



US 20240299996A1

(19) **United States**

(12) **Patent Application Publication**
TAKAHASHI et al.

(10) **Pub. No.: US 2024/0299996 A1**

(43) **Pub. Date: Sep. 12, 2024**

(54) **METHOD FOR SHAPING WIRE MATERIAL AND WIRE MATERIAL SHAPING DEVICE**

Publication Classification

(71) Applicant: **HITACHI ASTEMO, LTD.**,
Hitachinaka-shi, Ibaraki (JP)

(51) **Int. Cl.**
B21B 1/18 (2006.01)
B21F 1/02 (2006.01)

(72) Inventors: **Yoshiko TAKAHASHI**, Hitachinaka-shi (JP); **Akira TOBA**, Hitachinaka-shi (JP); **Shota KAWAGUCHI**, Hitachinaka-shi (JP)

(52) **U.S. Cl.**
CPC . **B21B 1/18** (2013.01); **B21F 1/02** (2013.01)

(73) Assignee: **HITACHI ASTEMO, LTD.**,
Hitachinaka-shi, Ibaraki (JP)

(57) **ABSTRACT**

(21) Appl. No.: **18/547,531**

A method for shaping a wire material that moves from the upstream side to the downstream side includes a first step of feeding the wire material while pressing the wire material by a first roller group including a plurality of rollers driven by a motor and a second step of feeding the wire material while pressing the wire material by a second roller group including a plurality of rotatably supported rollers. The first step is provided upstream side of the second step, and a push-in amount that is the difference between the outer dimension of the wire material and the gap between rollers through which the wire material passes is larger in the first step than in the second step.

(22) PCT Filed: **Oct. 18, 2021**

(86) PCT No.: **PCT/JP2021/038485**

§ 371 (c)(1),
(2) Date: **Aug. 23, 2023**

(30) **Foreign Application Priority Data**

Feb. 26, 2021 (JP) 2021-030265

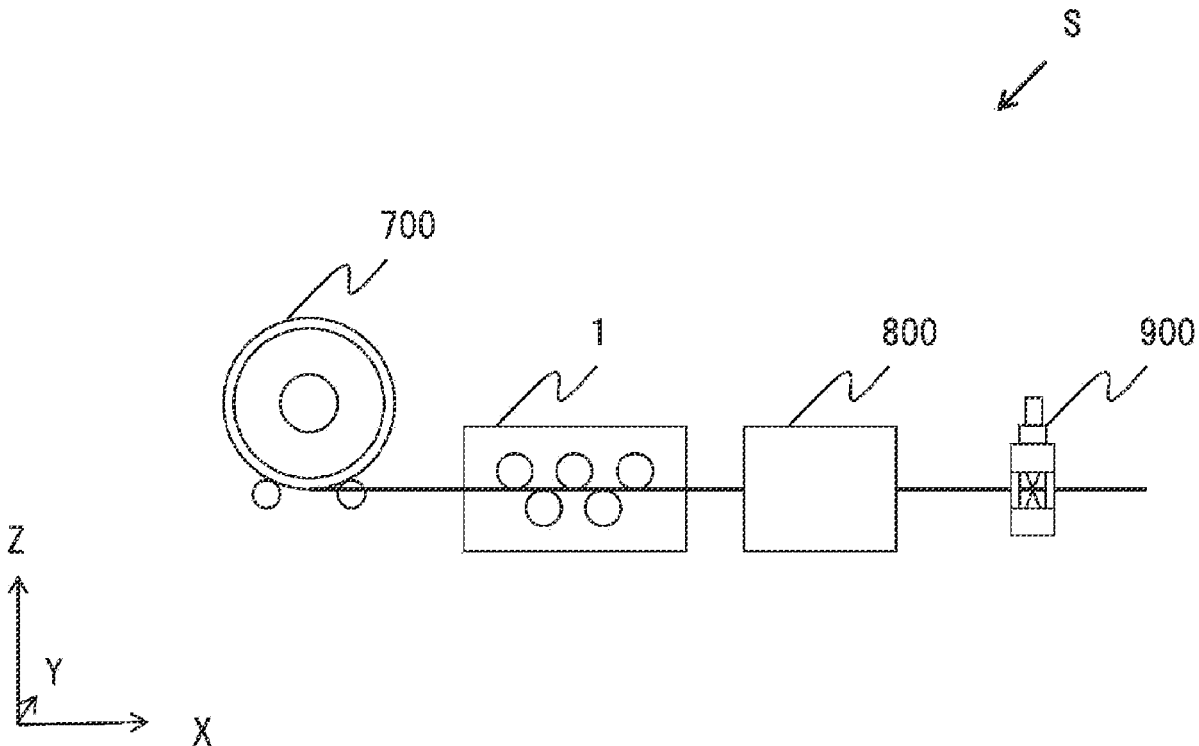


FIG. 1

S ↘

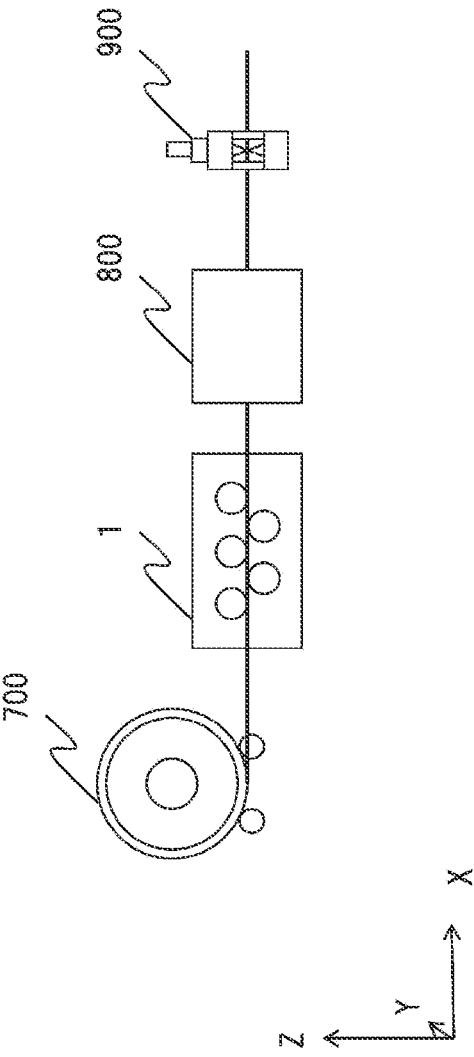


FIG. 2

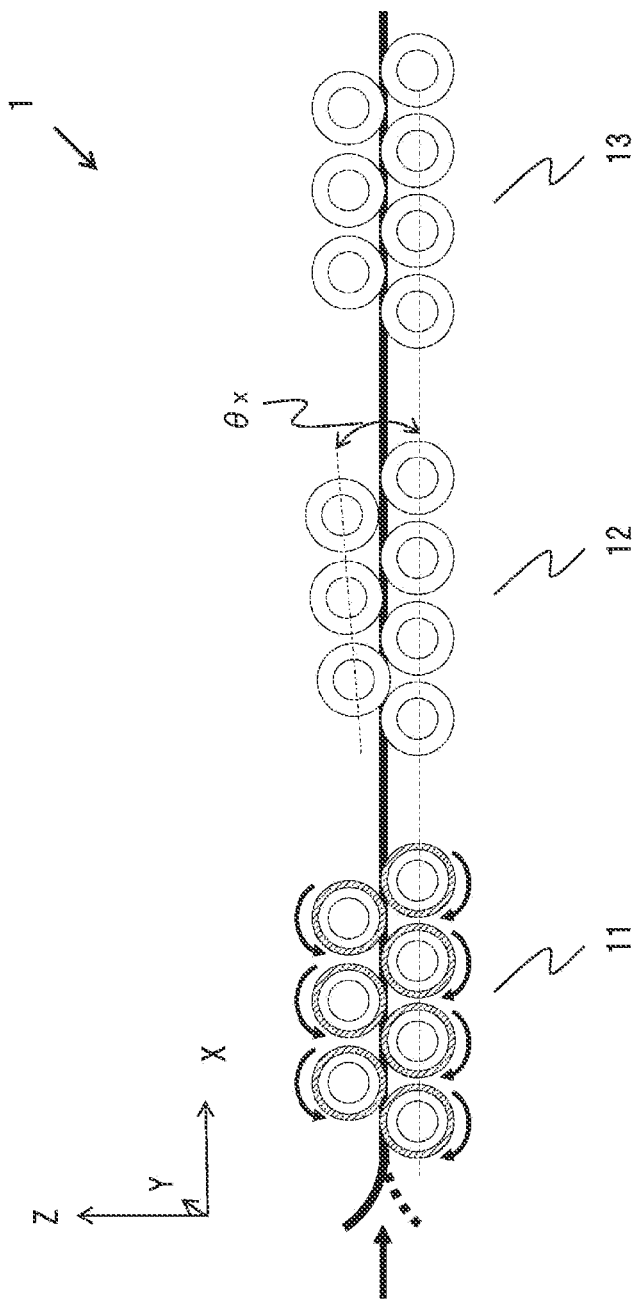


FIG. 3

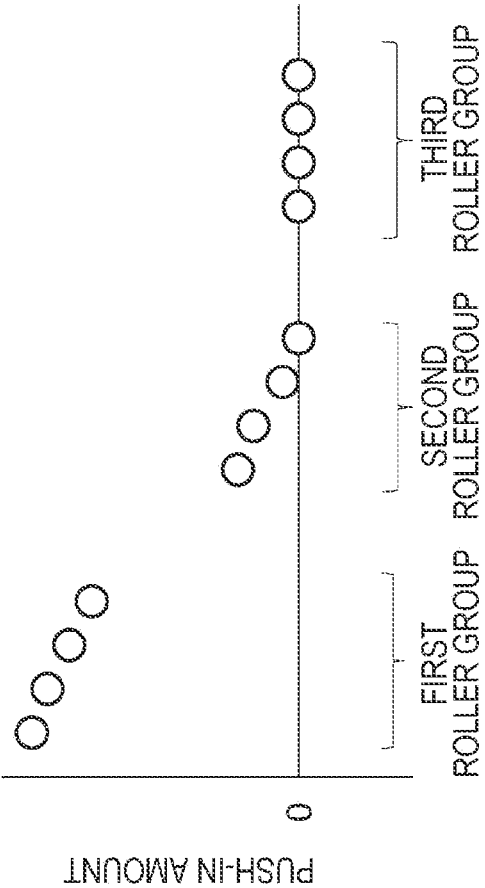


FIG. 4

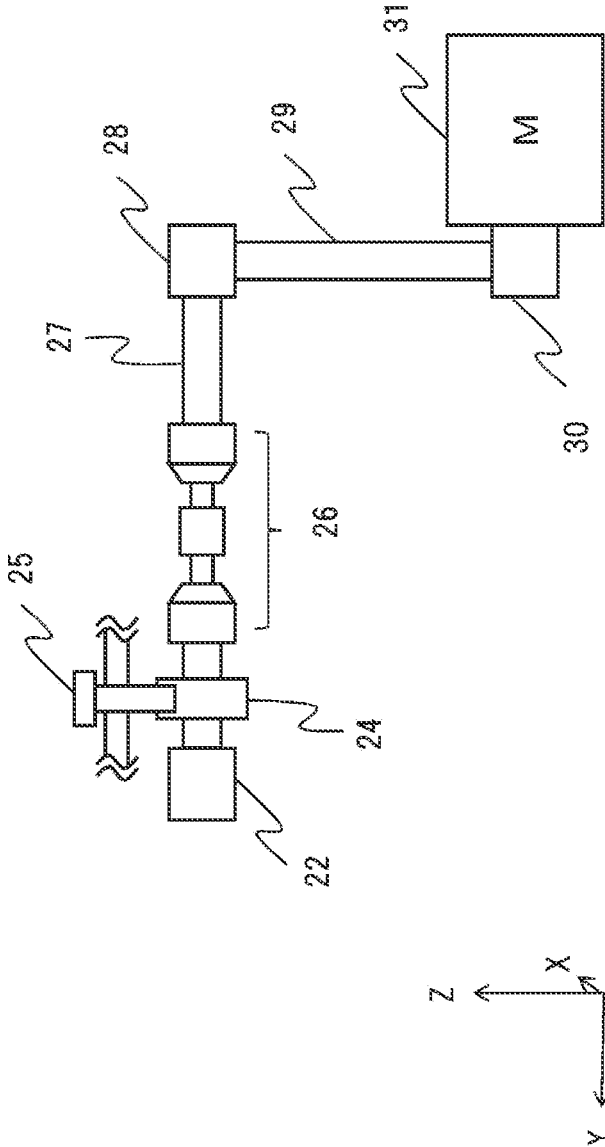
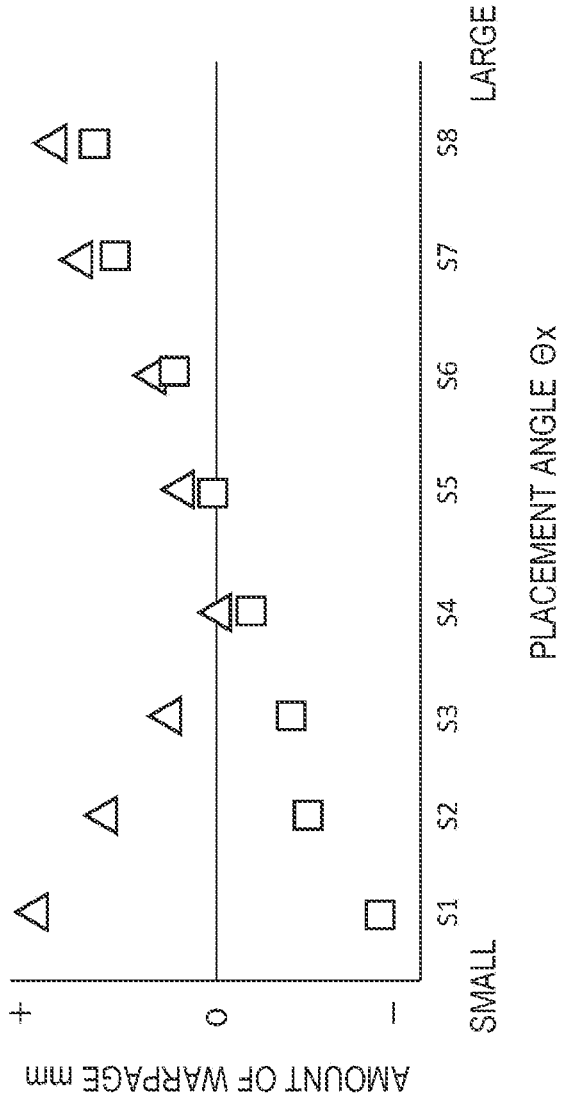


FIG. 5



METHOD FOR SHAPING WIRE MATERIAL AND WIRE MATERIAL SHAPING DEVICE

TECHNICAL FIELD

[0001] The present invention relates to a method for shaping a wire material and a wire material shaping device.

BACKGROUND ART

[0002] A metal wire material is generally wound around a bobbin in a manufacturing process. In processing this wire material, a process called “shaping” or “straightening” for reducing warpage caused by winding is required. Patent Literature 1 discloses a rod wire material straightener that easily improves the straightness of a rod wire material and performs straightening by passing a metal rod wire material between a plurality of rolls. This straightener is characterized as follows. The straightener includes at least one unit group including two or more adjacent units, with the directions of straightening the rod wire material of the two or more units forming an angle of +15°. The unit includes two or more fixed rolls and movable rolls fewer than the fixed rolls by one. The fixed rolls and the movable rolls are arranged in a staggered manner so as to sandwich the running rod wire material with the fixed rolls arranged on one side of the running rod wire material and the movable rolls arranged on a side opposite to the fixed rolls with respect to the rod wire material. The push-in amounts of the movable roll closest to the inlet side and the movable roll closest to the outlet side of each unit can be set, and the push-in amounts of the adjacent units satisfy a predetermined relationship.

CITATION LIST

Patent Literature

[0003] PTL: WO 2018/174272

SUMMARY OF INVENTION

Technical Problem

[0004] In the invention described in PTL 1, there is room for improvement in shaping.

Solution to Problem

[0005] A method for shaping a wire material according to the first aspect of the present invention is a method for shaping a wire material that moves from an upstream side to a downstream side which includes a first step of feeding the wire material while pressing the wire material by a first roller group including a plurality of rollers driven by a motor and a second step of feeding the wire material while pressing the wire material by a second roller group including a plurality of rotatably supported rollers. The first step is provided upstream side of the second step. A push-in amount that is the difference between the outer dimension of the wire material and the gap between rollers through which the wire material passes is larger in the first step than in the second step.

[0006] A wire material shaping device according to the second aspect of the present invention includes a feeding unit that feeds a wire material, a first roller group including a plurality of rollers driven by a motor to press the wire

material fed by the feeding unit and a second roller group that includes a plurality of rollers configured to further press the wire material pressed by the first roller group and is rotatably supported. A push-in amount that is the difference between the outer dimension of the wire material and the gap between rollers through which the wire material passes is larger in the first roller group than in the second roller group.

Advantageous Effects of Invention

[0007] According to the present invention, the warpage of a wire material can be stably reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. 1 is a schematic diagram of a wire material processing system including a shaping device.

[0009] FIG. 2 is a schematic configuration diagram of the shaping device.

[0010] FIG. 3 is a schematic view of push-in amounts in the shaping device.

[0011] FIG. 4 is a diagram illustrating an example of the configuration of a driving roller.

[0012] FIG. 5 is a conceptual diagram of a test result for determining a placement angle θ_x .

DESCRIPTION OF EMBODIMENT

Embodiment

[0013] Hereinafter, an embodiment of a wire material shaping device and a method for shaping a wire material according to the present invention will be described with reference to FIGS. 1 to 5.

(Overall Configuration Diagram)

[0014] FIG. 1 is a schematic view of a wire material processing system S including a shaping device 1. FIG. 1 illustrates the X-, Y-, and Z-axes orthogonal to each other for the sake of explanation. The X-axis is parallel to the left-right direction in FIG. 1, and the right side in the drawing is a positive direction. The Z-axis is parallel to the up-down direction in FIG. 1, and the upward direction in the drawing is a positive direction. With regard to the Y-axis, the depth direction in FIG. 1 is a positive direction.

[0015] The wire material processing system S includes a feeding device 700, the shaping device 1, a peeling device 800, and a cutting device 900. The wire material moves from left to right in the drawing and is processed in order. Hereinafter, the left side in the drawing is also referred to as “upstream”, and the right side in the drawing is also referred to as “downstream”.

[0016] In the feeding device 700, a bobbin around which a wire material is wound is placed with its rotation axis parallel to the Y-axis. The feeding device 700 feeds the wire material wound around the bobbin to the shaping device 1. The wire material is warped in the Z direction in FIG. 1 by being wound around the bobbin. The shaping device 1 straightens the warpage of the wire material in the Z direction fed from the feeding device 700 and feeds the wire material to the peeling device 800. The “warpage” is also called “bend” or “warping tendency”.

[0017] The peeling device 800 peels the insulating coating of the wire material by cutting, laser irradiation, or the like. The cutting device 900 cuts the wire material to a predetermined length. Hereinafter, the configuration and operation

of the shaping device **1** will be described in detail. Note that, referring to FIG. **1**, it is for convenience of drawing that the wire material is drawn in a straight line and is not an essential constituent element.

(Configuration of Shaping Device)

[0018] FIG. **2** is a schematic configuration diagram of the shaping device **1**. The shaping device **1** includes a first roller group **11**, a second roller group **12**, and a third roller group **13**. The wire material is first shaped by the first roller group **11**, then shaped by the second roller group **12**, and finally shaped by the third roller group **13**. Hereinafter, the shaping of the wire material by the first roller group **11** is referred to as a “first step”, the shaping of the wire material by the second roller group **12** is referred to as a “second step”, and the shaping of the wire material by the third roller group **13** is referred to as a “third step”. In both the first step and the second step, the wire material is plastically deformed.

[0019] In the present embodiment, the difference between the outer dimension of a predetermined wire material and the gap between rollers through which the wire material passes is referred to as a “push-in amount”. For example, when the outer dimension of the predetermined wire material is “1.000 mm” and the roller interval is “0.998 mm”, the push-in amount is “0.002 mm”.

[0020] The first roller group **11**, the second roller group **12**, and the third roller group **13** each have rollers arranged in upper and lower two rows, and a wire material passes through substantially the center thereof. The first roller group **11**, the second roller group **12**, and the third roller group **13** each include at least three rollers. The first roller group **11**, the second roller group **12**, and the third roller group **13** may include different numbers of rollers. Referring to FIG. **2**, all the rollers in the lower rows of the first roller group **11**, the second roller group **12**, and the third roller group **13** are arranged in a straight line, but this is merely an example of the configuration.

[0021] Each roller of the first roller group **11** is a driving roller whose outer periphery is molded with urethane rubber and driven by a motor as described later. The direction in which each roller is driven is a direction along the movement of the wire material. Specifically, the upper rollers in the drawing are driven counterclockwise, and the lower rollers in the drawing are driven clockwise. The gap between the rollers through which the wire material passes in the first roller group **11** is set such that the push-in amount sequentially decreases from the upstream side to the downstream side. Hereinafter, the gap between the rollers through which the wire material passes is also referred to as a “roller interval”.

[0022] Each roller of the second roller group **12** and the third roller group **13** is made of metal and is not driven by external power. The interval between the rollers of the second roller group **12** is set such that the push-in amount sequentially decreases from the upstream side to the downstream side, and the final push-in amount in the second roller group **12** is set to zero. The push-in amount on the most upstream of the second roller group **12** is smaller than the push-in amount on the most downstream of the first roller group **11**. The push-in amounts in the third roller group **13** are all set to zero.

[0023] The second roller group **12** is configured such that the plurality of rollers in the upper row are integrally fixed and are rotatable about the roller at the end of the upper row

as an axis. The position of the roller at the end of the upper row is determined in advance so that the last push-in amount in the second roller group **12** becomes zero, and the position of the roller is not readjusted unless the wire material is changed. In the present embodiment, the angle formed by a straight line connecting the centers of the rollers in the upper row of the second roller group **12** and a straight line connecting the centers of the rollers in the lower row of the second roller group **12** is referred to as a “placement angle θ_x ”. Assume that the placement angle θ_x is 0° , although this can occur only in the process of adjustment to be described later. In this case, the upper row and the lower row are parallel, and the push-in amounts in the second roller group **12** are all zero. In the second roller group **12** in a state where the adjustment is completed and the wire material is shaped, the placement angle θ_x is set such that the push-in amount becomes larger toward the upstream side.

[0024] FIG. **3** is a schematic view of push-in amounts in the shaping device **1**. Referring to FIG. **3**, the ordinate represents the push-in amount, and the values at higher positions in the drawing represents larger positive values, and the minimum value is zero. The abscissa in FIG. **3** indicates the X-coordinate value of the position where the shaping device **1** is pushed in, and the left side in the drawing indicates the upstream side and the right side in the drawing indicates the downstream side. In the first roller group **11** and the second roller group as a whole, the push-in amount sequentially decreases from the upstream side to the downstream side and reaches zero. The push-in amounts in the third roller group **13** are all zero. Referring to FIG. **3**, the ratio between the minimum push-in amount in the first roller group **11** and the maximum push-in amount in the second roller group **12** is several times, but may be 10 times or more or 50 times or more.

[0025] FIG. **4** is a diagram illustrating an example of the configuration of each roller constituting the first roller group **11**, that is, a driving roller. A driving roller **22** is driven by obtaining power energy from a motor **31** illustrated at the lower right in FIG. **4**. The rotational energy generated by the motor **31** is transmitted to a shaft **27** via a timing pulley **30**, a timing belt **29**, and a timing pulley **28**. The position of the driving roller **22** can be adjusted as described above, and in FIG. **4**, the position can be adjusted in the Z direction by a shaft sliding screw **25** and a shaft sliding box **24**. A universal joint **26** is interposed between the shaft **27** and the driving roller **22** so as to cope with this position adjustment.

(Position of Roller)

[0026] A procedure for determining the push-in amounts, in other words, a procedure for determining the interval between the rollers, in the first roller group **11** and the second roller group **12** will be described. Since all the rollers of the third roller group **13** have a push-in amount of zero as described above, the roller interval is the same as the defined dimension of the wire material, and thus a description thereof will be omitted here. As described below, the first roller group **11** is adjusted first, and then the second roller group **12** is adjusted. The adjustment described below may be executed by, for example, an operator or may be calculated by a computer.

[0027] In the determination of the push-in amount in the first roller group **11**, first, a strain corresponding to “tensile strength” that is the maximum stress in the wire material is specified from the composition of the wire material. For this

specification, for example, a physical property table or a database can be used. Next, the product between the specified strain and a predetermined ratio, for example, “0.6” is calculated and is referred to as a “target strain”. The push-in amount of each roller in the first roller group **11** is determined so that the push-in amount sequentially decreases and the “target strain” is obtained when the first step is completed. For this determination, the result of calculation using simulation software may be used, or the results of one or a plurality of experiments using the shaping device **1** may be used.

[0028] If the push-in amount of each roller in the first roller group **11** can be determined by the above procedure, the position of the first roller group **11** can be determined according to a predetermined policy. The predetermined policy includes, for example, fixing the position of a lower roller of the first roller group **11** and adjusting the position of an upper roller to set a roller interval to the determined value. The first roller group **11** is set at the determined position of the first roller group **11**, and the process proceeds to the next determination processing of the push-in amount of the second roller group **12**.

[0029] The push-in amount in the second roller group **12** is determined by the placement angle θ_x . The optimum placement angle θ_x is determined, for example, by the operator changing θ_x in a plurality of ways and actually measuring the processing result of the second step. Specific examples will be described below.

[0030] FIG. **5** is a conceptual diagram of a test result for determining the placement angle θ_x . Referring to FIG. **5**, the ordinate represents the amount of warpage, and the abscissa represents the placement angle θ_x . Referring to FIG. **5**, the placement angle θ_x is represented by eight angles **S1** to **S8**, but these eight angles are merely examples, and the number of angles may be larger or smaller than eight. An amount of warpage on the positive side of the Z-axis means warpage toward the positive side of the Z-axis, and an amount of warpage on the negative side of the Z-axis means warpage toward the negative side of the Z-axis. FIG. **5** shows two independent test results. The plotted triangles show a case where the wire material output from the first step is largely biased to the positive side, and the plotted squares show a case where the wire material output from the first step is largely biased to the negative side.

[0031] In a case where the wire material output from the first step is largely biased to the positive side as indicated by the plotted triangles, it is indicated that the straightening of the warpage in the second step does not work much and the value is still a large positive value in a case where the placement angle θ_x is the small angle **S1**. The amount of warpage decreases as the placement angle θ_x increases, and in the example illustrated in FIG. **5**, the amount of warpage is substantially zero when the placement angle θ_x is the angle **S4**. When the placement angle θ_x is further increased from the angle **S4**, the amount of warpage turns to increase and continues to increase. When the results of the plotted triangles shown in FIG. **5** are obtained, the operator determines the angle **S4** corresponding to the smallest absolute value of the amount of warpage as the placement angle θ_x .

[0032] In a case where the wire material output from the first step is largely biased to the negative side as indicated by the plotted squares, it is indicated that the straightening of the warpage in the second step does not work much and the value is still a large negative value in a case where the

placement angle θ_x is the small angle **S1**. The amount of warpage decreases as the placement angle θ_x approaches zero, and in the example illustrated in FIG. **5**, the amount of warpage is substantially zero when the placement angle θ_x is the angle **S5**. When the placement angle θ_x is further increased from the angle **S5**, the amount of warpage continues to increase and becomes a large positive value. When the results of the plotted squares shown in FIG. **5** are obtained, the operator determines the angle **S5** corresponding to the smallest absolute value of the amount of warpage as the placement angle θ_x .

[0033] According to the embodiment described above, the following operational effects can be obtained.

[0034] (1) The shaping device **1** shapes a wire material moving from the upstream side corresponding to the left side in FIG. **2** to the downstream side corresponding to the right side in FIG. **2** as follows. The wire material shaping by the shaping device **1** includes the following first step and second step. In the first step, the wire material is fed while being pressed by the first roller group **11** which is a plurality of rollers driven by the motor **31**. In the second step, the wire material is fed while being pressed by the second roller group **12** which is a plurality of rotatably supported rollers. The first step is provided upstream side of the second step, that is, on the left side in the drawing. The push-in amount, which is the difference between the outer dimension of the wire material and the gap between the rollers through which the wire material passes, is larger in the first step than in the second step. Therefore, in the first step, by feeding the wire material using the driven first roller group **11**, the tension generated in the wire material is reduced to reduce the warpage suppressing the elongation, and in the second step, by setting the push-in amount to be lower than that in the first step, the warpage of the wire material can be stably reduced. That is, the warpage of the wire material can be stably reduced by the shaping method by the shaping device **1**.

[0035] (2) In the first step, the push-in amount sequentially decreases from the upstream side to the downstream side. Accordingly, the warpage of the wire material can be more stably reduced.

[0036] (3) In the second step, the push-in amount sequentially decreases to zero from the upstream side to the downstream side. Accordingly, the warpage of the wire material can be more stably reduced.

[0037] (4) The minimum push-in amount in the first step is at least 10 times the maximum push-in amount in the second step. Therefore, in the first step, a strong strain is applied to the wire material, and mechanical properties can be made uniform by work hardening.

[0038] (5) The shaping of the wire material by the shaping device **1** includes a third step of feeding the wire material by the third roller group **13**, which includes a plurality of rotatably supported rollers, in addition to the first step and the second step. The third step is provided downstream of the second step, that is, on the right side in the drawing. The push-in amount in the third step is zero. Therefore, using the third roller group **13** in which the push-in amount is zero makes it possible to straighten the warpage of the wire material itself and suppress the variation.

[0039] (6) Each of the rollers constituting the first roller group **11** has a surface made of urethane rubber. Accordingly, the followability of the wire material to each driving roller is improved, and the warpage of the wire material can be further reduced.

First Modification

[0040] The above-described embodiment may be modified as in the following <1> to <5>, and <1> to <5> may be arbitrarily combined. That is, all the modifications of <1> to <4> may be added to the configuration of the embodiment, or any one or more modifications of <1> to <5> may be added.

[0041] <1> The shaping device **1** may not include the third roller group **13** and may not include the third step in the shaping of the wire material.

[0042] <2> The ratio between the minimum push-in amount in the first step and the maximum push-in amount in the second step may be several times.

[0043] <3> In the first step, the push-in amount may not sequentially decrease from the upstream side to the downstream side.

[0044] <4> In the second step, the push-in amount may not sequentially decrease from the upstream side to the downstream side.

[0045] <5> The rollers constituting the first roller group **11** each may have a surface made of a metal without molding urethane rubber on the outer periphery.

[0046] According to the first modification, there are a disadvantage that the reduction of the warpage is insufficient and a disadvantage that the stability is lacking as compared with the above-described embodiment, but the adjustment of a roller position becomes easy. In addition, these disadvantages may exist as long as the required accuracy is satisfied.

Second Modification

[0047] The method of determining the push-in amount in the second roller group **12** described in the above-described embodiment is merely an example. For example, the position of each upper roller of the second roller group **12** may be individually adjustable, and the amount of warpage may be measured while changing the position of each roller little by little to determine the position of the roller corresponding to the smallest amount of warpage. In this case, the number of times of roller position adjustment and the number of times of measuring the amount of warpage significantly increase as compared with the embodiment, but there is a possibility that the absolute value of the amount of warpage can be made smaller than that in the embodiment.

[0048] Although various embodiments and modifications have been described above, the present invention is not limited to these contents. Other aspects conceivable within the scope of the technical idea of the present invention are also included within the scope of the present invention.

REFERENCE SIGNS LIST

[0049] **1** shaping device
 [0050] **11** first roller group
 [0051] **12** second roller group
 [0052] **13** third roller group
 [0053] **31** motor

1. A method for shaping a wire material that moves from an upstream side to a downstream side, the method comprising:

a first step of feeding the wire material while pressing the wire material by a first roller group including a plurality of rollers driven by a motor; and

a second step of feeding the wire material while pressing the wire material by a second roller group including a plurality of rotatably supported rollers, wherein

the first step is provided upstream of the second step, and a push-in amount that is a difference between an outer dimension of the wire material and a gap between rollers through which the wire material passes is larger in the first step than in the second step.

2. The method for shaping a wire material according to claim **1**, wherein in the first step, the push-in amount sequentially decreases from the upstream side to the downstream side.

3. The method for shaping a wire material according to claim **1**, wherein in the second step, the push-in amount sequentially decreases to zero from the upstream side to the downstream side.

4. The method for shaping a wire material according to claim **1**, wherein a minimum push-in amount in the first step is at least 10 times as large as a maximum push-in amount in the second step.

5. The method for shaping a wire material according to claim **1**, further comprising a third step of feeding the wire material by a third roller group including a plurality of rotatably supported rollers, wherein

the third step is provided downstream of the second step, and

the push-in amount in the third step is zero.

6. The method for shaping a wire material according to claim **1**, wherein a surface of each roller constituting the first roller group is urethane rubber.

7. A wire material shaping device comprising:

a feeding unit that feeds a wire material;

a first roller group including a plurality of rollers driven by a motor to press the wire material fed by the feeding unit; and

a second roller group that includes a plurality of rollers configured to further press the wire material pressed by the first roller group and is rotatably supported, wherein a push-in amount that is a difference between an outer dimension of the wire material and a gap between rollers through which the wire material passes is larger in the first roller group than in the second roller group.

8. The wire material shaping device according to claim **7**, wherein

the first roller group is placed between the feeding unit and the second roller group, and

the push-in amount in the first roller group sequentially decreases from the feeding unit to the second roller group.

9. The wire material shaping device according to claim **7**, wherein the push-in amount in the second roller group sequentially decreases to zero from the first roller group to an opposite side.

10. The wire material shaping device according to claim **7**, wherein a minimum push-in amount in the first roller group is at least 10 times a maximum push-in amount in the second roller group.

11. The wire material shaping device according to claim 7, further comprising a third roller group rotatably supported and including a plurality of rollers that further press the wire material pressed by the second roller group, wherein the push-in amount in the third roller group is zero.

12. The wire material shaping device according to claim 7, wherein a surface of each roller constituting the first roller group is urethane rubber.

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