

COATING MATERIAL APPLICATION DEVICE AND
COATING MATERIAL APPLICATION METHOD

TECHNICAL FIELD OF THE INVENTION

5 [0001] The present invention relates to a device and a method for applying a coating material to a core wire, such as a wire. More particularly, it relates to a device and a method for applying a coating material containing particles, such as abrasive grains, to a
10 core wire. Further, the present invention relates to a device and a method for applying a coating material (paste) containing abrasive grains in production of a fixed abrasive grain wire saw, above all, a resin bond wire saw (a wire saw formed by fixing abrasive grains
15 to a core wire with a resin adhesive).

BACKGROUND OF THE INVENTION

[0002] Year after year, silicon ingots for use in TFT (thin-layer transistor) and solar cells have
20 increasingly been having larger diameters. In slice cutting of such silicon ingots, cut processing by use of a wire saw has been performed. This cutting process is performed by causing the wire saw to travel while causing the wire saw to pressure weld an object
25 to be cut.

[0003] Wire saws to be used for such a cutting process include fixed abrasive grain wire saws where abrasive

grains such as diamond particles are fixed on a surface of the core wire. Methods for fixing abrasive grains to a surface of a core wire include a resin-bonding method and an electrodeposition method.

5 [0004] The resin-bonding method is a method for doing a heat treatment with an infrared heating furnace and an enamel baking furnace by applying a paste which is a mixture of a resin adhesive such as a phenol resin and abrasive grains on a surface of a core wire such
10 as a steel wire (For example, Japanese Patent No. 5792208 B and Japanese Patent No. 3078020 B).

[0005] A method for continuously applying a coating material such as a paste to a surface of a core wire includes a method for applying a paste to a core wire
15 by squeezing the paste from a nozzle with a smaller diameter by use of a dispenser (syringe) or an application method by use of a floating die (For example, Japanese Examined Utility Model Application Publication No. 57-005765 B).

20 [0006] FIG. 17 is a schematic view of a coating material application device obtained by a conventional application method with use of a floating die.

[0007] A conventional application device 102 shown in FIG. 17 includes a storage tank 108 for storing a
25 coating material 103 to be applied on a surface of a core wire 106 travelling upward (in an arrow 10 direction), a coating die 116, and an insertion hole

131. The core wire 106 passes through the insertion hole 131 and a die hole 156 in the coating die 116 in this order. The coating material 103 is introduced from an inlet port 146 provided on a side wall 109 of the storage tank 108 into the storage tank.

[0008] The coating die 116 is a floating die provided above the insertion hole 131. The lower end of the die hole 156 in the coating die 116 is formed in a tapered state to be provided such that the diameter of an inlet side of the core wire 106 becomes greater. When the core wire 106 stops, the coating die 116 is embedded in the coating material 103 and is in contact with a bottom wall 130. When the core wire 106 is travelling, the coating die 116 floats up due to frictional resistance caused by viscosity of the coating material 103 at the time when the core wire 106 passes through the die hole 156.

[0009] While the floating state of the coating die 116 varies depending on the shape of the coating die 116 and viscosity of the coating material 103, in Japanese Examined Utility Model Application No. 57-005765 B, the coating die 116 is in a state of projecting from a liquid level 105 and floating up. The faster the travelling speed of the core wire is, the greater the floating of the coating die 116 becomes.

[0010] The core wire 106 is introduced from the insertion hole 131 provided on the bottom wall 130 of

the storage tank 108 and travels in the coating material 103. As a result, the core wire 106 passes through the die hole 156 in the coating die 116 to be a core wire 106a to which the coating material 103 is
5 being applied. The core wire 106a is subsequently introduced into a heating furnace not shown, resulting in solidification of the coating material 103.

PRIOR ART DOCUMENTS

10 PATENT DOCUMENTS

[0011] Patent document 1: Japanese Patent No. 5792208

B

Patent document 2: Japanese Patent No. 3078020

B

15 Patent document 3: Japanese Examined Utility Model

Application No. 57-005765 B

SUMMARY OF THE INVENTION

20 PROBLEMS TO BE SOLVED BY THE INVENTION

[0012] In such a coating material application device 102, when a diameter of an insertion hole 131 is too small so as to prevent liquid leakage from being generated, a core wire 106 and the insertion hole 131
25 may be damaged due to a touch with the travelling core wire 106. As a result, it is needed to enlarge the diameter of the insertion hole 131 enough to prevent

the core wire 106 from being damaged. When the core wire 106 passes through the insertion hole 131, quite a great amount of air is accompanied to be brought into a storage tank 108 due to the large diameter of the insertion hole 131. Such brought air becomes air bubbles and thus reaching a die hole 156 in a coating die 116 along with a coating material 103 accompanying the core wire 106. Such air bubbles remain in an area near an inlet of the die hole 156 that is at a lower surface side of the coating die 116. Consequently, the content of the air bubbles of the coating material 103 in this area increases with the passage of time for the core wire 106 to pass through. This allows a great amount of air bubbles along with the coating material 103 to also adhere to the core wire 106 that has passed through the coating die 116. There is a tendency that distribution of abrasive grains in the coating material adhering to the core wire 106a is not uniform due to effects of the air bubbles. It has been revealed that the thickness of a coating layer is not uniform. In addition, it has revealed that a quite great amount of air bubbles remain.

[0013] The present invention has made to solve these problems. It is an object of the present invention to provide a device and a method for applying a coating material capable of obtaining a coated core wire

having a uniform outer diameter with little mixture of air bubbles into a coating material.

MEANS FOR SOLVING THE PROBLEMS

5 [0014] The summary of the present invention is described as below.

In a first preferred aspect, there is provided a coating material application device for applying a coating material to a core wire travelling upward
10 according to the present invention, which includes a storage tank for storing the coating material and having an insertion hole in which the core wire is inserted on its bottom, a die group composed of at least three dies including a lower die and at least
15 one middle die embedded in the coating material stored in the storage tank, and an upper die in which its upper surface projects from a liquid level of the coating material stored in the storage tank, the at least three dies being arranged at intervals so that
20 the core wire can sequentially pass through the at least three dies.

[0015] In a second preferred aspect of the coating material application device according to the present invention, a die hole in the upper die has a diameter
25 of not greater than the diameter of the die hole in the middle die.

[0016] In a third preferred aspect, the coating material application device according to the present invention further includes means for introducing a coating material into the storage tank, means for
5 draining the coating material stored in the storage tank, and means for maintaining a liquid level of the coating material stored in the storage tank at a level that the upper die projects from the liquid level of the coating material.

10 [0017] In a fourth preferred aspect, the coating material application device according to the present invention further includes means for introducing the coating material stored in the storage tank, and a weir for overflowing the coating material stored in
15 the storage tank.

[0018] In a fifth preferred aspect of the coating material application device according to the present invention, a first pedestal where the middle die is placed and a second pedestal where the upper die is
20 placed are arranged inside the storage tank, and an insertion hole for inserting the core wire is each formed in the first and second pedestals.

[0019] In a sixth preferred aspect of the coating material application device according to the present
25 invention, the storage tank is divided into a pre-storage part and a main storage part by a partition plate, an opening for bringing the pre-storage part

and the main storage part into conduction is provided between a lower end of the partition plate and a bottom wall of the storage tank, an inlet port for introducing the coating material into the storage tank is provided in the pre-storage part, and the die group is provided in the main storage part.

[0020] In a seventh preferred aspect of the coating material application device according to the present invention, the at least one middle die comprises a plurality of middle dies.

[0021] In an eighth preferred aspect of the coating material application device according to the present invention, the plurality of middle dies are floating dies floating up in the coating material stored in the storage tank by inserting the core wire into the die holes in the middle dies and causing the core wire to travel in the coating material stored in the storage tank.

[0022] In a ninth preferred aspect of the coating material application device according to the present invention, the upper die is a floating die floating up on the liquid level of the coating material stored in the storage tank by inserting the core wire into the die hole in the upper die and causing the core wire to travel in the coating material stored in the storage tank.

[0023] In a tenth preferred aspect of the coating material application device according to the present invention, a stopper attaching member having an insertion hole in which the core wire travels and a
5 stopper for restricting a lifting movement of the at least one middle die in accordance with travelling of the core wire is provided in the storage tank.

[0024] In an eleventh preferred aspect of the coating material application device according to the present
10 invention, the coating material contains abrasive grains.

[0025] In a twelfth preferred aspect, there is provided a method for applying a coating material to a core wire travelling upward according to the present
15 invention, which includes the steps of: deriving the core wire from a die hole in a lower die provided in a storage tank for storing the coating material; deriving the core wire from a die hole in each of at least one middle die embedded in the coating material
20 and freely movable; and causing the core wire to travel by deriving a die hole in an upper die that is freely movable and projects from a liquid level of the coating material.

[0026] In a thirteenth preferred aspect of the method
25 for applying a coating material according to the present invention, the die hole in the upper die has a

diameter of not greater than a diameter of the die hole in each of the at least one middle die.

[0027] In a fourteenth preferred aspect of the method for applying a coating material according to the present invention, the at least one middle die comprises a plurality of middle dies.

ADVANTAGES OF THE INVENTION

[0028] According to a device and a method for applying a coating material of the present invention, it is possible to obtain a coated core wire having a substantially uniform outer diameter with little mixture of air bubbles in the coating material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

FIG. 1 is a schematic view showing a configuration of a coating material application device of the present invention;

FIG. 2 is a cross-section schematic view of the coating material application device taken on line A-A shown in FIG. 1;

FIG. 3 is an explanatory view showing a state of air bubbles retaining near an inlet of a die hole;

FIG. 4 is a schematic view showing a configuration of a coating material application device of the present invention in another embodiment;

FIG. 5 is a schematic view showing a configuration of a coating material application device of the present invention in still another embodiment;

FIG. 6 is a cross-section schematic view of the
5 coating material application device viewed along the line B-B shown in FIG. 5;

FIG. 7 is a schematic view showing a configuration of a coating material application device of the present invention in a further embodiment;

10 FIG. 8 is a schematic view showing a configuration of a coating material application device of the present invention in a still further embodiment;

FIG. 9 is a schematic view showing a
15 configuration of a coating material application device of the present invention in another embodiment;

FIG. 10 is an enlarged photograph of a resin bond wire saw;

FIG. 11 is an enlarged photograph of a resin bond
20 wire saw;

FIG. 12 is an enlarged photograph of a resin bond wire saw;

FIG. 13 is an enlarged photograph of a resin bond wire saw;

25 FIG. 14 is an enlarged photograph of a resin bond wire saw;

FIG. 15 is an enlarged photograph of a resin bond wire saw;

FIG. 16 is a graph showing cutting performance of Examples and Comparative Examples; and

5 FIG. 17 is a schematic view showing a configuration of a conventional coating material application device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 [0030] A coating material application device to be used in the present invention is a coating material application device containing particles, such as abrasive grains (hereafter also referred to as a coating material) to a peripheral surface of a core
15 wire such as a wire.

 [0031] The coating material application device of the present invention is a coating material application device which applies a coating material to a surface of a core wire travelling upward, which includes a die
20 group composed of at least three dies including a lower die, at least one middle die, and an upper die. The lower die, the at least one middle die, and the upper die are so located that the core wire may pass through in this order.

25 [0032] FIGS. 1 and 2 each show an example of an embodiment of a coating material application device of the present invention. Same reference numerals shown

in each drawing are identical to or the same as the previous ones. With reference to the detailed description of the present invention, a method for applying a coating material will be described along with the detailed description of the coating material application device.

[0033] In FIGS. 1 and 2, a coating material application device 2 of the present invention includes a storage tank 8 for storing a coating material 3 to be applied to a peripheral surface of a core wire 6 travelling substantially vertical upward (an arrow 10 direction), a lower die 12, a middle die 14, and an upper die 16. The core wire 6 passes through the lower die 12, the middle die 14, and the upper die 16 in this order.

[0034] The coating material 3 is introduced into the storage tank 8 from an inlet port 46 provided on a side wall 9 of the storage tank 8 by means for introducing the coating material 3 into the storage tank 8. The coating material 3 may be introduced from an upper opening of the storage tank 8. The inlet port 46 of the coating material 3 may be provided on a bottom wall 30. A configuration including a coating material tank having an agitator, a feeding liquid pump, and a pipe line that connects the feeding liquid pump to the inlet port 46 is exemplified as the means for introducing a coating material.

[0035] The lower die 12 is embedded in the coating material 3 and is fixed to the bottom wall 30 of the storage tank 8. An insertion hole 31 which penetrates the bottom wall 30 having an axis which is the same as the axis of a die hole 52 in the lower die 12 is provided on the bottom wall 30 of the storage tank 8. The core wire 6 is inserted in the die hole 52 in the lower die 12 via the insertion hole 31 from outside the storage tank 8 to be introduced into the storage tank 8 where the coating material 3 is filled. To easily insert the core wire 6, the die hole 52 in the lower die 12 preferably has a large inlet and a small outlet. While the minimum internal diameter of the die hole 52 is set to be greater than the diameter of the core wire 6, the die hole 52 preferably has a sufficient size of the internal diameter to prevent the coating material 3 from leaking from the die hole 52 by viscosity and surface tension of the coating material 3. While the internal diameter of the insertion hole 31 may be set close to the maximum internal diameter of the die hole 52, the internal diameter may be not limited to particular values. While the shape of the die hole 52 in the lower die 12 is not limited to the shape shown in drawings, for example, the shape may be a straight cylindrical shape. In addition, the lower die 12 and the bottom wall 30 of the storage tank 8 may integrally be formed. The

insertion hole 31 and the die hole 52 in the lower die 12 may integrally be formed. As the core wire 6 travels upward, a significant amount of air is brought into the coating material 3 in the storage tank 8 as
5 air bubbles. The faster the core wire 6 is travelling, the more air bubbles are brought together with the core wire 6.

[0036] The middle die 14 being spaced apart from the lower die 12 is provided above the lower die 12. The
10 middle die 14 is disposed in a state of being embedded in the coating material 3 of the storage tank 8 and is placed on a first pedestal 18. The die hole 54 in the middle die 14 has a wide inlet side from which the core wire 6 is introduced and a narrow outlet port
15 side. The internal diameter (diameter) of the die hole 54 in the middle die 14 is set at a little greater than the outer diameter of the coating material 3 to be applied on the peripheral surface of the core wire 6. The first pedestal 18 on which the
20 middle die 14 is placed is formed of a plate projecting from the storage tank 8 and a first through-hole 32 is formed coaxially with the axis of the die hole 52 in the lower die 12. While the internal diameter of the first through-hole 32 may be
25 greater than the outer diameter of the core wire 6, the internal diameter is not limited to a particular size. The middle die 14, which is a floating die, is

freely movable in the coating material 3 when the core wire 6 is not inserted in the middle die 14. As shown in FIG. 1, when the core wire 6 travels with the core wire 6 inserted in the die hole 54, the middle die 14 is in a state of floating from the first pedestal 18. In other words, when the core wire 6 travels through the die hole 54 in the middle die 14, the coating material 3 being applied to the peripheral surface of the core wire 6 also passes through the die hole 54. At this time, the middle die 14 is about to be lifted due to viscosity of the coating material 3. On the other hand, the middle die 14 is about to drop by the force excluding buoyancy from the self-weight of the middle die 14. The balance of the self-weight and the buoyancy makes the middle die 14 in a floating state in the coating material 3. Space 25 to be described later is formed below the middle die 14 by the floating of the middle die 14 to secure a path of air bubbles. At this time, when the travelling speed of the core wire 6 is fast, the middle die 14 moves upward in a floating state. When the travelling speed of the core wire 6 is slow, the middle die 14 remains on a side of the first pedestal 18.

[0037] When the core wire 6 passes through the die hole 54 in the middle die 14, the coating material 3 situated below the middle die 14 is brought into the die hole 54 with the movement of the core wire 6. At

this time, in a horizontal direction which is orthogonal to a direction where the core wire 6 travels, it is presumed that reaction force is generated on a side wall of the die hole 54 and the peripheral surface of the core wire 6 respectively via the coating material 3 due to viscosity resistance generated by compression of the coating material 3. The middle die 14 moves in such a manner that the balance of this reaction force conforms the axis of the core wire 6 to the axis of the die hole 54. As a result, the coating material 3 is brought into contact with the peripheral surface of the core wire 6 coaxially with the axis of the core wire 6.

[0038] A significant amount of air is brought into the coating material 3 in the storage tank 8 with the travelling of the core wire 6. When the core wire 6 passes through the die hole 52 in the lower die 12, air that adheres to the peripheral surface of the core wire 6 is brought into the coating material 3 in the storage tank 8 as air bubbles. Air bubbles move upward while diffusing in the coating material 3 and partially pass through the first through-hole 32 in the first pedestal 18. The rest of the air bubbles moves upward in the storage tank 8 from the circumference of the first pedestal 18. The air bubbles that have passed through the first through-hole 32 in the first pedestal 18 are partially brought

into the die hole 54 in the middle die 14 by the travelling of the core wire 6. At this time, pressure is applied to the coating material 3 adhering to the peripheral surface of the core wire 6 to separate air bubbles contained in the coating material 3 from the circumference of the core wire 6. The air bubbles separated from the circumference of the core wire 6 move to the space 25 situated below the middle die 14 to be mixed with the coating material 3. This means that the coating material 3 containing a significant amount of air bubbles unevenly distributes in the space 25. On the other hand, abrasive grains being dispersed in the coating material 3 are pressed to be in contact with the circumference of the core wire 6.

[0039] As shown in FIG. 3, when a number of air bubbles 64 that have arrived at the middle die 14 with the travelling of the core wire 6 pass through the die hole 54 in the middle die 14, the air bubbles are separated from the coating material 3 adhering to the peripheral surface of the core wire 6. The separated air bubbles 64 are diffused in an outer circumferential direction from the center of the middle die 14 (near the die hole 54) to rise along a drainage route 17 (See FIGS. 1 and 2) in the storage tank 8. The air bubbles 64, however, pass through the die hole 54 in the middle die 14 while partially remaining in the coating material 3 adhering to the

peripheral surface of the core wire 6. The air bubbles that have partially passed through the die hole 54 are greatly compressed by the die hole 54. As a result, the air bubbles are instantly released when
5 the air bubbles move out of the die hole 54, and greatly expand, resulting in separation from the circumference of the core wire 6.

[0040] The first pedestal 18 is provided inside the storage tank 8 such that a gap 23 filled with the
10 coating material 3 and gaps 92 shown in FIG. 2 are formed between the first pedestal 18 and the side wall 9 of the storage tank 8. The coating material 3 in the storage tank 8 is movable, passing through the gaps 23 and 92. Travelling of the core wire 6 enables
15 the coating material 3 to adhere to the peripheral surface of the core wire 6 and move to a middle die 14 side after passing through the first through-hole 32 in the first pedestal 18 along with the core wire 6. As a result, the coating material 3 passes through the
20 gaps 23 and 92 to be replenished between the lower die 12 and the first pedestal 18.

[0041] The upper die 16 is positioned above the middle die
14, spacing apart from the middle die 14 and is placed
25 on a second pedestal 28 formed in a plate shape. The second pedestal 28 on which the upper die 16 is placed
is

formed in a plate shape projecting from the storage tank 8.

A second through-hole 36 is formed coaxially with the axis

5 of the die hole 56 in the upper die 16. The inner diameter

of the second through-hole 36 is preferably sufficiently

greater than the outer diameter of the core wire 6,

10 which

is not limited to particular values. When the core wire 6

is not inserted in the upper die 16, the upper die 16 is in

15 a state of being freely movable in the coating material 3.

As shown in FIG. 1, when the core wire 6 is inserted in the

die hole 56 and travels, the upper die 16 that is a floating die whose upper portion protrudes from the liquid

20 level 5 becomes in a state of floating from the second pedestal 28 and being not in contact with the second pedestal 28. That is, when the core wire 6 travels on the

25 die hole 56 in the upper die 16, the coating material

being applied to the peripheral surface of the core
wire 6

also passes through the die hole 56. At this time,
the

5 upper die 16 is about to be lifted by the action of
viscosity of the coating material 3. On the other
hand,

the upper die 16 is about to drop with a force
excluding a

10 buoyancy from the self-weight of the upper die 16.

The
balance between these forces creates a state in which
the
upper die 16 is floating.

15 [0042] When the core wire 6 passes through the die
hole 56 in the upper die 16, the coating material 3
situated in the spaces 27 and 270 that is below the
upper die 16 is brought into the small space of the
die hole 56 with the movement of the core wire 6. At
20 this time, in a horizontal direction that is
orthogonal to the direction where the core wire 6
travels, it is anticipated that reaction force is
caused both on the side wall of the die hole 56 and on
the peripheral surface of the core wire 6 by viscosity
25 resistance due to compression of the coating material
3. The balance of this reaction force moves the upper
die 16 such that the axis of the core wire 6

corresponds to the axis of the die hole 56.

[0043] The second pedestal 28 is provided inside the storage tank 8 so as to form a gap 29 filled with the coating material 3 and a gap 90 shown in FIG. 2

5 between the second pedestal 28 and the side wall 9 of the storage tank 8. The coating material 3 in the storage tank 8 is movable, passing through the gaps 29, 90.

[0044] This makes the spaces 25 and 27 filled with the
10 coating material 3 in the state where the coating material 3 is movable, passing through near the gaps 23, 92. The coating material 3 is in a state of being brought into conduction in the storage tank 8 filled with the coating material 3. The majority of air
15 bubbles brought from the die hole 52 in the lower die 12 passes through the gaps 23, 29 and the gaps 90, 92 shown in FIG. 2 from the spaces 25, 27 along with the drainage route 17 without passing through the middle die 14 and the upper die 16 to move along the drainage
20 route 17 with the coating material 3.

[0045] The coating material 3 containing air bubbles having moved along the drainage route 17 is drained outside the storage tank 8 by a coating material draining means. In this embodiment, as shown in FIG.
25 1, a coating material draining means for including a weir 60 for overflowing the coating material 3 at a predetermined liquid level and a recovery tank 61 for

receiving the overflown coating material 3 is provided.
The coating material 3 having been overflown over the
weir 60 drops in the recovery tank 61. And then the
coating material 3 is drained outside the storage tank
5 8 by a drainage pump (not shown) or a drainage pipe
(not shown) connected to the drainage pump. The weir
60 has functions for a liquid level maintaining means
to maintain the liquid level 5 at the height of the
upper end of the weir. The weir 60 is set in such a
10 manner that the liquid level is near the center
(thickness direction) of the upper die 16 placed on
the second pedestal 28. The coating material 3 is
drained outside the storage tank 8 and then air
bubbles contained in the coating material are removed
15 to be reused by adjusting components of the coating
material.

[0046] Alternatively, the coating material 3 may
directly be drained from the storage tank 8 by a
coating material draining means not shown without the
20 weir 60 and the recovery tank 61. The coating
material 3 is drained outside the tank and is
introduced to the inside of the tank by the coating
material draining means, the coating material
introducing means, and the liquid level maintaining
25 means (not shown). A drainage equivalent amount of
the coating material 3 and an attachment equivalent
amount of the coating material 3 that is brought

outside the storage tank 8 with attachment to the core wire 6a are replenished from the inlet port 46 that is an element of the coating material introducing means to maintain at a predetermined liquid level. The coating material draining means includes a drainage pump and a drainage pipe connected to the drainage pump. The liquid level maintaining means includes a detection sensor for detecting a liquid level and a controller for receiving its detection signals and transmitting control signals to the coating material introducing means. The coating material introducing means includes a feeding liquid pump and a feeding pipe connected to the feeding pump.

[0047] When the traveling speed of the core wire 6 is fast, the middle die 14 becomes elevated in the coating material 3. Accordingly, a stopper 35 may be provided below the second pedestal 28 to control the elevation of the middle die 14. The stopper 35 shown in FIG. 1 is provided on a lower surface of a stopper attaching member 34. The stopper attaching member 34 is a plate-shaped member that protrudes from an inner wall of the storage tank 8 to the horizontal direction. A through-hole 33 where the core wire 6 is inserted is coaxially provided with the axes of a die hole 52 in the lower die 12, the first through-hole 32 in the first pedestal 18, and the second through-hole 36 in the second pedestal 28. At least three projection-

shaped stoppers 35 are provided around the lower surface of the through-hole 33 of the stopper attaching member 34. The height of each of the stoppers 35 may be preferably greater than the maximum diameter of abrasive grains contained in the coating material 3. A smooth material, such as a fluororesin is used for each stopper 35. This enables the coating material 3 to be uniformly applied to the core wire 6 by up and down and left and right movements of the middle die 14 in response to misalignment of the core wire 6 even when the middle die 14 is in contact with the stoppers 35. The lower surface of the stopper attaching member 34 itself may be used as a stopper instead of the stoppers 35. In addition, a plurality of stoppers 35 may be provided on the lower surface of the second pedestal 28 without the stopper attachment member 34. The middle die 14 can be more easily exchanged when the first pedestal 18, the second pedestal 28 or the stopper attaching member 34 are detachably/attachably arranged relative to the storage tank 8, which is more preferable.

[0048] As shown in FIG. 2, while the width direction dimensions of the first pedestal 18 and the second pedestal 28 are not particularly limited, the dimensions may be equivalent to the width direction dimensions of the middle die 14 and the upper die 16 or a little greater. Similarly, while the width

dimensions of the stopper attaching member 34 formed by a plate-shape member are the dimensions large enough to attach the stoppers 35, the dimensions are not limited to particular dimensions.

5 [0049] The core wire 6 is set in the coating material application device 2 according to the configuration mentioned above as below. The core wire 6 wound up in a coil state is unreeled to be introduced from an insertion hole 31 formed on the bottom wall 30 of the storage tank 8 without the coating material 3. First, 10 the core wire 6 is caused to pass through the die hole 52 in the lower die 12. Second, the core wire 6 is caused to pass through the first through-hole 32 in the first pedestal 18, the die hole 54 in the middle die 14, the through-hole 33 in the stopper attaching member 34, the second through-hole 36 in the second pedestal 28, and the die hole 56 in the upper die 16 in order to prepare. Subsequently, the core wire 6 is introduced into a heating furnace not shown to prepare 15 for solidifying the coating material 3 to be applied on the core wire 6 and for winding in a coil state. After the aforementioned preparation has been made, the coating material 3 is filled in the storage tank 8. The coating material 3 is obtained by mixing abrasive 20 grains, such as diamond grains or a filler with, for example, one kind or two kinds of thermosetting resin, if necessary. The coating material 3 is allowed to 25

overflow from the weir 60, while replenishing the coating material 3 from the inlet port 46. The core wire 6 is caused to travel from the bottom to the top as soon as the aforementioned preparation has been completed. The middle die 14 and the upper die 16 are each in contact with the first pedestal 18 and the second pedestal 28. The middle die 14 and the upper die 16, however, each float above the first pedestal 18 and the second pedestal 28 as the traveling speed of the core wire 6 increases. The coating material 3 is being uniformly applied to the peripheral surface of the core wire 6 derived from the die hole 56 in the upper die 16 and is fed to a heating furnace to be solidified. As a result, a resin bond wire saw is obtained. The resin bond wire saw is a wire saw in which abrasive grains are attached to all over the surface of the wire with a resin adhesive, which is used for slicing a silicon ingot.

[0050] In preparation of the coating material 3, when a coating material is successively applied on the traveling core wire 6, it is preferable to adjust the viscosity of the coating material 3 to be from 2 Pa·s to 10 Pa·s by adding a solvent to an adhesive composition composed of a thermosetting resin, such as a phenol-based resin to obtain an even amount of application. The viscosity of the coating material 3 is further preferably adjusted in a range of 3 Pa·s to

8 Pa.s. For instance, the solvent is preferably set in a range of 100 weight parts to 200 weight parts relative to 100 weight parts of an adhesive composition. While the solvent for adjusting the

5 viscosity of the coating material 3 is not particularly limited, o-cresol at a low boiling point is preferable even in isomers of o-, m-, p-.

[0051] While the abrasive grains to be used in the present invention are not particularly limited as long
10 as abrasive grains for a resin bond wire saw, examples of the abrasive grains include diamond abrasive grains, cubic system boron nitride (CBN) abrasive grains, alumina abrasive grains, and silicon carbide abrasive grains. The size of the abrasive grains is selected
15 in accordance with the purpose or the core wire diameter. From a viewpoint of slicing a silicon ingot with few kerf loss (cutting waste), however, the size of the abrasive grains is preferably some micrometer (μm) to 25 micrometer (μm).

20 [0052] A method for irradiating near-infrared rays to a core wire 6a where the coating material 3 is applied with use of an infrared lamp as a heating furnace for heating the traveling core wire 6 is preferably adopted. This prevents foaming of a resin adhesive
25 after curing by promoting dehydration and cross-linkage of the resin adhesive constituting the coating material 3, and suppressing foaming of the resin

adhesive caused by gasification of water generated by dehydration reaction.

[0053] The lower die 12 is fixed to the bottom wall 30 to avoid generation of liquid leakage. In general, this needs to enlarge the diameter of the die hole 52 in the lower die 12 enough to prevent the core wire 6 or the lower die 12 from being damaged due to friction between the side wall of the die hole 52 and the core wire 6. As the diameter of the die hole 52 is great, a significant amount of air is brought into the tank when the core wire 6 passes through the die hole 52 in the lower die 12. Such air brought into the tank reaches the die hole 54 in the middle die 14 along with the coating material 3 in an air bubble state accompanying to the core wire 6. As shown in FIG. 3, air bubbles 64 partially remain in an area near the inlet of the die hole 54 situated on the lower surface of the middle die 14. As a result, the content of the air bubbles 64 contained in the coating material 3 in this area increases as time for the core wire 6 passing through. On the other hand, most of the air bubbles 64 in this area are exhausted from the area near the inlet of the die hole 54 in the middle die 14 to outside the area by accompanying streams of the coating material 3 that move in association with the core wire 6 when the core wire 6 travels. The air bubbles 64 that have remained in the area near the

inlet of the die hole 54 without being exhausted outside the area, however, remain in a mixed state with the coating material 3 and adhere to the core wire 6 that has passed through the middle die 14. The
5 air bubbles 64 tend to affect to cause non-uniform distribution of abrasive grains in the coating material being applied to the core wire 6, although the distribution of the abrasive grains is sufficiently corrected compared with the case of
10 without the middle die 14. In addition, the thickness of the coating material is non-uniform.

[0054] The core wire 6 further passes through the coating material 3 filled in the spaces 27, 270. This allows the coating material 3 to be filled in a place
15 where air bubbles exist to further improve the non-uniform distribution of the abrasive grains. The core wire 6 passes through the die hole 56 in the upper die 16 and thus making the distribution of the abrasive grains contained in the coating material adhering to
20 the core wire 6 uniform. In addition, a coated layer having a uniform thickness free from air bubbles can be obtained. The core wire 6 passes through the die hole 56 in the upper die 16 to obtain the core wire 6a where the coating material 3 having a predetermined
25 diameter has been applied.

[0055] The diameter of the die hole 56 in the upper die 16 is preferably smaller than the diameter of the

die hole 54 in the middle die 14. Since the diameter of the die hole 56 is smaller than the diameter of the die hole 54, the coating material 3 with few air bubbles is pressed against the core wire 6 in the upper die 16 to make sure to fix abrasive grains to the peripheral surface of the core wire 6. This further makes sure to obtain an advantage to make the distribution of the abrasive grains in the coating material adhering to the core wire 6 uniform and an advantage to obtain a coating layer with a uniform thickness free from air bubbles as well as adjusting the application amount of the coating material applied on the core wire 6 with use of the diameter of the die hole 56 in the upper die 16. The diameter of the die hole herein refers to a hole diameter in a place where the diameter of the die hole becomes the minimum.

[0056] When the core wire 6 travels in the space 25 filled with the coating material 3, accompanying streams of the coating material 3 that move in association with the core wire 6 are generated. Such accompanying streams are blocked by the lower surface of the middle die 14 or the first pedestal 18 and spread in a lateral direction. As a result, the coating material 3 containing air bubbles moves and is exhausted outside the tank by a coating material draining means via the drainage route 17.

[0057] The coating material introducing means in the

coating material application device 2 is used to newly replenish the coating material 3 instead of the coating material 3 containing the air bubbles drained outside the tank by the coating material draining means as well as to replenish the coating material 3 taken outside the tank with the coating material applied to the core wire 6.

[0058] Next, another embodiment will now be described. Like a coating material application device 2a shown in FIG. 4, when the coating material 3 to be introduced into a storage tank 8a from the inlet port 46 contains air bubbles, a partition plate 45 is preferably placed in the storage tank 8a and is preferably divided into a pre-storage part 38 and a main storage part 40 inside the storage tank 8a via the partition plate 45. Die kinds are installed in the main storage part 40. An opening 44 is provided between the lower end of the partition plate 45 and the bottom wall 30 of the storage tank 8a. The pre-storage part 38 is in conduction with the main storage part 40 via the opening 44. In addition, the coating material application device 2a has a side cross-section and a configuration similar to those in FIG. 2.

[0059] The coating material 3 is first introduced into the pre-storage part 38 from the inlet port 46. The introduced coating material 3 is once blocked from moving by the existence of the partition plate 45

situated in the travelling direction of the coating material 3. As a result, the coating material 3 moves to the main storage part 40 after passing through the opening 44 situated below the partition plate 45. The coating material 3 introduced into the pre-storage part 38 is once blocked by the partition plate 45. As a result, air bubbles contained in the coating material 3 move upward to be separated from the coating material 3.

10 [0060] FIGS. 5 and 6 each illustrate an example of still another embodiments of the coating material application device 2 of the present invention. In FIG. 5, a coating material application device 2b of the present invention includes a storage tank 8b for
15 storing a coating material 3, a lower die 12, a first middle part die 14a, a second middle part die 14b, and an upper die 16. A core wire 6 passes through the lower die 12, the first middle part die 14a, the second middle part die 14b, and the upper die 16 in
20 this sequence.

[0061] The coating material 3 is introduced into a pre-storage part 38b from an inlet port 46 provided on a side wall 9 of the storage tank 8b by means for introducing the coating material 3 into the storage
25 tank 8 which is not shown. A partition plate 45 is placed in the storage tank 8b to divide the inside of the storage tank 8b into the pre-storage part 38b and

a main storage part 40b via the partition plate 45.

[0062] The lower die 12 is embedded in the coating material 3 to be fixed to the bottom wall 30 of the storage tank 8b. A through-hole 31 for inserting the
5 core wire 6 is formed on the bottom wall 30.

[0063] The first middle part die 14a is embedded in the coating material 3 stored in the storage tank 8b and is situated above the lower die 12, being spaced apart from the lower die 12, and is placed on a middle
10 first pedestal 18a. The first middle part die 14a becomes uplifted from the middle first pedestal 18a when the core wire 6 travels.

[0064] The second middle part die 14b is situated above the first middle part die 14a and is placed on a
15 middle second pedestal 18b, spacing apart from the first middle part die 14a. The second middle part die 14b becomes uplifted from the middle second pedestal 18b when the core wire 6 travels.

[0065] The upper die 16 is situated above the second
20 middle part die 14b and is placed on the second pedestal 28, being spaced apart from the second middle part die 14b. The upper die 16 partially protrudes from a liquid level 5 by floating up from the second pedestal 28 when the core wire 6 travels.

25 [0066] The middle first pedestal 18a, the middle second pedestal 18b, and the second pedestal 28 are provided inside the storage tank 8b in such a manner

that a gap 29 filled with the coating material 3 can be each formed between each of the middle first pedestal 18a, the middle second pedestal 18b, and the second pedestal 28, and the partition plate 45. The coating material 3 in the storage tank 8b is movable, passing through an opening 44, the gap 29, and a gap 90 shown in FIG. 6.

[0067] Consequently, a drainage route 17 for draining the coating material 3 containing air bubbles that exist below and near the first middle part die 14a and the second middle part die 14b in the storage tank 8b is secured.

[0068] In addition, the coating material application device 2b includes means for maintaining the liquid level 5 of the coating material 3 stored in the storage tank 8b at such a level that the distance between the liquid level 5 and the upper surface of the second pedestal 28 is not more than the thickness dimensions of the upper die 16 and the coating material 3 fully spreads to a space between the upper surface of the second pedestal 28 and the lower surface of the upper die 16. The distance between the liquid level 5 and the upper surface of the second pedestal 28 is set not more than the thickness dimensions of the upper die 16 to prevent the upper die 16 from being embedded in the coating material 3 when the core wire 6 is caused to travel at a slow

rate. The liquid level 5 is preferably maintained at the level around the center of the upper die 16 (in a thickness direction).

- [0069] The coating material application device 2b includes means for draining the coating material 3 stored in the storage tank 8b outside the storage tank which is not shown. In the coating material application device 2b, a weir 60 is a portion of the coating material draining means.
- 10 [0070] The first middle part die 14a and the second middle part die 14b are not fixed to the storage tank 8b. When the core wire 6 travels, viscosity resistance generated between the core wire 6 and a die hole 54a in the first middle part die 14a and between
- 15 the core wire 6 and a die hole 54b in the second middle part die 14b usually makes the first middle part die 14a and the second middle part die 14b float up. Consequently, a stopper to restrict the lifting of these dies is preferably provided in the coating
- 20 material application device 2b. In the coating material application device 2b, a stopper 35a is provided on the lower surface of the middle second pedestal 18b and a stopper 35b is provided on the lower surface of the second pedestal 28.
- 25 [0071] The diameter of the die hole 56 in the upper die 16 is set not greater than the diameter of the die hole 54b in the second middle part die 14b. The

diameter of the die hole 54b in the second middle part die 14b is set not greater than the diameter of the die hole 54a in the first middle part die 14a. The coating material 3 containing abrasive grains that are
5 tightly in contact with the surface of the core wire by each die hole can further be brought in tightly contact in order and can further remove air bubbles adhering to the surface of the core wire by sequentially equalizing or minimizing the diameter of
10 each die hole.

[0072] The first middle part die 14a and the second middle part die 14b function similar to the middle die 14 in the coating material application device 2 shown in FIG. 1 with respect to the removal of air bubbles.
15 To make the core wire 6 pass through the die hole 54b in the second middle part die 14b in addition to the die hole 54a in the first middle part die 14a, in the coating material application device 2b (FIG. 5), air bubbles are more surely removed from the core wire 6
20 than those of the coating material application device 2 (FIG. 1).

[0073] The core wire 6 is introduced from the insertion hole 31 formed on the bottom wall 30 of the storage tank 8b and passes through the die hole 52 in
25 the lower die 12, the first through-hole 32 in the middle first pedestal 18a, the die hole 54a in the first middle part die 14a, a through-hole 33 in the

middle second pedestal 18b, the die hole 54b in the second middle part die 14b, the second through-hole 36 in the second pedestal 28, and the die hole 56 in the upper die 16 in order to become a core wire 6a which the coating material 3 has been applied to. The core wire 6a is then introduced into a heating furnace not shown to solidify the coating material 3.

[0074] The coating material introducing means in the coating material application device 2b is used to newly replenish a coating material 3 instead of the coating material 3 containing such air bubbles exhausted outside the tank by the coating material draining means as well as to replenish the coating material 3 adhering to the core wire 6 to be taken outside the tank.

[0075] The inside of the storage tank 8b may be divided into a pre-storage part 38b and a main storage part 40b provided in the storage tank 8b via a partition plate 45. Die kinds are installed on the main storage part 40b. There is an opening 44 between the lower end of the partition plate 45 and the bottom wall 30 of the storage tank 8b. The pre-storage part 38b is in conduction with the main storage part 40b via the opening 44.

[0076] As shown in FIG. 7, as a variant of FIG. 1, for example, at least three corners of the middle die 14 may be connected to the bottom wall 30 of the storage

tank by a flexible fine resin yarn 70. This enables the middle die 14 to remain at a spatial position filled with the coating material 3 without a rise to the liquid level 5 because the middle die 14 is
5 constrained by the resin yarn 70. Consequently, the first pedestal and the stopper attaching member can be omitted. When the core wire 6 does not travel, even when the middle die 14 falls due to its self- weight, the resin yarn 70 sags to be placed on the lower die
10 12 of the bottom wall 30. In addition, a first pedestal may be provided to be connected to the middle die 14 by the resin yarn 70.

[0077] As shown in FIG. 8, when two middle dies (a first middle part die 14a and a second middle part die
15 14b) are placed in a storage tank 8, for instance, the first middle part die 14a may be coupled to a bottom wall 30 of the storage tank 8 and the first middle part die 14a may be coupled to the second middle part die 14b with flexible fine resin yarns 70, 72. This
20 makes the first middle part die 14a and the second middle part die 14b constrained by the resin yarns 70, 72 and thus resulting in remaining at a spatial position filled with a coating material 3 without a rise to a liquid level 5. Consequently, it is
25 possible to omit a first middle pedestal, a second middle pedestal, and a stopper attaching member. A first pedestal may be provided and coupled to the

first middle part die 14a by a resin yarn 70 also in this example.

[0078] As shown in FIG. 9, a recess where a middle die 14 is embedded may be formed in a first pedestal 18 on which the middle die 14 is placed. A plurality of regulating plates 80 may be provided above the middle die 14. A gap is formed in a horizontal direction of the recess and the middle die 14 so that the middle die 14 is horizontally movable. The dimensional relationship between the regulating plates 80 and a longitudinal direction of the middle die 14 is preferable to form a gap to slightly float between the regulating plates 80 and the middle die 14. That is, a gap which is large enough for air bubbles to be evacuated on an outer circumference side of the die is preferably formed. This can maintain the middle die 14 at a position of the recess of the first pedestal 18 without the need for the stopper attaching member. Even when the traveling speed of the core wire 6 is fast, an upper die does not get out of a liquid level due to surface tension between the upper die and the coating material. When the travelling speed of the core wire 6 further increases, it is, however, also possible to prevent an upper die from protruding from a liquid level with use of a plurality of stoppers provided above the upper die.

[0079] In the coating material application device 2 of

the present invention, a tank for storing the coating material 3 with die kinds built in may store the coating material 3 without replacement of the coating material 3. In this case, however, the more the
5 device is activated, the more increases the content of air bubbles of the coating material 3 in the tank. At the same time, the quantity of the coating material 3 decreases, so that replacement or replenishment of the coating material 3 is needed after a predetermined
10 time.

[0080] As mentioned above, the coating material application device 2 of the present invention can make distribution of abrasive grains contained in the coating material adhering to the core wire 6 uniform.
15 The coating material application device 2 of the present invention is also applicable when applying a coating material containing particles other than abrasive grains to the core wire 6, resulting in uniform distribution of the particles contained in the
20 coating material adhering to the core wire 6.

[0081] Dies to be used in the present invention are not particularly limited, like varnish coating dies, which are used to apply a paste-type coating solution on the core wire and are properly selected depending
25 on the kind of the core wire and the property of the coating material.

EXAMPLES

[0082] <EXAMPLE 1>

A coating material application device 2b (four dies) of the present invention shown in FIG. 5 was used to produce a resin bond wire saw. Diameters of die holes in Example 1 are as below.

Diameter of a die hole in an upper die: 160 μm

Diameter of a die hole in a first middle part die: 170 μm

Diameter of a die hole in a second middle part

die: 165 μm

Diameter of a die hole in a lower die: 130 μm

[0083] <EXAMPLE 2>

A coating material application device 2a (three dies) of the present invention shown in FIG. 4 was used to produce a resin bond wire saw. Diameters of die holes in Example 2 are as below.

Diameter of a die hole in an upper die: 160 μm

Diameter of a die hole in a middle die: 170 μm

Diameter of a die hole in a lower die: 130 μm

[0084] COMPARATIVE EXAMPLES

[0085] <COMPARATIVE EXAMPLE 1>

A conventional coating material application device 102 (one die, one insertion hole) shown in FIG. 17 was used to produce a resin bond wire saw.

Diameters of a die hole and an insertion hole in Comparative Example 1 are as below.

Diameter of a die hole in a coating die: 160 μm

Diameter of an insertion hole: 130 μm

[0086]

Manufacturing conditions except for the number of dies and die diameters of each resin bond wire saw described in the aforementioned Examples 1, 2 and Comparative Example 1 are indicated below.

Core wire: Steel wire (diameter: 100 μm)

Components of an adhesive in a coating material:

Phenol-based resin 100 weight parts

10 Amine-based silane coupling agent 1 weight part

Content ratio of the coating material (paste):

o-cresol 150 weight parts

Abrasive grains (Diamond coated with metal

(average

15 particle size: 12 μm)): 80 weight parts

Filler (average particle size: 2 μm): 60 weight parts

Travelling speed of the core wire in applying and heating: 1.2 m/sec.

20 Heating temperature of a heating furnace: 700°C to 750°C

[0087] FIGS. 10 to 15 each show an enlarged photograph of the produced resin bond wire saw. FIGS. 13 to 15 were photographed under the conditions where contrast is strong so as to emphasize an image of abrasive grains.

[0088] FIGS. 10, 13 are each an enlarged photograph of

a resin bond wire saw in Example 1. FIGS. 11, 14 are each an enlarged photograph of a resin bond wire saw in Example 2. FIGS. 12, 15 are each an enlarged photograph of a resin bond wire saw in Comparative Example 1.

[0089] It was confirmed from these enlarged photographs that each resin bond wire saw in Examples 1 and 2 was uniformly distributed with the abrasive grains on a surface thereof. In addition, no traces of air bubbles were admitted on the surface of the resin bond wire saw in Example 1 (FIG. 10). While a trace of air bubbles (FIG. 11, arrow) was insensibly admitted on the surface of the resin bond wire saw in Example 2, it is sufficiently corrected, compared with the time when the middle die 14 is not provided. All sizes do not have any problems in use, which are ignorable. In the resin bond wire saw in Comparative Example 1, the distribution of abrasive grains fixed to the surface of a core wire was non-uniform. A trace of large air bubbles (FIG. 12, arrows) was admitted on the surface of the resin bond wire saw and thus being non-uniform in thickness of the coating material in the periphery thereof.

[0090] As an image of abrasive grains is emphasized, according to enlarged photographs (See FIGS. 13 to 15) taken under photographing conditions of strong contrast, in each resin bond wire saw in Examples 1

and 2, abrasive grains were quite uniformly distributed on the surface of the core wire (FIGS. 13 and 14). Compared with the resin bond wire saws in Examples 1 and 2, the distribution of the surface of the core wire in Comparative Example 1 was non-uniform and thus being non-uniform in thickness of an adhesive (FIG. 15).

[0091] FIG. 16 shows a graph of cutting performance at the time of cutting a silicon piece with use of each of the resin bond wire saws in Examples 1, 2, and Comparative Example 1. The cutting performance indicates a depth of a notch at the time when the cutting speed and other cutting conditions are maintained constant and cutting was performed for a certain time. The deeper the notch depth is, the higher the cutting performance becomes. The cutting performance of a longitudinal axis in FIG. 16 is defined as follows:

Cutting performance (%) = [(Notch depth at the time of cutting with use of a resin bond wire saw produced in Examples 1, 2, and Comparative Example 1) / (Notch depth at the time of cutting with use of a resin bond wire saw produced in Example 1)] × 100

[0092] It was confirmed that the resin bond wire saws in Examples 1 and 2 are more superior to the resin bond wire saw in Comparative Example 1 in cutting performance.

[0093] It is believed obvious that those skilled in the art may make various changes and modifications in the invention within the scope of the claims. The present invention is not limited to the aforementioned
5 embodiments but to be changeable within the scope of the claims when necessary. In the aforementioned embodiments, when the shape and the position of elements are referred to, the present invention is not limited to the shape and the position except for the
10 case where the present invention is principally limited to a specific shape and position.

INDUSTRIAL APPLICABILITY

[0094] The device and the method for applying a
15 coating material of the present invention are applicable to the case of applying a coating material excluding particles, such as abrasive grains to a core wire. This enables to obtain a coated core wire having a uniform diameter with little mixture of air
20 bubbles.

DESCRIPTION OF REFERENCE NUMERALS

[0095] 2, 2a, 2b, 102: a coating material application device; 3, 103: coating material; 5, 105: liquid
25 level; 6, 6a, 106, 106a: core wire; 8, 8a, 8b, 108: storage tank; 12, 112: lower die; 14: middle die; 14a: first middle part die; 14b: second middle part die; 16,

116: upper die; 17: drainage route; 18: first
pedestal; 18a: middle first pedestal; 18b: middle
second pedestal; 28: second pedestal; 30: bottom wall;
31: insertion hole; 32: first through-hole; 33, 136:
5 through-hole; 36: second through-hole; 34: stopper
attaching member; 35, 35a, 35b: stopper; 38, 38b: pre-
storage part; 40, 40b: main storage part; 44: opening;
45: partition plate; 46: inlet port; 52, 54, 54a, 54b,
56, 152, 156: die hole; 60: weir; 128: pedestal

CLAIMS

1. A coating material application device for
applying a coating material to a core wire travelling
5 upward, comprising:
a storage tank for storing the coating material
and having an insertion hole in which the core wire is
inserted on its bottom; and
a die group composed of at least three dies
10 including a lower die and at least one middle die
embedded in the coating material stored in the storage
tank, and an upper die in which its upper surface
projects from a liquid level of the coating material
stored in the storage tank, the at least three dies
15 being arranged at intervals so that the core wire can
sequentially pass through the at least three dies.
2. The device according to claim 1, wherein a die
hole in the upper die has a diameter of not greater
20 than a diameter of a die hole in the middle die.
3. The device according to claim 1 or claim 2,
further comprising:
means for introducing a coating material into the
25 storage tank;
means for draining the coating material stored in
the storage tank; and

means for maintaining a liquid level of the coating material stored in the storage tank at a level that the upper die projects from the liquid level of the coating material.

5

4. The device according to claim 1 or claim 2, further comprising:

means for introducing the coating material stored in the storage tank; and

10 a weir for overflowing the coating material stored in the storage tank.

5. The device according to any one of claims 1 to 4, wherein a first pedestal where the middle die is placed and a second pedestal where the upper die is placed are arranged inside the storage tank, and an insertion hole for inserting the core wire is each formed in the first and second pedestals.

20 6. The device according to any one of claims 1 to 5, wherein the storage tank is divided into a pre-storage part and a main storage part by a partition plate, an opening for bringing the pre-storage part and the main storage part into conduction is provided between a lower end of the partition plate and a bottom wall of the storage tank, an inlet port for introducing the coating material into the storage tank is provided in

25

the pre-storage part, and the die group is provided in the main storage part.

7. The device according to any one of claims 1 to 6,
5 wherein the at least one middle die comprises a plurality of middle dies.

8. The device according to any one of claims 1 to 7,
10 wherein the at least one middle die is a floating die floating up in the coating material stored in the storage tank by inserting the core wire into each die hole in the at least one middle die and causing the core wire to travel in the coating material stored in the storage tank.

15

9. The device according to any one of claims 1 to 8,
wherein the upper die is a floating die floating up on the liquid level of the coating material stored in the storage tank by inserting the core wire into the die
20 hole in the upper die and causing the core wire to travel in the coating material stored in the storage tank.

10. The device according to any one of claims 1 to 9,
25 wherein a stopper attaching member having an insertion hole in which the core wire travels and a stopper for restricting a lifting movement of the at least one

middle die in accordance with travelling of the core wire is provided in the storage tank.

11. The device according to any one of claims 1 to 10, wherein the coating material contains abrasive grains.

5

12. A method for applying a coating material to a core wire travelling upward, comprising the steps of:

deriving the core wire from a die hole in a lower die provided in a storage tank for storing the coating material;

10

deriving the core wire from a die hole in each of at least one middle die embedded in the coating material which is freely movable; and

causing the core wire to travel by deriving a die hole in an upper die which is freely movable projecting from a liquid level of the coating material.

15

13. The method according to claim 12, wherein the die hole in the upper die has a diameter of not greater than a diameter of the die hole in each of the at least one middle die.

20

14. The method according to claim 12 or claim 13, wherein the at least one middle die comprises a plurality of middle dies.

25