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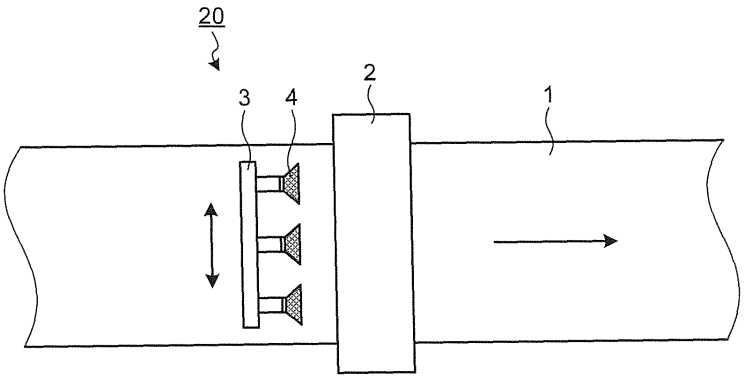
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(54) SLURRY COATING DEVICE AND SLURRY COATING METHOD

(57) A slurry coating device according to one embodiment of the present invention applies slurry on a running band-like body, and includes a slurry dispensing unit configured to be able to feed the slurry on the band-like body. The slurry coating device feeds the slurry on the band-like body by the slurry dispensing unit while varying the relative positional relation of the slurry dispensing unit and the band-like body in a direction substantially parallel to a face of the band-like body and substantially perpendicular to a running direction of the band-like body.

FIG.1



EP 2 848 319 A1

Description

Field

[0001] The present invention relates to a slurry coating device and a slurry coating method that apply, on a grain-oriented electrical steel sheet, slurry that is an annealing separator to prevent seizure at the time of performing high temperature annealing on a coil in which the grain-oriented electrical steel sheet was wound. Background

[0002] Conventionally, a grain-oriented electrical steel sheet is mainly used as iron core material for transformers, power generators, and other electric devices. Thus, the grain-oriented electrical steel sheet is required to have good surface films, in addition to good magnetic characteristics (iron loss).

[0003] The surface film of the steel sheet is composed of a ceramic film referred to as a forsterite film. In forming a forsterite film, with a steel sheet rolled to a given sheet thickness by cold rolling as material, an oxide film (subscale), which is primarily composed of silicon oxide (SiO_2), to be a ground is first formed on the material. Next, after magnesium oxide (MgO) is applied on the oxide film, the steel sheet is wound into a coil shape. Subsequently, in a finish annealing process, heat treatment at a high temperature of 1000°C or higher is performed on the grain-oriented electrical steel sheet in a coil shape. Consequently, SiO_2 and MgO react to each other on the surface of the steel sheet, and a forsterite film (Mg_2SiO_4 film) is formed thereon. The MgO applied on the surface of the steel sheet also serves as an adhesion inhibitor to prevent adhesion between coil layers in the finish annealing process, and is also referred to as an annealing separator. After the finish annealing process, flattening annealing is performed on the steel sheet to correct the shape of the steel sheet and to make it a product.

[0004] The annealing separator such as MgO is generally suspended in water and made into slurry. Then, on the outlet side of a continuous annealing furnace in a decarburization annealing process, feeding nozzles and squeeze rolls apply the slurry to be in a given film thickness on both surfaces of an upper surface and a lower surface of a band-like body. At this time, on the upper surface side of the band-like body, a liquid pool is often formed on the inlet side of the squeeze rolls. Subsequently, after the annealing separator is dried in a drying furnace, the band-like body is wound into a coil.

[0005] Conventionally, as described in Patent Literature 1, these feeding nozzles and squeeze rolls are disposed such that, after the slurry is fed on the band-like body by the feeding nozzles, the film thickness of the slurry can be adjusted by the squeeze rolls such as rough coating rolls and coating rolls. Note that, depending on the required accuracy of film thickness or the restriction of installation space, there may be cases in which only one of the rough coating rolls and the coating rolls are installed, and in which, by further providing nozzles between the rough coating rolls and the coating rolls, the feeding nozzles and the squeeze rolls are configured to supply the slurry by the nozzles.

[0006] Furthermore, as described in Patent Literature 2, there may be a case in which the slurry is fed to the band-like body by the feeding nozzles after the band-like body passes through all of the coating rolls. In this case, a plurality of nozzles that feed the slurry are installed, at intervals of a few 100 millimeters, in a width direction that is a direction perpendicular to the running direction of the band-like body.

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Patent Application Laid-open No. 2004-057971
Patent Literature 2: Japanese Patent Application Laid-open No. S62-067118

Summary

Technical Problem

[0008] Meanwhile, after the flattening annealing in the above-described manufacturing process of steel sheet, there have been cases in which shape defects, which are wrinkle-like and are parallel to the longitudinal direction of the steel sheet, can occur on the band-like body that is the steel sheet. In the band-like body, the portions in which such shape defects have occurred are not made to be a product and thus need to be discarded. Consequently, the occurrence of shape defects results in deterioration in a yield in the manufacture of steel sheet. However, the detail of the mechanism for the occurrence of this wrinkle-like shape defect was not clear, and thus the development of the technology to suppress the occurrence of the wrinkle-like shape defect has been desired.

[0009] In view of the situations in the foregoing, an object of the present invention is to provide a slurry coating device

and a slurry coating method that can suppress the occurrence of wrinkle-like shape defects that are along the longitudinal direction of a steel sheet and are likely to occur after flattening annealing in the manufacture of steel sheet, and can improve the yield in the manufacture of steel sheet.

Solution to Problem

[0010] To solve the above-described problem and achieve the object, a slurry coating device according to the present invention applies slurry on a running band-like body, and includes a slurry dispensing unit configured to be able to feed the slurry on the band-like body, wherein the slurry coating device feeds the slurry on the band-like body by the slurry dispensing unit while varying a relative positional relation of the slurry dispensing unit and the band-like body in a direction substantially parallel to a face of the band-like body and substantially perpendicular to a running direction of the band-like body.

[0011] Moreover, the slurry coating device according to the present invention, in the above-described invention, includes a pair of coating units configured to be able to apply the fed slurry on a surface of the band-like body by holding and pressing the band-like body, wherein the slurry dispensing unit is configured to be able to swing relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body.

[0012] Moreover, the slurry coating device according to the present invention, in the above-described invention, includes a second slurry dispensing unit configured to be able to feed the slurry on the band-like body, wherein the slurry dispensing unit is provided upstream of the pair of coating units along the running direction of the band-like body, and the second slurry dispensing unit is provided downstream of the pair of coating units along the running direction of the band-like body.

[0013] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes the second slurry dispensing unit be configured to be able to swing relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body.

[0014] Moreover, the slurry coating device according to the present invention, in the above-described invention, includes a third slurry dispensing unit configured to be able to feed the slurry on the band-like body, wherein the slurry dispensing unit is provided downstream of the pair of coating units along the running direction of the band-like body, and the third slurry dispensing unit is provided upstream of the pair of coating units along the running direction of the band-like body.

[0015] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes time variation in an amount of swing in the swing be in a square wave form, a sinusoidal wave form, or a triangular wave form.

[0016] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes the slurry coating device that holds the slurry dispensing unit be configured to be able to wholly swing relatively to the band-like body.

[0017] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes a swing frequency of the slurry dispensing unit be set based on a turn pitch of a coil in which the band-like body is wound.

[0018] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes the swing frequency of the slurry dispensing unit be set based on the turn pitch multiplied by an even number.

[0019] Moreover, the slurry coating device according to the present invention, in the above-described invention, includes a band-like body swinging unit configured to be able to swing the band-like body relatively to the slurry dispensing unit in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body, and a pair of coating units configured to be able to apply the fed slurry on a surface of the band-like body by holding and pressing the band-like body.

[0020] Moreover, the slurry coating device according to the present invention, in the above-described invention, includes a pair of second coating units provided downstream of the pair of coating units along the running direction of the band-like body and configured to be able to apply the slurry on the surface of the band-like body by holding and pressing the band-like body.

[0021] Moreover, the slurry coating device according to the present invention, in the above-described invention, includes a second slurry dispensing unit provided downstream of the pair of coating units along the running direction of the band-like body and configured to be able to feed the slurry on the band-like body.

[0022] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes time variation in an amount of swing of the band-like body be in a square wave form, a sinusoidal wave form, or a triangular wave form.

[0023] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes a swing frequency of the band-like body be set based on a turn pitch of a coil in which the band-like body is wound.

[0024] Moreover, the slurry coating device according to the present invention, in the above-described invention, makes the swing frequency of the band-like body be set based on the turn pitch multiplied by an even number.

[0025] Moreover, a slurry coating method according to the present invention applies slurry on a running band-like body, wherein the slurry is fed on the band-like body while varying a relative positional relation of a dispensing spout for the slurry and the band-like body in a direction substantially parallel to a face of the band-like body and substantially perpendicular to a running direction of the band-like body.

[0026] Moreover, the slurry coating method according to the present invention, in the above-described invention, includes a slurry feeding step of feeding the slurry on the band-like body while swinging the dispensing spout relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body, and a slurry coating step of applying the slurry on a surface of the band-like body by holding and pressing the band-like body on which the slurry is fed.

[0027] Moreover, the slurry coating method according to the present invention, in the above-described invention, includes a slurry feeding step of feeding the slurry on the band-like body while swinging the band-like body relatively to the dispensing spout in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body, and a slurry coating step of applying the slurry on a surface of the band-like body by holding and pressing the band-like body on which the slurry is fed.

[0028] Moreover, the slurry coating method according to the present invention, in the above-described invention, includes a second slurry coating step of applying the slurry on the surface of the band-like body by holding and pressing the band-like body on which the slurry is fed after the slurry coating step.

[0029] Moreover, the slurry coating method according to the present invention, in the above-described invention, includes a second slurry feeding step of feeding the slurry on the band-like body after the slurry coating step.

[0030] Moreover, the slurry coating method according to the present invention, in the above-described invention, at the second slurry feeding, feeds the slurry on the band-like body while swinging the dispensing spout for the slurry relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body.

[0031] Moreover, the slurry coating method according to the present invention, in the above-described invention, further includes third slurry feeding to feed the slurry on the band-like body before the slurry feeding, and second slurry coating to apply the slurry on the surface of the band-like body by holding and pressing the band-like body on which the slurry is fed at the third slurry feeding.

[0032] Moreover, the slurry coating method according to the present invention, in the above-described invention, makes time variation in the amount of swing in the swing be in a square wave form, a sinusoidal wave form, or a triangular wave form.

[0033] Moreover, the slurry coating method according to the present invention, in the above-described invention, sets a swing frequency of the swing based on a turn pitch of a coil in which the band-like body is wound.

[0034] Moreover, the slurry coating method according to the present invention, in the above-described invention, sets the swing frequency of the swing based on the turn pitch multiplied by an even number.

[0035] Moreover, the slurry coating method according to the present invention, in the above-described invention, makes time variation in an amount of swing of the band-like body be in a square wave form, a sinusoidal wave form, or a triangular wave form.

[0036] Moreover, the slurry coating method according to the present invention, in the above-described invention, makes a swing frequency of the band-like body be set based on a turn pitch of a coil in which the band-like body is wound.

[0037] Moreover, the slurry coating method according to the present invention, in the above-described invention, makes the swing frequency of the band-like body be set based on the turn pitch multiplied by an even number. Advantageous Effects of Invention

[0038] The slurry coating device and the slurry coating method according to the present invention have an effect in which the occurrence of wrinkle-like shape defects along the longitudinal direction of a steel sheet can be suppressed and the yield in the manufacture of steel sheet can be improved.

Brief Description of Drawings

[0039]

FIG. 1 is a diagram illustrating one example of the configuration of a slurry coating device according to a first embodiment of the invention.

FIG. 2 is a conceptual drawing illustrating a conventional slurry coating device, and film thickness distribution of annealing separator slurry that is applied on the surface of a band-like body.

FIG. 3A is a cross-sectional perspective view of a conventional coil of the band-like body coated with annealing separator slurry.

FIG. 3B is a partial enlarged cross-sectional view of a portion surrounded by a broken line in FIG. 3A.
FIG. 4A is a graphic chart illustrating one example of swing control of a slurry feeding nozzle performed by the slurry coating device in the first embodiment.
FIG. 4B is a graphic chart illustrating another example of the swing control of the slurry feeding nozzle performed by the slurry coating device in the first embodiment.
FIG. 4C is a graphic chart illustrating still another example of the swing control of the slurry feeding nozzle performed by the slurry coating device in the first embodiment.
FIG. 5 is a conceptual drawing illustrating the slurry coating device in the first embodiment, and the film thickness distribution of annealing separator slurry on the surface of a band-like body when the slurry feeding nozzle was controlled in a sinusoidal wave form.
FIG. 6A is a conceptual drawing illustrating the slurry coating device in the first embodiment, and the film thickness distribution of annealing separator slurry on the surface of the band-like body when the slurry feeding nozzle was controlled in a square wave form.
FIG. 6B is a partial enlarged cross-sectional view of the band-like body coated with the annealing separator slurry which was formed in a coil-like condition in the first embodiment.
FIG. 7A is a configuration diagram illustrating a first modification of the slurry coating device in the first embodiment.
FIG. 7B is a configuration diagram illustrating a second modification of the slurry coating device in the first embodiment.
FIG. 7C is a configuration diagram illustrating a third modification of the slurry coating device in the first embodiment.
FIG. 8 is a diagram illustrating one example of the configuration of a slurry coating device according to a second embodiment.
FIG. 9A is a graphic chart illustrating one example of swing control performed on a band-like body in the second embodiment.
FIG. 9B is a graphic chart illustrating another example of the swing control performed on the band-like body in the second embodiment.
FIG. 9C is a graphic chart illustrating yet another example of the swing control performed on the band-like body in the second embodiment.
FIG. 10 is a conceptual drawing illustrating the slurry coating device in the second embodiment, and the film thickness distribution of annealing separator slurry on the surface of the band-like body when the swing control was performed on the band-like body in a sinusoidal wave form.
FIG. 11A is a conceptual drawing illustrating the slurry coating device in the second embodiment, and the film thickness distribution of annealing separator slurry on the surface of a band-like body when the swing control was performed on the band-like body in a square wave form.
FIG. 11B is a partial enlarged cross-sectional view of the band-like body coated with the annealing separator slurry which was formed in a coil-like condition in the second embodiment.
FIG. 12A is a configuration diagram illustrating a first modification of the slurry coating device in the second embodiment.
FIG. 12B is a configuration diagram illustrating a second modification of the slurry coating device in the second embodiment.
FIG. 12C is a configuration diagram illustrating a third modification of the slurry coating device in the second embodiment.

Description of Embodiments

[0040] The following describes preferred embodiments of a slurry coating device and a slurry coating method according to the present invention with reference to the accompanying drawings. Note that, in all of the drawings in the following embodiments, the same or corresponding portions bear the same reference numerals or symbols. Furthermore, the invention is not intended to be limited by the following exemplary embodiments described.

First Embodiment

[0041] First, to make the details of the invention easier to understand, investigations earnestly performed by the inventors will be described. A slurry coating device according to a first embodiment of the invention will be described first. FIG. 1 is a diagram illustrating one example of the configuration of the slurry coating device in the first embodiment.

[0042] As illustrated in FIG. 1, a slurry coating device 20 according to the first embodiment is a device that applies annealing separator slurry 4 on a steel sheet, and includes squeeze rolls 2 and slurry feeding nozzle 3. The slurry feeding nozzle 3 is a slurry dispensing unit including a plurality of dispensing spouts that feed the annealing separator slurry 4 on a band-like body 1 that is a grain-oriented electrical steel sheet. The squeeze rolls 2 are a pair of applicators that

squeezes the annealing separator slurry 4 applied on the band-like body 1 into a given thickness. Although the details will be described later, the slurry feeding nozzle 3 in the first embodiment is configured to be able to swing relatively to the band-like body 1 in a direction substantially parallel to a face of the band-like body 1 and substantially perpendicular to a direction of discharging the band-like body 1 (a running direction of the band-like body 1), that is, a width direction of the band-like body 1.

[0043] In applying the annealing separator slurry 4 by using the slurry coating device 20 thus configured, after the slurry feeding nozzle 3 dispensed and fed the annealing separator slurry 4 on the surface of the band-like body 1, the squeeze rolls 2 hold and press (clamp) the band-like body 1 in the thickness direction thereof, and squeeze the annealing separator slurry 4 applied on the surface of the band-like body 1 down to a given film thickness. Subsequently, the band-like body 1 goes through various processes such as a finish annealing process (secondary recrystallization annealing process), a coating process, and a flattening annealing process, and is eventually made into a product of electrical steel sheet.

[0044] The inventors examined wrinkle-like shape defects formed on the surface of the band-like body 1 after the flattening annealing when a conventional slurry coating device was used. As a result, the inventors have found that, concerning the shape defects, a certain correlation is present between the location of the occurrence along the width direction of the band-like body 1 and the installed position of the slurry feeding nozzle 3 along the width direction. The inventors then focused on the film thickness of the annealing separator slurry 4 being non-uniformly distributed along the width direction of the band-like body 1, and came to evoke that this film thickness distribution influences the shape defects.

[0045] FIG. 2 illustrates the configuration of this conventional slurry coating device, and the film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1 after the annealing separator slurry 4 on the band-like body 1 was squeezed into a given film thickness.

[0046] As illustrated in FIG. 2, when a slurry feeding nozzle 103 of a conventional slurry coating device 100 feeds the annealing separator slurry 4 on the surface of the band-like body 1, it can be considered that the film thickness of the annealing separator slurry 4 is large at positions close to respective dispensing spouts of the slurry feeding nozzle 103 and is small at positions away from them. Thus, the conventional slurry coating device 100 controlled the film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1 and the film thickness distribution of the annealing separator slurry 4 along the longitudinal direction of the band-like body 1. Consequently, the thickness differences in the film thickness of the annealing separator slurry 4 on the surface of the band-like body 1 fall within a given range. However, even when the thickness differences in the film thickness of the annealing separator slurry 4 were made to fall within the given range, it was not possible to avoid the occurrence of the above-described wrinkle-like shape defects.

[0047] According to the findings of the inventors, the occurrence of minute differences in the film thickness distribution of the annealing separator slurry 4 on the surface of the band-like body 1 attributed to the installed positions of the dispensing spouts of the slurry feeding nozzle 103 is unavoidable. In other words, the uneven application of the annealing separator slurry 4, which is composed of crest portions in which the film thickness is relatively large and trough portions in which the film thickness is relatively small, is attributed to the positions of the dispensing spouts of the slurry feeding nozzle 103, and thus it can be considered as an unavoidable phenomenon.

[0048] Consequently, the inventors made a careful investigation and further examined the influence of uneven application of the annealing separator slurry 4 on the occurrence of shape defects.

[0049] The inventors then focused on the point in which, when the band-like body 1 coated with the annealing separator slurry 4 is wound into a coil, the crest portions and the trough portions of the annealing separator slurry 4 on the band-like body 1 are present at the same position in the width direction of the band-like body 1 at all times. FIG. 3A is a cross-sectional perspective view of a conventional coil of the band-like body coated with the annealing separator slurry. In FIG. 3A, illustrated is a cross section of the band-like body 1 along the width direction thereof in a state of a coil 10 in which the band-like body 1 coated with the annealing separator slurry 4 by the slurry feeding nozzle 103 is wound. FIG. 3B is a partial enlarged cross-sectional view illustrating a cross section of the portion surrounded by the broken line in FIG. 3A.

[0050] More specifically, as illustrated in FIG. 3A, when the band-like body 1 is wound into a coil shape to be the coil 10 of a hollow and columnar shape, as illustrated in FIG. 3B, the crest portions of the annealing separator slurry 4 on the surface of the band-like body 1 are layer-stacked in sequence in the radius direction of a circle in the cross section along the longitudinal direction of the band-like body 1 in the coil 10, and what is called buildups arise and the annealing separator slurry 4 projects (inside the surrounding broken lines in FIG. 3B). Then, it can be considered that the buildups at the crest portions of the annealing separator slurry 4 on the surface of the band-like body 1 cause the occurrence of shape defects of the band-like body 1 in the finish annealing process. Note that the positions of streaks by uneven application that are visible after the annealing separator slurry 4 is fed on the surface of the band-like body 1 and the positions of shape defects formed on the surface of the band-like body 1 do not necessarily match.

[0051] From the foregoing, the inventors evoked that, rather than completely suppressing the occurrence of non-

uniform film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1, which is unavoidable, the occurrence of shape defects can be controlled, on the assumption of the occurrence of non-uniform film thickness distribution, if the film thickness distribution can be made as smooth as possible and if the buildups can be suppressed when the band-like body 1 is made into a coil.

[0052] Consequently, the slurry coating device 20 in the first embodiment employs, as illustrated in FIG. 1, a configuration in which the slurry feeding nozzle 3 including a plurality of dispensing nozzles is made to swing relatively to the band-like body 1 in a direction parallel to the face of the band-like body 1 and perpendicular to the running direction of the band-like body 1, that is, along the width direction of the band-like body 1. The slurry feeding nozzle 3 dispenses and feeds the annealing separator slurry 4 on the surface of the band-like body 1 while swinging relatively to the band-like body 1 along the width direction of the band-like body 1. This enables the slurry feeding nozzle 3 to feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing nozzles thereof and the band-like body 1 along the width direction of the band-like body 1 with time.

[0053] FIGS. 4A to 4C are all graphic charts illustrating the examples of the control method of varying the amount of swing over time in swinging the slurry feeding nozzle 3. FIG. 5 is a conceptual drawing illustrating the slurry coating device in the first embodiment, and the film thickness distribution of the annealing separator slurry on the surface of the band-like body when the slurry feeding nozzle was controlled in a sinusoidal wave form. In FIG. 5, illustrated are the configuration diagram of the slurry coating device 20, and the graphic chart illustrating the film thickness distribution of the annealing separator slurry 4 on the surface of the band-like body 1 when the swing of the slurry feeding nozzle 3 was controlled based on the graphic chart illustrated in FIG. 4A.

[0054] The slurry feeding nozzle 3, along the width direction of the band-like body 1, swings in a sinusoidal wave form as illustrated in FIG. 4A, or swings in a triangular wave form as illustrated in FIG. 4B. Consequently, as illustrated in the graphic chart of the film thickness distribution of the annealing separator slurry 4 in FIG. 5, the film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1 is smoother as compared with the conventional case (see FIG. 2) in which the annealing separator slurry 4 is dispensed while the slurry feeding nozzle 3 is fixed without being made to swing. Here, the width of swing of the slurry feeding nozzle 3 illustrated in FIG. 5 is preferably substantially one half the distance between adjacent dispensing spouts out of the dispensing spouts of the slurry feeding nozzle 3. This averages the supply of the annealing separator slurry 4 in the width direction of the band-like body 1 between the dispensing spouts of the slurry feeding nozzle 3.

[0055] Furthermore, the pitch T indicated in FIGS. 4A and 4B is preferably 1 to 150 seconds, and more preferably, 2 to 120 seconds. Thus, as compared with the non-uniformity in the film thickness distribution of the annealing separator slurry 4 illustrated in FIG. 2, as illustrated in FIG. 5, the annealing separator slurry 4 is gently applied on the surface of the band-like body 1 and the crest portions and the trough portions of the annealing separator slurry 4 are modestly formed, and thus the thickness difference in the film thickness distribution is eased and made smooth. Consequently, the occurrence of shape defects on the surface of the band-like body 1 can be prevented. In controlling the slurry feeding nozzle 3 in a triangular wave form, in actuality, as illustrated in FIG. 4B, the waveform may be in a substantially triangular wave form for which the turning end portions thereof are smooth due to the restriction of a swing mechanism, or may be in a trapezoidal wave form as the slurry feeding nozzle 3 stops for a finite time at the turning end portions thereof. However, these swings are included also in the swing in a triangular wave form.

[0056] FIG. 6A is a conceptual drawing illustrating the slurry coating device in the first embodiment, and the film thickness distribution of annealing separator slurry on the surface of the band-like body when the slurry feeding nozzle was controlled in a square wave form. In FIG. 6A, illustrated are the configuration diagram of the slurry coating device 20, and the graphic chart illustrating the film thickness distribution of the annealing separator slurry 4 on the surface of the band-like body 1 for two layers when the amount of swing of the slurry feeding nozzle 3 was controlled based on the graphic chart illustrated in FIG. 4C. FIG. 6B is a partial enlarged cross-sectional view of the band-like body coated with the annealing separator slurry which was formed in a coil-like condition in the first embodiment. In FIG. 6B, illustrated is the layer-stacked structure of the coil 10 that corresponds to FIG. 3B when, after the annealing separator slurry 4 was applied on the surface of the band-like body 1 as illustrated in FIG. 6A, the band-like body 1 was wound into a coil to be the coil 10 illustrated in FIG. 3A.

[0057] As illustrated in FIG. 4C, when the slurry feeding nozzle 3 swings along the width direction of the band-like body 1 in a square wave form, the crest portions and the trough portions of the annealing separator slurry 4, as illustrated in the graphic chart of the film thickness distribution in FIG. 6A, overlap with each other between the two layers of the layer-stacked band-like body 1 at the time the band-like body 1 is formed into the coil 10. Here, the width of swing of the slurry feeding nozzle 3 is preferably substantially one half the distance between adjacent dispensing spouts out of the dispensing spouts thereof.

[0058] Furthermore, the pitch T indicated in FIG. 4C is preferably 1 to 150 seconds, and more preferably, 2 to 120 seconds. This is because, when the time variation in the amount of swing of the slurry feeding nozzle 3 is controlled in a square wave form, if the pitch T is too shorter than one second, the non-uniformity in the film thickness of the annealing separator slurry 4 as illustrated in FIG. 2 remains. If the pitch T is too longer than 150 seconds, the shift amount for each

winding is small at the time the band-like body 1 is made into the coil 10 and the crest portions and the trough portions of the annealing separator slurry 4 do not overlap with each other between two layers, whereby the buildups as illustrated in FIG. 3 arise. Even when the swing of the slurry feeding nozzle 3 is controlled in a square wave form, it is difficult to move the nozzle instantly along the width direction as the moving velocity of the slurry feeding nozzle 3 is limited, and thus the actual swing is substantially in a trapezoidal wave form. However, this swing is also included in the swing in a square wave form.

[0059] Consequently, as illustrated in FIG. 6B, the crest portions and the trough portions in the film thickness distribution of the annealing separator slurry 4 are layer-stacked in sequence in the radial direction of a circle in the cross section along the longitudinal direction of the band-like body 1 in the coil 10, and the above-described buildups can be prevented. Thus, the occurrence of shape defects on the band-like body 1 can be suppressed.

[0060] As for the swing of the slurry feeding nozzle 3, making only the slurry feeding nozzle 3 swing is simple. However, it is not limited to this. More specifically, the whole slurry coating device 20, which holds the slurry feeding nozzle 3, may be made to swing relatively to the running band-like body 1 to swing the slurry feeding nozzle 3 with respect to the band-like body 1, and subsidiary facilities such as coating rolls of the slurry coating device 20 may be made to swing together.

Modifications in First Embodiment

[0061] Next, the configurations of slurry coating devicees in a separator coating process, to which the device configuration in the foregoing first embodiment is applicable, will be described. FIGS. 7A, 7B, and 7C are configuration diagrams illustrating a first modification, a second modification, and a third modification, respectively, of the slurry coating device in the first embodiment.

First Modification in First Embodiment

[0062] As illustrated in FIG. 7A, a slurry coating device 21 according to the first modification in the first embodiment includes rough coating rolls 2a, a pair of backup rolls 2b, a pair of coating rolls 2c, and a pair of before-rough coating roll nozzles 3a. The pair of before-rough coating roll nozzles 3a is a pair of slurry dispensing units that dispenses and feeds the annealing separator slurry 4 onto both surfaces of the band-like body 1. The pair of rough coating rolls 2a is a pair of applicators that coarsely applies the annealing separator slurry 4 fed by the pair of before-rough coating roll nozzles 3a onto both surfaces of the band-like body 1 by pressing (clamping) the band-like body 1 while holding the band-like body 1 in the thickness direction thereof. The pair of coating rolls 2c is an applicator that is supported by the pair of backup rolls 2b provided on both surface sides of the band-like body 1, and squeezes the coarsely applied annealing separator slurry 4. In the slurry coating device 21 in the first modification, the before-rough coating roll nozzles 3a are configured to be able to swing relatively to the band-like body 1 along the width direction (direction perpendicular to the drawing in FIG. 7A) of the band-like body 1. The before-rough coating roll nozzles 3a dispense and feed the annealing separator slurry 4 on both surfaces of the band-like body 1 while swinging in this way. Consequently, the before-rough coating roll nozzles 3a can feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing spouts thereof and the band-like body 1 along the width direction of the band-like body 1 with time.

Second Modification in First Embodiment

[0063] A slurry coating device 22 according to the second modification in the first embodiment includes, as illustrated in FIG. 7B, downstream of the before-rough coating roll nozzle 3a as the same slurry dispensing unit of the slurry coating device 21 in the first modification or as a second or a third slurry dispensing unit and upstream of the pair of coating rolls 2c in the running direction of the band-like body 1, a before-coating roll nozzle 3b as a slurry dispensing unit or as the third or the second slurry dispensing unit on one surface side of the band-like body 1. In the slurry coating device 22, at least one of the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b is configured to be able to swing relatively to the band-like body 1 along the width direction (direction perpendicular to the drawing in FIG. 7B) of the band-like body 1. At least one of the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b dispenses and feeds the annealing separator slurry 4 on both surfaces of or one surface of the band-like body 1 while swinging in this way. Consequently, at least one of the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b can feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing spouts thereof and the band-like body 1 along the width direction of the band-like body 1 with time.

Third Modification in First Embodiment

[0064] A slurry coating device 23 according to the third modification in the first embodiment, as illustrated in FIG. 7C,

has the same configuration as that of the slurry coating device 21 in the first modification, and in addition, includes an after-coating roll nozzle 3c as a second slurry dispensing unit downstream of the pair of coating rolls 2c in the running direction of the band-like body 1. In the slurry coating device 23 in the third modification, at least one of the before-rough coating roll nozzles 3a and the after-coating roll nozzle 3c is configured to be able to swing relatively to the band-like body 1 along the width direction (direction perpendicular to the drawing in FIG. 7C) of the band-like body 1. At least one of the before-rough coating roll nozzles 3a and the after-coating roll nozzle 3c dispenses and feeds the annealing separator slurry 4 on both surfaces of or one surface of the band-like body 1 while swinging in this way. Consequently, at least one of the before-rough coating roll nozzles 3a and the after-coating roll nozzle 3c can feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing spouts thereof and the band-like body 1 along the width direction of the band-like body 1 with time.

[0065] Next, the following describes examples based on the above-described second modification in the first embodiment and comparative examples based on the conventional technology. Note that the invention is not intended to be limited by the examples.

Examples 1 to 30 and Comparative Example 1

[0066] In examples 1 to 30 and a comparative example 1, a cold-rolled grain-oriented electrical steel sheet of a final sheet thickness of 0.3 millimeters containing 3.4 weight percent silicon (Si) is used as the band-like body 1. After decarburization annealing was performed on the band-like body 1, the annealing separator slurry 4 was then applied on the band-like body 1 by using the slurry coating device 22 of the above-described second modification in the first embodiment. More specifically, by the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b, magnesium oxide (MgO) is applied on both surfaces of the band-like body 1 with the applying weight of 7.0 g/m^2 as the coating amount of the annealing separator slurry 4 per one surface. Subsequently, after the band-like body 1 is wound into the coil 10, finish annealing is performed on the coil 10 in a temperature condition of 1200°C. After the finish annealing, in a flattening annealing furnace, a shape correction of the band-like body 1 is performed under the condition in which the temperature is at 850°C. Then, on the shape-corrected band-like body 1, the presence of shape defects along the longitudinal direction was inspected visually.

[0067] In these examples 1 to 30, the swing of at least one of the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b at the time the annealing separator slurry 4 is applied on the surface of the band-like body 1 is performed in the following manner.

[0068] In the examples 1 to 5, only the before-rough coating roll nozzles 3a are made to swing by controlling the time variation in the amount of swing thereof in a sinusoidal wave form with the pitch T indicated in FIG. 4A of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 6 to 10, only the before-coating roll nozzle 3b is made to swing by controlling the time variation in the amount of swing thereof in a sinusoidal wave form with the pitch T indicated in FIG. 4A of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 11 to 15, only the before-rough coating roll nozzles 3a are made to swing by controlling the time variation in the amount of swing thereof in a square wave form with the pitch T indicated in FIG. 4C of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 16 to 20, only the before-coating roll nozzle 3b is made to swing by controlling the time variation in the amount of swing thereof in a square wave form with the pitch T indicated in FIG. 4C of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 21 to 25, the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b are both made to swing by controlling the time variation in the amount of swing thereof in a sinusoidal wave form with the pitch T indicated in FIG. 4A of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 26 to 30, the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b are both made to swing by controlling the time variation in the amount of swing thereof in a square wave form with the pitch T indicated in FIG. 4C of 1, 2, 60, 120, and 150 seconds, respectively. Furthermore, in the comparative example 1, as is conventionally performed, without making the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b swing, the annealing separator slurry 4 is applied on the surface of the band-like body 1. Table 1 is a table representing the results of the examples 1 to 30 and the comparative example 1.

Table 1

Examples	Before-Rough Coating Roll Nozzles			Before-Coating Roll Nozzle			Shape Defects
	Swing	Waveform	Pitch	Swing	Waveform	Pitch	
1	Present	Sinusoidal	1 sec.	None	-	-	Reduced
2	Present	Sinusoidal	2 sec.	None	-	-	None
3	Present	Sinusoidal	60 sec.	None	-	-	None
4	Present	Sinusoidal	120 sec.	None	-	-	None

(continued)

Examples	Before-Rough Coating Roll Nozzles			Before-Coating Roll Nozzle			Shape Defects
	Swing	Waveform	Pitch	Swing	Waveform	Pitch	
5	Present	Sinusoidal	150 sec.	None	-	-	Reduced
6	None	-	-	Present	Sinusoidal	1 sec.	Reduced
7	None	-	-	Present	Sinusoidal	2 sec.	None
8	None	-	-	Present	Sinusoidal	60 sec.	None
9	None	-	-	Present	Sinusoidal	120 sec.	None
10	None	-	-	Present	Sinusoidal	150 sec.	Reduced
11	Present	Square	1 sec.	None	-	-	Reduced
12	Present	Square	2 sec.	None	-	-	None
13	Present	Square	60 sec.	None	-	-	None
14	Present	Square	120 sec.	None	-	-	None
15	Present	Square	150 sec.	None	-	-	Reduced
16	None	-	-	Present	Square	1 sec.	Reduced
17	None	-	-	Present	Square	2 sec.	None
18	None	-	-	Present	Square	60 sec.	None
19	None	-	-	Present	Square	120 sec.	None
20	None	-	-	Present	Square	150 sec.	Reduced
21	Present	Sinusoidal	1 sec.	Present	Sinusoidal	1 sec.	Reduced
22	Present	Sinusoidal	2 sec.	Present	Sinusoidal	2 sec.	None
23	Present	Sinusoidal	60 sec.	Present	Sinusoidal	60 sec.	None
24	Present	Sinusoidal	120 sec.	Present	Sinusoidal	120 sec.	None
25	Present	Sinusoidal	150 sec.	Present	Sinusoidal	150 sec.	Reduced
26	Present	Square	1 sec.	Present	Square	1 sec.	Reduced
27	Present	Square	2 sec.	Present	Square	2 sec.	None
28	Present	Square	60 sec.	Present	Square	60 sec.	None
29	Present	Square	120 sec.	Present	Square	120 sec.	None
30	Present	Square	150 sec.	Present	Square	150 sec.	Reduced
Comparative Example 1	None	-	-	None	-	-	Present

[0069] Table 1 can tell that, in the examples 1 to 30, the occurrence of shape defects on the grain-oriented electrical steel sheet that is the band-like body 1 is not present at all, or is reduced as compared with the conventional case. In contrast, in the comparative example 1, it can tell that shape defects occurred. From the comparisons of the examples 1 to 30 with the comparative example 1, it can tell that, as in the examples 1 to 30, making at least one of the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b swing relatively to the band-like body 1 along the width direction of the band-like body 1 can suppress the occurrence of shape defects on the grain-oriented electrical steel sheet.

[0070] In Table 1, it can further tell that, when the examples in which shape defects are reduced and the examples in which no shape defects is present are compared, no shape defects are to occur on the grain-oriented electrical steel sheet by applying the annealing separator slurry 4 while making at least one of the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b swing with the pitch T of 2 to 120 seconds. Consequently, it suggests that the pitch T in the swing of the slurry feeding nozzle 3 is preferably 2 to 120 seconds.

Examples 31 to 36 and Comparative Example 2

[0071] In examples 31 to 36 and a comparative example 2, a cold-rolled grain-oriented electrical steel sheet of a final sheet thickness of 0.23 millimeters containing 3.4 weight percent silicon (Si) is used as the band-like body 1. After decarburization annealing was performed on the band-like body 1, the annealing separator slurry 4 was then applied on the band-like body 1 by using the slurry coating device 22 of the above-described second modification in the first embodiment. More specifically, by the before-rough coating roll nozzles 3a and the before-coating roll nozzle 3b, magnesium oxide (MgO) is applied on both surfaces of the band-like body 1 with the applying weight of 7.0 g/m^2 as the coating amount of the annealing separator slurry 4 per one surface. Subsequently, after the band-like body 1 is wound into the coil 10, finish annealing is performed on the coil 10 in a condition at a temperature of 1200°C. After the finish annealing, in a flattening annealing furnace, a shape correction of the band-like body 1 is performed under the condition in which the temperature is at 850°C. Then, on the shape-corrected band-like body 1, the presence of shape defects along the longitudinal direction was inspected visually.

[0072] In these examples 31 to 36, at the time the annealing separator slurry 4 was applied on the surface of the band-like body 1, the before-rough coating roll nozzles 3a were made to swing based on the following technical ideas.

[0073] The effect of making the coating nozzle for the annealing separator slurry 4 swing in the width direction of the steel sheet in the invention is to promote the uniformity in the coating amount of the annealing separator slurry 4 on the steel sheet by dispersing the minute variations in the coating amount of the annealing separator slurry 4, which are attributed to the placement of the coating nozzle, in the width direction of the steel sheet. It is further conceivable that, because the steel sheet is wound into a coil after the annealing separator slurry 4 is applied, it is more preferable that the combination of the coating amount of the adjacent or neighboring annealing separator slurry 4 on the steel sheet in the radial direction of the coil be made uniform.

[0074] It is evoked that, when based on such ideas, it is preferable to vary the swing period of the coating nozzle for the annealing separator slurry 4 by considering the turn pitch of the coil of the steel sheet. In the first embodiment, the coating nozzle is made to swing one period not for each one turn pitch but for each two turn pitches. The inventors found that this had a possibility in which the total of the coating amount of the annealing separator slurry 4 between the layers of the steel sheet in a coil condition is further homogenized in the width direction of the steel sheet.

[0075] Consequently, in the examples 31 to 36, the ratio (V/2L) of the line velocity V of the band-like body 1 and twice the turn pitch L of the coil 10 is defined as a turn-pitch frequency (in unit of "Hz"), and the line velocity V and the coil diameter of the coil 10 were set such that the turn-pitch frequency was to be 0.665 Hz. At this time, the annealing separator slurry 4 was applied on the surface of the band-like body 1 while the swing frequency of the before-rough coating roll nozzles 3a was varied within the range of 0.010 to 1.000 Hz. Furthermore, the time variation in the amount of swing of the before-rough coating roll nozzles 3a was controlled in a sinusoidal wave form. Meanwhile, in the comparative example 2, as is conventionally performed, without making the before-rough coating roll nozzles 3a swing, the annealing separator slurry 4 was applied on the surface of the band-like body 1. Table 2 represents the respective inspection results of shape defects in the foregoing examples 31 to 36 and the comparative example 2.

Table 2

	Swing	Ratio (V/2L)	SwingFrequency	Shape Defects
Example 31	Present	0.665 Hz	1.000 Hz	None
Example 32	Present	0.665 Hz	0.665 Hz	None
Example 33	Present	0.665 Hz	0.500 Hz	None
Example 34	Present	0.665 Hz	0.050 Hz	Reduced
Example 35	Present	0.665 Hz	0.025 Hz	Reduced
Example 36	Present	0.665 Hz	0.010 Hz	Reduced
Comparative Example 2	None	-	-	Present

[0076] Table 2 can tell that, in the examples 31 to 36, the occurrence of shape defects on the band-like body 1 (grain-oriented electrical steel sheet) is not present at all, or is reduced as compared with the conventional case. In the examples 31 to 33, it can further tell that, when the swing frequency of the before-rough coating roll nozzles 3a is in a condition of being close to the turn-pitch frequency, that is, being at the same value as or in the neighborhood of 0.665 Hz, the shape defects of the band-like body 1 do not occur. In contrast, in the comparative example 2, it can tell that shape defects of the band-like body 1 occurred.

[0077] While the time variation in the amount of swing of the before-rough coating roll nozzles 3a was controlled in a

sinusoidal wave form in the examples 31 to 36, even when the time variation in the amount of swing was controlled in a square wave form or in a triangular wave form, no difference was observed in the inspection results of the shape defects of the band-like body 1.

[0078] Furthermore, in the examples 31 to 36, represented were the results when the turn-pitch frequency is at 0.665 Hz. However, even if the turn-pitch frequency is at a value other than 0.665 Hz, the same results as those when the turn-pitch frequency is at 0.665 Hz were obtained by bringing the swing frequency of the before-rough coating roll nozzles 3a close to the turn-pitch frequency.

[0079] Moreover, in the examples 31 to 36, the turn-pitch frequency was set based on twice the turn pitch as in the foregoing, and the swing of the before-rough coating roll nozzles 3a was controlled based on this turn-pitch frequency. This obtained good results as represented in Table 2. However, even in a coating condition in which such an idea was amplified, more specifically, the turn-pitch frequency was set based on the turn pitch multiplied by an even number and the before-rough coating roll nozzles 3a were made to swing matching the turn-pitch frequency thus set, the same effect was obtained.

[0080] In accordance with the first embodiment of the invention in the foregoing, the slurry feeding nozzle 3 is made to swing along the width direction of the band-like body 1 at the time the annealing separator slurry 4 is applied on the surface of the band-like body 1 by using the slurry feeding nozzle 3. This makes the non-uniformity in the film thickness distribution of the annealing separator slurry 4 along the width direction smooth, and the buildups can be prevented even when the band-like body 1 is wound into the coil 10. Thus, it is possible to suppress the occurrence of wrinkle-like shape defects that are along the longitudinal direction of a steel sheet and are likely to occur after the flattening annealing in the manufacture of steel sheet, more specifically, the occurrence of the above-described shape defects on the band-like body 1. As a consequence, the yield in the manufacture of steel sheet can be improved.

Second Embodiment

[0081] The following describes a second embodiment of the invention. In the first embodiment in the foregoing, a slurry dispensing unit such as the slurry feeding nozzle 3 has been made to swing relatively to the band-like body 1 along the width direction of the band-like body 1, thereby feeding the annealing separator slurry 4 onto the band-like body 1 while the relative positional relation of the band-like body 1 and the slurry dispensing unit along the width direction of the band-like body 1 was varied over time. In contrast, in the second embodiment, the band-like body 1 is made to swing relatively to the slurry dispensing unit along the width direction of the band-like body 1, thereby feeding the annealing separator slurry 4 onto the band-like body 1 while the relative positional relation of the band-like body 1 and the slurry dispensing unit along the width direction of the band-like body 1 is varied over time.

[0082] First, a slurry coating device according to the second embodiment will be described. FIG. 8 is a diagram illustrating one example of the configuration of the slurry coating device in the second embodiment.

[0083] As illustrated in FIG. 8, a slurry coating device 30 according to the second embodiment is a device that applies annealing separator slurry on a steel sheet, and includes squeeze rolls 12, a slurry feeding nozzle 13, and band-like body conveying rolls 15. The slurry feeding nozzle 13 is a slurry dispensing unit including a plurality of dispensing spouts that feed the annealing separator slurry 4 on the band-like body 1 that is a grain-oriented electrical steel sheet. The squeeze rolls 12 are a pair of applicators that clamps the band-like body 1 in the thickness direction thereof and squeezes the annealing separator slurry 4 applied on the band-like body 1 into a given thickness. The band-like body conveying rolls 15 are each a band-like body conveying unit that is structured in a columnar shape, for example, and is configured to be able to convey the band-like body 1 by rotating around the central axis of the circle of the column. Although the details will be described later, the squeeze rolls 12 and the band-like body conveying rolls 15 in the second embodiment are a band-like body conveying unit that is configured to be able to swing the band-like body 1 relatively to the slurry dispensing unit in a direction substantially parallel to the surface of the band-like body 1 and substantially perpendicular to the running direction of the band-like body 1, that is, the width direction of the band-like body 1.

[0084] In applying the annealing separator slurry 4 by using the slurry coating device 30 thus configured, the slurry feeding nozzle 13 first dispenses and feeds the annealing separator slurry 4 on the surface of the band-like body 1. Then, the squeeze rolls 12 hold and press the band-like body 1 in the thickness direction thereof, and squeeze the annealing separator slurry 4 applied on the surface of the band-like body 1 into a given thickness. Subsequently, the band-like body 1 goes through various processes such as a finish annealing process (secondary recrystallization annealing process), a coating process, and a flattening annealing process, and is eventually made into a product of electrical steel sheet.

[0085] In the second embodiment also, the inventors examined wrinkle-like shape defects formed on the surface of the band-like body 1 after the flattening annealing process as the same as that done in the above-described first embodiment. As a result, the inventors have found that, concerning the shape defects, a certain correlation is present between the location of the occurrence along the width direction of the band-like body 1 and the installed position of the slurry feeding nozzle 13 along the width direction. The inventors then focused on the film thickness of the annealing

separator slurry 4 being non-uniformly distributed along the width direction of the band-like body 1, and came to evoke that this film thickness distribution influences the shape defects.

[0086] As illustrated in FIG. 2 in the foregoing, when the slurry feeding nozzle 103 of the conventional slurry coating device 100 feeds the annealing separator slurry 4 on the surface of the band-like body 1, the film thickness of the annealing separator slurry 4 is large at positions close to the respective dispensing spouts of the slurry feeding nozzle 103 and is small at positions away from them. Thus, the conventional slurry coating device 100, as in the foregoing, controlled the film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1 and the film thickness distribution of the annealing separator slurry 4 along the longitudinal direction of the band-like body 1. Consequently, the thickness differences in the film thickness of the annealing separator slurry 4 on the surface of the band-like body 1 fall within a given range. Even when the thickness differences in the film thickness of the annealing separator slurry 4 were made to fall within the given range, however, it was not possible to avoid the occurrence of the above-described wrinkle-like shape defects.

[0087] According to the findings of the inventors, uneven application of the annealing separator slurry 4, which is composed of crest portions in which the film thickness is relatively large and trough portions in which the film thickness is relatively small, is attributed to the positions of the dispensing spouts of the slurry feeding nozzle 103 as in the foregoing, and thus it can be considered as an unavoidable phenomenon.

[0088] Consequently, the inventors made a careful investigation and further examined the influence of uneven application of the annealing separator slurry 4 on the occurrence of shape defects. As a result, the inventors evoked that, as the same as that in the first embodiment, rather than completely suppressing the occurrence of non-uniform film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1, which is unavoidable, the occurrence of shape defects can be controlled, on the assumption of the occurrence of non-uniform film thickness distribution, if the film thickness distribution can be made as smooth as possible and if the buildups can be suppressed when the band-like body 1 is made into a coil.

[0089] Consequently, as illustrated in FIG. 8, the slurry coating device 30 in the second embodiment employs a configuration in which the band-like body 1 is made to swing, by the squeeze rolls 12 and the band-like body conveying rolls 15, relatively to the slurry feeding nozzle 3 in a direction parallel to the face of the band-like body 1 and perpendicular to the running direction of the band-like body 1, that is, along the width direction of the band-like body 1. In the slurry coating device 30 thus configured, the slurry feeding nozzle 13 dispenses and feeds the annealing separator slurry 4 on the surface of the band-like body 1 that is swinging and running while the squeeze rolls 12 and the band-like body conveying rolls 15 make the band-like body 1 swing along the width direction of the band-like body 1 relatively to the slurry feeding nozzle 13. This enables the slurry feeding nozzle 13 to feed the annealing separator slurry 4 onto the band-like body 1 while varying the relative positional relation of the dispensing nozzles thereof and the band-like body 1 along the width direction of the band-like body 1 with time.

[0090] FIGS. 9A to 9C are all graphic charts illustrating the examples of time variation in the amount of swing in the swing control for the band-like body 1 at the time the band-like body 1 is made to swing by the squeeze rolls 12 and the band-like body conveying rolls 15. FIG. 10 is a conceptual drawing illustrating the slurry coating device in the second embodiment, and the film thickness distribution of annealing separator slurry on the surface of the band-like body when the swing control was performed on the band-like body in a sinusoidal wave form. In FIG. 10, illustrated are the configuration diagram of the slurry coating device 30, and the graphic chart illustrating the film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1 when the swing control was performed on the band-like body 1 based on the graphic chart illustrated in FIG. 9A.

[0091] The squeeze rolls 12 and the band-like body conveying rolls 15 make the band-like body 1 swing in a sinusoidal wave form as illustrated in FIG. 9A along the width direction of the band-like body 1, or make it swing in a triangular wave form as illustrated in FIG. 9B. Consequently, as is apparent when a broken line portion and a bold line portion in the graphic chart of the film thickness distribution of the annealing separator slurry 4 illustrated in FIG. 10 are compared, the film thickness distribution of the annealing separator slurry 4 along the width direction of the band-like body 1 is smoother as compared with the conventional case (see FIG. 2 and the broken line portion in the graphic chart in FIG. 10) in which the annealing separator slurry 4 is dispensed in a condition of the band-like body 1 being conveyed without being made to swing. Here, the width of swing of the band-like body 1 illustrated in FIG. 10 is preferably substantially one half the distance between adjacent dispensing spouts out of the dispensing spouts of the slurry feeding nozzle 13. This can average the supply of the annealing separator slurry 4 in the width direction of the band-like body 1 between the dispensing spouts of the slurry feeding nozzle 13.

[0092] Furthermore, the pitch T as a swing period of the band-like body 1 indicated in FIGS. 9A and 9B is preferably 1 to 150 seconds, and more preferably, 2 to 120 seconds. Consequently, as compared with the non-uniformity in the film thickness distribution of the annealing separator slurry 4 illustrated in FIG. 2, as illustrated in FIG. 10, the annealing separator slurry 4 is gently applied on the surface of the band-like body 1 and the crest portions and the trough portions of the annealing separator slurry 4 are modestly formed. Thus, the thickness differences in the film thickness distribution of the annealing separator slurry 4 are eased and made smooth, and as a result, the occurrence of shape defects on

the surface of the band-like body 1 can be prevented. In performing the swing control on the band-like body 1 in a triangular wave form, in actuality, as illustrated in FIG. 9B, the waveform may become a substantially triangular wave form for which the turning end portions thereof are smooth due to the restriction of a swing mechanism, or may become a trapezoidal wave form as the band-like body 1 is made to stop at the turning end portions thereof for a finite time. However, these swings are included also in the swing in a triangular wave form.

[0093] FIG. 11A is a conceptual drawing illustrating the slurry coating device in the second embodiment, and the film thickness distribution of annealing separator slurry on the surface of the band-like body when the swing control was performed on the band-like body in a square wave form. In FIG. 11A, illustrated are the configuration diagram of the slurry coating device 30, and the graphic chart illustrating the film thickness distribution of the annealing separator slurry 4 on the surface of the band-like body 1 for two layers when the swing control was performed on the band-like body 1 based on the graphic chart illustrated in FIG. 9C. FIG. 11B is a partial enlarged cross-sectional view of the band-like body coated with the annealing separator slurry which was formed in a coil-like condition in the second embodiment. In FIG. 11B, illustrated is the layer-stacked structure of the coil 10 that corresponds to FIG. 3B when, after the annealing separator slurry 4 was applied on the surface of the band-like body 1 as illustrated in FIG. 11A, the band-like body 1 was wound into a coil to be the coil 10 illustrated in FIG. 3A.

[0094] As illustrated in FIG. 9C, when the band-like body 1 swings along the width direction of the band-like body 1 in a square wave form, as illustrated in the graphic chart of the film thickness distribution in FIG. 11A, the crest portions and the trough portions of the annealing separator slurry 4 overlap with each other between the two layers of the layer-stacked band-like body 1 at the time the band-like body 1 was formed into the coil 10. Here, the width of swing of the band-like body 1 is preferably substantially one half the distance between adjacent dispensing spouts out of the dispensing spouts of the slurry feeding nozzle 13.

[0095] Furthermore, the pitch T that is a swing period of the band-like body 1 indicated in FIG. 9C is preferably 1 to 150 seconds, and more preferably, 2 to 120 seconds. This is because, when the time variation in the amount of swing of the band-like body 1 is controlled in a square wave form, if the pitch T is too shorter than one second, the non-uniformity in the film thickness of the annealing separator slurry 4 as illustrated in FIG. 2 remains. If the pitch T is too longer than 150 seconds, the amount of shift for each winding is small at the time the band-like body 1 is made into the coil 10, and the crest portions and the trough portions of the annealing separator slurry 4 between two layers do not overlap with each other appropriately, whereby the buildups as illustrated in FIG. 3B arise. In actuality, when the swing control is performed on the band-like body 1 in a square wave form, it is difficult to move the band-like body 1 along the width direction thereof instantly as the moving velocity of the band-like body 1 is limited, and thus the swing of the band-like body 1 itself is substantially in a trapezoidal wave form. However, such swing control is also included in the swing in a square wave form.

[0096] Consequently, as illustrated in FIG. 11B, the crest portions and the trough portions in the film thickness distribution of the annealing separator slurry 4 are layer-stacked alternately in sequence in the radial direction of a circle of the cross section along the longitudinal direction of the band-like body 1 in the coil 10, and the above-described buildups can be prevented. Thus, the occurrence of shape defects on the band-like body 1 can be suppressed.

Modifications in Second Embodiment

[0097] Next, the configurations of slurry coating devicees in a separator coating process, to which the device configuration in the foregoing second embodiment is applicable, will be described. FIGS. 12A, 12B, and 12C are configuration diagrams illustrating a first modification, a second modification, and a third modification, respectively, of the slurry coating device in the second embodiment.

First Modification in Second Embodiment

[0098] As illustrated in FIG. 12A, a slurry coating device 31 according to the first modification in the second embodiment includes a pair of rough coating rolls 12a, a pair of backup rolls 12b, a pair of coating rolls 12c, and a pair of before-rough coating roll nozzles 13a. The pair of before-rough coating roll nozzles 13a is a pair of slurry dispensing units that dispenses the annealing separator slurry 4 onto both surfaces of the band-like body 1. The pair of rough coating rolls 12a is a pair of applicators that coarsely applies the annealing separator slurry 4 fed by the before-rough coating roll nozzles 13a onto both surfaces of the band-like body 1 by pressing (clamping) the band-like body 1 while holding it in the thickness direction thereof. The pair of coating rolls 12c is a pair of second applicators that is supported by the pair of backup rolls 12b provided on both surface sides of the band-like body 1, and presses (clamps) the band-like body 1 while holding it in the thickness direction thereof and squeezes the coarsely applied annealing separator slurry 4. In the slurry coating device 31 in the first modification, the band-like body conveying rolls (not depicted), the rough coating rolls 12a, and the coating rolls 12c, with the backup rolls 12b as necessary, are configured as a band-like body swinging unit to be able to swing with the band-like body 1 relatively to the before-rough coating roll nozzles 13a along the width

direction (direction perpendicular to the drawing in FIG. 12A) of the band-like body 1. While the band-like body swinging unit thus configured swings the band-like body 1 relatively to the before-rough coating roll nozzles 13a along the width direction of the band-like body 1, the before-rough coating roll nozzles 13a dispense and feed the annealing separator slurry 4 on both surfaces of the band-like body 1 that is swinging and running. Consequently, the before-rough coating roll nozzles 13a can feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing spouts thereof and the band-like body 1 along the width direction of the band-like body 1 with time.

Second Modification in Second Embodiment

[0099] As illustrated in FIG. 12B, a slurry coating device 32 according to the second modification in the second embodiment has the same configuration as that of the slurry coating device 31 in the first modification, and further includes a before-coating roll nozzle 13b as a second slurry dispensing unit on one surface side of the band-like body 1 downstream of the before-rough coating roll nozzles 13a as a slurry dispensing unit and upstream of the pair of coating rolls 12c along the running direction of the band-like body 1. In the slurry coating device 32 also, the band-like body conveying rolls (not depicted), the rough coating rolls 12a, and the coating rolls 12c, with the backup rolls 12b as necessary, are configured as a band-like body swinging unit to be able to swing with the band-like body 1 relatively to the before-rough coating roll nozzles 13a along the width direction (direction perpendicular to the drawing in FIG. 12B) of the band-like body 1. While such a band-like body swinging unit swings the band-like body 1 relatively to the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b along the width direction of the band-like body 1, the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b dispense and feed the annealing separator slurry 4 on both surfaces of or one surface of the band-like body 1 that is swinging and running. Consequently, the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b can feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing spouts thereof and the band-like body 1 along the width direction of the band-like body 1 with time. Here, as the same as that of the second modification in the first embodiment, either one of the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b may be configured to swing with the squeeze rolls integrally, more specifically, only either one of the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b may be configured to swing relatively to the band-like body 1.

Third Modification in Second Embodiment

[0100] As illustrated in FIG. 12C, a slurry coating device 33 according to the third modification in the second embodiment has the same configuration as that of the slurry coating device 31 in the first modification, and further includes an after-coating roll nozzle 13c as a second slurry dispensing unit on the other surface side of the band-like body 1 downstream of the pair of coating rolls 12c along the running direction of the band-like body 1. In the slurry coating device 33 also, the band-like body conveying rolls (not depicted), the rough coating rolls 12a, and the coating rolls 12c, with the backup rolls 12b as necessary, are configured as a band-like body swinging unit to be able to swing with the band-like body 1 relatively to the before-rough coating roll nozzles 13a along the width direction (direction perpendicular to the drawing in FIG. 12C) of the band-like body 1. While such a band-like body swinging unit swings the band-like body 1 relatively to the before-rough coating roll nozzles 13a and the after-coating roll nozzle 3c along the width direction of the band-like body 1, the before-rough coating roll nozzles 13a and the after-coating roll nozzle 13c dispense and feed the annealing separator slurry 4 on both surfaces of or one surface of the band-like body 1 that is swinging and running. Consequently, the before-rough coating roll nozzles 13a and the after-coating roll nozzle 13c can feed the annealing separator slurry 4 to the band-like body 1 while varying the relative positional relation of the dispensing spouts thereof and the band-like body 1 along the width direction of the band-like body 1 with time. Here, as the same as that of the second modification in the first embodiment, either one of the before-rough coating roll nozzles 13a and the after-coating roll nozzle 13c may be configured to swing with the squeeze rolls integrally, more specifically, only either one of the before-rough coating roll nozzles 13a and the after-coating roll nozzle 13c may be configured to swing relatively to the band-like body 1.

[0101] Next, the following describes examples based on the second modification in the second embodiment in the foregoing and comparative examples based on the conventional technology. Note that the invention is not intended to be limited by the examples.

Examples 37 to 51 and Comparative Example 3

[0102] In examples 37 to 51 and a comparative example 3, a cold-rolled grain-oriented electrical steel sheet of a final sheet thickness of 0.3 millimeters containing 3.4 weight percent silicon (Si) was used as the band-like body 1. After decarburization annealing was performed on the band-like body 1, the annealing separator slurry 4 was then applied on the band-like body 1 by using the slurry coating device 32 of the above-described second modification in the second embodiment. More specifically, by the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b,

magnesium oxide (MgO) is applied on both surfaces of the band-like body 1 with the applying weight of 7.0 g/m^2 as the coating amount of the annealing separator slurry 4 per one surface. Subsequently, after the band-like body 1 is wound into the coil 10, finish annealing is performed on the coil 10 in a condition at a temperature of 1200°C. After the finish annealing, in a flattening annealing furnace, a shape correction of the band-like body 1 is performed under the condition in which the temperature is at 850°C. Then, on the shape-corrected band-like body 1, the presence of shape defects along the longitudinal direction was inspected visually.

[0103] In these examples 37 to 51, the control of the swing of the band-like body 1 at the time the annealing separator slurry 4 is applied on the surface of the band-like body 1 is performed in the following manner.

[0104] More specifically, in the examples 37 to 41, the swing control is performed on the band-like body 1 in a sinusoidal wave form with the pitch T indicated in FIG. 9A of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 42 to 46, the swing control is performed on the band-like body 1 in a triangular wave form with the pitch T indicated in FIG. 9B of 1, 2, 60, 120, and 150 seconds, respectively. In the examples 47 to 51, the swing control is performed on the band-like body 1 in a square wave form with the pitch T indicated in FIG. 9C of 1, 2, 60, 120, and 150 seconds, respectively. Furthermore, in the comparative example 3, as is conventionally performed, without making the band-like body 1 swing, the annealing separator slurry 4 is applied on the surface of the band-like body 1. Table 3 is a table representing the results of the examples 37 to 51 and the comparative example 3.

Table 3

	Swing	Waveform	Pitch	Shape Defects
Example 37	Present	Sinusoidal	1 sec.	Reduced
Example 38	Present	Sinusoidal	2 sec.	None
Example 39	Present	Sinusoidal	60 sec.	None
Example 40	Present	Sinusoidal	120 sec.	None
Example 41	Present	Sinusoidal	150 sec.	Reduced
Example 42	Present	Triangular	1 sec.	Reduced
Example 43	Present	Triangular	2 sec.	None
Example 44	Present	Triangular	60 sec.	None
Example 45	Present	Triangular	120 sec.	None
Example 46	Present	Triangular	150 sec.	Reduced
Example 47	Present	Square	1 sec.	Reduced
Example 48	Present	Square	2 sec.	None
Example 49	Present	Square	60 sec.	None
Example 50	Present	Square	120 sec.	None
Example 51	Present	Square	150 sec.	Reduced
Comparative Example 3	None	-	-	Present

[0105] Table 3 can tell that, in the examples 37 to 51, the occurrence of shape defects on the grain-oriented electrical steel sheet that is the band-like body 1 is not present at all, or is reduced as compared with the conventional case. In contrast, in the comparative example 3, it can tell that shape defects occurred. From the comparisons of the examples 37 to 51 with the comparative example 3, it can tell that, as in the examples 37 to 51, performing the swing control on the band-like body 1 along the width direction of the band-like body 1 by making the band-like body conveying rolls 15 and the squeeze rolls 12 as a band-like body swinging unit swing relatively to the slurry dispensing unit can suppress the occurrence of shape defects in the grain-oriented electrical steel sheet.

[0106] In Table 3, it can further tell that, when the examples in which shape defects were reduced and the examples in which no shape defects is present are compared, no shape defects are to occur in the grain-oriented electrical steel sheet by applying the annealing separator slurry 4 while the band-like body 1 is made to swing with the pitch T of 2 to 120 seconds. Consequently, it suggests that the pitch T in the swing control for the band-like body 1 is preferably 2 to 120 seconds.

Examples 52 to 57 and Comparative Example 4

[0107] In examples 52 to 57 and a comparative example 4, a cold-rolled grain-oriented electrical steel sheet of a final sheet thickness of 0.23 millimeters containing 3.4 weight percent silicon (Si) is used as the band-like body 1. After decarburization annealing was performed on the band-like body 1, the annealing separator slurry 4 was then applied on the band-like body 1 by using the slurry coating device 32 of the above-described second modification in the second embodiment. More specifically, by the before-rough coating roll nozzles 13a and the before-coating roll nozzle 13b, magnesium oxide (MgO) is applied on both surfaces of the band-like body 1 with the applying weight of 7.0 g/m^2 as the coating amount of the annealing separator slurry 4 per one surface. Subsequently, after the band-like body 1 is wound into the coil 10, finish annealing is performed on the coil 10 in a condition at a temperature of 1200°C. After the finish annealing, in a flattening annealing furnace, a shape correction of the band-like body 1 is performed under the condition in which the temperature is at 850°C. Then, on the shape-corrected band-like body 1, the presence of shape defects along the longitudinal direction was inspected visually.

[0108] In these examples 52 to 57, at the time the annealing separator slurry 4 was applied on the surface of the band-like body 1, the band-like body 1 was made to swing based on the following technical ideas.

[0109] The effect of making the band-like body 1 swing in the width direction of the steel sheet thereof by the band-like body swinging unit in the invention is to promote the uniformity in the coating amount of the annealing separator slurry 4 on the band-like body 1 by dispersing the minute variations in the coating amount of the annealing separator slurry 4, which are attributed to the placement of the coating nozzle, in the width direction of the steel sheet of the band-like body 1. It is further conceivable that, because the band-like body 1 is wound into a coil after the annealing separator slurry 4 is applied, it is more preferable that the combination of the coating amount of the adjacent or neighboring annealing separator slurry 4 on the steel sheet in the radial direction of the coil be made uniform.

[0110] It is evoked that, when based on such ideas, it is preferable to vary the swing period of the band-like body 1 by considering the turn pitch of the coil in which the band-like body 1 is wound. In the second embodiment, the band-like body 1 is made to swing one period not for each one turn pitch but for each two turn pitches. The inventors found that this had a possibility in which the total of the coating amount of the annealing separator slurry 4 between the layers of the steel sheet in a coil condition is further homogenized in the width direction of the steel sheet.

[0111] Consequently, in the examples 52 to 57, the ratio (V/2L) of the line velocity V of the band-like body 1 and twice the turn pitch L of the coil 10 is defined as the turn pitch frequency (in unit of "Hz"), and the line velocity V and the coil diameter of the coil 10 were set such that the turn pitch frequency was to be 0.665 Hz. At this time, the annealing separator slurry 4 was applied on the surface of the band-like body 1 while the swing frequency of the band-like body 1 was varied within the range of 0.010 to 1.000 Hz. Furthermore, the time variation in the amount of swing of the band-like body 1 was controlled in a sinusoidal wave form. Meanwhile, in the comparative example 4, as is conventionally performed, without making the band-like body 1 swing, the annealing separator slurry 4 was applied on the surface of the band-like body 1. Table 4 represents the respective inspection results of shape defects in the foregoing examples 52 to 57 and the comparative example 4.

Table 4

	Swing	Ratio (V/2L)	Swing Frequency	Shape Defects
Example 52	Present	0.665 Hz	1.000 Hz	None
Example 53	Present	0.665 Hz	0.665 Hz	None
Example 54	Present	0.665 Hz	0.500 Hz	None
Example 55	Present	0.665 Hz	0.050 Hz	Reduced
Example 56	Present	0.665 Hz	0.025 Hz	Reduced
Example 57	Present	0.665 Hz	0.010 Hz	Reduced
Comparative Example 4	None	-	-	Present

[0112] Table 4 can tell that, in the examples 52 to 57, the occurrence of shape defects on the band-like body 1 (grain-oriented electrical steel sheet) is not present at all, or is reduced as compared with the conventional case. In the examples 52 to 54, it further suggests that, when the swing frequency of the band-like body 1 is in a condition of being close to the turn pitch frequency, that is, being at the same value as or in the neighborhood of 0.665 Hz, the shape defects of the band-like body 1 do not occur. In contrast, in the comparative example 4, it can tell that shape defects of the band-like body 1 occurred.

[0113] While the time variation in the amount of swing of the band-like body 1 was controlled in a sinusoidal wave

form in the examples 52 to 57, even when the time variation in the amount of swing was controlled in a square wave form or in a triangular wave form, no difference was observed in the inspection results of the shape defects of the band-like body 1.

[0114] Furthermore, in the examples 52 to 57, represented were the results when the turn-pitch frequency is at 0.665 Hz. However, even if the turn-pitch frequency is at a value other than 0.665 Hz, the same results as those when the turn-pitch frequency is at 0.665 Hz were obtained by bringing the swing frequency of the band-like body 1 close to the turn-pitch frequency.

[0115] Moreover, in the examples 52 to 57, the turn-pitch frequency was set based on twice the turn pitch as in the foregoing, and the swing of the band-like body 1 was controlled based on this turn-pitch frequency. This obtained good results as represented in Table 4. However, even in an applying condition in which such an idea was amplified, more specifically, the turn-pitch frequency was set based on the turn pitch multiplied by an even number and the band-like body 1 was made to swing matching the turn-pitch frequency thus set, the same effect was obtained.

[0116] In accordance with the second embodiment of the invention as in the foregoing, the band-like body 1 is made to swing along the width direction of the band-like body 1 by the band-like body conveying rolls 15 and the squeeze rolls 12 at the time the annealing separator slurry 4 is applied on the surface of the band-like body 1. This makes the non-uniformity in the film thickness distribution of the annealing separator slurry 4 along the width direction smooth, and the buildups can be prevented when the band-like body 1 is wound into the coil 10. Thus, it is possible to suppress the occurrence of wrinkle-like shape defects along the longitudinal direction of a steel sheet which are likely to occur after the flattening annealing is performed in the manufacture of steel sheet, that is, the occurrence of the above-described shape defects on the band-like body 1. As a consequence, the yield in the manufacture of steel sheet can be improved.

[0117] While the first and the second embodiments of the invention have been described specifically in the foregoing, the invention is not limited to the above-described first and second embodiments and various modifications based on the technical ideas of the invention can be made. For example, the numerical values cited in the first and the second embodiments are mere examples, and numerical values different from those may be used as necessary.

[0118] Furthermore, in the first embodiment, the pitch T at the time of controlling the slurry feeding nozzle 3 in a sinusoidal wave form or a square wave form is set to 2 to 120 seconds, and the swing frequency of the coating nozzle is set to a given value (for example, 0.665 Hz) matching the turn pitch of the coil 10. However, the period and the frequency may be made variable in response to the line velocity of the band-like body 1 and the position of the coil 10 after the winding.

[0119] Moreover, in the second embodiment, the band-like body 1 is made to swing by using the band-like body conveying rolls 15. However, without using the band-like body conveying rolls 15, the band-like body 1 can also be made to swing by using a pinch roll and a bridle roll provided on inlet and outlet sides of an annealing separator coating device as a slurry coating device.

[0120] Furthermore, in the second embodiment, the pitch T at the time the swing control is performed on the band-like body 1 in a sinusoidal wave form, a triangular wave form, or a square wave form is set to 2 to 120 seconds, and the swing frequency of the band-like body 1 is set to a given value (for example, 0.665 Hz) matching the turn pitch of the coil 10. However, the period and the frequency can be made variable to various values in response to the line velocity of the band-like body 1 and the position of the coil 10 after the winding.

[0121] In the second embodiment, exemplified has been a situation of the slurry feeding nozzle 13 being fixed. However, the slurry feeding nozzle 13 may also be made to swing while coordinating with the swing control performed on the band-like body 1.

Industrial Applicability

[0122] As in the foregoing, the slurry coating device and the slurry coating method according to the present invention are useful for applying slurry such as annealing separator on the surface of a steel sheet, and in particular, are suitable for suppressing shape defects of the steel sheet and improve the yield in the manufacture of steel sheet.

Reference Signs List

[0123]

1	band-like body
2, 12	squeeze rolls
2a, 12a	rough coating rolls
2b, 12b	backup rolls
2c, 12c	coating rolls
3, 13	slurry feeding nozzle

3a, 13a	before-rough coating roll nozzles
3b, 13b	before-coating roll nozzle
3c, 13c	after-coating roll nozzle
4	annealing separator slurry
10	coil
15	band-like body conveying rolls
20, 21, 22, 23, 30, 31, 32, 33, 100	slurry coating device

Claims

1. A slurry coating device that applies slurry on a running band-like body, the slurry coating device comprising:

a slurry dispensing unit configured to be able to feed the slurry on the band-like body, wherein
the slurry coating device feeds the slurry on the band-like body by the slurry dispensing unit while varying a relative positional relation of the slurry dispensing unit and the band-like body in a direction substantially parallel to a face of the band-like body and substantially perpendicular to a running direction of the band-like body.

2. The slurry coating device according to claim 1, further comprising:

a pair of coating units configured to be able to apply the fed slurry on a surface of the band-like body by holding and pressing the band-like body, wherein
the slurry dispensing unit is configured to be able to swing relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body.

3. The slurry coating device according to claim 2, further comprising:

a second slurry dispensing unit configured to be able to feed the slurry on the band-like body, wherein
the slurry dispensing unit is provided upstream of the pair of coating units along the running direction of the band-like body, and
the second slurry dispensing unit is provided downstream of the pair of coating units along the running direction of the band-like body.

4. The slurry coating device according to claim 3, wherein the second slurry dispensing unit is configured to be able to swing relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body.

5. The slurry coating device according to claim 2, further comprising:

a third slurry dispensing unit configured to be able to feed the slurry on the band-like body, wherein
the slurry dispensing unit is provided downstream of the pair of coating units along the running direction of the band-like body, and
the third slurry dispensing unit is provided upstream of the pair of coating units along the running direction of the band-like body.

6. The slurry coating device according to any one of claims 2 to 5, wherein time variation in an amount of swing in the swing is in a square wave form, a sinusoidal wave form, or a triangular wave form.

7. The slurry coating device according to any one of claims 2 to 6, wherein the slurry coating device that holds the slurry dispensing unit is configured to be able to wholly swing relatively to the band-like body.

8. The slurry coating device according to any one of claims 2 to 7, wherein a swing frequency of the slurry dispensing unit is set based on a turn pitch of a coil in which the band-like body is wound.

9. The slurry coating device according to claim 8, wherein the swing frequency of the slurry dispensing unit is set based on the turn pitch multiplied by an even number.

10. The slurry coating device according to claim 1, further comprising:

a band-like body swinging unit configured to be able to swing the band-like body relatively to the slurry dispensing unit in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body; and
a pair of coating units configured to be able to apply the fed slurry on a surface of the band-like body by holding and pressing the band-like body.

11. The slurry coating device according to claim 10, further comprising a pair of second coating units provided downstream of the pair of coating units along the running direction of the band-like body and configured to be able to apply the slurry on the surface of the band-like body by holding and pressing the band-like body.

12. The slurry coating device according to claim 10 or 11, further comprising a second slurry dispensing unit provided downstream of the pair of coating units along the running direction of the band-like body and configured to be able to feed the slurry on the band-like body.

13. The slurry coating device according to any one of claims 10 to 12, wherein time variation in an amount of swing of the band-like body is in a square wave form, a sinusoidal wave form, or a triangular wave form.

14. The slurry coating device according to any one of claims 10 to 13, wherein a swing frequency of the band-like body is set based on a turn pitch of a coil in which the band-like body is wound.

15. The slurry coating device according to claim 14, wherein the swing frequency of the band-like body is set based on the turn pitch multiplied by an even number.

16. A slurry coating method for applying slurry on a running band-like body, wherein the slurry is fed on the band-like body while varying a relative positional relation of a dispensing spout for the slurry and the band-like body in a direction substantially parallel to a face of the band-like body and substantially perpendicular to a running direction of the band-like body.

17. The slurry coating method according to claim 16, comprising:

a slurry feeding step of feeding the slurry on the band-like body while swinging the dispensing spout relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body; and
a slurry coating step of applying the slurry on a surface of the band-like body by holding and pressing the band-like body on which the slurry is fed.

18. The slurry coating method according to claim 17, further comprising a second slurry feeding step of feeding the slurry on the band-like body after the slurry coating step.

19. The slurry coating method according to claim 18, wherein at the second slurry feeding step, the slurry is fed on the band-like body while the dispensing spout for the slurry is swung relatively to the band-like body in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body.

20. The slurry coating method according to claim 17, further comprising:

a third slurry feeding step of feeding the slurry on the band-like body before the slurry feeding step; and
a second slurry coating step of applying the slurry on the surface of the band-like body by holding and pressing the band-like body on which the slurry is fed at the third slurry feeding step.

21. The slurry coating method according to any one of claims 17 to 20, wherein time variation in an amount of swing in the swing is in a square wave form, a sinusoidal wave form, or a triangular wave form.

22. The slurry coating method according to any one of claims 17 to 21, wherein a swing frequency of the swing is set based on a turn pitch of a coil in which the band-like body is wound.

23. The slurry coating method according to claim 22, wherein the swing frequency of the swing is set based on the turn pitch multiplied by an even number.

24. The slurry coating method according to claim 16, comprising:

a slurry feeding step of feeding the slurry on the band-like body while swinging the band-like body relatively to the dispensing spout in a direction substantially parallel to the face of the band-like body and substantially perpendicular to the running direction of the band-like body; and
a slurry coating step of applying the slurry on a surface of the band-like body by holding and pressing the band-like body on which the slurry is fed.

25. The slurry coating method according to claim 24, further comprising a second slurry coating step of applying the slurry on the surface of the band-like body by holding and pressing the band-like body on which the slurry is fed after the slurry coating step.

26. The slurry coating method according to claim 24 or 25, further comprising a second slurry feeding step of feeding the slurry on the band-like body after the slurry coating step.

27. The slurry coating method according to any one of claims 24 to 26, wherein time variation in an amount of swing of the band-like body is in a square wave form, a sinusoidal wave form, or a triangular wave form.

28. The slurry coating method according to any one of claims 24 to 27, wherein a swing frequency of the band-like body is set based on a turn pitch of a coil in which the band-like body is wound.

29. The slurry coating method according to claim 28, wherein the swing frequency of the band-like body is set based on the turn pitch multiplied by an even number.

FIG.1

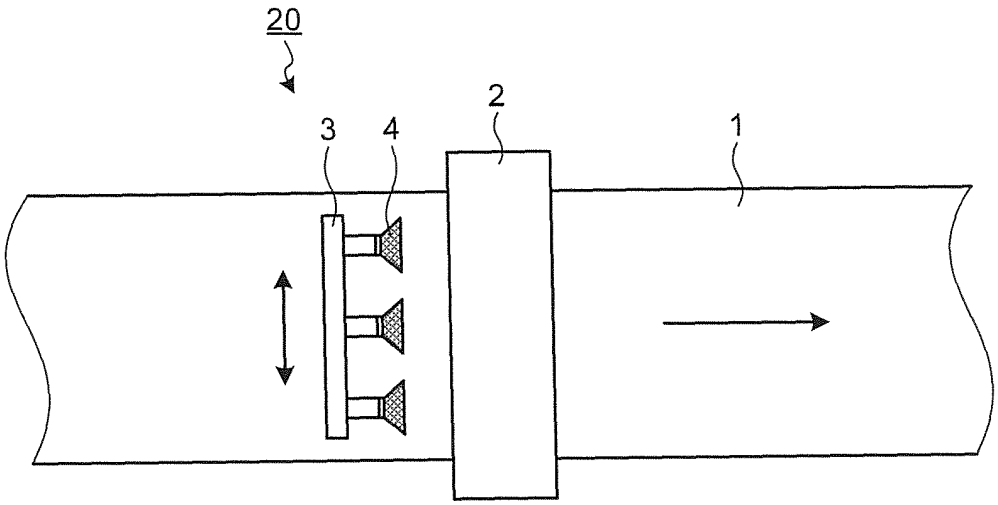


FIG.2

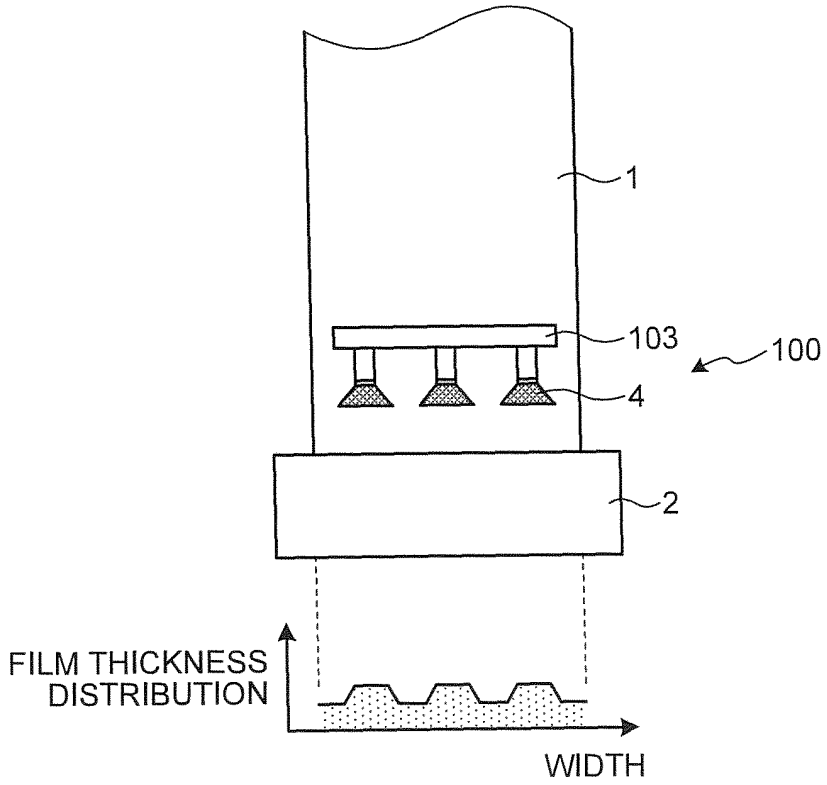


FIG.3A

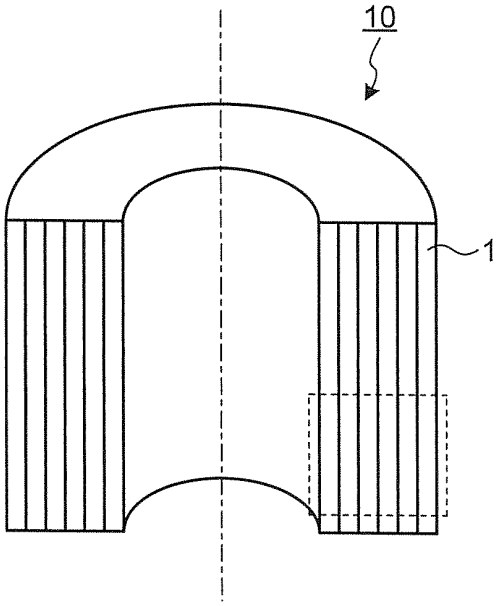


FIG.3B

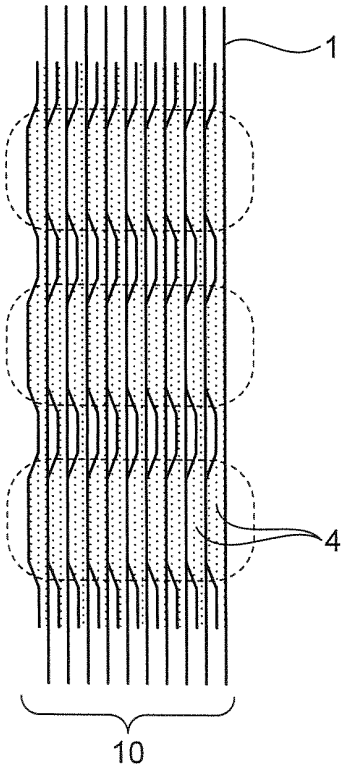


FIG.4A

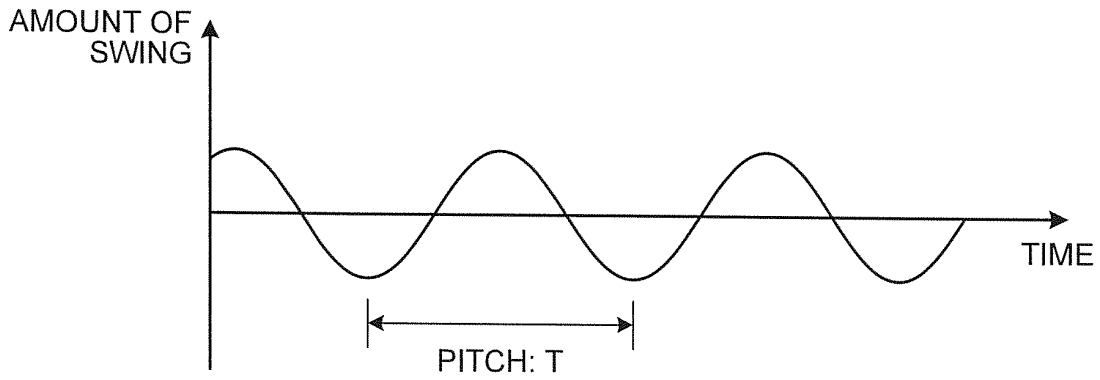


FIG.4B

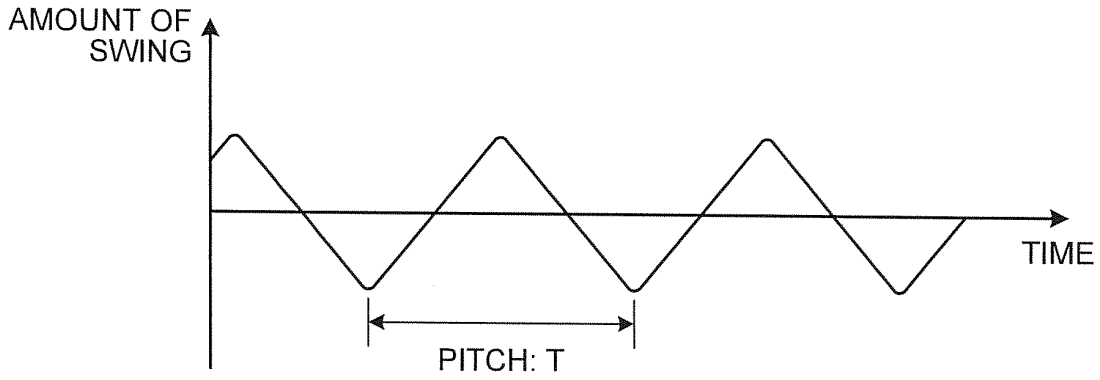


FIG.4C

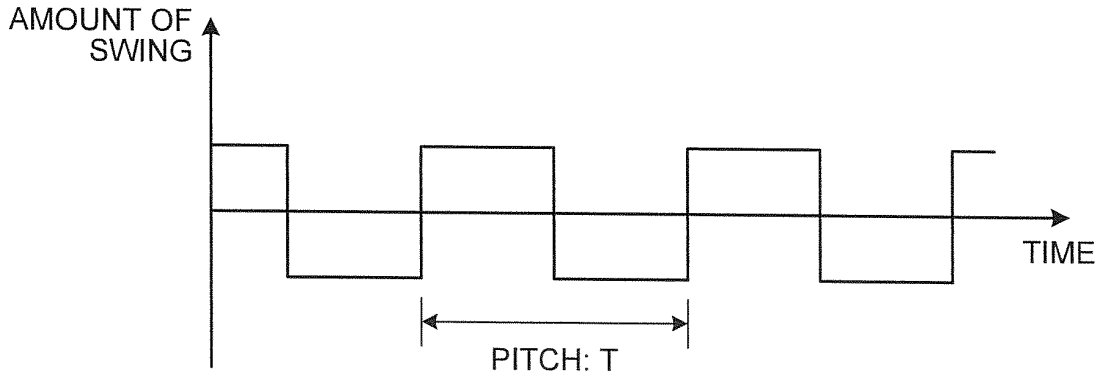


FIG.5

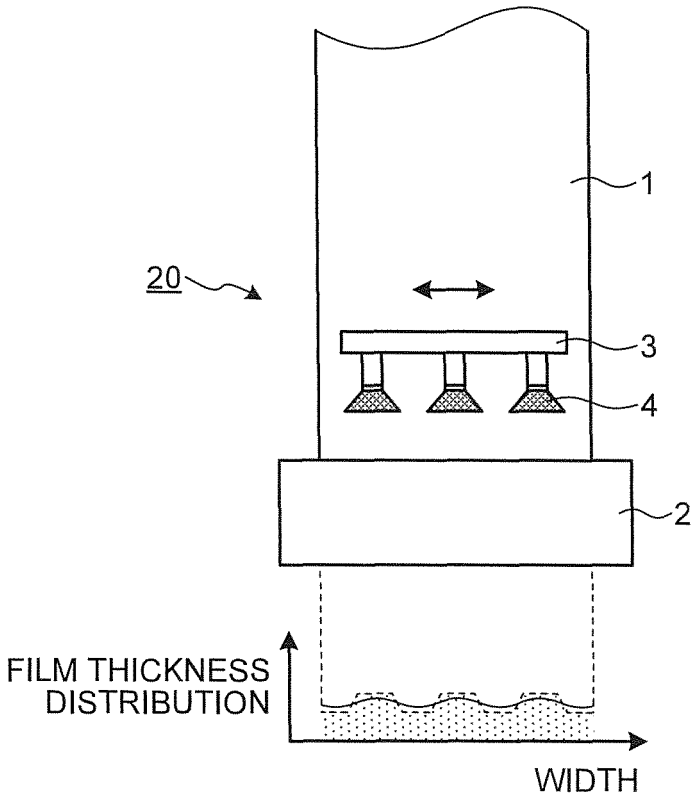


FIG.6A

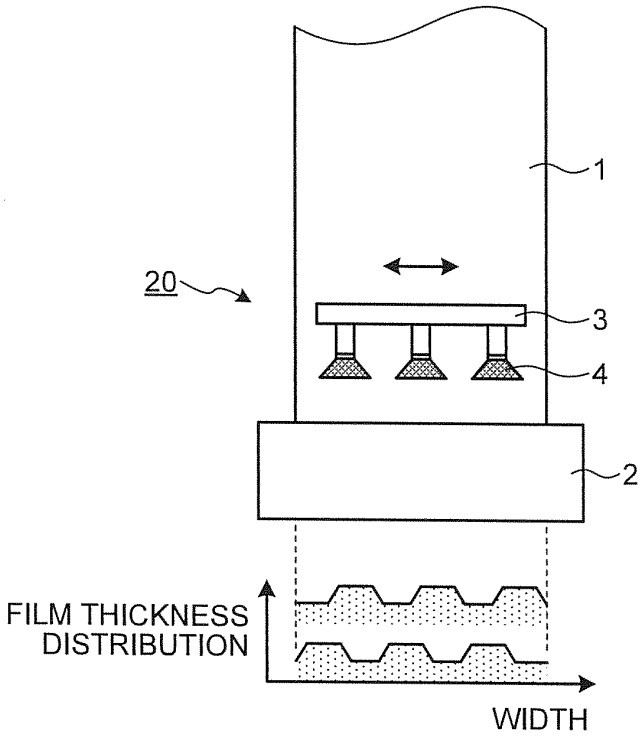


FIG.6B

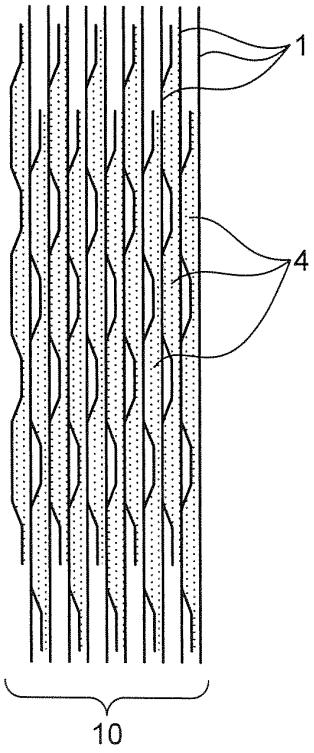


FIG.7A

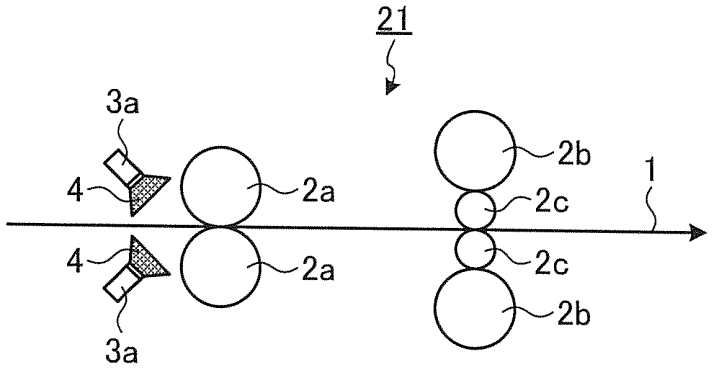


FIG.7B

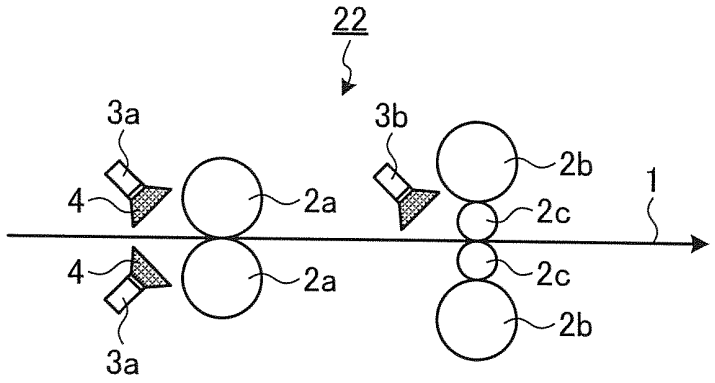


FIG.7C

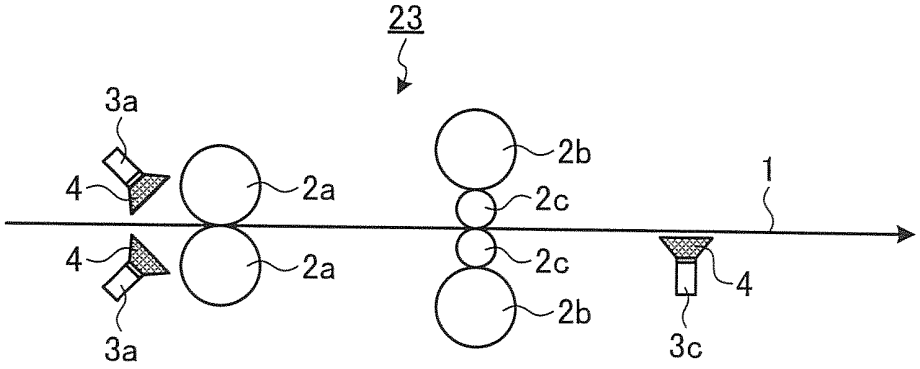


FIG.8

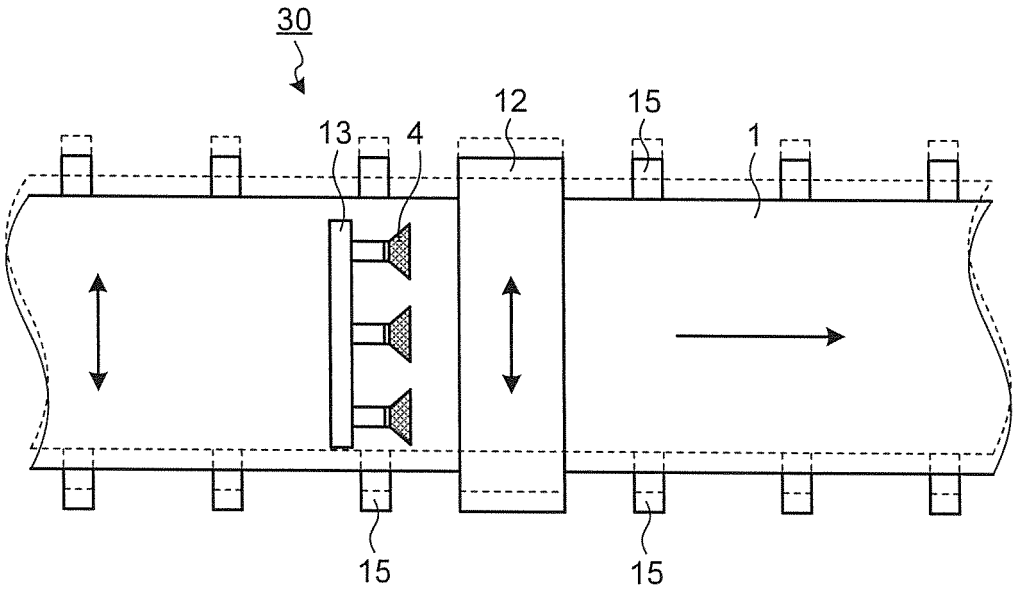


FIG.9A

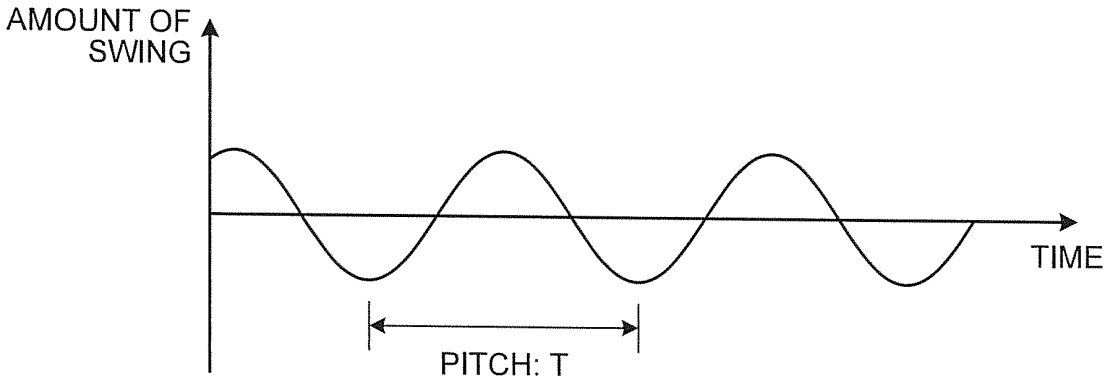


FIG.9B

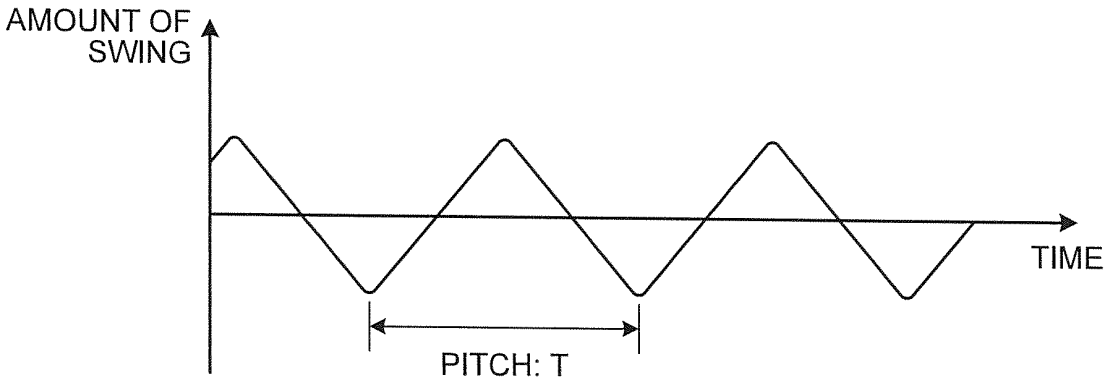


FIG.9C

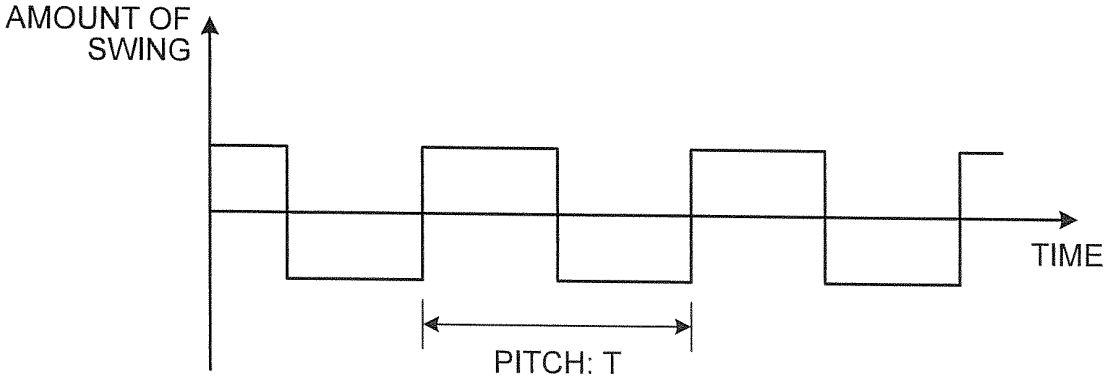


FIG.10

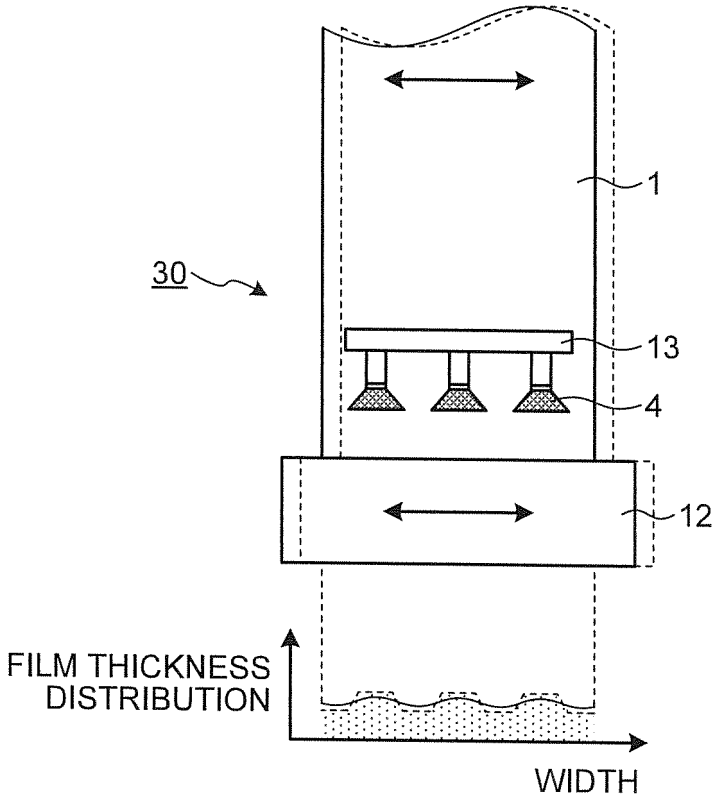


FIG.11A

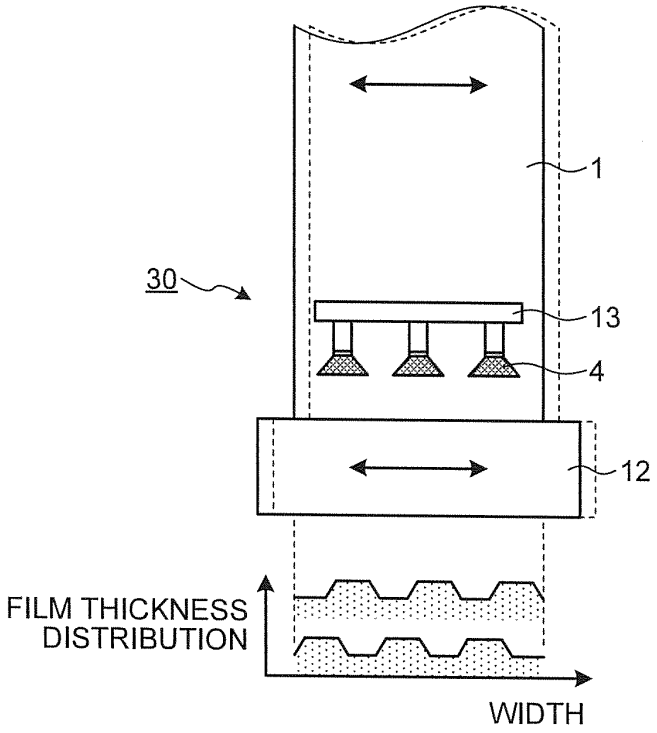


FIG.11B

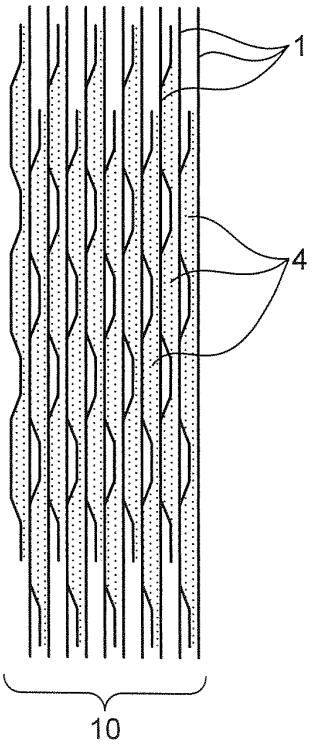


FIG.12A

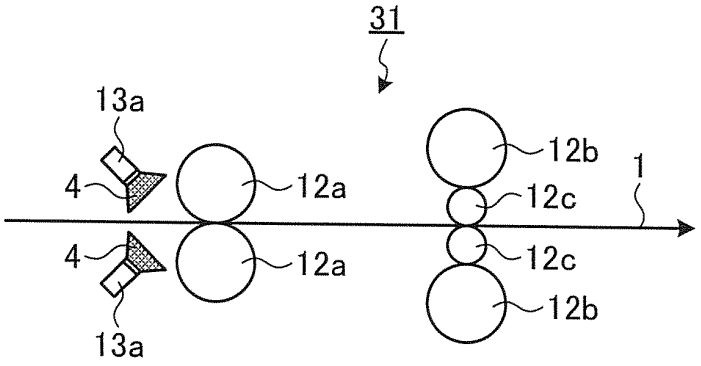


FIG.12B

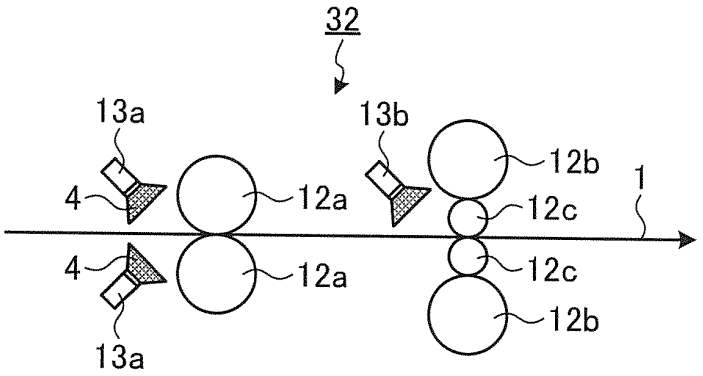
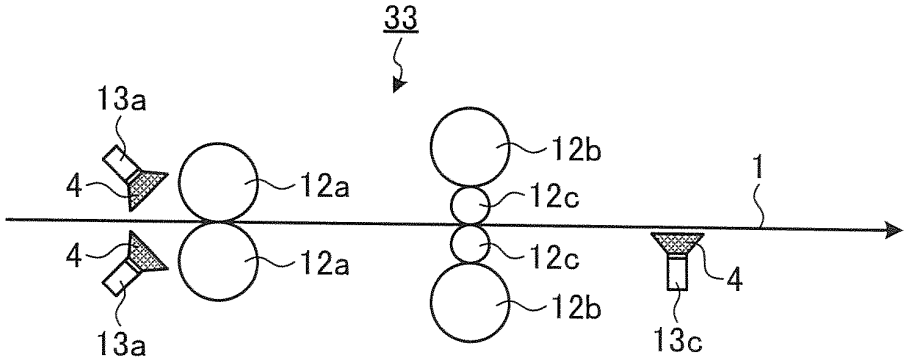


FIG.12C



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/063077

A. CLASSIFICATION OF SUBJECT MATTER
B05C11/02(2006.01)i, *B05C1/08*(2006.01)i, *B05D1/28*(2006.01)i, *B05D7/24*(2006.01)i

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)
B05C11/02, B05C1/08, B05D1/28, B05D7/24, C21D8/12, C21D9/46

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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2005-66962 A (Sumitomo Bakelite Co., Ltd.), 17 March 2005 (17.03.2005), paragraphs [0034], [0035]; fig. 1, 2 (Family: none)	1,16 2-7,10-13, 17-21,24-27 8,9,14,15, 22,23,28,29
Y	JP 2004-57971 A (JFE Steel Corp.), 26 February 2004 (26.02.2004), paragraphs [0015] to [0018]; fig. 1 (Family: none)	2-7,10-13, 17-21,24-27
Y	JP 3-188973 A (Kawasaki Steel Corp.), 16 August 1991 (16.08.1991), page 2, upper right column, line 10 to lower left column, line 15; fig. 1 (Family: none)	10-13,24-27

☒ 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	Date of mailing of the international search report
01 August, 2013 (01.08.13)	13 August, 2013 (13.08.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/063077

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-40613 A (Nippon Steel Corp.), 08 February 2000 (08.02.2000), paragraphs [0009], [0010]; fig. 1, 2 (Family: none)	1-29

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004057971 A **[0007]**
- JP S62067118 B **[0007]**