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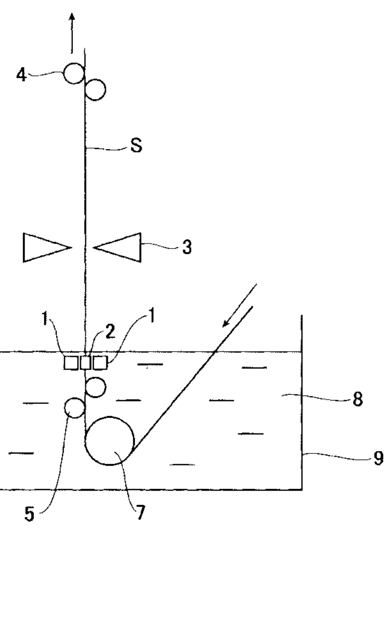
(54) **APPARATUS FOR PRODUCING MOLTEN METAL PLATED STEEL STRIP AND PROCESS FOR PRODUCING MOLTEN METAL PLATED STEEL STRIP**

(57) An apparatus for manufacturing a molten metal coated steel strip according to the present invention, the apparatus being configured to control the amount of a metal coated on surfaces of a steel strip S by blowing a gas from gas wiping nozzles 3 to the surfaces of the steel strip S continuously drawn from a molten metal 8, includes molten-metal-reducing members 1 arranged on both sides of the steel strip S below the surface of the molten metal in the coating bath 9 so as to face the steel strip S, each of the molten-metal-reducing members 1 having a length equal to or longer than the steel-strip width, and shields 2 arranged between the molten-metal-reducing members 1 each extending along an extension of a corresponding one of the surfaces of the steel strip S, the molten-metal-reducing members 1 being arranged so as to face the steel strip S. The use of the apparatus reduces an excess amount of molten metal sticking to the steel strip drawn from the molten metal across the entire width of the steel strip, thereby reducing the occurrence of splashing in the gas wiping step.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an apparatus for manufacturing a molten metal coated steel strip in a molten metal coating process, the apparatus being configured to reduce splashing of a molten metal, and a method for manufacturing a molten metal coated steel strip with the apparatus.

Background Art

[0002] A typical apparatus and process for continuous molten metal coating will be described with reference to Fig. 7. A gas wiping device is arranged, the gas wiping device being configured to control the amount of a molten metal (coating weight) coated on a steel strip S by blowing a pressurized gas from gas wiping nozzles 3 to the steel strip to remove an excess amount of the molten metal, the gas wiping nozzles 3 extending in the direction of the width of the steel strip and being arranged on both sides of the steel strip S so as to face the steel strip S, in order that the molten metal sticking to the surface of the steel strip uniformly has a predetermined thickness in the transverse and longitudinal directions, the blowing step being performed after the steps of immersing the steel strip S in the molten metal 8 contained in a coating bath 9, changing the travel direction using a sink roll 7, and drawing the steel strip S in the vertical direction.

[0003] To stabilize the travel position of the steel strip in the gas wiping portion, submersed support rolls 5 are usually arranged above the sink roll 7 and below the molten metal surface. In the case of performing alloying treatment, support rolls 4 outside the bath are arranged above the gas wiping nozzles 3, as needed.

[0004] The gas wiping nozzles 3 are usually longer than the width of the steel strip, i.e., each extend beyond the ends of the steel strip S in the width direction, in order to correspond steel strips with various widths and the displacement in the width direction in drawing the steel strip. In the case of using such a gas wiping device, splashing, in which the molten metal dropping toward the lower portion of the steel strip is spattered, due to the turbulence of a jet impinging on the steel strip S occurs, leading to a reduction in the surface quality of the steel strip.

[0005] To increase the volume of production in the continuous process, the threading speed may be increased. In the case where in the continuous molten metal coating process, the coating weight is controlled by the gas wiping method, the initial amount of the molten metal applied to the steel strip immediately after the steel strip passes through the molten metal is increased with increasing line speed due to the viscosity of the molten metal. Thus, to control the coating weight within a certain range, the wiping gas pressure is forced to be set at a higher level. This results in a significant increase in the amount of splash, thereby reducing the surface quality.

[0006] To overcome the foregoing problems, a method for reducing an excess amount of molten metal sticking to a steel strip to some extent before the steel strip reaches the wiping nozzles to reduce the initial amount of the molten metal sticking to the steel strip immediately after the steel strip passes through the molten metal is disclosed.

[0007] Japanese Unexamined Patent Application Publication No. 2004-76082 discloses an apparatus including molten-metal-reducing members arranged on both sides of a steel strip so as to face the steel strip in a noncontact manner and arranged between submersed support rolls 5 and wiping nozzles 3 in a molten metal, in which an excess amount of molten metal is removed, and then gas wiping is performed to control the coating thickness. Each of the molten-metal-reducing members preferably has a rectangular shape, a shape having an entry portion in which the distance between the member and the corresponding surface of the steel strip increases with decreasing distance from the lower end of the member, or a columnar shape. The patent document states that the molten-metal-reducing members are most preferably located so as to cross the surface of the molten metal. The patent document also states that the molten-metal-reducing members are preferably arranged so as to surround the steel strip.

[0008] In this method, the molten-metal-reducing members can reduce an excess amount of the molten metal sticking to the middle portion of the steel strip in the width direction. However, the flow of the molten metal from the outside of both ends of the steel strip in the width direction into the middle portion of the steel strip in the width direction reduces the effect of reducing the molten metal at both ends of the steel strip in the width direction, thus increasing the difference in excess amount of molten metal between the middle portion and both ends in the width direction compared with the case where the molten-metal-reducing members are not arranged. This reduces the effect of reducing splashing in the subsequent gas-wiping step. Furthermore, the molten-metal-reducing members arranged so as to surround the steel strip as disclosed in this method cannot correspond a change in the width of a steel strip produced and thus limits the strip width such that the effect of reducing the molten metal can be provided.

[0009] In consideration of the foregoing problems, it is an object of the present invention to provide an apparatus for stably manufacturing a molten metal coated steel strip having excellent surface appearance, in which an excess amount of molten metal sticking to a steel strip drawn from a molten metal can be reduced across the entire width of the steel strip even when the width of the steel strip is changed, so that the occurrence of splashing can be suppressed in a gas-wiping step.

[0010] It is another object of the present invention to provide a method for stably manufacturing a molten metal coated steel strip having excellent surface appearance, in which the occurrence of splashing can be suppressed in the gas-wiping step.

Disclosure of Invention

[0011] The present invention provides (1) an apparatus for manufacturing a molten metal coated steel strip, the apparatus being configured to control the amount of a metal coated on surfaces of a steel strip by blowing a gas from gas wiping nozzles to the surfaces of the steel strip continuously drawn from a molten metal, including molten-metal-reducing members arranged on both sides of the steel strip below the surface of the molten metal in the coating bath so as to face the steel strip, each of the molten-metal-reducing members having a length equal to or longer than the width of the steel strip, and shields arranged between the molten-metal-reducing members each extending along an extension of a corresponding one of the surfaces of the steel strip, the molten-metal-reducing members being arranged so as to face the steel strip.

[0012] Furthermore, (2) in the apparatus for manufacturing a molten metal coated steel strip described in item (1), the length of a surface of each of the shields facing the steel strip in the travel direction of the steel strip is 50% or more of the length of a steel-strip-facing surface of each of the molten-metal-reducing members in the travel direction of the steel strip (when the steel-strip-facing surfaces of the molten-metal-reducing members in the travel direction of the steel strip have different lengths on both sides of the steel strip, the length of the surface of each of the shields facing the steel strip in the travel direction of the steel strip is 50% or more of the length of the steel-strip-facing surface of the molten-metal-reducing member having a shorter length of the steel-strip-facing surface in the travel direction of the steel strip), and the distance between the molten-metal-reducing members and the shields is 3 mm or less.

[0013] There is also provided (3) a method for manufacturing a molten metal coated steel strip including coating a steel strip with a molten metal using the apparatus for manufacturing a molten metal coated steel strip described in item (1) or (2).

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a cross-sectional view of an apparatus for manufacturing a molten metal coated steel strip according to an embodiment of the present invention.

[Fig. 2] Figs. 2(a) and 2(b) illustrate the operation of molten-metal-reducing members and a shield of an apparatus for manufacturing a molten metal coated steel strip according to the present invention.

[Fig. 3] Fig. 3 is a first drawing illustrating an exemplary combination of cross-sectional shapes of molten-metal-reducing members and a shield used in an apparatus for manufacturing a molten metal coated steel strip according to the present invention.

[Fig. 4] Figs. 4(a) and 4(b) are second drawings illustrating exemplary combinations of cross-sectional shapes of molten-metal-reducing members and the cross-sectional shape of a shield arranged in an apparatus for manufacturing a molten metal coated steel strip according to the present invention.

[Fig. 5] Figs. 5(a) and 5(b) are third drawings illustrating exemplary combinations of cross-sectional shapes of molten-metal-reducing members and the cross-sectional shape of a shield arranged in an apparatus for manufacturing a molten metal coated steel strip according to the present invention.

[Fig. 6] Figs. 6(a) and 6(b) are fourth drawings illustrating exemplary combinations of cross-sectional shapes of molten-metal-reducing members and the cross-sectional shape of a shield arranged in an apparatus for manufacturing a molten metal coated steel strip according to the present invention.

[Fig. 7] Fig. 7 is a cross-sectional view of a general apparatus for manufacturing a molten metal coated steel strip.

Best Modes for Carrying Out the Invention

[0015] In the case where the molten-metal-reducing members for removing an excess amount of molten metal are arranged between a sink roll and gas wiping nozzles, the molten metal removed by gas wiping flows down to form pools between the steel strip and the molten-metal-reducing members. If the distance between the pools and the gas wiping portion is short, an excess amount of molten metal cannot be reduced. The inventors have thus come to the conclusion that the best position of the molten-metal-reducing member arranged is below the molten metal surface.

[0016] However, merely arranging the molten-metal-reducing members leads to a small effect of reducing the molten metal at both ends of the steel strip. To effectively reduce the amount of the molten metal sticking to the steel strip drawn from the molten metal, flow analysis was made in detail with a model apparatus for simulating flows of the molten metal around the molten-metal-reducing member using water. The analysis showed that suppression of flows from both ends to the middle portion of the steel strip is effective in reducing the amount of molten metal sticking to the steel strip.

[0017] The inventors have accomplished the present invention on the basis of these findings.

[0018] Embodiments of the present invention will be described below with reference to the attached drawings. In the following figures, elements having the same functions as the elements shown in the explained figure are designated using the same reference numerals, and redundant descriptions are not made.

[0019] Fig. 1 is a cross-sectional view of an apparatus for manufacturing a molten metal coated steel strip according to an embodiment of the present invention. In Fig. 1, reference numeral 1 denotes molten-metal-reducing members arranged in a molten metal, above the submersed support rolls 5, and on both sides of the steel strip S, each of the molten-metal-reducing members being disposed a predetermined distance apart from a corresponding one of the surfaces of the steel strip. Reference numeral 2 denotes shields arranged close to both ends of the steel strip S and between the molten-metal-reducing members 1 which each extend along an extension of a corresponding one of the surfaces of the steel strip and which are located so as to face the steel strip S. The phrase "along an extension of a corresponding one of the surfaces of the steel strip" indicates "along a line parallel to the width direction of the steel strip". The term "shields" indicates a member configured to shield the molten metal and inhibit flows from both ends to the middle portion of the steel strip.

[0020] Figs. 2(a) and 2(b) illustrate the operation of the molten-metal-reducing members and the shields of the apparatus of the present invention. Fig. 2(a) is a top view illustrating flows of a molten metal at an end of a steel strip in a region between the molten-metal-reducing members when only the molten-metal-reducing members are arranged. Fig. 2(b) is a top view illustrating flows of a molten metal at an end of a steel strip in a region between the molten-metal-reducing members when the molten-metal-reducing members and the shields 2 are arranged. Even in the case where the molten-metal-reducing members 1 has any shape, the arrangement of only the molten-metal-reducing members 1 produces flows 11 of the molten metal from the ends to the middle portion of the steel strip as shown in Fig. 2(a). A larger molten-metal-reducing effect of the molten-metal-reducing members 1 is liable to cause an increase in the flows 11 as if the flows 11 compensate for the effect, thereby disadvantageously reducing or eliminating the reduction effect of the molten-metal-reducing members 1 at both ends of the steel strip. In the case where the shields 2 are arranged between the molten-metal-reducing members which each extend along an extension of a corresponding one of the surfaces of the steel strip and which are located so as to face the steel strip as shown in Fig. 2(b), the flows of the molten metal from the ends to the middle portion of the steel strip can be shielded; hence, the effect of reducing an excess amount of molten metal by the molten-metal-reducing members 1 can be uniformly provided across the entire width of the steel strip.

[0021] The thickness of the molten metal can be controlled by the gas wiping nozzles after an excess amount of molten metal sticking to the steel strip is reduced across the entire width of the steel strip using the molten-metal-reducing members and the shields even when the width of the steel strip is changed, thereby significantly reducing the amount of splashing. According to the present invention, the effect of reducing the molten metal can be provided even at a significantly increased threading speed, thereby significantly reducing the amount of splashing. It is thus possible to manufacture a surface defect-free molten metal coated steel strip with high productivity.

[0022] An end face of each shield 2 adjacent to the steel strip is desirably perpendicular to the steel strip surfaces as shown in Fig. 2(b). The distance between each end of the steel strip and a corresponding one of the end faces of each shield 2 adjacent to the steel strip is desirably 5 mm or less. A smaller distance therebetween is more desirable. As most suitable conditions, the ends of the steel strip are in contact with the end faces of the shields 2 while no pressing force is being applied to the steel strip.

[0023] The clearance between the molten-metal-reducing members 1 and the shields 2 is desirably 3 mm or less. A smaller clearance therebetween is more desirable.

[0024] From the viewpoint of preventing the flows of the molten metal toward the middle portion of the steel strip between the molten-metal-reducing members 1, the length of a surface of each shield 2 facing the steel strip in the travel direction of the steel strip (the length in the vertical direction) is preferably at least 50% or more of the length of the molten-metal-reducing members 1 in the travel direction of the steel strip and most preferably a length comparable to the length of the molten-metal-reducing members 1.

[0025] In the case where the distance between the steel strip and the surface of each molten-metal-reducing member 1 facing the steel strip is changed in the travel direction of the steel strip, the clearance between molten-metal-reducing members 1 and the shields 2 is preferably maintained constant. For example, when the molten-metal-reducing members 1 each have a circular cross-section as shown in Fig. 3, each of the shields 2 preferably has concave arcuate surfaces facing the molten-metal-reducing members 1, each of the concave arcuate surfaces having a radius of curvature slightly larger than that of the circular arc of each molten-metal-reducing member 1.

[0026] The cross-sectional shape of each of the molten-metal-reducing members is not limited to the shape shown in Fig. 3. The molten-metal-reducing members may have various cross-sectional shapes as described below. For example, as shown in Fig. 4(a), in the case where each of the molten-metal-reducing members 1 has a triangular cross-section, a surface facing the steel strip S, and the top surface facing the molten-metal surface, the surface facing the steel strip S being parallel to the steel strip S, and the top surface being parallel to the molten-metal surface, the molten-metal-reducing members 1 can provide an improved effect of reducing the molten metal. In the case of using the molten-metal-reducing members 1 each having the shape, even if the flow (accompanying flow) 11 associated with the travel of the steel strip S is generated, the flow 11 branches off at the bottom of the molten-metal-reducing members 1 to form a flow 13 because fluid flows easily in the low-resistance direction; hence, the molten-metal-reducing members 1 have the function to prevent the growth of the flow 11. Furthermore, the flow 13 flows in the direction away from the steel strip S and thus faces a flow 12 flowing toward the steel strip S above the molten-metal-reducing members 1; hence, the molten-metal-reducing members 1 also have the effect of reducing the velocity of the flow 12. The molten-metal-reducing members 1 can control the flow as described above and thus can significantly suppress accompanying flows near the steel strip S drawn from the molten metal, thereby reducing an excess amount of molten metal sticking to the steel strip S. As a result, the pressure of a wiping gas can be lowered to reduce the amount of splashing of the molten metal, so that a steel strip having satisfactory surface quality can be produced. In this case, each of the shields 2 may have a rectangular cross-section as shown in Fig. 4(b).

[0027] Each of the molten-metal-reducing members 1 shown in Fig. 5(a) has a cross-sectional shape in which an upper profile curve and a lower profile curve are both arcuate and convex in the direction in which the steel strip is drawn from the molten metal and in which the upper curve has a radius of curvature smaller than that of the lower curve. Furthermore, the thickness of each of the molten-metal-reducing members 1 decreases with increasing distance from the steel strip and from the molten-metal surface. This shape of each molten-metal-reducing member 1 most notably provides the effect of branching the flow 11 to form the flow 13 and the effect of forming a flow opposite the flow 12.

[0028] In this case, as shown in Fig. 5(b), each of the shields 2 preferably has concave arcuate surfaces facing the molten-metal-reducing members 1, each of the concave arcuate surfaces having a radius of curvature slightly larger than that of the circular arc of a surface of each molten-metal-reducing member 1 facing the shields 2, and the distance between each molten-metal-reducing member 1 and the corresponding shield 2 is preferably maintained constant.

[0029] Molten-metal-reducing members 1a and 1b shown in Fig. 6(a) each have a roll-covering portion and a steel-strip-facing portion, each of the roll-covering portions being configured to cover the periphery of a corresponding one of the submersed support rolls 5 near to the molten metal surface, and each of the steel-strip-facing portions being arranged above a corresponding one of the steel-strip-facing portions and facing the steel strip. The submersed support rolls 5 are arranged on both sides of the steel strip so as to be in contact with the steel strip, the submersed support rolls 5 being located at different positions in the vertical direction. Thus, the steel-strip-facing portions of the molten-metal-reducing members 1a and 1b arranged on both sides of the steel strip S have different lengths in the travel direction of the steel strip. Each of the steel-strip-facing portions of the molten-metal-reducing members 1a and 1b may be parallel or oblique to the surfaces of the steel strip.

[0030] The arrangement of the molten-metal-reducing members 1a and 1b results in the generation of flows 14 due to the submersed support rolls 5 between the submersed support rolls 5 and the molten-metal-reducing members 1a and 1b. The generation of the flows 14 results in the generation of forced flows 16 between the steel strip S and the molten-metal-reducing members 1a and 1b, the forced flows 16 flowing in the direction opposite to the travel direction of the steel strip S, even when accompanying flows 15 are generated by the travel of the steel strip S, thereby significantly suppressing the accompanying flows 15. This results in a reduction in an excess amount of molten metal sticking to the steel strip S drawn from the molten metal.

[0031] The molten-metal-reducing members may have only the steel-strip-facing portions of the molten-metal-reducing members 1a and 1b shown in Fig. 6(a). In this case, the steel-strip-facing portions of the molten-metal-reducing members 1a and 1b arranged on both sides of the steel strip may have the same length.

[0032] In the case of the molten-metal-reducing members described above or shown in Fig. 6(a), each of the shields 2 may have a rectangular cross section as shown in Fig. 6(b). In this case, the length of the surface of each shield 2 facing the steel strip in the travel direction of the steel strip is preferably at least 50% or more of the length of the steel-strip-facing surfaces of the molten-metal-reducing members in the travel direction of the steel strip (when the steel-strip-facing surfaces of the molten-metal-reducing members in the travel direction of the steel strip have different lengths on both sides of the steel strip, the length of the surface of each shield 2 facing the steel strip in the travel direction of the steel strip is preferably 50% or more of the length of the steel-strip-facing surface of the molten-metal-reducing member having a shorter length of the steel-strip-facing surface in the travel direction of the steel strip). More preferably, the length of the surface of each shield 2 facing the steel strip in the travel direction of the steel strip is comparable to the length of the steel-strip-facing surfaces of the molten-metal-reducing members in the travel direction of the steel strip (when the steel-strip-facing surfaces of the molten-metal-reducing members in the travel direction of the steel strip have different lengths on both sides of the steel strip, the length of the surface of each shield 2 facing the steel strip in the travel direction of the steel strip is more preferably comparable to the length of the steel-strip-facing surface of the molten-metal-reducing member having a shorter length of the steel-strip-facing surface in the travel direction of the steel strip).

[0033] The shape and dimensions of the molten-metal-reducing members need to be appropriately determined in view of the threading speed, facility, and the like.

[0034] The height position of the shields 2 in the travel direction of the steel strip is preferably comparable to that of the molten-metal-reducing members 1. The upper and lower ends of each shield 2 are preferably located at the same vertical positions as those of the upper and lower ends of the molten-metal-reducing members 1. In the case where the length of shields 2 in the travel direction of the steel strip is shorter than the length of the molten-metal-reducing members 1 in the travel direction of the steel strip, the shields 2 are preferably arranged near to the molten-metal surface, i.e., the shields 2 are preferably arranged in such a manner that the upper end of each shield 2 is located at substantially the same position as the upper ends of the molten-metal-reducing members 1. Each of the shields 2 preferably has a length of 100 mm or more in the width direction of the steel strip. Although the upper limit thereof is not limited, the length is preferably about 500 mm or less because a larger length requires a larger facility.

EXAMPLES

[0035] The apparatus for manufacturing a molten metal coated steel strip as shown in Fig. 1 was installed in a continuous hot-dip galvanizing line. An experiment for producing a hot-dip galvanized steel strip was performed. The amount of offset of the submersed support rolls arranged on both sides of the steel strip S was 200 mm in the vertical direction. The distance between the molten-metal surface and the top of the submersed support roll closer to the molten metal surface was 80 mm. Each of the submersed support rolls had a diameter of 400 mm.

[0036] The length of the molten-metal-reducing members 1 in the width direction of the steel strip was 2,000 mm comparable to that of the gas wiping nozzles. The molten-metal-reducing members 1 are securely arranged on both sides of the steel strip so as to face the surfaces of the steel strip and in such a manner that the distance between the upper ends of the molten-metal-reducing members and the molten-metal surface was 5 mm and that the distance between the molten-metal-reducing members 1 and the steel strip was 3 mm (excluding Comparative Example 5 and Example 4). The shields 2 had a length of 200 mm in the width direction of the steel strip. The shields 2 were directly coupled to frames extending from position controllers with servomotors arranged on the outside and were thus movable in response to the width of the steel strip.

[0037] Conditions for manufacturing the hot-dip galvanized steel strip were as follows: the slit gap of each gas wiping nozzle: 0.8 mm, gas wiping nozzle-steel strip distance: 7 mm, nozzle height from the molten zinc surface: 400 mm, and the temperature of the molten zinc bath: 460°C. The steel strip to be manufactured had a thickness of 0.8 mm, a width of 1.2 m, and a coating weight of 45 g/m^2 per side. The distance between the shields 2 and the ends of the steel strip was about 3 mm.

[0038] Table 1 shows other manufacturing conditions and the amount of splashing serving as a product quality index. Shapes and dimensions of the molten-metal-reducing members and the shields used in comparative examples and examples will be described below. The amount of splashing is defined as the ratio of the length of the steel strip determined as a strip having splash defects in an inspection step to the length of the steel strip fed under such production conditions. The resulting steel strips contained practically negligible splash defects.

Table 1

	Operation conditions		Presence or absence and cross-sectional shape of molten-metal-reducing member	Presence or absence and cross-sectional shape of shield	Amount of splashing
	Wiping pressure	Threading speed			
Example 1	0.6 kgf/cm^2	2.5 m/sec	Present (square)	Present (rectangle)	0.72%
Example 2	0.6 kgf/cm^2	2.5 m/sec	Present (triangle, [Fig. 4(a)])	Present ([Fig. 4(b)])	0.28%
Example 3	0.6 kgf/cm^2	2.5 m/sec	Present (arcuate, [Fig. 5(a)])	Present ([Fig. 5(b)])	0.16%
Example 4	0.6 kgf/cm^2	2.5 m/sec	Present (with arcuate roll-covering portion and steel-strip-facing portion parallel to steel strip surface, [Fig. 6(a)])	Present ([Fig. 6(b)])	0.09%
Comparative Example 1	0.6 kgf/cm^2	2.5 m/sec	Absent	Absent	1.40%
Comparative Example 2	0.6 kgf/cm^2	2.5 m/sec	Present (square)	Absent	1.05%
Comparative Example 3	0.6 kgf/cm^2	2.5 m/sec	Present (triangle, [Fig. 4(a)])	Absent	0.41%
Comparative Example 4	0.6 kgf/cm^2	2.5 m/sec	Present (arcuate, [Fig. 5(a)])	Absent	0.23%
Comparative Example 5	0.6 kgf/cm^2	2.5 m/sec	Present (with arcuate roll-covering portion and steel-strip-facing portion parallel to steel strip surface, [Fig. 6(a)])	Absent	0.21%

[0039] In Comparative Example 1 (related example), none of the molten-metal-reducing members and the shields were arranged. The splash rate was 1.40%.

[0040] In Comparative Example 2, only molten-metal-reducing members each having a square cross-section with a length in the travel direction of the steel strip of 50 mm and a length of in the horizontal direction of 50 mm were used. In Example 1, shields each having a rectangular cross-section with a length in the travel direction of the steel strip of 50 mm and a length in the horizontal direction of 4 mm were arranged in addition to the structure in Comparative Example 2 (the distance between the molten-metal-reducing members and the shields was 1 mm). In Comparative Example 2, the splash rate was reduced by about 25% with respect to that in Comparative Example 1. In Example 1, the splash rate was reduced by almost half with respect to that in Comparative Example 1 and by about 31% with respect to Comparative Example 2.

[0041] In Comparative Example 3, only molten-metal-reducing members each having a triangular cross-section with a length in the travel direction of the steel strip of 50 mm and a length of in the horizontal direction of 50 mm were arranged as shown in Fig. 4(a). In Example 2, shields each having a rectangular cross-section with dimensions the same as in Example 1 were arranged as shown in Fig. 4(b) in addition to the structure in Comparative Example 3 (the distance between the molten-metal-reducing members and the shields was 1 mm). In Comparative Example 3, the splash rate was reduced by about 70% with respect to that in Comparative Example 1. In Comparative Example 2, the splash rate was reduced by about 80% with respect to that in Comparative Example 1 and by about 32% with respect to that in Comparative Example 3.

[0042] In Comparative Example 4, only molten-metal-reducing members each having an arcuate cross-section with a length in the travel direction of the steel strip of 50 mm and a length of in the horizontal direction of 50 mm (the upper curve had a radius of curvature of 60 mmR, and the lower curve had a radius of curvature of 100 mmR) were arranged as shown in Fig. 5(a). The distance between bottoms of the molten-metal-reducing members and the steel strip was 3 mm.

[0043] In Example 3, shields each having a cross-sectional shape shown in Fig. 5(b), i.e., shields each having concave arcuate surfaces facing the molten-metal-reducing members were arranged as shown in Fig. 5(b) in addition to the structure in Comparative Example 4, each of the shield having a length in the travel direction of the steel strip of 50 mm, each of the concave arcuate surfaces having a radius of curvature slightly larger than that of the circular arc of a surface of each molten-metal-reducing member facing the shields, and the distance between the shields and the molten-metal-reducing members being 1 mm.

[0044] In Comparative Example 4, the splash rate was reduced by about 84% with respect to that in Comparative Example 1. In Example 3, the splash rate was reduced by about 90% with respect to that in Comparative Example 1 and by about 30% with respect to that in Comparative Example 4.

[0045] In Comparative Example 5, only molten-metal-reducing members 1a and 1b each having an arcuate roll-covering portion and a plate steel-strip-facing portion were arranged as shown in Fig. 6(a), each of the arcuate roll-covering portions covering the periphery of a corresponding one of the submersed support rolls 5 near to the molten metal surface and being arranged in such a manner that the distance between the submersed support rolls 5 and the molten-metal-reducing members 1a and 1b is 30 mm, and each of the plate steel-strip-facing portions being arranged in such a manner that the distance between the steel strip and the molten-metal-reducing members 1a and 1b is fixed to 20 mm and the upper end of the molten-metal-reducing members 1a and 1b and the molten-metal surface is 30 mm.

[0046] In Example 4, shields each having a length in the travel direction of the steel strip of 100 mm and a length in the horizontal direction of 36 mm were arranged as shown in Fig. 6(b) in addition to the structure in Comparative Example 5. The distance between the shields and the molten-metal-reducing members was 2 mm. The rate of the length of each shield in the travel direction of the steel strip to the length of the steel-strip-facing portion of the molten-metal-reducing members 1b in the travel direction of the steel strip was about 90%.

[0047] In Comparative Example 5, the splash rate was reduced by about 85% with respect to that in Comparative Example 1. In Example 4, the splash rate was reduced by about 94% with respect to that in Comparative Example 1 and by about 33% with respect to that in Comparative Example 5.

[0048] As described above, according to the present invention, the thickness of the coating metal can be controlled by the gas wiping nozzles after an excess amount of molten metal sticking to the steel strip is reduced across the entire width of the steel strip using the molten-metal-reducing members and the shields arranged below the molten-metal surface even when the width of the steel strip is changed, thereby significantly reducing the amount of splashing. Furthermore, the amount of splashing can be significantly reduced even at a significantly increased threading speed, thereby manufacturing a surface defect-free molten metal coated steel strip with high productivity.

Industrial Applicability

[0049] The apparatus according to the present invention suppresses the occurrence of splashing and thus can be used as an apparatus for manufacturing a molten metal coated steel strip having excellent surface appearance. The apparatus according to the present invention can suppress the occurrence of splashing even at high-speed threading and thus can be used as an apparatus for manufacturing a molten metal coated steel strip having excellent surface appearance with high productivity. Furthermore, the method for manufacturing a steel strip according to the present invention can be used as a method for manufacturing a molten metal coated steel strip having excellent surface appearance by reducing the occurrence of splashing.

Claims

1. An apparatus for manufacturing a molten metal coated steel strip, the apparatus being configured to control the amount of a metal coated on surfaces of a steel strip by blowing a gas from gas wiping nozzles to the surfaces of the steel strip continuously drawn from a molten metal, comprising molten-metal-reducing members arranged on both sides of the steel strip below the surface of the molten metal in the coating bath so as to face the steel strip, each of the molten-metal-reducing members having a length equal to or longer than the width of the steel strip, and shields arranged between the molten-metal-reducing members each extending along an extension of a corresponding one of the surfaces of the steel strip, the molten-metal-reducing members being arranged so as to face the steel strip.

2. The apparatus for manufacturing a molten metal coated steel strip according to Claim 1, wherein the length of a surface of each of the shields facing the steel strip in the travel direction of the steel strip is 50% or more of the length of a steel-strip-facing surface of each of the molten-metal-reducing members in the travel direction of the steel strip (when the steel-strip-facing surfaces of the molten-metal-reducing members in the travel direction of the steel strip have different lengths on both sides of the steel strip, the length of the surface of each of the shields facing the steel strip in the travel direction of the steel strip is 50% or more of the length of the steel-strip-facing surface of the molten-metal-reducing member having a shorter length of the steel-strip-facing surface in the travel direction of the steel strip), and wherein the distance between the molten-metal-reducing members and the shields is 3 mm or less.

3. A method for manufacturing a molten metal coated steel strip comprising coating a steel strip with a molten metal using the apparatus for manufacturing a molten metal coated steel strip according to Claim 1 or 2.

FIG. 1

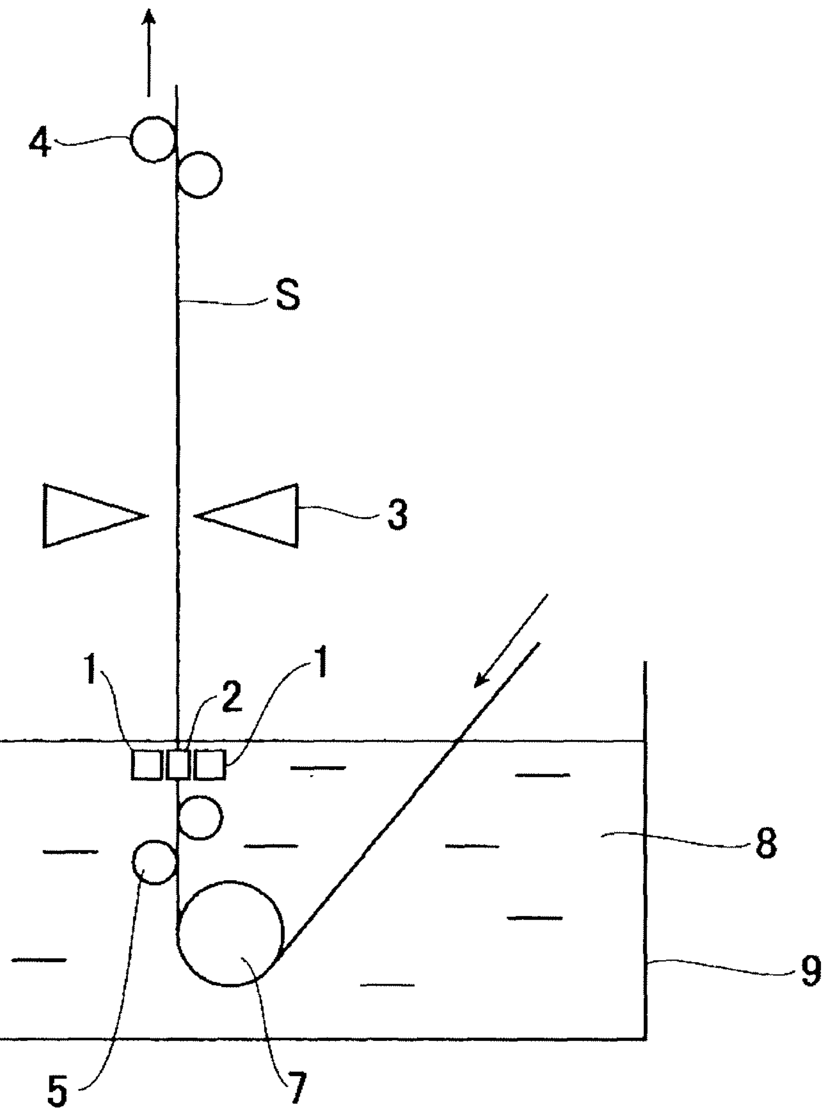


FIG. 2 (a)

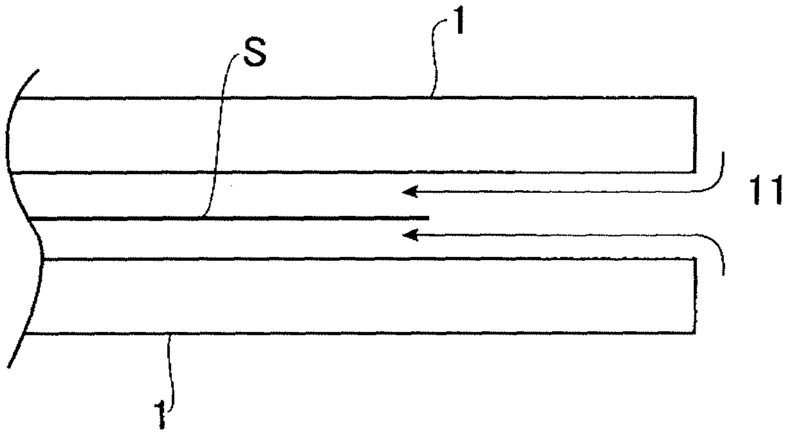


FIG. 2 (b)

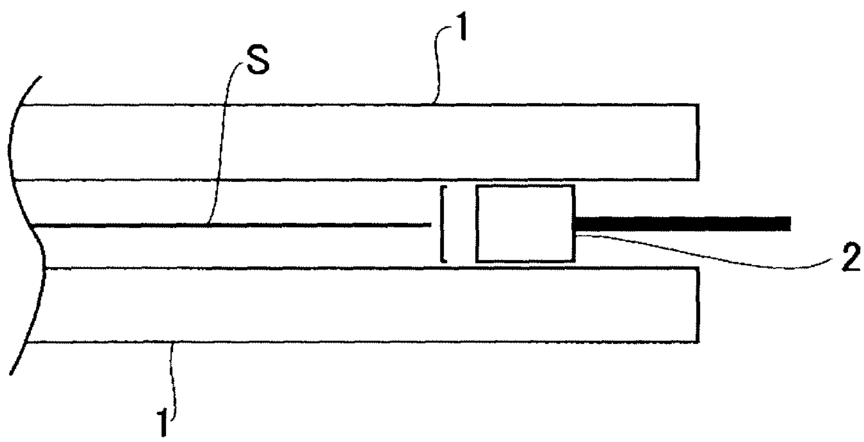


FIG. 3

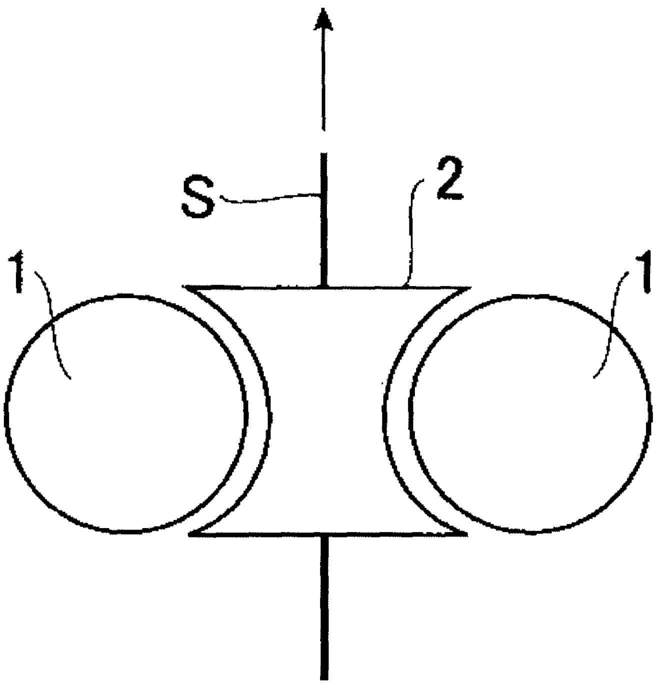


FIG. 4 (a)

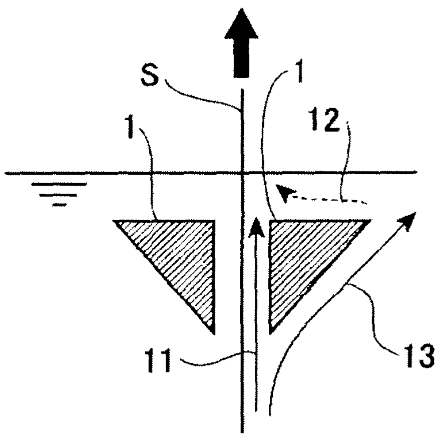


FIG. 4 (b)

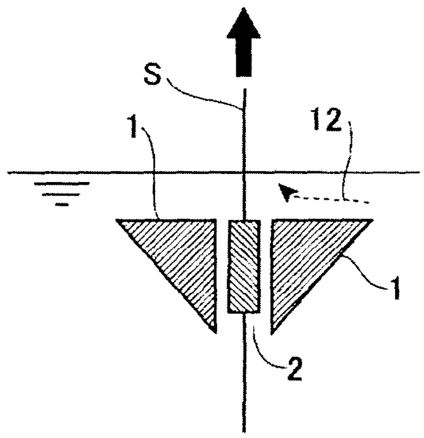


図 5(a)

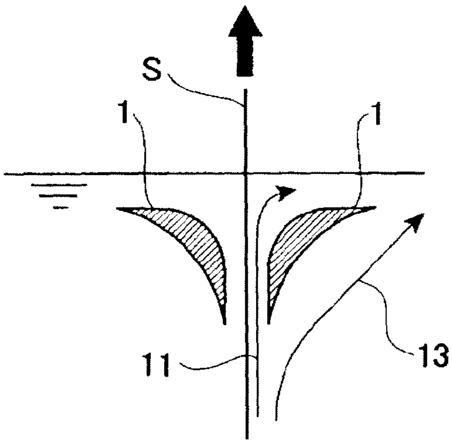


図 5(b)

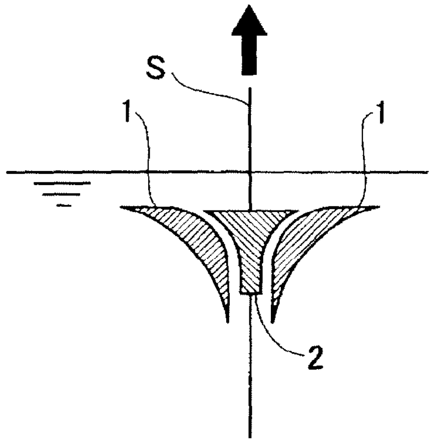


図 6(a)

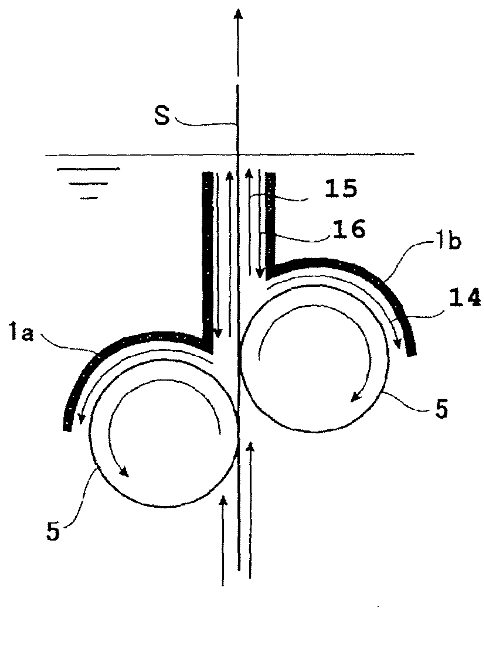


図 6(b)

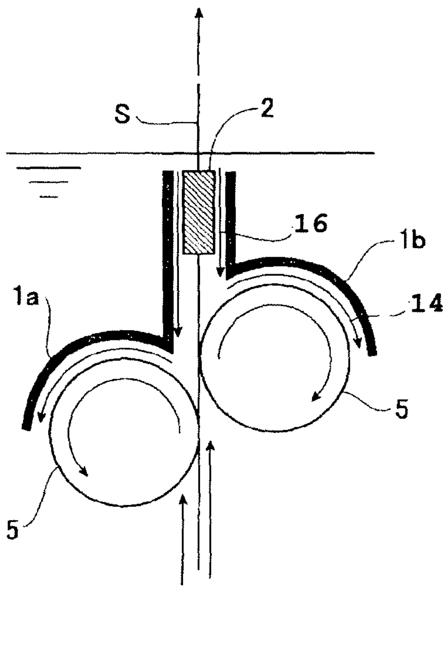
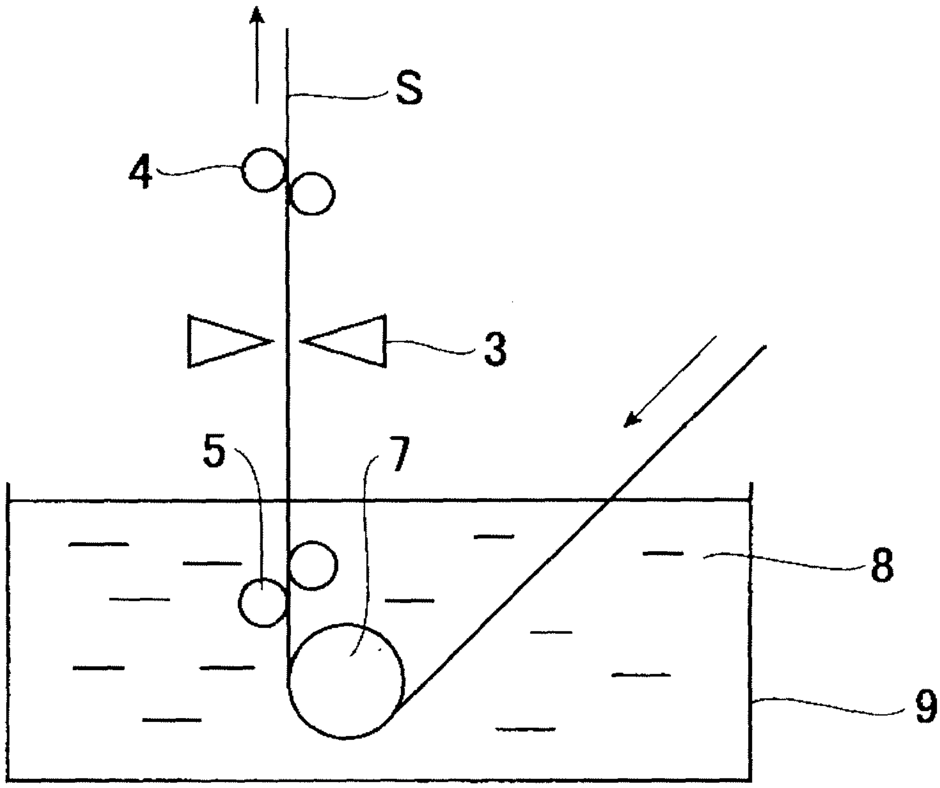


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/068134

A. CLASSIFICATION OF SUBJECT MATTER
C23C2/18(2006.01)i, *C23C2/06*(2006.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C2/00-2/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI (C23C_002_18/ic)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 06-207263 A (NKK Corp.), 26 July, 1994 (26.07.94), Claim 2; Par. No. [0022]; Fig. 2 (Family: none)	1-3 1-3
Y	JP 07-224366 A (NKK Corp.), 22 August, 1995 (22.08.95), Claims 1 to 3; Par. Nos. [0018], [0020]; Figs. 4, 5 (Family: none)	1-3

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
15 October, 2008 (15.10.08)

Date of mailing of the international search report
28 October, 2008 (28.10.08)

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Patent documents cited in the description

- JP 2004076082 A **[0007]**