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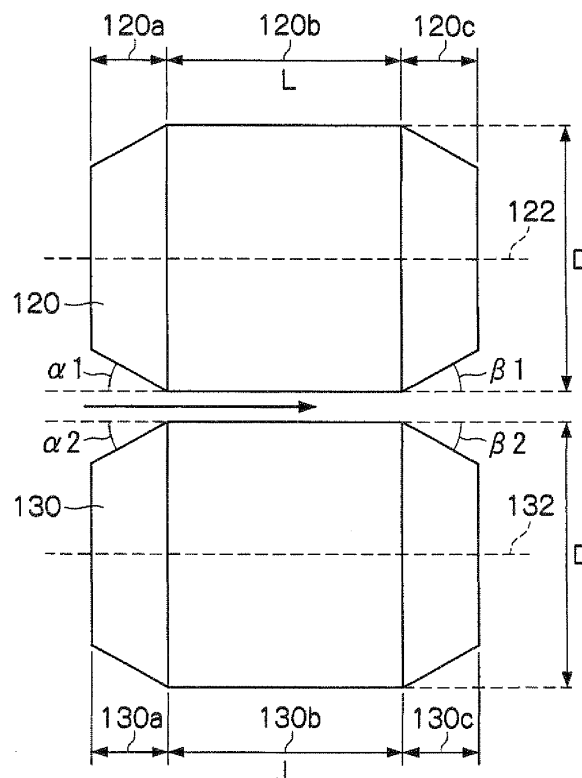
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(54) **Rolling die and method of producing coating rod using the same**

(57) A method of producing a coating rod (12) capable of eliminating a scratch and coating irregularities on a web is provided. The method includes the steps of: preparing a rod material (20); arranging paired rolling dies (120,130) each having a plurality of convex shapes formed on an outer perimeter surface, having a chamfer part (120a,130a), a parallel part (120b,130b), and a relief part (120c,130c) from an approaching side toward an exiting side of the rod material, and having a relief angle formed by a surface forming the relief part and a surface of the parallel part of 0.01° to 0.45°, so that the parallel parts face each other; inserting the rod material from a chamfer part side in a space interposed between the paired rolling dies; and forwarding the rod material to a relief part side by the paired rolling dies pressuring the rod material therebetween while rotating and performing a rolling process on a surface of the rod material.

FIG.4



Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates to rolling dies and methods of producing a coating rod using the rolling dies and, in particular, to a method of producing a coating rod for applying various liquid substances (coating fluids) on a sheet-like or strip-like support (hereinafter referred to as a web) such as a continuously-running thin metal plate, paper, or film and smoothing the liquid substances after coating.

Description of the Related Art

[0002] Various coating apparatuses have been known for applying various coating fluids onto a web such as a thin metal plate, paper, or a plastic film, including a roll coater, an air-knife coater, a coater using a die, and a rod coater.

[0003] Among these coating apparatuses, the rod coater is a simple coating apparatus and can apply various coating fluids on various webs, and therefore has been widely used. Rod coaters can be classified into a type of scraping off an excess of the coating fluid applied onto the web with a coating rod (also referred to as a bar) and a type of both coating onto the web and adjusting the amount of coating fluid with one coating rod. In either type of rod coater, many grooves are formed in a circumferential direction on the surface of the coating rod. By adjusting the depth and width of these grooves, the amount of coating fluid to be applied onto the web and the amount of coating fluid to be scraped off are adjusted.

[0004] As a method of forming grooves on the surface of a coating rod, a method of forming grooves by rolling has been known. In this method, a rod material is interposed between two rolling dies having grooves formed thereon, and the rod material is moved forward in an axial direction while these two rolling dies are rotated, thereby forming grooves on the surface of the rod material.

[0005] As a method of forming grooves on the surface of a rod material by using these rolling dies, "Coating rod and its manufacturing method" (Japanese Patent No. 4460257) has been disclosed. As these rolling dies, "Rolling dies" (Japanese Utility-Model Application Laid-Open No. 5-88733) has been disclosed.

[0006] In "Coating rod and its manufacturing method" disclosed in Japanese Patent No. 4460257, by polishing the surface (mountain parts) of the coating rod after rolling, an overlap between orthogonal sections of mountain parts in an axial direction is equal or higher than 99.5%. With this, when the depths of the grooves formed on the surface of the rod material are not uniform due to rolling irregularities, it is possible to solve the problem that the highest part locally makes contact with the web to cause a scratch.

[0007] In "Rolling dies" disclosed in Japanese Utility-Model Application Laid-Open No. 5-88733, a relief part has a relief angle equal to or larger than $0^{\circ}30'$ and smaller than 2° . With this, deformation of the ball groove shape and degradation in accuracy can be prevented.

SUMMARY OF THE INVENTION

[0008] However, in the method disclosed in Japanese Patent No. 4460257, the mountain parts are polished after rolling without consideration of the shape of valley parts. Thus, the sectional areas of the grooves are changed by polishing to possibly cause coating irregularities. Here, coating irregularities are density irregularities caused on a coating surface due to a localized difference in the amount of coating.

[0009] Also, in the rolling dies disclosed in Japanese Utility-Model Application Laid-Open No. 5-88733, attention is focused on every ball groove, and an effect of suppressing irregularities in effective diameters of the ball grooves may be achieved. However, unevenness of the depth of the grooves formed on the surface of the rod material cannot be prevented. For this reason, if these rolling dies are used, the highest part of a groove locally makes contact with the web, thereby disadvantageously causing a scratch.

[0010] Furthermore, in general, the magnitude (depth) of grooves formed on the surface of the coating rod is 0.001 mm to 0.1 mm and, compared with the ball screw of Japanese Utility-Model Application Laid-Open No. 5-88733, the depth is extremely small. For this reason, an influence of rolling irregularities on the accuracy of the groove shape is relatively large, and therefore rolling irregularities have to be suppressed more severely.

[0011] The present invention has been made in view of these circumstances, and an object of the present invention is to provide a method of producing a coating rod capable of eliminating a scratch and coating irregularities on the web.

[0012] A method of producing a coating rod according to an aspect of the present invention is mainly characterized by including the steps of: preparing a rod material; arranging paired rolling dies each having a plurality of convex shapes formed on an outer perimeter surface, having a chamfer part, a parallel part, and a relief part from an approaching side

toward an exiting side of the rod material, and having a relief angle formed by a surface forming the relief part and a surface of the parallel part of 0.01° to 0.45° , so that the parallel parts face each other; inserting the rod material from a chamfer part side in a space interposed between the paired rolling dies; and forwarding the rod material to a relief part side by the paired rolling dies pressuring the rod material therebetween while rotating and performing a rolling process on a surface of the rod material.

[0013] With this, a coating rod capable of reducing scratches and coating irregularities can be produced.

[0014] A rolling die according to another aspect of the present invention is mainly characterized in that the rolling die includes a chamfer part, a parallel part, and a relief part from an approaching side toward an exiting side of the rod material, the parallel part has a columnar shape, the chamfer part has a shape of a frustum with an outer diameter gradually increasing from a tip to a portion connected to the parallel part so as to have an outer diameter of the parallel part, the relief part has a shape of a cone with an outer diameter gradually decreasing from the outer diameter of the parallel part from a tip to a portion connected to the parallel part, and an relief angle formed by a surface forming the relief part and a surface of the parallel part is 0.01° to 0.45° .

[0015] With this, by using these rolling dies, a coating rod capable of reducing scratches and coating irregularities can be produced.

[0016] According to the present invention, a coating rod capable of preventing scratches and coating irregularities on a web can be produced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Fig. 1 is a schematic view of a rod coater including a coating rod;
 Fig. 2 is a perspective view partially showing the coating rod;
 Fig. 3 is a perspective view of a rod material;
 Fig. 4 is schematic view of paired rolling dies;
 Fig. 5 is a plan view of a rolling processing apparatus;
 Fig. 6 is a sectional view of a polishing apparatus; and
 Fig. 7 is an enlarged view of an outer perimeter surface of the coating rod.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Preferred embodiments of the present invention are described below according to the attached drawings. While the present invention is described based on the preferred embodiments below, modifications can be made with various techniques without deviating from the scope of the present invention, and embodiments other than the present embodiments can also be used. Therefore, all modifications within the scope of the present invention are included in the claims. Also, in the specification, a range of numerical values using "to" means a range including numerical values before and after "to".

[0019] Fig. 1 shows a rod coater including a coating rod. A rod coater 10 includes a coating rod 12, a rod support block 13 rotatably supporting the coating rod 12 (which may be hereinafter also simply referred to as a rod), and a gate member 16 adjacent to the rod support block 13. A coating fluid 15 is supplied to a coating-fluid supply path 17 formed by the rod support block 13 and the gate member 16. As being in contact with a running web 11, the coating rod 12 is arranged in a width direction of the web 11. In the rod coater 10, one coating rod 12 both supplies the coating fluid to the web 11 and adjusts the amount of coating fluid. The coating rod 12 may be rotated in the same direction as a web running direction, be in a still state, or be rotated in a direction opposite to the web running direction.

[0020] Next, a coating method using the rod coater 10 is described. At a contact part between the continuously-running web 11 and the coating rod 12, a bank 18 of the coating fluid 15 is formed. With the rotating coating rod 12, the coating fluid 15 in the bank 18 is measured and applied onto the web 11.

[0021] Fig. 2 is a schematic structural view of the coating rod. As depicted in Fig. 2, the coating rod 12 is configured of a columnar rod material 20. The rod material 20 is made of a material such as SUS (Steel Use Stainless, or Stainless Steel). In a circumferential direction on a perimeter surface of the rod material 20, grooves (concave parts) 21 are formed substantially throughout the length of the rod material 20. A width where the grooves 21 are formed is larger than a coating width W. The amount of coating fluid is adjusted with the depth, width, and pitch of each grooves (concave parts) 21. As for the shape of the groove, the groove has a depth (a difference in height between each convex part and each concave part) in a range of 0.001 mm to 0.1 mm and a pitch between the concave part and the convex part (a distance between the center of the concave part and the center of the convex part in a rod axial direction) in a range of 0.1 mm to 0.5 mm.

[0022] Next, a method of producing a coating rod is described. As shown in Fig. 3, the rod material 20 for configuring

a coating rod is prepared. The rod material 20 is made of, for example, SUS, and has a columnar shape with an outer diameter (R) of 3 mm to 70 mm.

[0023] Fig. 4 is a schematic structural diagram of paired rolling dies for forming grooves on the rod material. A first rolling die 120 and a second rolling die 130 each have a substantially columnar shape, and rotate with main axes 122 and 132, respectively, as a rotation center. The first rolling die 120 and the second rolling die 130 substantially have the same dimension. The first rolling die 120 and the second rolling die 130 each have a length in a main axial direction of generally 10 mm to 500 mm. Here, the rolling dies may be simply referred to as dies.

[0024] To form grooves on the rod material, the first rolling die 120 and the second rolling die 130 each have an outer perimeter surface with a plurality of convexes in reverse to a groove shape. The first rolling die 120 and the second rolling die 130 have chamfer parts 120a and 130a, parallel parts 120b and 130b, and relief parts 120c and 130c, respectively, from an approaching side toward an exiting side of the rod material.

[0025] In the chamfer parts 120a and 130a, predetermined chamfer angles α_1 and α_2 are provided from each end toward the parallel parts 120b and 130b, respectively. With this, the outer diameter of each rolling die gradually increases to be eventually equal to the outer diameter of the parallel parts 120b and 130b at a connecting portion between the chamfer parts 120a and 130a and the parallel parts 120b and 130b, respectively.

[0026] In the parallel parts 120b and 130b, the outer diameters of the rolling dies are substantially equal to each other. In the relief parts 120c and 130c, predetermined relief angles β_1 and β_2 are provided from the parallel parts 120b and 130b, respectively, toward each end. With this, the outer diameter of each rolling die gradually decreases from the same outer diameter of each of the parallel parts 120b and 130b.

[0027] The chamfer angle α_1 refers to an angle formed by a surface of the chamfer part 120a and a plane extended from the parallel part 120b. The chamfer angle α_2 refers to an angle formed by a surface of the chamfer part 130a and a plane extended from the parallel part 130b. The relief angle β_1 refers to an angle formed by a surface of the relief part 120c and a plane extended from the parallel part 120b. The relief angle β_2 refers to an angle formed by a surface of the relief part 130c and a plane extended from the parallel part 130b.

[0028] The chamfer parts 120a and 130a and the relief parts 120c and 130c each have a length of, for example, 5 mm to 30 mm. The chamfer angle α_1 and α_2 are preferably equal to or smaller than 1° , and more preferably equal to or smaller than 0.5° . The chamfer angle α_1 and the chamfer angle α_2 are preferably equal to each other. The relief angle β_1 and the relief angle β_2 are preferably 0.01° to 0.45° and more preferably 0.01° to 0.1° . The relief angle β_1 and the relief angle β_2 are preferably equal to each other. The lengths of the chamfer part, the parallel part, and the relief part of the rolling die are set as appropriate as needed.

[0029] The rod material is inserted in a space between the first rolling die 120 and the second rolling die 130 from chamfer part 120a and 130a sides. The first rolling die 120 and the second rolling die 130 pressure the rod material therebetween while rotating, and transfer a shape formed on the first rolling die 120 and the second rolling die 130 (the shape is referred to as a die surface shape) onto the surface of the rod material.

[0030] Here, the shape to be transferred onto the surface of the rod material is the die surface shape with its concaves and convexes in reverse. While being subjected to a rolling process on its surface, the rod material is forwarded from chamfer part 120a and 130a sides to relief part 120c and 130c side in an axial direction of the rod material.

[0031] As a result of further studies by the inventors about suppression of rolling irregularities, it has been confirmed that the diameter of the rolling die and the length of the parallel part of the rolling die are effective as factors in suppressing rolling irregularities. With the relief angles β_1 and β_2 in a range of 0.01° to 0.45° , when the rolling dies 120 and 130 have a diameter D and the parallel parts 120b and 130b of the rolling dies 120 and 130 have a length L, it has been confirmed that the diameter D is preferably smaller and the parallel part length L is preferably larger. The diameter D of the rolling die is preferably in a range of $60\text{ mm} \leq D \leq 180\text{ mm}$, and more preferably in a range of $60\text{ mm} \leq D \leq 150\text{ mm}$. The parallel part length L of the rolling die is preferably in a range of $6\text{ mm} \leq L \leq 50\text{ mm}$, and more preferably in a range of $10\text{ mm} \leq L \leq 50\text{ mm}$.

[0032] Fig. 5 is a plane view of a rolling processing apparatus. The rolling processing apparatus includes the first rolling die 120 and the second rolling die 130 for pressuring the rod material therebetween for rolling process, and a base 140 for supporting a rod material.

[0033] To adjust the pressure for pressuring the rod material 20, a distance (a space) X between the first rolling die 120 and the second rolling die 130 and a distance (a space) Y between a main axis of each of the first rolling die 120 and the second rolling die 130 and a center axis 22 of the rod material 20 in a height direction are adjusted. Also, an angle formed by the main axes 122 and 132 is preferably 0° (the main axes 122 and 132 are parallel to each other), but an adjustment can be made so that these axes form an angle (other than 0°).

[0034] In the present embodiment, by adjusting the distance X, an amount of pushing the paired rolling dies 120 and 130 into the rod material (a rolling pressure) is adjusted. By adjusting the distance Y, a work height is adjusted. Here, the work height means a position of a work in a vertical direction with reference to the main axes 122 and 132 of the rolling dies 120 and 130.

[0035] Here, since the rolling process is accompanied by plastic deformation, the outer shape of the rod before and

after rolling is changed. That is, the material subjected to plastic deformation on the parallel parts is pushed to the relief parts 120c and 130c. Here, if the rolling dies 120 and 130 themselves have fluctuations in diameter in a circumferential direction and variations in installation accuracy, the rod becomes in a wavy shape, and its amplitude is changed according to the relief angles β_1 and β_2 of the rolling dies 120 and 130.

[0036] Since it is difficult to completely eliminate vibrations of the rolling dies 120 and 130, fundamentally solving rolling irregularities is extremely difficult. However, by minimizing the relief angle to suppress the amplitude of rolling irregularities to minimum, a polishing process after rolling can be minimized to prevent a scratch. Also, variations in sectional area of each groove can be brought into a predetermined range, thereby obtaining a good surface state.

[0037] The surface of the coating rod subjected to the rolling process can be polished by a polishing apparatus. At this time, it is important to perform polishing in a range in which the sectional areas of the grooves after polishing are not varied. Also, a surface treatment process such as plating may be performed after rolling and before polishing the surface. Plating refers to chrome plating, nickel plating and other composite metal plating, or a diamond like carbon process or the like to be performed by chemical vapor deposition, sputtering, ion plating, or others.

[0038] Fig. 6 is a sectional view of the polishing apparatus. The polishing apparatus includes a polishing part 31, and this polishing part 31 includes many wrappers 35 holding the coating rod 12 so as to interpose it from a vertical direction, a holding base 36 holding these wrappers 35, abrasive supply part 38 supplying an abrasive 37 to a contact surface between the wrappers 35 and the coating rod 12.

[0039] The wrappers 35 are each divided into two in a vertical direction, configured of an upper wrapper body 35a and a lower wrapper body 35b. Many wrappers 35 are aligned in the axial direction of the coating rod 12 and are arranged in the holding base 36.

[0040] In the wrapper bodies 35a and 35b, a polishing surface 40 is formed, which is configured of an inner perimeter surface having a diameter approximately equal to the diameter of the coating rod 12. The wrappers 35 each have a length in a rod axial direction of, for example, 80 mm, and, for example, 25 such wrappers 35 are provided so as aligned. The number of wrappers 35 is determined according to the coating width of the coating rod 12 or the length of the convex area in the rod axial direction.

[0041] The upper wrapper body 35a is held by an upper support base 36a. The wrapper body 35a is pressed by its own weight toward the coating rod 12. The lower wrapper body 35b is held by a lower support base 36b. The wrapper 35 is made of a material such as a resin compound, in addition to cast iron and a copper alloy.

[0042] To supply the abrasive 37 to the polishing surface 40 of the wrapper 35, the abrasive supply part 38 has a supply pipe 41 and a pump 42. The abrasive 37 from an abrasive supply tank 43 is supplied to the polishing surface 40 of the wrapper 35. Examples of the abrasive 37 for use include iron oxide, aluminum oxide, and pumice.

[0043] A polishing method is described. First, the coating rod 12 is set on the polishing surface 40 in the wrapper 35, and then one end of the coating rod 12 is held by a fastener. Next, the abrasive supply part 38 is driven to supply the abrasive (lapping agent) 37 to the polishing surface 40 of each wrapper 35. Then, the coating rod 12 is caused to reciprocate in the axial direction of the coating rod 12 as being rotated. With this, the convex parts of the coating rod 12 are polished to be approximately flattened.

[Examples]

[0044] The present invention is described in more detail below with reference to specific examples of the present invention. However, these are not meant to be restrictive.

[0045] First, a rod material in a columnar shape having an outer diameter of 10 mm and a length of 1000 mm and made of SUS 304 was prepared. By using a plurality of rolling dies having different relief angles β , grooves were formed on the rod material by a rolling processing apparatus performing a rolling process to produce a rod. In the rolling process, a relief angle of a first rolling die and a relief angle of a second rolling die for use were the same. Here, as a condition of the rolling process, the rolling process was performed with parallel parts of the rolling paired dies being set as parallel to each other.

[0046] Furthermore, the relief angle β was fixed at 0.45° , and a plurality of rolling dies having different diameters D and parallel part lengths L were used to form grooves on a rod material by a rolling processing apparatus performing a rolling process to produce a rod.

[0047] For the rod having grooves formed thereon by the rolling dies with different relief angles β , a coating surface state before mountain parts were subjected to a polishing process was evaluated. For the rod having grooves formed thereon by the plurality of rolling dies with different diameters D and parallel part lengths L , a coating surface state before mountain parts were subjected to a polishing process was evaluated. As evaluations of the coating surface state, evaluations of rolling irregularities and scratches were performed.

[0048] First, evaluations of rolling irregularities are described. Fig. 7 is an enlarged view of an outer perimeter surface of the coating rod. First, a maximum value Z_1 and a minimum value Z_2 of a height orthogonal to an axial direction of mountain parts on the outer perimeter surface are found, and then a difference Z_{12} between the maximum value Z_1 and

the minimum value Z_2 is found. Similarly, a maximum value Z_3 and a minimum value Z_4 of a height orthogonal to an axial direction of valley parts on the outer perimeter surface are found, and then a difference Z_{34} between the maximum value Z_3 and the minimum value Z_4 is found. Either one of the difference Z_{12} and the difference Z_{34} that is larger is taken as a rolling irregularity Z (μm). A reference line is set by, for example, being placed on a surface plate. In this case, $Z_4=0$.

[0049] Note that the rolling irregularity after polishing was also found by measuring in a similar manner. However, to differentiate the rolling irregularity before polishing, the rolling irregularity after polishing is referred to as a rolling irregularity Y (μm).

[0050] In evaluation of scratches, after the surface of the coating film was visually checked, the coating film was peeled off, and then it was visually checked whether there was a scratch on a board. The case where there is no scratch on both of the coating film and the board is marked with A (best), the case where a scratch is on the board but no scratch is on the coating film is marked with B (good), and the case where there is a scratch on both of the coating film and the board is marked with C (bad).

[0051] In evaluation of coating irregularities, the surface immediately after coating and the surface immediately after the end of drying were visually checked. The case where the surface is in a good condition both immediately after coating and immediately after the end of drying is marked with A (best), the case where irregularities are observed immediately after coating but the surface is in a good condition after the end of drying is marked with B (good), and the case where irregularities occur both immediately after coating and immediately after the end of drying is marked with C (bad). Here, coating irregularities are density irregularities caused on a coating surface due to a localized difference in the amount of coating. The evaluation results are shown in Table 1.

55 50 45 40 35 30 25 20 15 10 5

Table 1

	RELIE F ANGLE β (deg)	PARALLEL PART LENGTH L (mm)	DIAMETER D (mm)	BEFORE POLISHING			AFTER POLISHING		
				ROLLING IRREGULARITIES (μm)	EVALUATION OF SCRATCHES	EVALUATION OF COATING IRREGULARITIES	ROLLING IRREGUL ARITIES (μm)	EVALUATION OF SCRATCHES	EVALUATION OF COATING IRREGULARITIES
Test 1	0.01	30	100	0.02	A	A	0.02	A	A
Test 2	0.10	30	100	0.20	A	A	0.20	A	A
Test 3	0.45	30	100	0.50	B	A	0.30	A	A
Test 4	0.50	30	100	1.00	c	B	0.50	B	c
Test 5	0.00	30	100	*	-	-	-	-	-
Test 6	0.45	6	100	0.70	B	B	0.30	A	B
Test 7	0.45	10	100	0.60	B	A	0.30	A	A
Test 8	0.45	50	100	0.20	A	A	0.20	A	A
Test 9	0.45	30	180	0.70	B	B	0.30	A	B
Test 10	0.45	30	150	0.60	B	A	0.30	A	A
Test 11	0.45	30	60	0.30	A	A	0.20	A	A
Test 12	0.01	30	60	0.01	A	A	0.01	A	A

[0052] As shown in Table 1, when the relief angle β is in a range of 0.01° to 0.45° (Test 1 to Test 3), the results of evaluations of scratches and coating irregularities are best or good both before and after polishing, achieving good values such that the value of the rolling irregularity Z is equal to or smaller than $0.5\ \mu\text{m}$ and the value of the rolling irregularity Y is equal to or smaller than $0.3\ \mu\text{m}$.

[0053] When the relief angle β is in a range of 0.01° to 0.1° (Test 1 to Test 2), the results of evaluations of scratches and coating irregularities are all best both before and after polishing, achieving better values such that the values of the rolling irregularity Z and the rolling irregularity Y are both equal to or smaller than $0.2\ \mu\text{m}$. Therefore, the relief angle β is preferably 0.01° to 0.45° and, more preferably 0.01° to 0.1° . When the relief angle β is in a range of 0.01° to 0.1° , the rolling irregularity Z and the rolling irregularity Y are not substantially different. Therefore, a polishing process may not be performed.

[0054] However, when the relief angle β is 0.5° (Test 4), the value of the rolling irregularity Z before polishing is $1.0\ \mu\text{m}$, which is a value indicating large rolling irregularities, and the scratch evaluation result before polishing is marked with C (bad). By polishing, the rolling irregularity Y after polishing of the rod in this Test 4 is $0.5\ \mu\text{m}$, and the scratch evaluation result thereof is B (good) but, conversely, the coating irregularity evaluation result is C (bad).

[0055] The reason for this can be thought such that the shape of the grooves is locally changed by the polishing process to increase variations in sectional area of each groove, thereby causing coating irregularities.

[0056] The phenomenon in which a scratch state becomes improved by polishing as described above was also observed in Test 3. In Test 3, while the scratch evaluation result is marked with B (good) before polishing, the result after polishing is marked with A (best).

[0057] Next, with reference to Test 5, when the relief angle β is 0° , an end of the die damaged the rod surface and it was impossible to form intended grooves. Therefore, measurement of the rolling irregularities Z and Y, scratch evaluation, and coating irregularity evaluation was not able to be performed. Thus, it was found that a good rod cannot be produced with the relief angle β of 0° .

[0058] Next, the results show that when the parallel part length L is in a range of 6 mm to 50 mm (Test 6 to Test 8), basically, as the parallel part length L is longer, the value of the rolling irregularity Z is smaller. The results show that when the diameter D is in a range of 180 mm to 60 mm (Test 9 to Test 11), basically, as the diameter D is smaller, the value of the rolling irregularities Z is smaller. The reason can be thought such that when the diameter D is decreased, the travelling amount of the rod material while the rolling dies rotate once (the amount is referred to as a pace) is decreased and, as a result, swelling of the rod material at the relief parts of the rolling dies is decreased.

[0059] From the studies above, it has been found that the rolling irregularity Z before polishing is $0.01\ \mu\text{m}$, which is a minimum value, when the relief angle β is 0.01° , the parallel part length L is 30 mm, and the diameter D is 60 mm (Test 12).

[0060] From the above, the following has been revealed.

[0061] When the amount to be processed in polishing exceeds a predetermined amount, the sectional area of the groove varies, leading to the occurrence of coating irregularities. Therefore, to obtain a good coating surface, it is important to suppress the value of the rolling irregularity Z within a predetermined range only with rolling by appropriately setting operation conditions.

[0062] If the value of the rolling irregularity Z can be suppressed within a predetermined range only with rolling, an influence on the sectional area of the groove by polishing is small, and therefore a good coating surface condition can be obtained by a polishing process under further wider conditions.

[0063] Also, by adjusting the relief angle β to an appropriate value to suppress the value of the rolling irregularity Z within a predetermined range, the rod is in contact with the web uniformly at the time of coating, thereby suppressing imbalanced wearing of the rod. With this, the life of the rod can be extended.

Claims

1. A method of producing a coating rod (12), **characterized by** comprising the steps of:

preparing a rod material (20);

arranging paired rolling dies (120, 130) each having a plurality of convex shapes formed on an outer perimeter surface, having a chamfer part (120a, 130a), a parallel part (120b, 130b), and a relief part (120c, 130c) from an approaching side toward an exiting side of the rod material (20), and having a relief angle formed by a surface forming the relief part (120c, 130c) and a surface of the parallel part (120b, 130b) of 0.01° to 0.45° , so that the parallel parts (120b, 130b) face each other;

inserting the rod material (20) from a chamfer part (120a, 130a) side in a space interposed between the paired rolling dies (120, 130); and

forwarding the rod material (20) to a relief part (120c, 130c) side by the paired rolling dies (120, 130) pressuring the rod material (20) therebetween while rotating and performing a rolling process on a surface of the rod

material (20).

2. The method of producing a coating rod (12) according to claim 1, **characterized by** further comprising a step of polishing the surface of the rod material (20) after the rolling process.
3. The method of producing a coating rod (12) according to claim 1 or 2, wherein, in the rolling process, the rod material (20) is supported by a base (140).
4. The method of producing a coating rod (12) according to any one of claims 1 to 3, wherein a distance between the paired rolling dies (120, 130) and a space between a main axis (122, 132) of each of the rolling dies (120, 130) and a center axis (22) of the rod material (20) in a height direction are adjusted.
5. The method of producing a coating rod (12) according to any one of claims 1 to 4, wherein the parallel part (120b, 130b) of each of the rolling dies (120, 130) has a diameter D satisfying $60\text{ mm} \leq D \leq 180\text{ mm}$.
6. The method of producing a coating rod (12) according to any one of claims 1 to 5, wherein the parallel part (120b, 130b) of each of the rolling dies (120, 130) has a length L satisfying $6\text{ mm} \leq L \leq 50\text{ mm}$.
7. A rolling die (120, 130) for producing a coating rod (12) by performing a rolling process on a rod material (20), the rolling die (120, 130) including a chamfer part (120a, 130a), a parallel part (120b, 130b), and a relief part (120c, 130c) from an approaching side toward an exiting side of the rod material (20), the parallel part (120b, 130b) having a columnar shape, the chamfer part (120a, 130a) having a shape of a frustum with an outer diameter gradually increasing from a tip to a portion connected to the parallel part (120b, 130b) so as to have an outer diameter of the parallel part (120b, 130b), the relief part (120c, 130c) having a shape of a cone with an outer diameter gradually decreasing from the outer diameter of the parallel part (120b, 130b) from a tip to a portion connected to the parallel part (120b, 130b), and an relief angle formed by a surface forming the relief part (120c, 130c) and a surface of the parallel part (120b, 130b) being 0.01° to 0.45° .
8. The rolling die (120, 130) according to claim 7, wherein the parallel part (120b, 130b) of the rolling die (120, 130) has a diameter D satisfying $60\text{ mm} \leq D \leq 180\text{ mm}$.
9. The rolling die according to claim 7 or 8, wherein the parallel part (120b, 130b) of the rolling die (120, 130) has a length L satisfying $6\text{ mm} \leq L \leq 50\text{ mm}$.

FIG.1

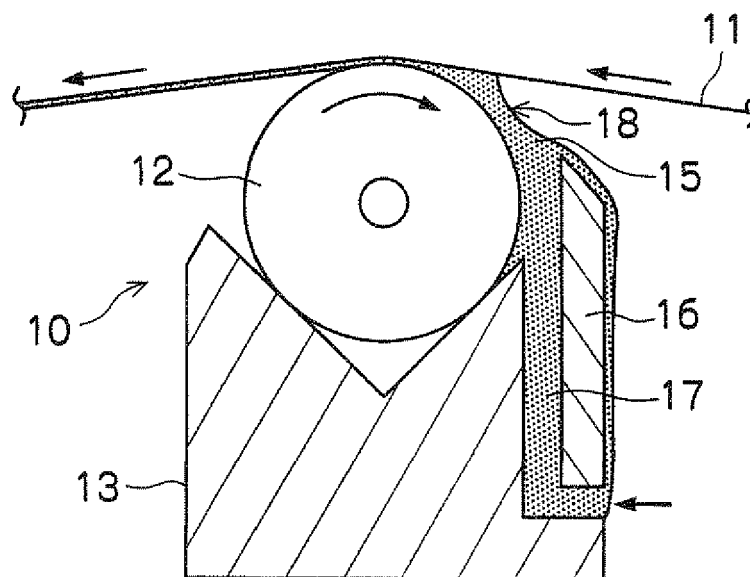


FIG.2

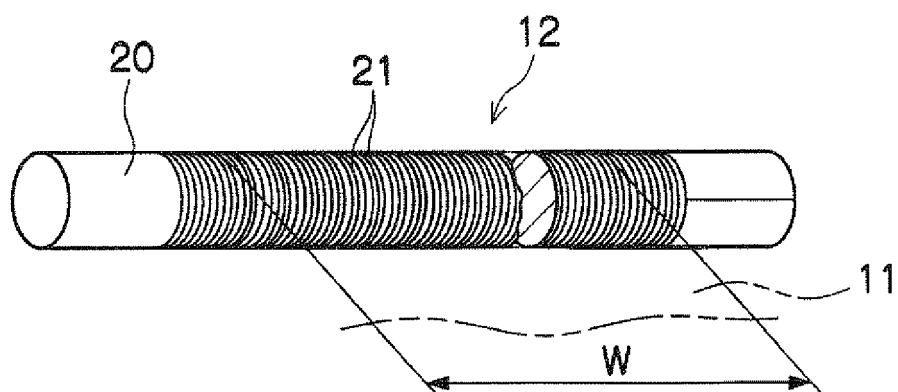


FIG.3

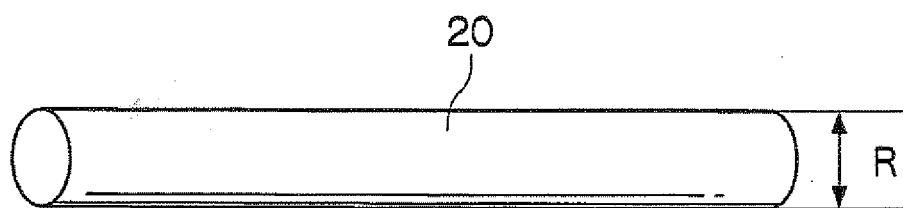


FIG.4

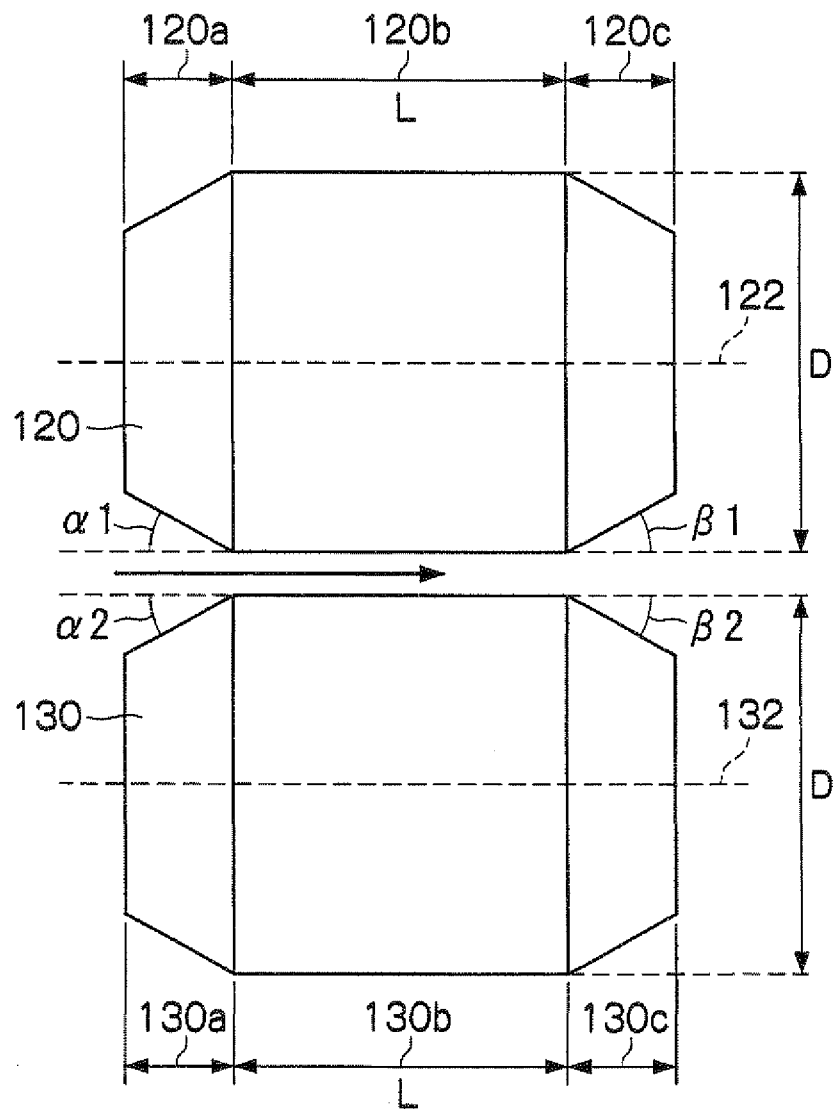


FIG.5

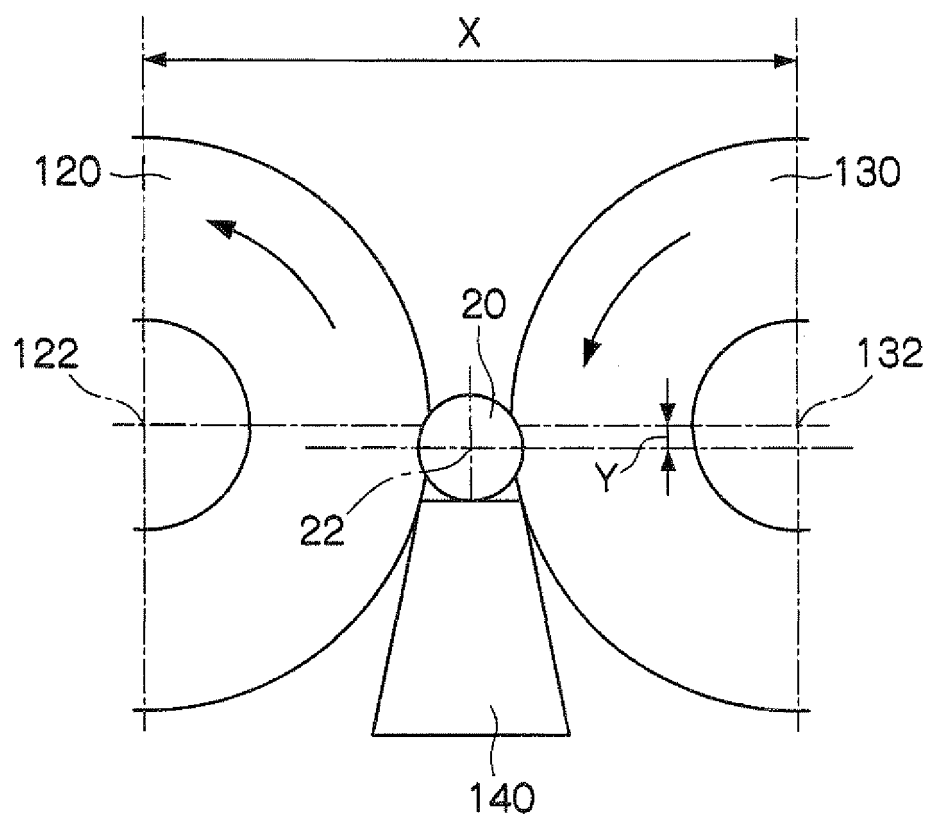


FIG.6

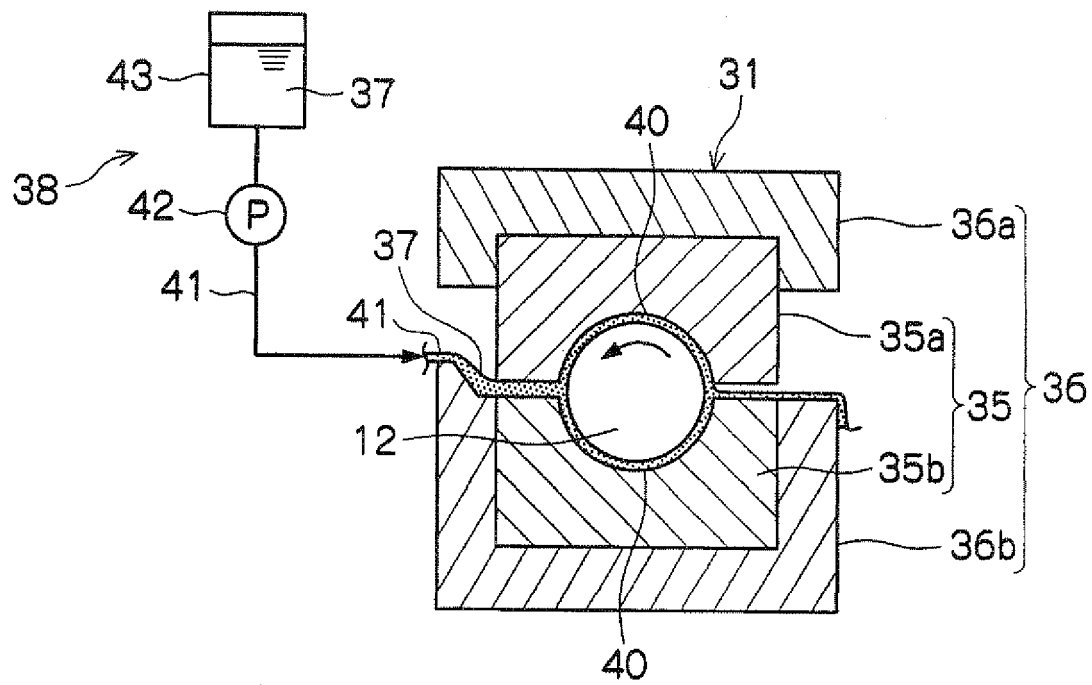
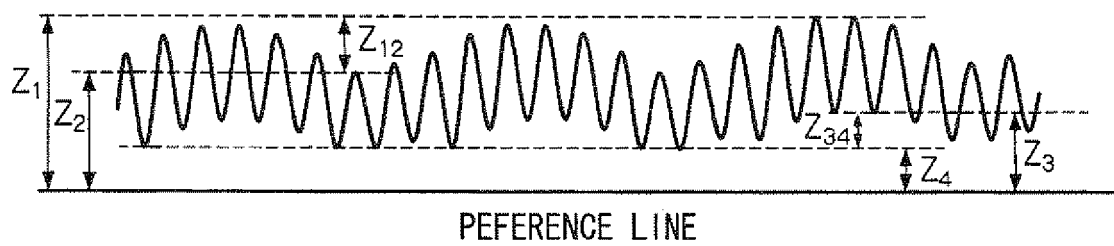


FIG.7



REFERENCES CITED IN THE DESCRIPTION

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