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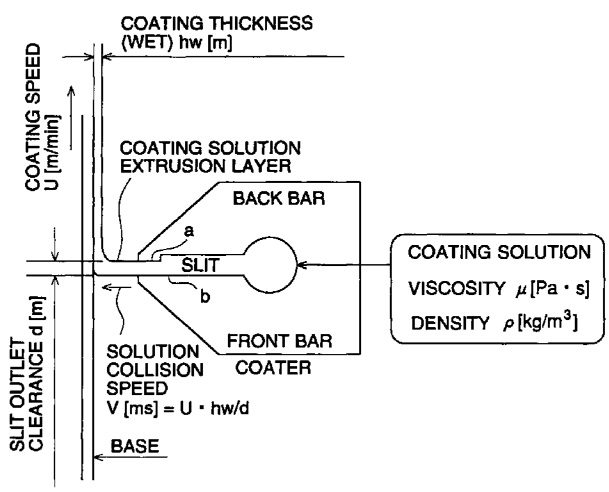
(54) Coating apparatus

(57) In a coating apparatus provided with a conveyor to convey a substrate to be coated; and a coater including two surfaces (a,b) opposite to each other so that a slit is formed therebetween, a coating solution is introduced from an inlet of the slit, passes through the slit between the two surfaces and is discharged from the outlet of the slit, the gap distance d of the slit at the outlet being made so as to satisfy the following formula: $0 < d \leq 50 \times 10^{-5}$ (m), and at least a part of the outlet section of the two surfaces (a,b) being formed by a member having a water-repelling property.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a coating method and a coating apparatus, and in particular, to a coating method and a coating apparatus employing a coater head which conducts high speed thin layer coating of a coating solution extruded continuously toward the surface of a substrate to be coated which moves relatively to the coating head on the surface of the substrate to be coated so that the thin layer may be of a uniform thickness.

[0002] A method for coating a prescribed coating solution on the surface of a flexible substrate to be coated has so far been studied in many ways and has been put to practical use. Among these various methods, a coating apparatus of an extrusion type which conducts high speed thin layer coating of a coating solution extruded continuously toward the surface of a moving substrate to be coated on the surface of the substrate to be coated, for example, is superior to other roll type coating methods such as, for example, reverse roll, kiss roll and gravure roll methods in terms of uniformity of coating, layer thinness and a range of coating speed. Further, the coating method of an extrusion type can conduct simultaneous multi-layer coating on the so-called wet-on-wet basis, and it is extremely effective in terms of cost and performance for the application to manufacture recent coated products with high value added. For attaining the multi-layer system, on the other hand, there has been used a method to form the aforesaid coated layers of a multi-layer type by coating a coating solution and drying it for each layer on the substrate to be coated, as disclosed in TOKKAISHO Nos. 51-119204, 52-51908 and 53-16604. In this method wherein steps of coating and drying are repeated, however, there have been problems that productivity is poor and it is difficult to make the uppermost layer to be thin. So, TOKKAISHO Nos. 48-98803 and 61-111168 disclose manufacturing methods of a type of wet-on-wet simultaneous multi-layer coating for magnetic recording media. However, both methods represent a method wherein coating solutions superposed in layers in advance are coated on the aforesaid substrate to be coated which is supported on a back roll and is running continuously, which has caused problems that uneven and nonuniform coating tends to be caused in the longitudinal coating direction because of insufficient rotational accuracy of the back roll, a distance between a substrate to be coated and the tip of a coater which can not be narrowed makes high speed thin layer coating to be difficult, and manufacture of optimum magnetic recording media is difficult.

[0003] From the background stated above, there have been proposed a method disclosed in TOKKAISHO No. 62-124631 to coat the upper layer with a single layer extrusion coater on a substrate to be coated that is not supported by a back roll while a lower layer is wet, and coater heads disclosed in TOKKAISHO No. 63-88080 and TOKKAIHEI No. 2-251265 each having a slit from which two coating solutions are extruded. However, the problem of this extrusion type coating method is that it is impossible to thoroughly eliminate defects called the so-called pencil lines which are caused in the coating direction by foreign materials or dried coating solutions caught at the tip of an edge of a coater.

[0004] When conducting coating between two support rolls without conducting coating on a substrate to be coated that is held firmly on a back roll, bending of the substrate to be coated in its lateral direction and that in its longitudinal direction become pressure distribution in the direction of the coater, and become layer thickness distribution in the lateral direction and that in the longitudinal direction, resulting in the occurrence of serious deterioration of coating quality. On the contrary, TOKKAIHEI Nos. 1-203075 and 6-254466 disclose a method to counteract a twist of the substrate in its lateral direction by changing a diameter of a support roll located just in front of or just behind an extrusion coater, and TOKKAIHEI No. 1-224071 discloses a method to make the twisted portion to be uniform by providing a means to apply fluid pressure from the reverse side of the twisted substrate to be coated. However, it is difficult for the method of this type to cope with a twist of several tens centimeters or less, though it can cope with a twist with a larger cycle, and it is substantially possible for the method to cope only with a twist with a cycle of a few meters. Though there has been proposed a method to uniformalize the amount of flowing coating solution in the lateral direction by changing shapes of a pocket portion and of a slit portion of an extrusion coater in the lateral direction as in TOKKAIHEI No. 6-508571, in addition to the foregoing, no effect is expected for the twist which fluctuates cyclically in the longitudinal direction as stated above.

[0005] As a countermeasure for the drawbacks mentioned above, there is disclosed in TOKKAISHO No. 6320070 an extrusion type coater for coating by letting a coating solution layer fall from a coater provided with its outlet facing downward while holding a substrate to be coated on a back roll, wherein pressure loss is lowered by using a coating apparatus whose slit is gradually narrowed toward the coating solution outlet, and thereby, coating of a solution having relatively high viscosity is made to be possible even through a slit which is relatively narrow. However, under the structure wherein the tip portion is gradually narrowed, pressure is too high when conducting high speed coating and when coating a coating solution with high viscosity, and it is impossible to thoroughly eliminate the problems that layer thickness distribution is not uniform because accuracy of a sharp edge portion at the tip is not obtained, and pencil lines are caused because a distance between the tip portion of a coater and a substrate to be coated is not actually broadened very much as in other extrusion type coaters.

SUMMARY OF THE INVENTION

[0006] Objects of the invention are to solve the problems of the prior art stated above and to provide a coating method and a coating apparatus wherein thin layer coating that is free from an influence of a twist of a substrate to be coated and from the occurrence of pencil lines caused by surrounding dust or by condensed products in a coating solution is made possible without being restricted by the coating speed, while making the most of advantageous points of an extrusion type coating system.

[0007] The objects stated above can be attained by the following coating apparatus.

[0008] A coating apparatus having the following structure:

a conveyance means for conveying a substrate to be coated;
a coater which is equipped with a slit having two faces which face each other, and extrudes a coating solution, the coating solution being injected through an inlet on the slit and passing through the clearance between the two faces facing each other and being extruded from an outlet on the slit,
clearance d of the outlet on the slit satisfying the following expression of $0 < d \leq 50 \times 10^{-5}$ (m), and
at least a part of the portion in the vicinity of the outlet of the two faces facing each other is formed with a water-repelling member.

[0009] Further, the objects mentioned above are attained by a preferable embodiment shown in either one of the following structures (1) - (18).

(1) A coating apparatus wherein a coating solution is extruded in a film shape from a slit formed with at least two or more bars constituting a coater, and the coating solution extruded in the shape of a film is collided with a substrate to be coated which is set or conveyed through the prescribed clearance from the coater on a non-contact basis, for coating.
(2) A coating apparatus in which a coating solution is extruded in a film shape from a slit formed with at least two or more bars constituting a coater, and the coating solution extruded in the shape of a film is collided with a substrate to be coated which is set or conveyed through the prescribed clearance from the coater on a non-contact basis, for coating, wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is constituted with a member that repels the coating solution.
(3) The coating apparatus according to Structure (2), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is constituted with a member whose contact angle with the coating solution is 45° or more.
(4) A coating apparatus in which a coating solution is extruded in a film shape from a slit formed with at least two or more bars constituting a coater, and the coating solution extruded in the shape of a film is collided with a substrate to be coated which is set or conveyed through the prescribed clearance from the coater on a non-contact basis, for coating, wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is constituted with a plane whose surface roughness Rmax satisfies the relation of $Rmax \leq 0.8$ (μm).
(5) The coating apparatus according to either one of Structures (1), (2) and (4), wherein a gap of the slit at the portion of an inlet for a coating solution is broader and that at the portion of an outlet for a coating solution is narrower, and gap d of the outlet on the slit satisfies the relation of $d \leq x 10^{-5}$ (m).
(6) The coating apparatus according to Structures (5), wherein the slit has on its outlet portion a section where two confronting surfaces are in parallel each other.
(7) The coating apparatus according to Structures (5), wherein the narrowest portion of the slit is constituted with a member whose Vickers hardness is 280 or more.
(8) The coating apparatus according to Structure (2) or (4), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is constituted with at least one kind of metal, ceramic, resin and glass.
(9) The coating apparatus according to Structure (2), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is given a repelling property by means of covering.
(10) The coating apparatus according to Structure (4), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is covered with a member whose surface roughness RMax satisfies the relation of $Rmax \leq 0.8$ (μm).
(11) The coating apparatus according to Structure (9) or (11), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is covered with at least one kind of fluorocarbon resin, silicon type resin and ceramic.
(12) The coating apparatus according to Structure (2) or (4), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is mirror-finished by means of grinding or the like.

(13) The coating apparatus according to Structure (2) or (4), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is a slit surface including at least a slit outlet portion on at least one bar constituting the coater.

(14) The coating apparatus according to Structure (2) or (4), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is a portion including at least an edge of at least one bar constituting the coater and a portion facing outside from the edge portion.

(15) The coating apparatus according to Structure (2) or (4), wherein a prescribed portion of the surface which comes in contact with a coating solution on the coater is a slit surface including at least a slit outlet portion, an edge and a portion facing outside from the edge on at least one bar constituting the coater.

(16) A coating method wherein a coating solution is extruded in a film shape from a slit formed with at least two or more bars constituting a coater, and the coating solution extruded in the shape of a film is collided with a substrate to be coated which is set or conveyed through the prescribed clearance from the coater on a non-contact basis, for coating.

(17) A coating method in which a coating solution is extruded in a film shape from a slit formed with at least two or more bars constituting a coater, and the coating solution extruded in the shape of a film is collided with a substrate to be coated which is set or conveyed through the prescribed clearance from the coater on a non-contact basis, for coating, wherein coating is conducted by the use of a coating apparatus in which a prescribed portion of the surface which comes in contact with a coating solution on the coater is constituted with a member that repels the coating solution.

(18) A coating method in which a coating solution is extruded in a film shape from a slit formed with at least two or more bars constituting a coater, and the coating solution extruded in the shape of a film is collided with a substrate to be coated which is set or conveyed through the prescribed clearance from the coater on a non-contact basis, for coating, wherein coating is conducted by the use of a coating apparatus in which a prescribed portion of the surface which comes in contact with a coating solution on the coater is constituted with a plane whose surface roughness Rmax satisfies the relation of $Rmax \le 0.8$ (μm).

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a side sectional view of a coater used in the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] An embodiment of the invention will be explained with reference to the side sectional view of the coater in Fig. 1.

[0012] A base is conveyed upward from the lower portion in Fig. 1 by paired rollers representing a conveyance means for conveying a base representing a substrate to be coated. A coating solution is injected into a slit through an inlet of the slit provided on a coater, then, it passes through the inside of the slit including two confronting surfaces (a) and (b), and is extruded through a slit outlet. Then, the coating solution extruded through the slit outlet forms a film of extruded coating solution between a portion where a coating solution comes in contact with a base and the coater, whereby, the film of extruded coating solution thus formed is coated on the base.

[0013] The inventors of the invention found that no dust is caught between the tip of a coater and a substrate to be coated, resulting in no occurrence of streak defects, and a substrate to be coated, when it is flexible, does not affect the coating, and thereby thin-layer coating is possible, when extruding a coating solution in a shape of an extremely thin layer by narrowing slit outlet clearance d of the coater to 50 μm or less, preferably 18 μm or less which is much narrower than that of the conventional extrusion type coater, and thereby coating by colliding the extruded coating solution film with a substrate to be coated which is conveyed or held to be away from the coater by the distance that is greater than that for the conventional extrusion type coater. It has also been cleared in this coating method that coating can be carried out independently of the coating speed once an extruded solution layer is formed, and the higher the coating speed is, the thinner the solution layer is, resulting in a thinner layer coating.

[0014] As a result of intensive studies for conditions which make it possible to coat to be thinner than that of the conventional coater, excepting the higher speed, the relation of $Hw \times U = Q$ holds in the coating method of the invention when Q ($m^3/m \cdot min$) represents an amount of extruded coating solution per a unit width to a substrate to be coated, Hw (m) represents a wet coating thickness of a coated layer, and U (m/min) represents conveyance speed for a substrate to be coated, and it is preferable to lower amount of extruded coating solution Q for thin layer coating. Namely, it is preferable either to lower the speed for extruding a coating solution or to lower the thickness of an extruded layer. It has also been found that it is preferable to make a coater to repel a coating solution and to make the coating solution to tend to leave the coater, by constituting a portion where the coater comes in contact with a coating solution with a member whose contact angle for a coating solution is large, or by mirror-finishing the surface of the portion. There are given a method to water-repellent-finish at least a portion of two confronting surfaces (a) and (b) of the slit, preferably to water-repellent-finish a portion that is closest to the outlet among (a) and (b) surfaces, and a method to form a portion of two confronting surfaces (a) and (b) of the slit with a water repellent member, preferably to form a portion that is closest to the outlet among (a) and (b) surfaces with a water repellent member. In this case, it is preferable that a contact angle of at least a portion of the two confronting surfaces (a) and (b) is 45° or more. It is also possible to attain by making surface roughness Rmax to be 0.8 μm or more. Even in this case, the surface roughness on the portion which is the same as the place for water repellent finishing can take the aforesaid value.

[0015] When a contact angle between a coater and a coating solution is 45° or more, water repellency is satisfactory and a thin extruded layer can be formed. However, when activators are added in a coating solution for the low surface tension or when a coating solution is of a solvent type, the surface tension of the coating solution itself is low and repellency is poor. Therefore, it is necessary to make the coater surface tension to be lower.

[0016] A portion where a coating solution comes in contact with a coater is enough as a place on the coater where a coating solution is repelled, and in particular, a fall of the speed of a running coating solution caused by the contact with a slit surface can be lessened at the portion where the slit clearance is smallest in the vicinity of an outlet of a slit which is a path for a coating solution to run out, which is effective because a thin extruded layer can easily be formed. Further, giving water repellency to the place near an edge section where a solution leaves a coater and starts jetting is also effective for forming of a thin extruded layer.

[0017] Means to cause a coater to repel a coating solution include a method to constitute a coater with highly repellent ceramic, Teflon resin, silicone resin and acrylate resin, a method of coating of other silicone type resins such as fluorine type one and silane, and a method of mirror finishing by means of grinding such as buffing and lapping. However, the invention is not limited to the aforesaid methods, and can employ any method provided that the method can offer the same effect.

[0018] When a coater is made of a metal, in particular, it is almost possible to make a contact angle to be 45° or more by making surface roughness Rmax to be 0.8 μm or less, preferably to be 0.1 μm or less, in a surface grinding method.

[0019] An effect of the invention can be obtained also on a coater for the so-called multi-layer coating which is structured with three bars or more and has two or more slits. In that case, the invention can be applied naturally to a front edge located at the uppermost stream side and a back edge located at the extremely downstream side on the coater for a substrate to be coated, and can be applied even to one or more center edges located between the front edge and the back edge.

[0020] In the invention wherein the tip of a coater is completely away from a substrate to be coated, pressure distribution caused by bending and twist does not occur even when the substrate to be coated is flexible, and coating thickness which is extremely uniform can be obtained. In the invention, excellent coating can be conducted without using a back roll if the twist of a substrate to be coated is corrected to a certain extent by relatively high tension, though it is preferable to spread a flexible substrate to be coated in the vicinity of the coating portion by using a back roll.

[0021] In the case of a high viscosity solution, slit resistance in a narrow outlet clearance of a slit like that in the invention is extremely high, namely, pressure loss is great, which requests fluid-forwarding pressure that is extremely great, and a liquid-forwarding means such as a gear pump used commonly has caused a fall of the amount of flowing solution, pulsation and pump troubles. As a measure to solve this problem, it is effective to attain the slit form wherein the slit clearance is gradually reduced in the direction from a slit inlet to a slit outlet by broadening the clearance of a slit on the part of an inlet for a coating solution instead of narrowing the clearance of a slit on the part of an outlet. For the thin layer coating, slit clearance on the part of an outlet of 50 μm or less is required, and that of 18 μm or less is preferable, and in that case, it is preferable to make the slit clearance on the part of an inlet to be a broad clearance of 100 μm or more, taking a fall of pressure into consideration.

[0022] As a method for this reduction stated above, the gradual reduction by tapering has been employed for forming. In this method, however, the tip portion of a coater becomes a sharp edge at the slit outlet, and in the case of a coater for single-layer coating, for example, it has been difficult to process accurately the height between the tip on the part of a front bar and the tip on the part of a back bar and parallelism, which has worsened coating thickness distribution in the direction of a coating width. However, when a portion where a slit surface of a front bar and a slit surface of a back bar are in parallel with each other without being tapered is provided at the position of an outlet of a slit, processing is easy and accuracy of straightness is improved, an extruded layer which is more uniform can be formed, and distribution of coating thickness in the coating width direction can be made excellent.

[0023] It has been cleared that when abrasives and metal powder are contained in a coating solution under the condition that a slit clearance on the part of an outlet is made to be narrower than that in a conventional extrusion type coater, the abrasives and metal powder grind and roughen an inner wall of the slit while they are flowing at high speed through the inside of the slit, causing deteriorated distribution of coating thickness and streak defects, to shorten life of the coater. However, it has been found, in terms of slit materials, that the problem stated above can be prevented by using a member having high hardness on the portion where the slit clearance in the vicinity of the slit outlet is narrowest. The hardness which represents Vickers hardness of 280 or more in practical use is sufficient, though it depends on a coating solution to be used. Although it is preferable that all surfaces of the slit are constituted with members having this hardness, it is also acceptable in practical use that only parallel portions in the slit outlet where the slit clearance is narrow are constituted with a member having Vickers hardness of 280 or more. Further, even when only the parts of the aforesaid parallel portions which are closest to the slit outlet are constituted with a member having Vickers hardness of 280° or more, deterioration of coating thickness distribution and streak defects cause by grinding and roughening can be prevented to a certain extent. This method can attain cost reduction when processing for higher hardness is expensive. It is preferable for its purposes that both slit surfaces of two bars structuring one slit are constituted with a member having Vickers hardness of 280° or more.

[0024] A coating apparatus or a coating method of the invention is naturally effective for direct coating on a substrate to be coated such as a flexible support such as PET, TAC, PEN, paper and aluminum plate and non-flexible support such as a glass plate, and is also capable of being applied even when coating a coating solution indirectly on a coating roll or a belt and transferring them onto a support. It is also possible to coat on a substrate which relatively lacks flatness.

EXAMPLE

Example 1

[0025]

Substrate to be coated: PET support web having thickness 100 μm and width 1000 mm was used.
Coater: One shown in a side sectional view in Fig. 1 was used.

[0026] A slit was reduced at a step at d = 40 μm and slit surfaces in the vicinity of outlet were parallel.

[0027] Distance between the coater and a substrate to be coated: 0.3 mm

Coating solution: Following magnetic coating (surface tension approx. 30 dyn/cm, viscosity approx. 50 cp • density approx. 1000 kg/m^3)
Coating length: 10,000 m

Composition of magnetic coating:

[0028]

Co-γ-Fe_2O_3 (Hc:900 oersted, BET value: 45 m^2/g)	10 parts
Diacetyl cellulose	100 parts
α-alumina (average particle size: 0.2 μm)	5 parts
Stearic acid	3 parts
Carnauba wax	10 parts
Cyclohexanone	100 parts
Acetone	200 parts

[0029] Under the conditions described above, materials of a member of a coater contacting a solution were changed variously, and coating thickness and distribution of coating thickness for various coating speeds were measured to confirm the limit of thin layer coating.

[0030] Table 1 shows the results of the example stated above.

Table 1

Coater	Coating speed (m/min)	Coating lower limit coating thicknes (μm)	Coating thickness distribution (%)
Comparative example: Conventional type	100 250 500	9 22 Unable to coat	3 5 -
Following example Slit surface is Teflon resin	100 250 500	6 3 2	1 2 3
Edge surface is Teflon resin	100 250 500	7 4 2	1 2 4
Slit & edge surfaces are Teflon resin	100 250 500	5 2 1	1 1 2
Overall surfaces are Teflon resin	100 250 500	5 3 1	1 1 3
Slit surface is coated with silicone resin	100 250 500	7 3 2	2 3 4
Edge surface is coated with silicone resin	100 250 500	7 4 2	1 2 4
Slit & edge surfaces are coated with silicone resin	100 250 500	4 2 1	2 3 4
Overall surfaces are coated with silicone resin	100 250 500	5 2 1	2 3 3
Slit surface is fluoroalkyl silane	100 250 500	6 3 2	1 2 4
Edge surface is fluoroalkyl silane	100 250 500	6 3 2	1 2 3
Slit & edge surfaces are fluoroalkyl silane	100 250 500	4 2 1	2 2 3
Overall surfaces are fluoroalkyl silane	100 250 500	4 2 1	2 3 4
SUS material is subjected to buffing to Rmax<0.8 μm for slit surface	100 250 500	7 3 1	1 1 1
Carbide steel is subjected to buffing to Rmax<0.8 μm for slit surface	100 250 500	6 3 2	1 1 2

* The surface roughness (Rmax) was measured by a surface roughness gauge on the condition that the cut-off length was 8 mm.

[0031] As a result, thin layer coating was possible when water repellency was given to the coater, and coating thickness distribution proved to be excellent.

[0032] In the case that the coating speed was 100 m/min., on comparison with the conventional type coater, by the coater whose edge surface is made of Teflon resin according to the present invention, for example, the lower limit thickness of coating layer was made thinner to the thickness of 7 μm. Further, the coating layer thickness distribution was improved to 1%. This improvement in the coating layer thickness distribution is the appreciable effect of the present invention.

[0033] Incidentally, under all conditions, neither streak defect nor coating mottle was caused, resulting in excellent results.

[0034] When coating conditions were established based on expressions of the invention, coating was not adversely affected by partial slackness or twist of a substrate to be coated, and it was possible to coat thin layer at high speed stably in a coating method which is free from streak defects. Further, by employing a coater slit shape of the invention, it was possible to obtain uniform coating thickness easily. Further, since the distance between the coater and the substrate to be coated is relatively large, roundness of a back roll, fluttering and twist of a substrate to be coated, straightness and bending of the coater tip hardly affect the coating thickness adversely. Whereby accuracy of them has nothing to do with coating, and reduction of apparatus cost, easy management and easy operation and work have been realized.

Claims

1. A coating apparatus, comprising:

conveyance means for conveying a substrate to be coated;
a coater including two surfaces opposite to each other so that a slit is formed therebetween, wherein a coating solution is introduced from an inlet of the slit, passes through the slit between the two surfaces and is discharged from the outlet of the slit,
the gap distance d of the slit at the outlet being made so as to satisfy the following formula:

$$0 < d \leq 50 \times 10^{-5} \text{ (m)},$$

and
at least a part of the outlet section of the two surfaces being formed by a member having a water-repelling property.

2. The coating apparatus of claim 1, wherein the contact angle of the part of the outlet section of the two surfaces is 45° or more.

3. The coating apparatus of claim 1, wherein the roughness (Rmax) of the part of the outlet section of the two surfaces is 0.8 μm or more.

4. The coating apparatus of claim 1, wherein the gap distance of the slit at the outlet is made narrower than that at the inlet.

5. The coating apparatus of claim 4, wherein the slit has on its outlet section a section where the two surfaces are parallel to each other.

6. The coating apparatus of claim 4, wherein the narrowest portion of the slit is constructed with a member whose Vickers hardness is 280 or more.

7. The coating apparatus of claim 1, wherein a predetermined portion of the surface of the coater which comes in contact with the coating solution is constructed with at least one kind of metal, ceramic, resin and glass.

8. The coating apparatus of claim 1, wherein a predetermined portion of the surface of the coater which comes in contact with a coating solution is given a repelling property by a covered layer.

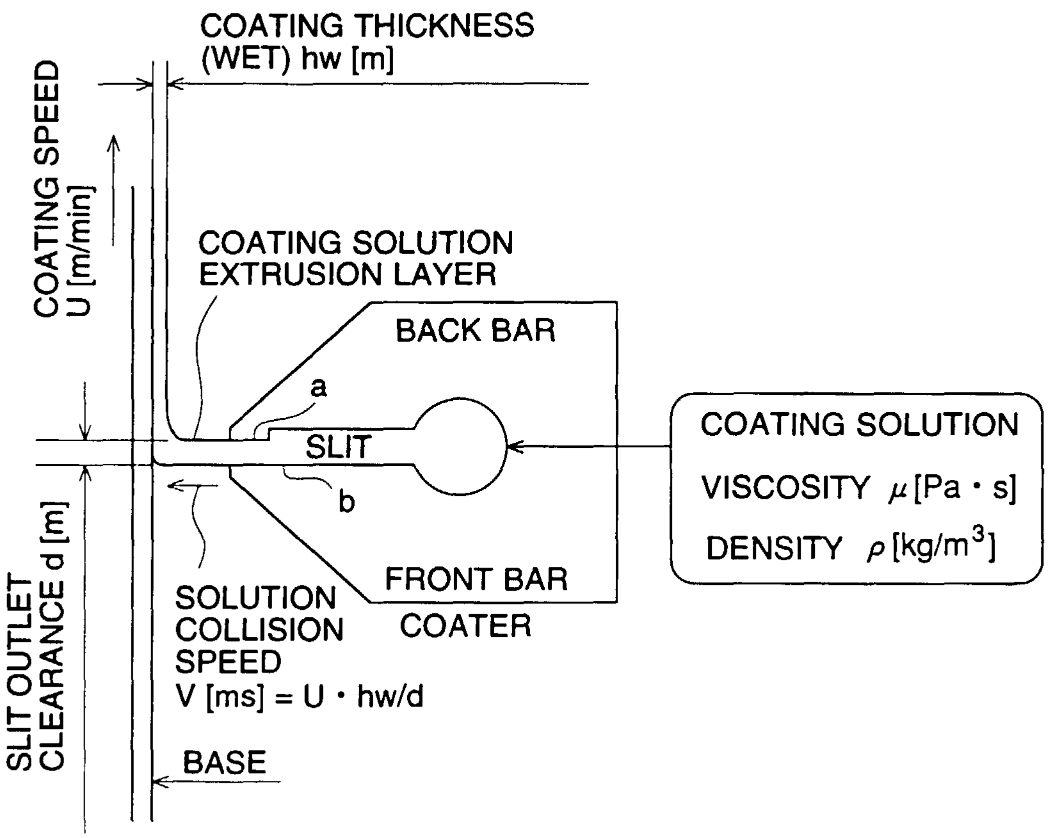
9. The coating apparatus of claim 3, wherein a predetermined portion of the surface of the coater which comes in contact with a coating solution is covered with a member whose surface roughness Rmax satisfies the relation of Rmax ≤ 0.8 (μm).

10. The coating apparatus of claim 8, wherein the predetermined portion of the surface of the coater is covered with at least one kind of fluorocarbon resin, silicon type resin and ceramic.

11. A coating apparatus, comprising

a coater including two bars forming a slit therebetween;
a conveyor for conveying a substrate to be coated in the vicinity of the coater such that a predetermined gap distance is kept between the substrate and the outlet of the sit; and
jetting means for jetting a coating solution in the form of a layer from the outlet of the slit through the gap onto the substrate.

FIG. 1


COATING THICKNESS (WET) hw [m]
COATING SPEED U [m/min]
COATING SOLUTION EXTRUSION LAYER
BACK BAR
a
SLIT
b
COATING SOLUTION
VISCOSITY μ [Pa · s]
DENSITY ρ [kg/m3]
FRONT BAR
COATER
SOLUTION COLLISION SPEED
V [ms] = U · hw/d
SLIT OUTLET CLEARANCE d [m]
BASE