. The right and left jetting nozzles are at slightly different heights from the bath surface. The width of the slit 4' in each nozzle is about 0.3 to 3 mm. Through this slit is jetted a stream of high temperature combustion gas at a pressure of 0.05 to 5 kg./cm.² gauge so that the excess part of the plating metal is wiped off while it is still in a fluid state just after being deposited and the plating thickness may be controlled as desired.

In this case, the compressed gas jetted out through the slit of each nozzle 4 for jetting a high temperature gas collides with the surface of the steel strip S and branches into an upward stream 6 and a downward stream 5, as shown in FIG. 3, being mainly influenced by the condition that immediately before the compressed gas collides with the steel strip the stream of the compressed gas is directed substantially vertically to the steel strip S. The action of wiping the excess plating is performed by only downward stream, while the upward stream makes substantially no contribution to this action. Rather, it has been discovered that this upward branch stream is the main source of the ripple shaped luster specks on the surface of the plating layer as above-described.

Therefore, the essential feature of the present invention is to eliminate these ripples on the plated surface of the steel strip S by directing a downward compressed gas stream toward each upward branch stream 6 produced when the wiping compressed gas jetted from the jetting nozzle 4 collides with the plated surface of the said steel strip, thereby to cancel the upward branch stream 6.

With reference again to FIG. 1, the present invention eliminates the above-mentioned ripples by jetting compressed gas streams 8 through jetting nozzles 7 for eliminating ripples, said nozzles being inclined downwardly and being at a distance above the plating bath where the plating metal layer remains in a fluid state. The position of the said ripple eliminating gas jetting nozzles 7 is above and near the wiping high temperature gas jetting nozzles 4 and the jetting slit of each of said ripple eliminating gas jetting nozzles 7 is parallel to the width direction of the band-shaped steel strip 6 in the same manner as the wiping gas jetting nozzles 4. From various experiments and research carried out by the inventor of the present invention, the preferred conditions which are effective in eliminating such ripples are as follows. That is to say, each

ripple eliminating gas jetting nozzle 7 should be mounted so that its height from the bath surface of the plating bath 1 is freely adjustable at a distance from the gas wiping nozzle in the direction of the advance of the plated metallic material sufficient for accommodating 1 to 3 nozzles. For the ripple eliminating gas there can be used an inert gas such as N₂, any reducing gas or air at the room temperature. If required, the gas to be used can be heated. The slit in each jetting nozzle 7 should be about 0.3 to 3 mm. wide, preferably about 1 mm. The angle of each jetting nozzle 7 to the strip S is not limited so long as the nozzle is inclined downwardly, but it is preferably at an angle α about 45 to 60 degrees to a normal to the band-shaped steel strip S. The distance between the tip of the jetting nozzle 7 and the steel strip S should preferably be in a range of about 100 to 150 mm. The pressure of the ripple eliminating compressed gas should be about the same as the pressure of the above-described wiping high temperature compressed gas but should be more than 0.1 kg./cm.² gauge or preferably about 0.3 to 5 kg./cm.² gauge provided it is higher than the pressure of the wiping high temperature compressed gas. It is necessary to keep the relative positions of each ripple eliminating gas jetting nozzle 7 and the corresponding wiping high temperature gas jetting nozzle 4 so that the distance between the point of collision of the wiping high temperature compressed gas with the steel strip surface and the point of collision of the ripple eliminating compressed gas with the steel strip surface is less than about 10 mm., and preferably less than 0.2mm. When a ripple eliminating gas jetting nozzle 7 is provided on each side of the metallic material, the points at which the respective ripple eliminating gas jets reach the metallic material should be offset from each other.

The range of the above-mentioned slit width of the jetting nozzle 7 is determined from the viewpoint of the quantity of gas and its pressure. The range of angular positions is determined by combining the results of the investigations and experiments with respect to the spacing from the sheet material and the downward component of the compressed gas. The ranges of the clearance between the above-mentioned jetting nozzle 7 and steel strip and the jetting pressure have also been determined by research and experiments. Further, the conditions of the compressed gas jetted through the jetting nozzle 7 should be properly determined in relation to the strength of the upward stream 6, the line speed and the quantity of the plating material on the metal strip. The line speed of the steel strip for the above-mentioned jetting conditions is oz./ft. 170 to 500 ft./min. A particularly effective film metal thickness range is 0.9 oz./ft.² maximum (of course, the present invention is not limited only to these ranges).

Example:

A band-shaped cold-drawn steel sheet 0.25 mm. thick and 914 mm. wide was dipped in and passed through a molten zinc plating bath at a line speed of 67 m./min. (220 ft./min.) and was advanced upward substantially vertically and a combustion gas at a temperature of 430° C. at a pressure of 0.25 kg./cm.² gauge was blown onto said steel sheet while the plating metal layer on the surface of the band-shaped steel sheet remained in a fluid state, through a wiping combustion gas nozzle having a slit 0.9 mm. wide, the jet of gas being directed slightly downwardly at an angle of 8 degrees to a normal to the strip steel surface, the nozzle being located at a height of 160 mm. above the plating metal bath surface, the clearance between the wiping gas nozzle and the steel sheet surface being 5 mm. and the slit being parallel to the width direction of said steel sheet surface. At the same time, compressed air at room temperature at a pressure of 3 kg./cm.³ gauge was blown onto the steel sheet through a ripple eliminating gas nozzle spaced from the wiping gas nozzle in the direction of the advance of the steel sheet above the wiping gas nozzle, the ripple eliminating gas nozzle being inclined downwardly at an angle of 60 degrees to a normal to the band-shaped plated steel sheet, the opening in the wiping gas nozzle extending in a direction parallel to the width direction of the steel plate, and while the plating layer remained in a fluid state. The said rip-

ple eliminating gas jetting nozzle had a slit of 1 mm. wide, and the distance between the nozzle tip and the steel sheet was 120 mm., and the distance between the points of collision of the wiping gas and the ripple eliminating gas with the surface of the steel plate was about 2 mm. By carrying out the process of the present invention a smooth zinc-plated sheet having no striped luster specks was obtained.

What I claim is:

1. An improvement in the method of controlling a metal plating coating placed on the surface of a sheet metal material in a hot-dip metal plating process by jetting at least one stream of compressed gas toward the metal plating coating on the surface of the sheet metal material drawn out of a hot-dip bath before said plating coating has solidified, the stream of compressed gas when it collides with the coated sheet metal material forming an upwardly flowing branch stream of gas, said improvement comprising directing at least one stream of ripple eliminating gas at a pressure at least substantially equal to the pressure of the first mentioned stream of compressed gas downwardly and toward the metal plating coating on the surface of the sheet material from a point above the point at which said first mentioned stream of gas is directed at the surface of the sheet material and at a point ahead of, with respect to the direction of advance of the sheet material, the point at which the metal plating coating solidifies and sufficiently close to the point at which the first mentioned stream of gas collides with said sheet material to cancel the upwardly flowing branch stream of gas, whereby ripple patterns on the plated surface of the sheet material are prevented.

2. The improvement as claimed in claim 1 in which the stream of ripple eliminating gas is directed downwardly at an angle of from 45 to 60° to a normal to the surface of the sheet material, and has an elongated cross sectional shape extending in the direction of the width of the sheet material.

3. The improvement as claimed in claim 1 in which the point at which the stream of ripple eliminating gas collides

with the sheet material is spaced a distance of up to 10 mm. above the point at which the first mentioned stream of gas collides with said sheet material.

4. The improvement as claimed in claim 3 in which the point at which the stream of ripple eliminating gas collides with the sheet material is spaced a distance of up to 2 mm. above the point at which the first mentioned stream of gas collides with said sheet material.

5. The improvement as claimed in claim 1 in which the stream of ripple eliminating gas is directed at the sheet material through a nozzle which is spaced a distance of from 100 to 150 mm. from the point at which the ripple eliminating gas collides with the sheet material, said distance being measured in the direction of said stream of ripple eliminating gas.

6. The improvement as claimed in claim 1 in which the stream of ripple eliminating gas is a gas taken from the group consisting of air and inert gas.

7. The improvement as claimed in claim 1 in which the ripple eliminating gas is nitrogen.

8. The improvement as claimed in claim 1 in which the sheet metal material is a strip of cold rolled steel sheet and said hot-dip bath is a metal taken from the group consisting of zinc and zinc alloy.

9. The improvement as claimed in claim 1 in which the pressure of the stream of ripple eliminating gas is greater than 0.1 kg./cm.² gauge.

10. The improvement as claimed in claim 9 in which the pressure of the stream of ripple eliminating gas is from 0.3 to 5 kg./cm.² gauge.

11. The improvement as claimed in claim 1 wherein there are a plurality of said first mentioned streams of compressed gas and a plurality of ripple eliminating streams of compressed gas, there being one stream of ripple eliminating gas for each of said first mentioned streams of gas.

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