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(54) **COILING MACHINE AND MANUFACTURING METHOD OF COIL SPRING**

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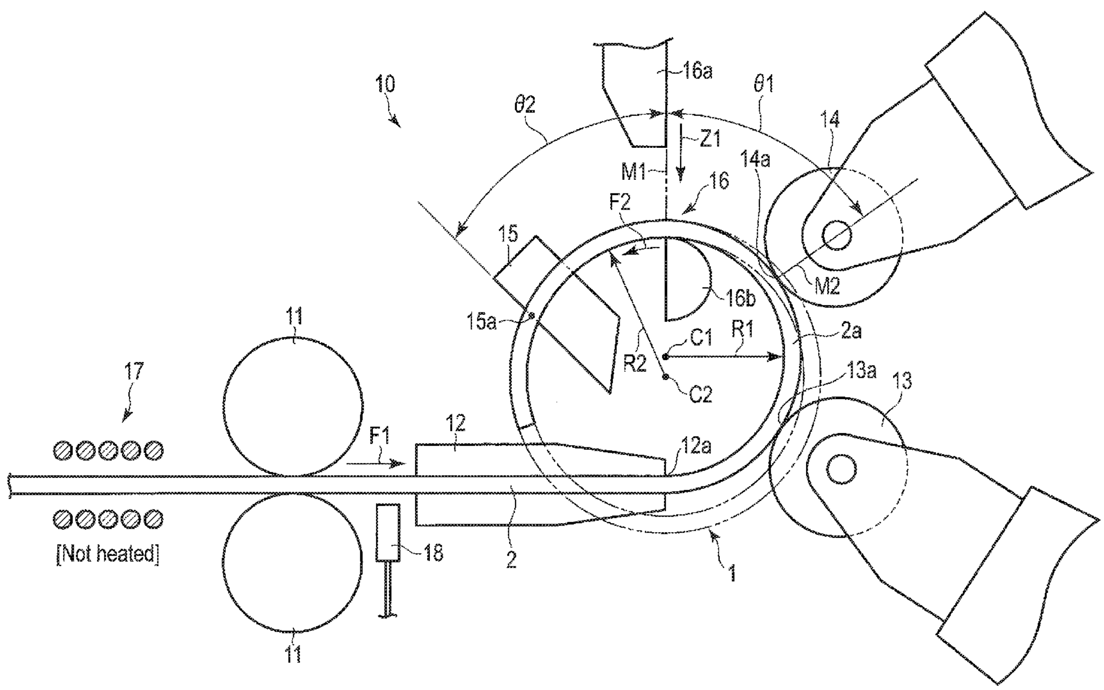
(57) **ABSTRACT**

A coiling machine includes a material guide, first pin, second pin, pitch tool, cutting tool, heating device, temperature sensor, and controller. A material is bent between the first pin and the second pin to form an arc part between the first pin and the second pin. The controller select control data corresponding to the temperature of the material from a plurality of control data corresponding to a processing temperature. Then, the positions of the first pin and the second pin are controlled such that a radius of curvature of the arc part increases when the temperature of the material increases, and the position of the cutting tool is controlled such that a gap between the center of curvature of the arc part and the cutting tool increases.



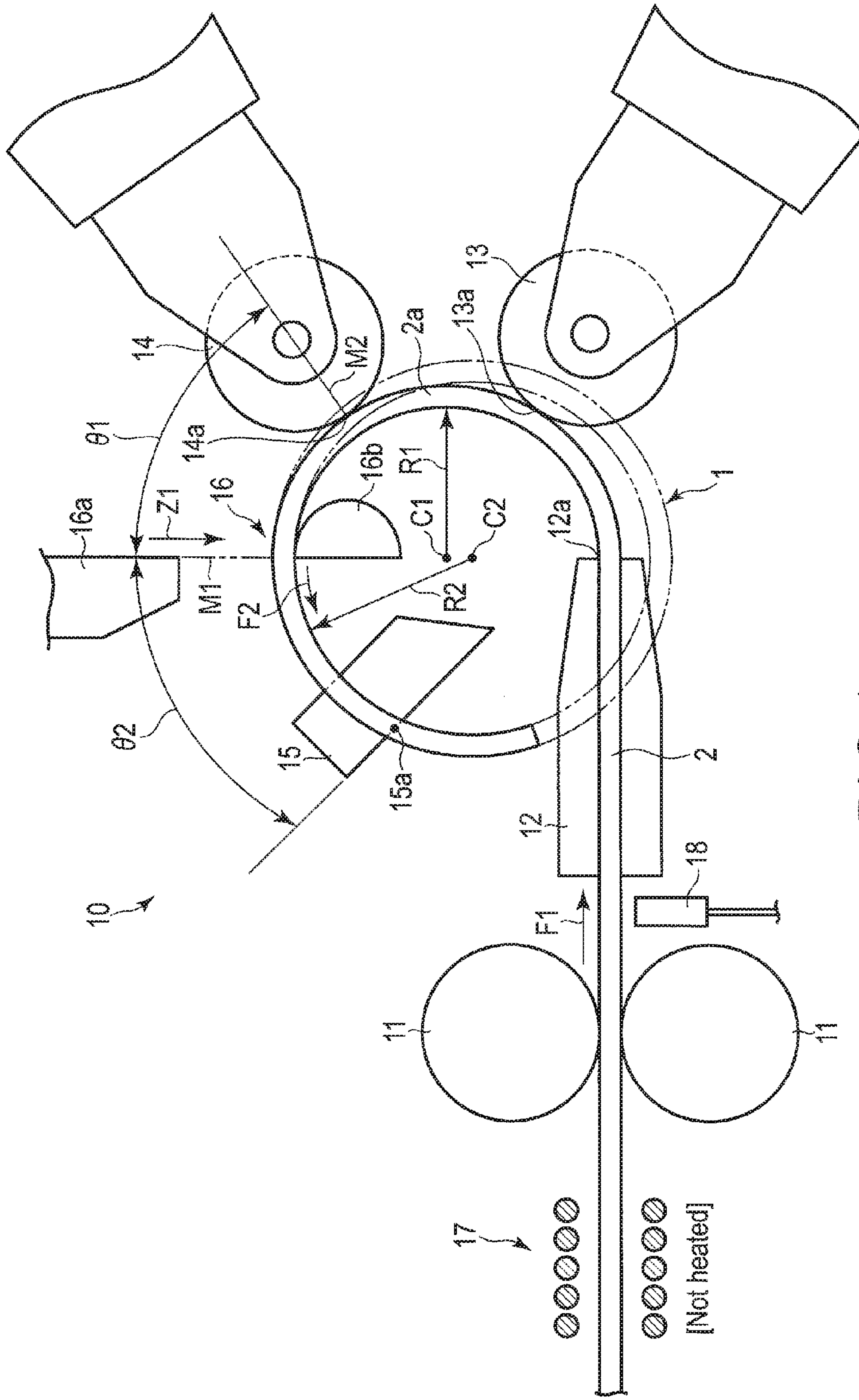

10
11
11
12
12a
13
13a
14
14a
15
15a
16
16a
16b
17
18
1
2
2a
C1
C2
R1
R2
M1
M2
F1
F2
Z1
θ1
θ2
[Not heated]

FIG. 1

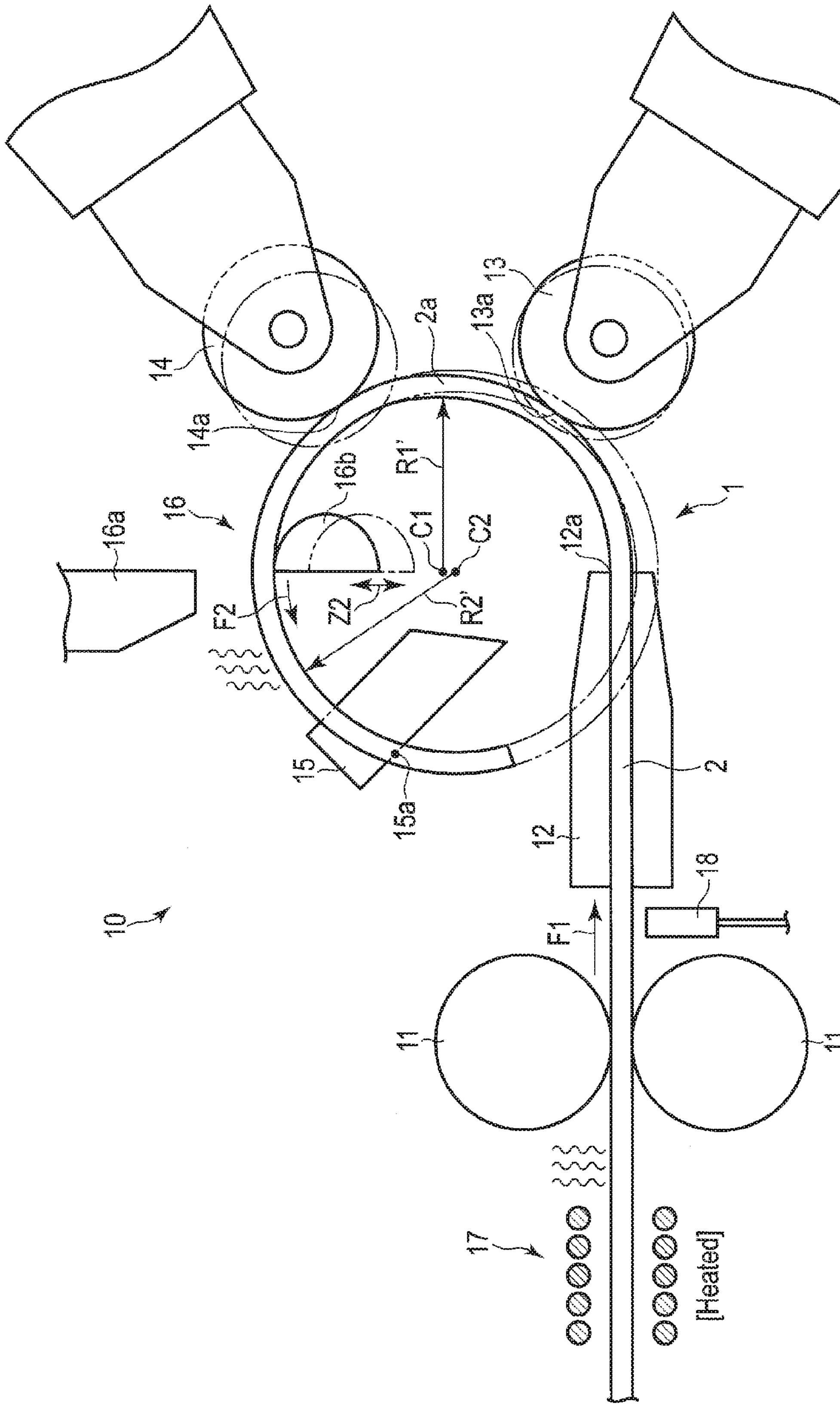

14
2a
13a
13
14a
R1'
16b
16
16a
C1
C2
12a
1
F2
Z2
R2'
15
15a
2
12
18
10
F1
11
11
17
[Heated]

FIG. 2

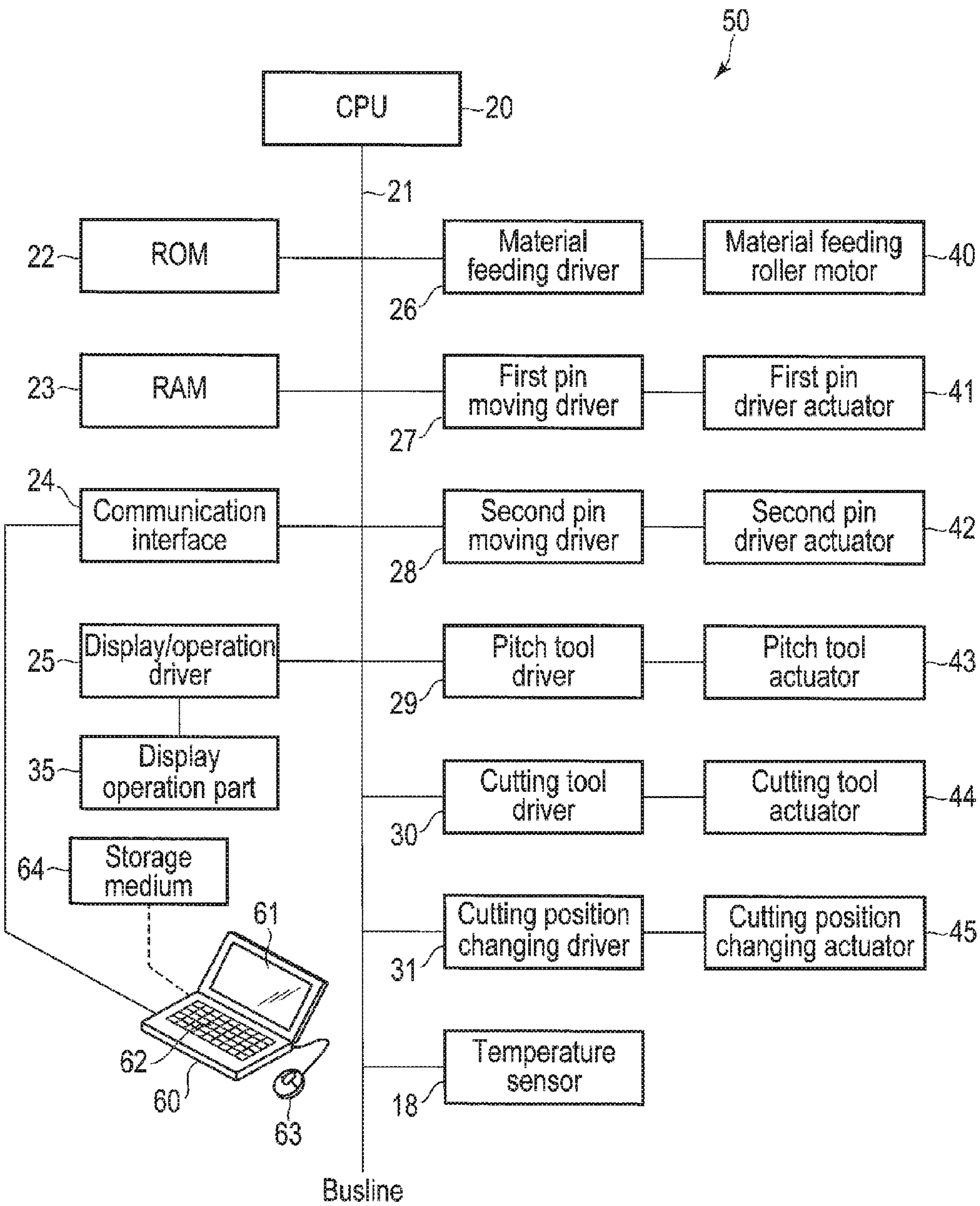
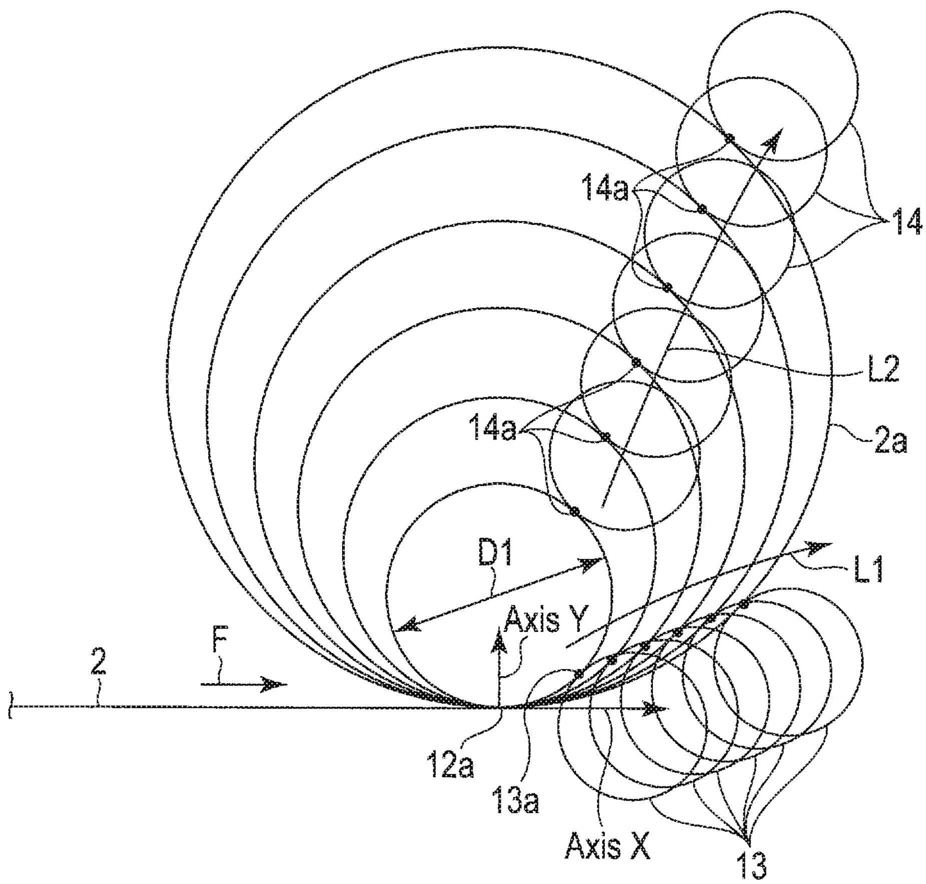
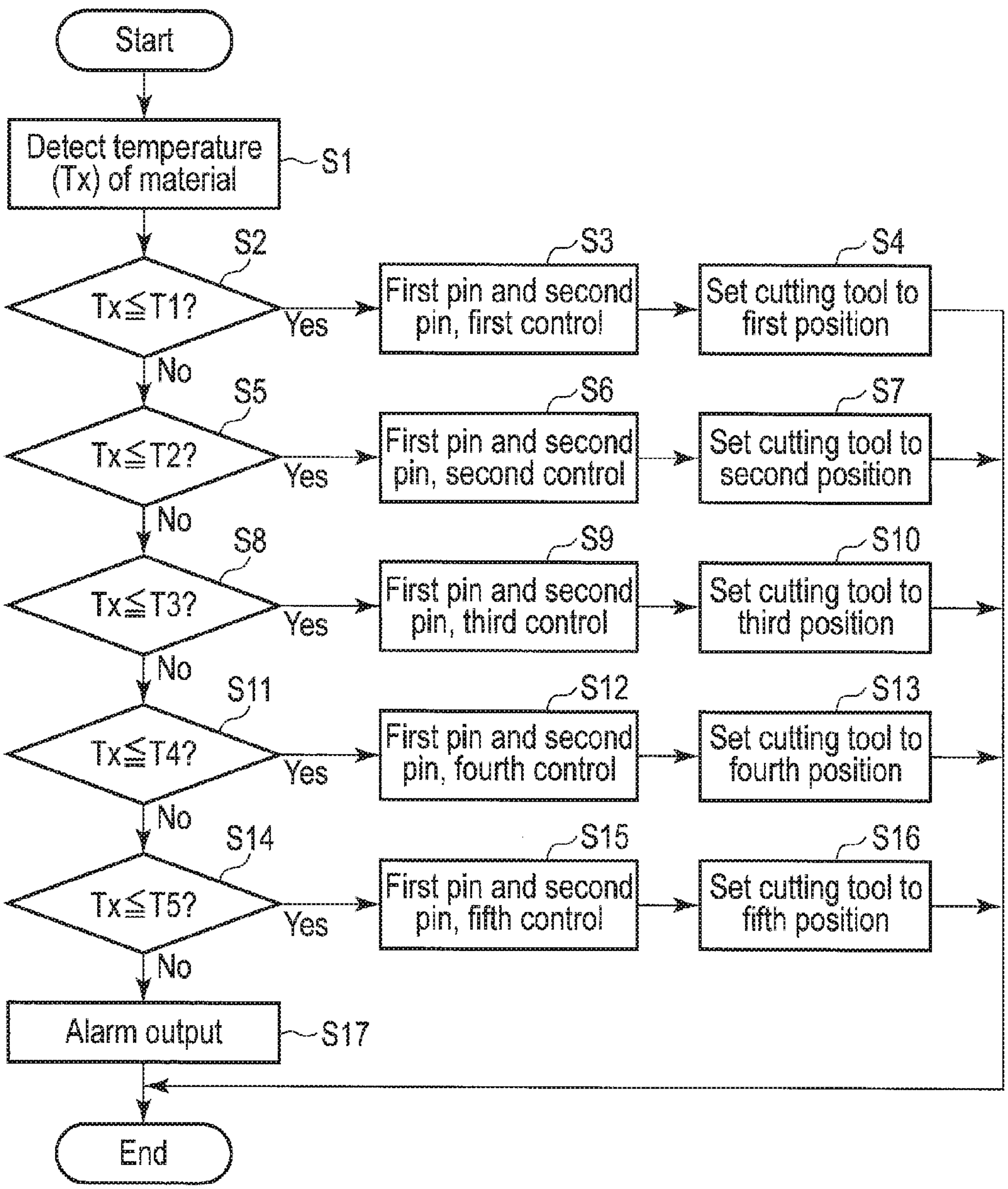

50
CPU
20
21
22
ROM
Material feeding driver
Material feeding roller motor
40
26
23
RAM
First pin moving driver
First pin driver actuator
41
27
24
Communication interface
Second pin moving driver
Second pin driver actuator
42
28
25
Display/operation driver
Pitch tool driver
Pitch tool actuator
43
29
35
Display operation part
Cutting tool driver
Cutting tool actuator
44
30
64
Storage medium
61
Cutting position changing driver
Cutting position changing actuator
45
31
62
60
63
Temperature sensor
18
Busline

FIG. 3



F I G. 4


Start
Detect temperature (Tx) of material
S1
S2
Tx≦T1?
Yes
No
S3
First pin and second pin, first control
S4
Set cutting tool to first position
S5
Tx≦T2?
Yes
No
S6
First pin and second pin, second control
S7
Set cutting tool to second position
S8
Tx≦T3?
Yes
No
S9
First pin and second pin, third control
S10
Set cutting tool to third position
S11
Tx≦T4?
Yes
No
S12
First pin and second pin, fourth control
S13
Set cutting tool to fourth position
S14
Tx≦T5?
Yes
No
S15
First pin and second pin, fifth control
S16
Set cutting tool to fifth position
Alarm output
S17
End

F I G. 5

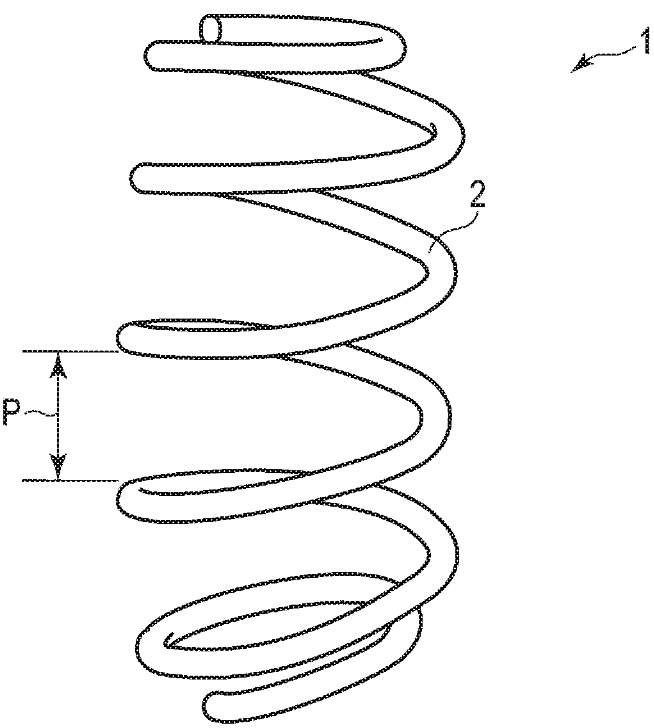


FIG. 6

COILING MACHINE AND MANUFACTURING METHOD OF COIL SPRING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation Application of PCT Application No. PCT/JP2016/053404, filed Feb. 4, 2016 and based upon and claiming the benefit of priority from prior Japanese Patent Application No. 2015-036456, filed Feb. 26, 2015, the entire contents of all of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention described herein relate generally to a mandrel-less coiling machine configured to manufacture a coil spring through cold working or through warm working, and a manufacturing method of a coil spring.

2. Description of the Related Art

[0003] An example of a coiling machine which manufactures a coil spring through cold working is disclosed in JP11-197775A (Patent Literature 1). Patent Literature 1 discloses a coiling machine without a mandrel (mandrel-less coiling machine). The mandrel-less coiling machine bends a material of a coil spring discharged from a tip of a material guide with a certain curvature by a first pin and a second pin and the bent material is pitched by a pitch tool.

[0004] Positions of the first pin and the second pin, the pitch tool, and the like are controlled on the basis of computer programs and control data corresponding to shape of the coil spring stored in a controller, for example. That is, the first pin and the second pin are moved to the positions corresponding to a coil radius by a cam and an actuator driven on the basis of the control data corresponding to the shape of the coil spring to be formed. JP 2013-226584A (Patent Literature 2) discloses a coiling machine which controls positions of a first pin and a second pin using a machine center as a reference. Conventional mandrel-less coiling machines as disclosed in Patent Literatures 1 and 2 manufacture a coil spring through cold working (at a normal temperature).

[0005] It is known that, depending on the kinds of spring steels, the hardness and the strength of the material are improved when the coil spring is processed in a higher temperature (a warm working range) than the temperature of the cold working process. The warm working process is performed in a temperature lower than a temperature used in a hot working process (a temperature equal to or lower than a recrystallization temperature of the material). For example, if a coil spring with a tempered martensite formed by a heating process is subjected to a warm working process in approximately 300° C., the yield strength is improved by dynamic strain aging in some of the spring steels.

[0006] If a coil spring is manufactured through a warm working process, a heating process such as strain relief annealing or an aftertreatment such as hot setting quenching can be performed using a residual heat of the warm working process. Thus, reheating after coiling is not required and the manufacturing process of the coil spring can be simplified. On the other hand, if a coil spring is manufactured through a cold working process, a heating process such as strain relief annealing and hot setting are performed after coiling, and thus, the coil spring must be reheated.

[0007] To perform a warm working process of a coil spring, using a conventional mandrel-less coiling machine for cold working process has been considered. However, if a material of a coil spring is heated to a warm working range to perform a warm working process of a coil spring, the shape of the coil spring formed through the warm working process may be significantly shifted from a desired shape depending on the temperature of the material. Furthermore, a position of a cutting tool is shifted from a proper position, an end or the coil spring may not be cut desirably. These points should be improved.

BRIEF SUMMARY OF THE INVENTION

[0008] Thus, the purpose of the present invention is to provide a coiling machine which can form a coil spring with a less difference from the desired shape through not only a cold working process but also a warm working process and a manufacturing method of the same.

[0009] According to an embodiment, a coiling machine includes a material guide to which a material of a coil spring is inserted, first pin, second pin, pitch tool, heating device configured to heat the material, temperature sensor configured to detect a temperature of the material, and controller. The material discharged from a tip of the material guide contacts the first pin. The second pin is disposed in a front side of a movement direction of the material with respect to the first pin. The material is bent between the first pin and the second pin to form an arc part. The pitch tool is disposed in a front side of the movement direction of the material with respect to the second pin and contacts the material. The controller changes positions of the first pin and the second pin on the basis of control data corresponding to a shape of the coil spring to be formed. Furthermore, the controller is configured to change a position of the first pin and a position of the second pin such that a radius of curvature of the arc part increases when the sensor increases, and to move the cutting tool such that a gap between a center of curvature of the arc part and the cutting tool increases when the temperature of the material increases.

[0010] According to the embodiment, a coil spring with a less difference from the desired shape can be manufactured through not only a cold working process but also a warm working process.

[0011] Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OP THE SEVERAL VIEWS OF THE DRAWING

[0012] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

[0013] FIG. **1** is a front view showing a cold working process in a part of a coiling machine of an embodiment.

[0014] FIG. **2** is a front view showing a warm working process in a part of the coiling machine of FIG. **1**.

[0015] FIG. **3** is a block diagram showing an electrical structure of the coiling machine of FIG. **1**.

[0016] FIG. **4** is a schematic view showing loci of movement of a first pin and a second pin of the coiling machine of FIG. **1**.

[0017] FIG. **5** is a flowchart of an example of a manufacturing process of a coil spring.

[0018] FIG. **6** is a perspective view showing an example of a coil spring.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Hereinafter, a coiling machine and a manufacturing method of a coil spring according to an embodiment will be described with reference to FIGS. **1** to **6**.

[0020] FIG. **6** shows an example of a coil spring **1**. The coil spring **1** is formed as a spiral of a material **2** which is a spring steel wound at a certain pitch P (which may not be constant). The shape of the coil spring **1** may be varied and a coil diameter and a pitch may change therein in some positions of winding. The coil spring may be formed as various shapes such as a barrel coil spring, a hourglass-shaped coil spring, tapered coil spring, uneven pitch coil spring, or partly minus pitched coil spring.

[0021] FIGS. **1** and **2** schematically show a part of the coiling machine **10** of an embodiment. FIG. **1** shows the coil spring **1** in a cold working process. FIG. **2** shows the coil spring **1** in a warm working process.

[0022] The coiling machine **10** includes at least a pair of material feeding rollers (feed rollers) **11**, material guide **12** to which a material **2** is inserted, first pin **13**, second pin **14**, pitch tool **15**, and cutting tool **16**. The material feeding roller **11** moves the material **2** of the coil spring in a direction indicated by arrow F1 in the figures. The material **2** discharged from a tip **12***a* of the material guide **12** initially contacts the first pin **13**. The material **2** bend by the first pin **13** contacts the second pin **14**. The cutting tool **16** cuts one unit of the formed coil spring.

[0023] The first pin **13** is disposed in a front side of a movement direction of the material **2** with respect to the tip **12***a* of the material guide **12** (in a downstream side of the movement direction). The second pin **14** is disposed in a front side of a movement direction of the material **2** with respect to the first pin **13**. The material **2** is moved from the tip **12***a* of the material guide **12** to the first pin **13**. The material **2** discharged from the tip **12***a* of the material guide **12** is bent in an arc shape between the tip **12***a* and a contact point **13***a* of the first pin **13** with the tip **12***a* of the material guide **12** as a substantial bending point. The material **2** passes de first pin **13** and is further bent in an arc shape while reaching a contact point **14***a* of the second pin **14**. Accordingly, an arc part **2***a* is formed continuously of radius of curvature R1 (shown in FIG. **1**) or of radius of curvature R1' (shown in FIG. **2**) between the first pin **13** and the second pin **14**.

[0024] The arc part **2***a* is formed between the first pin **13** and the second pin. **14**. The radius of curvature R1 of the arc part **2***a* during a cold working format on process (FIG. **1**) is minimized between the first pin **13** and the second pin **14**. After the radius of curvature R1 is minimized, the radius of curvature R1 gradually increases while the arc part **2***a* reaches the second pin **14** from the first pin **13** because of a spring back effect. The radius of curvature R1' of the arc part **2***a* during a warm working formation (FIG. **2**) is minimized between the first pin **13** and the second pin **14**. After the radius of curvature R1' is minimized, the radius of curvature R1' gradually increases while the arc part **2***a* reaches the second pin **14** from the first pin **13** because of a spring back effect to some extent.

[0025] The pitch tool **15** is disposed in a front side of a movement direction of the material **2** with respect to the second pin **14**. The pitch tool **15** contacts the material **2** which passed through the second pin **14** from a direction along an axis of the coil spring **1** at a contact point **15***a*. Thus, the coil spring **1** is pitched.

[0026] The cutting tool **16** includes a movable blade **16***a* and a receiving blade **16***b*. The rear end of one unit of the formed coil spring **1** (the front end of a next unit of the coil spring) is cut (sheared) between the movable blade **16***a* and the receiving blade **16***b*. The movable blade **16***a* moves in the direction of arrow Z1 (of FIG. **1**) to the receiving blade **16***b* while the material feeding roller **11** is stopped. Thereby, the material **2** is cut. The receiving blade **16***b* of the cutting tool **16** can move in the vertical directions (the directions of arrow **12** of FIG. **2**) by an actuator. The receiving blade **16***b* moves in the directions of arrow Z2, and a cutting position (cutting height) changes. Note that the cutting position may be changed by moving the movable blade **16***a* and the receiving blade **16***h* in the vertical directions to the same extent in synchronization with each other.

[0027] In a suitable example of the cutting tool **16**, the cutting tool **16** may be structured to move with the material **2** at the same speed in the movement direction F2 of the material **2** during the cutting process of the material **2**. In this structure, the movable blade **16***a* and the receiving blade **16***b* move with the material **2** at the same speed with and in the same movement direction of the material **2** which has passed the second pin **14**, and cut the material **2**.

[0028] A heating device **17** is disposed in the upstream side of the material feeding roller **11** (in the rear side of the movement direction of material) with respect to the movement direction of the material **2** (the directions of arrows F1 of FIGS. **1** and **2**). The heating device **17** is, for example, a high frequency heating device. The heating device **17** is turned off when the coil spring **1** is formed through a cold working process, and the material **2** is not heated. On the other hand, the heating device **17** is turned on when the coil spring **1** is formed through a warm working process. With the heating device **17** turned on, the material **2** is heated to a temperature suitable for the warm working process by high frequency guidance heating.

[0029] A temperature sensor **18** as temperature detection means is disposed in the downstream side of the material feeding roller **11** (in a front side of a movement direction of the material) with respect to the movement direction of the material **2**. The temperature sensor **18** detects a temperature of the material **2** (temperature of the material **2** immediately before becoming the coil spring **1**) and outputs a signal related to the detected temperature to CPU **20** which will be described below.

[0030] FIG. **3** is a block diagram showing an electrical structure of the coiling machine **10**. The coiling machine **10** includes a central processing unit (CPU) **20** which functions as a controller. To CPU **20**, through a bus line **21**, a read only memory (ROM), random access memory **23** (RAM), communication interface **24**, display/operation driver **25**, material feeding driver **26**, first pin moving driver **27**, second pin moving driver **28**, pitch tool driver **29**, cutting tool driver **30**, cutting position changing driver **31**, temperature sensor **18** are connected.

[0031] ROM **22** stores program to control CPU **20** and various fixed data. RAM **23** includes various data necessary to form the coil spring. Furthermore, RAM **23** includes various memory areas used to store various data necessary to obtain an estimated shape which will be describes later. The communication interface **24** controls data communication performed with external devices through a communication line (network). The display/operation driver **25** controls a display operation unit **35** including a display (display panel). The display operation part **35** is operated by an operator, and the data necessary to form the coil spring are stored in the memories such as RAM **23**.

[0032] The material feeding driver **26** controls a motor **40** which rotates the material feeding roller **11**. The first pin movement driver **27** controls a first pin driving mechanism **41**. The first pin driving mechanism **41** includes an actuator which drives the first pin **13**. The second pin movement driver **28** controls a second pin driving mechanism **42**. The second pin driving mechanism **42** includes an actuator which drives the second pin **14**. The pitch tool driver **29** controls a pitch tool driving mechanism **43**. The pitch tool driving mechanism **43** includes an actuator which drives the pitch tool **15**. The cutting tool driver **30** controls a cutting tool driving mechanism **44**. The cutting tool driving mechanism **44** includes an actuator which drives the cutting tool **16**. The cutting position changing driver **31** controls an actuator **45** which changes a position (height) of the receiving blade **16***b* of the cutting tool **16**.

[0033] The electrical structure of the coiling machine **10** including CPU **20** functions as a controller **50** which controls the operation or the like of the coiling machine **10**. The controller **50** includes a control circuit which controls the rotation operation of the material feeding roller **11** as a part of a material feeding mechanism. Furthermore, the controller **50** includes a control circuit which controls positions of the pins **13** and **14** through the pin driving mechanisms **41** and **42**. Furthermore, the controller **50** includes a control circuit which controls the position of the pitch tool **15** through the pitch tool driving mechanism **43**. Furthermore, the controller **50** includes a control circuit which controls the operation of the cutting tool **16** through the cutting tool driving mechanism **44**.

[0034] To the controller **50** of the present embodiment, a personal computer **60** is connected through the communication interface **24**. The personal computer **60** includes a display part **61** including a display panel, input operation part **62** including a key board, and pointing device **63** such as a mouse. The personal computer **60** includes a storage medium **64** which is detachably attached if necessary. The display operation part **35** of the controller **50** and the input operation part **62** of the personal computer **60** function as means to which shape data (control data) corresponding to the shape of the coil spring to be formed are input.

[0035] FIG. **4** schematically shows loci of movement of the first pin **13**, and the second pin **14** which change positions corresponding to a coil diameter D**1**. With respect to the positions of the first pin **13** and the second pin **14**, a direction F**1** of the material **2** discharged from the tip **12***a* of the material guide **12** is given axis X, and a direction orthogonal to the axis X is given axis Y. The controller **50** controls the first pin driving mechanism **41** and the second pin driving mechanism **42** such that positions X and Y of the first pin **13** and the second pin **14** change corresponding to the input shape data of the coil spring (for example, coil diameter).

[0036] Specifically, the positions of the first pin **13** and the second pin **14** are controlled such that a first angle **91** (shown in FIG. **1**) becomes constant regardless of the coil diameter of the coil spring to be formed. Here, the first angle θ**1** is an angle formed by a machine center M**1** (shown in FIG. **1**) and a line M**2** connecting the contact point **14***a* of the second pin **14** and the center of curvature C**2** of the material **2** which has passed the second pin **14**. The machine center M**1** is, for the convenience, set on an extension line of the blade surface of the cutting, tool **16** (cutter line). However, the machine center may be disposed in a different position by specifying original positions of the first pin **13** and the second pin **14**.

[0037] As shown in FIG. **4**, the controller **50** moves the first pin **13** and the second pin **14** corresponding to a coil diameter D**1**. Bending of the material starts at the tip **12***a* of the material guide **12**. When the coil diameter D**1** increases, the first pin **13** and the second pin **14** are moved such that a gap between the top **12***a* of the material guide **12** and the contact point **13***a* of the first pin **13** and a gap between the tip **12***a* of the material guide **12** and the contact point **14***a* of the second pin **14** increase. Furthermore, the positions of the first pin **13** and the second pin **14** are controlled such that a relationship between a position of turn at the contact point **14***a* of the second pin **14** with respect to the machine center M**1** (corresponding to the first angle θ**1** of FIG. **1**) and a position of turn at the contact point **15***a* of the pitch tool **15** with respect to the machine center M**1** (corresponding to a second angle θ**2** of FIG. **1**) becomes substantial constant.

[0038] A first line L**1** of FIG. **4** is an example of a locus of movement of the first pin **13**. The first line L**1** draws the locus of an arc shape such that the position Y increases when the position X increases, and the increase ratio of the position Y slightly decreases with respect to the increase ratio of the position X. A second line L**2** of FIG. **4** is an example of a locus of movement of the second pin **14**. The second line L**2** draws the locus of an arc shape such that the position Y greatly increases when the position X increases, and the increase ratio of the position Y slightly decreases with respect to the increase ratio of the position X.

[0039] CPU **20** of the controller **50** calculates the positions X and Y of the first pin **13** and the second pin **14** on the basis of the shape data of the coil spring to be formed. For example, when the coil diameter increases, the positions of the first pin **13** and the second pin **14** are controlled such that a gap between the tip **12***a* of the material guide **12** and the first pin **13** and a gap between the tip **12***a* of the material guide **12** and the second pin **14** increase. Furthermore, the positions of the first pin **13** and the second pin **14** are controlled such that the position of turn at the contact point **14***a* of the second pin **14** with respect to the machine center M**1** becomes constant regardless of the coil diameter. At that time, the position of the second pin **14** is controlled such that the position of turn at the contact point **15***a* of the pitch tool **15** becomes substantially constant.

[0040] As shown in FIG. **1**, the material **2** bent between the first pin **13** and the second pin **14** is released immediately after passing the second pin **14** and produces spring back.

Thus, a radius of curvature R2 of the material **2** which has passed the second pin **14** becomes greater than a radius of curvature R1 of the arc part **2***a* between the first pin **13** and the second pin **14**. Thus, CPU **20** controls the positions of the first pin **13** and the second pin **14** in consideration of the extent of spring back such that a center of curvature C2 after passing the second pin **14** is positioned on the machine center M1 of the coiling machine **10**. Thus, a relationship between the first angle θ1 and the second angle θ2 is maintained substantially constant regardless of the coil diameter (the second angle θ2 may change slightly). The first angle θ1 is an angle formed by the second pin **14** with respect to the machine center M1. The second angle θ2 is an angle formed by the contact point **15***a* of the pitch tool **15** with respect to the machine center M1. Most suitable positions of the first pin **13** and the second pin **14** can be preliminarily derived by trials.

[0041] The controller **50** stores a plurality of control data corresponding to process temperatures. In the present embodiment, the number of control data corresponding to process temperatures is five; however, the number thereof may vary.

[0042] For example, first control data are used to control the positions of the first pin **13** and the second pin **14** in consideration of the extent of spring back when the temperature of the material **2** falls within a first temperature range (temperature range of cold working) wherein a gap between the center of curvature C1 of the arc part **2***a* and the cutting tool **16** is set to be minimized.

[0043] Second control data are used to control the positions of the first pin **13** and the second pin **14** in consideration of the extent of spring back when the temperature of the material **2** falls within a second temperature range which is higher than the first temperature range wherein a gap between the center of curvature C1 of the arc part **2***a* and the cutting tool **16** is set to be slightly greater than that of the cold working process.

[0044] Third control data are used to control the positions of the first pin **13** and the second pin **14** in consideration of the extent of spring back when the temperature of the material **2** falls within a third temperature range which is higher than the second temperature range wherein a gap between the center of curvature C1 of the arc part **2***a* and the cutting tool **16** is set to be greater than that of the process of the second temperature range.

[0045] Fourth control data are used to control the positions of the first pin **13** and the second pin **14** in consideration of the extent of spring back when the temperature of the material **2** falls within a fourth temperature range which is higher than the third temperature range wherein a gap between the center of curvature C1 of the arc part **2***a* and the cutting tool **16** is set to be greater than that of the process of the third temperature range.

[0046] Fifth control data are used to control the positions of the first pin **13** and the second pin **14** in consideration of the extent of spring back when the temperature of the material **2** falls within a fifth temperature range which is higher than the fourth temperature range wherein a gap between the center of curvature C1 of the arc part **2***a* and the cutting tool **16** is set to be maximized.

[0047] FIG. **5** is a flowchart showing a manufacturing method of the coil spring **1** using the coil machine **10** through cold working or warm working. Hereinafter, the manufacturing method of the coil spring will be explained with reference to the flowchart.

[0048] If the coil spring is manufactured through cold working, the heating device **17** is turned off, and the material **2** is not heated. On the other hand, if the coil spring is manufactured through warm working, the heating device **17** is turned on and the material **2** is heated.

[0049] In step S1 of FIG. **5**, a temperature Tx of the material **2** is detected by the temperature sensor **18**. In the cold working process, the temperature Tx of the material **2** is a temperature T1 (for example, 30° C.) or less, which causes Yes in step S2 and the process proceeds to step S3. In step S3, the first control data for the cold working process are called and the first pin **13** and the second pin **14** are moved to the positions suitable for the cold working process on the basis of the first control data. In step S4, the cutting tool **16** moves to a first position (first cutting position) and a gap between the center of curvature C1 of the arc part **2***a* and the cutting tool **16** is minimized.

[0050] FIG. **1** schematically shows the positions of the first pin **13**, the second pin **14**, and the cutting tool **16** in the cold working process. The material **2** moves to the first pin **13** from the tip **12***a* of the material guide **12** and is formed in an arc shape by the first pin **13** and the second pin **14**. Thus, the arc part **2***a* with the radius of curvature R1 is formed between the first pin **13** and the second pin **14**. The radius of curvature R2 of the material **2** which has passed the second pin **14** and produced spring back becomes greater than the radius of curvature R1 of the arc part **2***a*. The upper surface of the receiving blade **16***b* of the cutting tool **16** is positioned approximately above the locus of movement of the material **2** which has passed the second pin **14**. In this state, the material **2** continuously moves from the tip **12***a* of the material guide **12**. When one unit of the coil spring **1** is formed, the movement of the material **2** stops for a while and the movable blade **16***a* of the cutting tool **16** works, and the rear end of the coil spring **1** (the front end of a next coil spring) is cut.

[0051] If the coil spring **1** is manufactured through the warm working process, the material **2** is heated by the heating device **17**. If the temperature Tx of the material detected by the temperature sensor **18** exceeds the first temperature T1, No is determined in step S2 of FIG. **5** and the process proceeds to step S5. In step S5, the temperature Tx of the material is compared to a second temperature T2 (for example, 100° C.), and if the temperature Tx of the material is equal to or less than the second temperature T2, the process proceeds to step S6. In step S6, the second control data are called, and the first pin **13** and the second pin **14** move to the positions suitably for the second temperature range. Furthermore, in step S7, the cutting tool **16** moves to the second position.

[0052] In step **55**, if the temperature Tx of the material exceeds the second temperature T2, the process proceeds to step S8. In step S8, the temperature Tx of the material is compared to a third temperature T3 (for example, 200° C.), and if the temperature Tx of the material is equal to or less than the third temperature T3, the process proceeds to step S9. In step S9, the third control data are called, and the first pin **13** and the second pin **14** are moved to the positions suitable for the third temperature range. Furthermore, in step S10, the cutting tool **16** moves to the third position.

[0053] In step S8, if the temperature Tx of the material exceeds the third temperature T3, the process proceeds to step S11. In step S11, the temperature Tx of the material is compared to a fourth temperature T4 (for example, 300° C.), and if the temperature Tx of the material is equal to or less than the fourth temperature T4, the process proceeds to step S12. In step S12, the fourth control data are called, and the first pin **13** and the second pin **14** are moved to the positions suitable for the fourth temperature range. Furthermore, in step S13, the cutting tool **16** moves to the fourth position.

[0054] In step S11, if the temperature Tx of the material exceeds the fourth temperature T4, the process proceeds to step S14. In step S14, the temperature Tx of the material is compared to a fifth temperature T5 (for example, 400° C.), and if the temperature Tx of the material is equal to or less than the fifth temperature T5, the process proceeds to step S15. In step S15, the fifth control data are called, and the first pin **13** and the second pin **14** are moved to the positions suitable for the fifth temperature range. Furthermore, in step S16, the cutting tool **16** moves to the fifth position.

[0055] In step S14, if the temperature Tx of the material exceeds the fifth temperature T5, the temperature is determined to be overheated for a warm working process, and the process proceeds to step S17. In step S17, a display indicative of an error or an alarm is output to, for example, the display part **61** (shown in FIG. **3**) to inform an operator.

[0056] FIG. **2** schematically shows the positions of the first pin **13**, the second pin **14**, and the cutting tool **16** in the warm working process. As in the cold working process, the material **2** continuously moves from the tip **12***a* of the material guide **12** and is formed in an arc shape by the first pin **13** and the second pin **14**. Thus, the arc part **2***a* with a radius of curvature R1' is formed between the first pin **13** and the second pin **14**.

[0057] Spring back produced in the warm working process less than that of the cold working process. Thus, if the radius of curvature R1' of the arc part **2***a* produced through the warm working process is set to the same as a radius of curvature R1 of the arc part **2***a* produced through the cold working process, the radius of curvature R2' of the material **2** after passing the second pin **14** in the warm working process (shown in FIG. **2**) becomes less than the radius of curvature R2 of the material **2** after passing the second pin **14** in the cold working process (shown in FIG. **1**). Furthermore, the cutting tool **16** in the warm working process is shifted from a locus of movement of the material **2**.

[0058] In contrast, the coiling machine **10** of the present embodiment manufactures the coil spring through the warm working process by suing control data corresponding to the temperature of the material **2** such that the radius of curvature R1' of the arc part **2***a* becomes greater than the radius of curvature R1 of the arc part **2***a* in the cold working process as compared to a case where the coil spring of the same diameter is manufactured through the cold working process. On the basis of the selected control data, the first pin **13**, second pin **14**, and cutting tool **16** are moved to the positions suitable for the process temperature. Thus, the radius of curvature R2' of the coil spring manufactured through the warm working process after spring back can be substantially equal to the radius of curvature R2 of the coil spring manufactured through the cold working process after spring back. Furthermore, the receiving blade **16***b* of the cutting tool **16** in the warm working process can be moved to the position above the locus of movement of the material **2**.

[0059] According to the coiling machine **10** of the present embodiment, a coil spring manufactured through a warm working process is formed in an accurate shape by first pin **13** and second pin **14** as in the case of cold working process, and the coil spring can be cut at a proper cutting position.

[0060] The coiling machine **10** of the present embodiment can manufacture coil springs of constant shape even if the temperature of the material heated by a heating device **17** in the warm working process changes for any reason. The coiling machine **10** can be used in both the cold working process and the warm working process.

[0061] As described above, a manufacturing method of the coil spring of the present embodiment includes the following steps when the coil spring **1** is formed through the warm working process.

[0062] (1) Heating a material **2** of a coil spring **1**;

[0063] (2) Detecting a temperature of the heated material **2**;

[0064] (3) Moving a first pin **13** and a second pin **14** such that, when the detected temperature of the material **2** becomes higher, a radius of curvature R1' of an arc part **2***a* formed between the first pin **13** and the second pin **14** becomes greater than a radius of curvature **1** of the arc part **2***a* of the coil spring in a cold working process;

[0065] (4) Moving the cutting tool **16** such that, when the temperature of the material **2** becomes higher, a gap between a center of curvature C1 of the arc part **2***a* and a cutting tool **16** becomes greater than a gap between a center of curvature C1 of the arc part **2***a* and the cutting tool **16** in the cold working process;

[0066] (5) Forming the coil spring **1** by continuously moving the heated material **2** from a tip **12***a* of a material guide **12** to the first pin **13** and bending the material **2** between the first pin **13** and the second pin **14**; and

[0067] (6) Cutting one unit of the formed coil spring **1** by the cutting tool **16**.

[0068] Note that, in the present embodiment, the number of control data corresponding to the process temperatures is five; however, the number may vary. Or, control data continuously change corresponding to process temperatures continuously change may be used. Furthermore, in order to achieve the present invention, as a matter of course, various changes may be applied, if necessary, to the structures and arrangements of each of the components of the coiling machine including the material guide, first pin, second pin, pitch tool, cutting tool, heating device, temperature sensor, etc.

[0069] The coiling machine of the present invention can be applied to manufacturing of coil springs of various types such as a cylinder coil spring, barrel coil spring, a hourglass-shaped coil spring, tapered coil spring, uneven pitch coil spring, or partly minus pitched coil spring.

[0070] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. A coiling machine comprising:

a material guide to which a material of a coil spring is inserted;

a first pin to which the material discharged from a tip of the material guide contacts;
a second pin disposed in a front side of a movement direction of the material with respect to the first pin, the second pin configured to form an arc part with the first pin by bending the material with the first pin;
a pitch tool disposed in a front side of a movement direction of the material with respect to the second pin, the pitch tool to which the material contacts;
a cutting tool configured to cut the material;
a heating device configured to heat the material;
a temperature sensor configured to detect a temperature of the material; and
a controller configured to change a position of the first pin and a position of the second pin on the basis of control data corresponding to a shape of a coil spring to be formed, wherein the first pin and the second pin are moved such that a radius of curvature of the arc part increases when the temperature of the material detected by the temperature sensor increases, and the cutting tool is moved such that a gap between a center of curvature of the arc part and the cutting tool increases when the temperature of the material increases.

2. A manufacturing method of a coil spring in which a coil spring is formed by bending a material in an arc shape between a first pin and the second pin, the method, when the coil spring is processed through warm working, comprising:

heating the material;

detecting a temperature of the material;

moving, when the temperature of the material detected increases, the first pin and the second pin such that a radius of curvature of the arc part formed between the first pin and the second pin becomes greater as compared to a case where the coil spring is processed through cold working, and the cutting tool such that a gap between a center of curvature of the arc part and the cutting tool increases;

forming the coil spring by continuously moving the heated material from a tip of a material guide to the first pin and bending the material between the first pin and the second pin and

cutting the coil spring formed as a single unit by the cutting tool.

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