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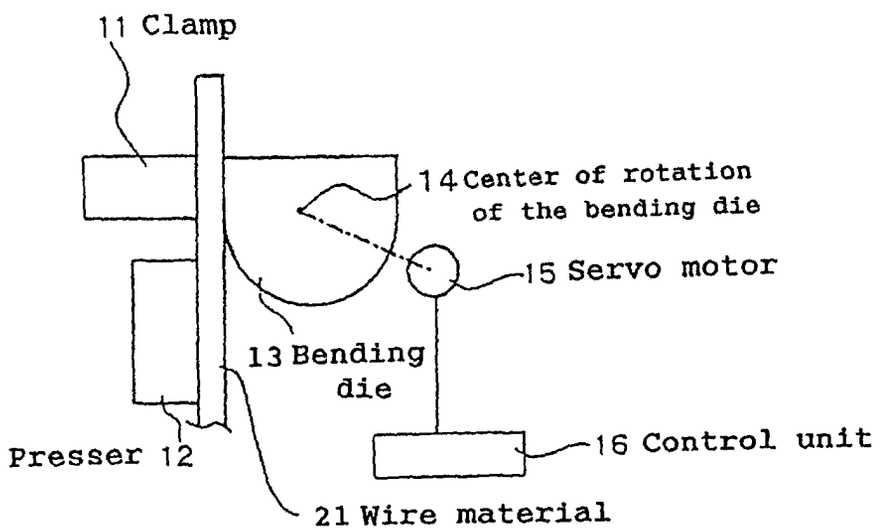
(54) WIRE BENDING MACHINE AND BENDING METHOD

(57) A wire bending machine and a bending method capable of providing a high-precision working independently of a level of the rigidity of a material. With a wire (21) held by a bending die (13), a clamp (11) and a presser (12), a shifting instruction in proportion to a deviation between a target position and a current position and a shifting instruction in proportion to the time integration of the deviation between the target position and the current position are given from a control unit (16) to a servo motor (15) driving the bending die (13), and the shifting instruction in proportion to the time integration is stopped when a current position reaches the target position, thereby the wire (21) can be bent up to a target position with a desired radius by turning the bending die (13) through a desired angle via the servo motor (15) based on the shifting instructions.

Fig. 1



EP 1 195 209 A1

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a wire bending machine and a wire bending method, and in particular it relates to a wire-bending machine whose bending accuracy is high, and a wire bending method therefor.

BACKGROUND OF THE INVENTION

[0002] A prior art wire bending machine includes a turnable bending die having a bending curvature of an appointed radius; a clamp that presses a wire material to a straight portion of the bending die, fixes the same thereat, rotates concentrically with and moves together with the center of rotation of the bending die corresponding to a rotation of the bending die; and a presser that holds a bending part of the wire material at the opposite side of the bending die and moves in the direction of disposition of the wire material corresponding to a rotation of the bending die, wherein a method for bending a wire material was employed, which comprises the steps of pressing the rear side of the wire material by the presser, holding the tip end of the wire material between the clamp and the bending die, turning the bending die, simultaneously causing the presser to advance along the wire material, and bending the wire material along the bending die.

[0003] The bending die is driven to rotate by a servo motor, and the control system is such that the position control thereof is carried out by applying an instruction in proportion to a deviation between a target position and the current position to the servo motor, and an appointed bending angle is generated.

[0004] In the above-described control system of the servo motor, unless the rotation angle of the bending die reaches a target angle, there may be a case where a reaction force of a wire material is made equal to the torque of the servo motor due to a shifting instruction (this is in proportion to a deviation between the target angle and the current angle and becomes smaller and smaller in line with approaching the target angle), and the rotation of the rotating axis of the bending die stops. That is, a problem occurs in that, where a wire material having high rigidity, the rotation thereof stops before the servomotor reaches the target position, the product accuracy is worsened.

[0005] It is therefore an object of the invention to provide a wire bending machine and a wire bending method by which highly accurate bending can be brought about regardless of the rigidity of wire materials.

DISCLOSURE OF THE INVENTION

[0006] A wire bending machine according to the invention comprises: a turnable bending die having a bending curvature of an appointed radius; a clamp that presses a wire material to a straight portion of the bending die, fixes the same thereat, rotates concentrically with and moves together with the center of rotation of the bending die corresponding to a rotation of the bending die; a presser that holds a bending part of the wire material at the opposite side of the bending die and moves in the direction of disposition of the wire material corresponding to a rotation of the bending die; a servo motor for driving and rotating a bending die; and a control unit for controlling the drive of the servo motor; wherein the control unit is provided with a calculating means that applies to the servo motor a shifting instruction in proportion to a deviation between a target position and a current position and a shifting instruction in proportion to time-integration of a deviation between the target position and the current position, and stops the shifting instruction in proportion to the time-integration at the moment when the current position reaches the target position, and a controlling means therefor.

[0007] Also, a wire bending method according to the invention includes the steps of: pinching a wire material between a turnable bending die having a bending curvature of an appointed radius, a clamp that presses a wire material to a straight portion of the bending die, fixes the same wire material, rotates concentrically with and moves together with the center of rotation of the bending die corresponding to the rotation of the bending die, and a presser that holds a bending portion of the wire material at the opposite side of the bending die and shifts in the disposition direction of the wire material corresponding to the rotation of the bending die; providing a servo motor, which drives the bending die, with a shifting instruction in proportion to a deviation between a target position and a current position, and a shifting instruction in proportion to the time-integration of the deviation between the target position and the current position, and stopping a shifting instruction in proportion to the time-integration at the moment when the current position reaches the target position; and turning the bending die via the servo motor that is driven on the basis of the shifting instructions and bending the wire material up to the target position at an appointed radius.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is an exemplary partial plan view of a wire bending machine according to an embodiment of the invention before the commencement of a bending action;

Fig. 2 is an exemplary partial plan view of a wire bending machine according to the embodiment of the invention after the commencement of a bending action; and

Fig. 3 is a flow chart of a wire bending method in which a wire bending process according to the embodiment of the invention is used.

BEST MODE FOR CARRYING OUT THE INVENTION

[0009] Next, a description is given of an embodiment of the invention with reference to the accompanying drawings. Fig. 1 is an exemplary partial plan view of a wire bending machine according to an embodiment of the invention before the commencement of a bending action, and Fig. 2 is an exemplary partial plan view of a wire bending machine according to the embodiment of the invention after the commencement of a bending action.

[0010] The problem, by which product accuracy is lowered due to stopping of a prior art servo motor before the prior art servo motor reaches a target position, has been solved so that the torque of the servo motor is made larger than the reaction force before the target position. In the present invention, a calculation that integrates a deviation between a current position of a bending die 13 and a target position thereof in terms of time is carried out along with application of a normal shifting instruction in proportion to a deviation between the current position of the bending die 13 and the target position thereof to a servo motor 15 that drives the bending die 13, and another shifting instruction in proportion to the calculation is applied to the servo motor 15, thereby generating a necessary torque.

[0011] A wire bending machine according to the embodiment of the invention includes a turnable bending die 13 having a bending curvature of an appointed radius; a clamp 11 that presses a wire material 21 to a straight portion of the bending die 13, fixes the wire material 21 thereat, rotates concentrically with and moves together with the center of rotation of the bending die 13 corresponding to a rotation of the bending die 13; a presser that holds a bending part of the wire material 21 at the opposite side of the bending die 13 and moves in the direction of disposition of the wire material 21 corresponding to a rotation of the bending die 13; a servo motor 15 for driving and rotating a bending die 13; and a control unit 16 for controlling the drive of the servo motor 15.

[0012] The control unit 16 is provided with a calculating means that applies to the servo motor 15 a shifting instruction in proportion to a deviation between a target position and a current position and a shifting instruction in proportion to time-integration of a deviation between the target position and the current position, and stops the shifting instruction in proportion to the time-integration at the moment when the current position reaches the target position, and a controlling means therefor.

[0013] Next, a description is given of a wire-bending machine according to an embodiment of the invention with the accompanying drawing. Fig. 3 is a flow chart of a wire bending method in which a wire bending process according to the embodiment of the invention is used.

[0014] When a bending process is commenced (S11), a wire material 21 is pinched by a bending die 13, a clamp 11, and a presser 12 (S12). When a bending action is commenced (S13), a deviation between a target position and a current position is calculated, value "A" is calculated by multiplying the deviation by a proportional gain, the time-integration of the deviation is performed, and value "B" is calculated by multiplying it by the integration gain. Then, a shifting instruction is applied to a servo motor 15 on the basis of the sum of value "A" plus value "B" (S14), wherein if the deviation is not less than 0 (S15N), the process returns to Step S14, and the steps are repeated from the calculation of the deviation. If the deviation is less than 0 (S15Y), a deviation between the target position and the current position is calculated, and a shifting instruction is applied to the servomotor on the basis of a value obtained by multiplying the deviation by a proportional gain. Then, the drive of the servo motor 15 is stopped (S16) at the target position, and the wire material 21 is removed from the bending die 13, clamp 11 and presser 12 (S17). Herein, the bending process is terminated (S18).

[0015] A detailed description is given thereof. A wire material 21 is pinched by the clamp 11, presser 12 and bending die 13 (See Fig.1). The bending die 13 is driven by the servomotor 14. That is, the bending die 13 is turned centering around the center 14 of rotation of the bending die when the servomotor 14 is driven. As a bending action is performed, the clamp 11 moves along with the bending die 13 while pinching the wire material 21. The presser 12 advances along the wire material 21 during the bending action. The angle that is constituted by the clamp 11 and presser 12 when the bending action is terminated becomes coincident with a bending angle of the wire material 21 (See Fig. 2). Therefore, the bending angle of the wire material 21 can be controlled by the turning angle of the servomotor 15.

[0016] In the bending process, the sum of an instruction calculated by (Target Position - Current Position) x Proportional Gain .... (Expression 1), and an instruction calculated by the time-integration of (Target Position - Current Position) x Integration Gain .... (Expression 2) is given from the control unit 16 to the servo motor 15, which drives the bending die 13, as an instruction that brings about an appointed bending angle of products.

[0017] Thereby, even if the torque of the servo motor 15, which is generated by an instruction resulting from the proportional gain calculated by Expression 1 and decreases in proportion to the approaching of the current position to the target position, is balanced with the reaction force of the wire material before reaching the target position, the torque overcomes the reaction force since the instruction obtained by the integration gain, which is calculated by Expression 2, increases in line with an elapse of time, thereby causing the bending die 13 to shift to an appointed position, and the wire material 21 can be bent up to an appointed angle. Since the value calculated by Expression 2 does not become 0 although the value calculated by Expression 1 becomes 0 at the moment when the turning angle of the bending die 13 reaches the target position, an overshoot occurs in the

turning angle of the bending die 13, wherein the bending angle exceeds an appointed angle. In order to prevent this from occurring, the calculation (by Expression 2) is stopped at the moment when the turning angle of the bending die 13 reaches the target position, and only the instruction calculated by Expression 1 is given to the servo motor 15 to stop the servo motor 15.

[0018] As described above, using the wire bending machine and wire bending method according to the invention, the torque of the servomotor is controlled before the target position so that the torque is made larger than the reaction force. That is, a calculation is carried out in regard to the time-integration of the deviation between the current position and target position of the bending die, and a shifting instruction in proportion to the result of the calculation is applied to the servo motor in addition to a shifting instruction in proportion to a normal deviation between the current position and target position of the bending die, which is applied to the servo motor that drives the bending die, whereby a necessary torque is generated, and the bending die can be accurately shifted to the target position. And, an effect can be brought about, by which highly accurate bending is enabled even for wire materials having high rigidity.

INDUSTRIAL APPLICABILITY

[0019] The present invention is applicable to highly accurate wire bending regardless of the level of product rigidity.

Claims

1. A wire bending machine comprising:

a turnable bending die having a bending curvature of an appointed radius; a clamp that presses a wire material to a straight portion of the bending die, fixes the same thereat, rotates concentrically with and moves together with the center of rotation of the bending die corresponding to a rotation of the bending die; a presser that holds a bending part of the wire material at the opposite side of the bending die and moves in the direction of disposition of the wire material corresponding to a rotation of the bending die; a servo motor for driving and rotating a bending die; and a control unit for controlling the drive of the servo motor; wherein the control unit is provided with a calculating means that applies to the servo motor a shifting instruction in proportion to a deviation between a target position and a current position and a shifting instruction in proportion to time-integration of a deviation between the target position and the current position, and stops the shifting instruction in proportion to the time-integration at the moment when the current position reaches the target position, and a controlling means therefor.

2. A wire bending method including the steps of: pinching a wire material between a turnable bending die having a bending curvature of an appointed radius, a clamp that presses a wire material to a straight portion of the bending die, fixes the same wire material, rotates concentrically with and moves together with the center of rotation of the bending die corresponding to the rotation of the bending die, and a presser that holds a bending portion of the wire material at the opposite side of the bending die and shifts in the disposition direction of the wire material corresponding to the rotation of the bending die; providing a servo motor, which drives the bending die, with a shifting instruction in proportion to a deviation between a target position and a current position, and a shifting instruction in proportion to the time-integration of the deviation between the target position and the current position, and stopping a shifting instruction in proportion to the time-integration at the moment when the current position reaches the target position; and turning the bending die via the servo motor that is driven on the basis of the shifting instructions and bending the wire material up to the target position at an appointed radius.

Fig. 1

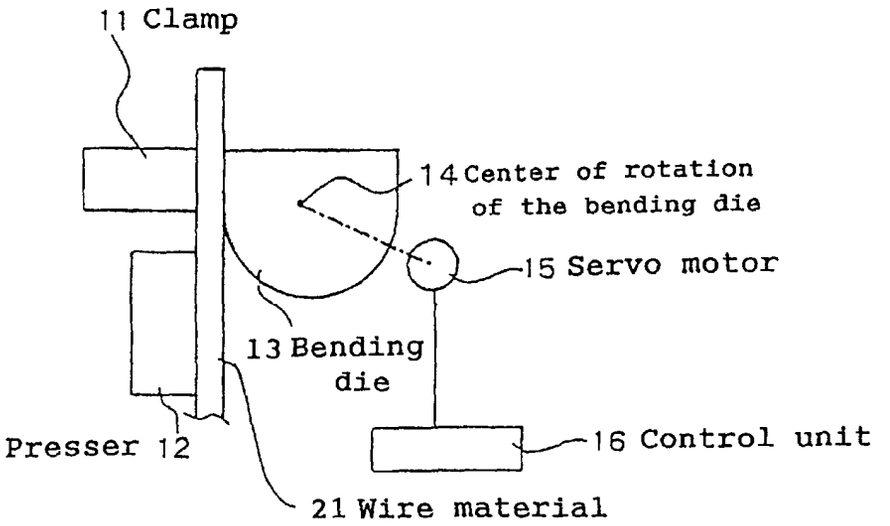

11 Clamp
14 Center of rotation of the bending die
15 Servo motor
13 Bending die
Presser 12
16 Control unit
21 Wire material

Fig. 2

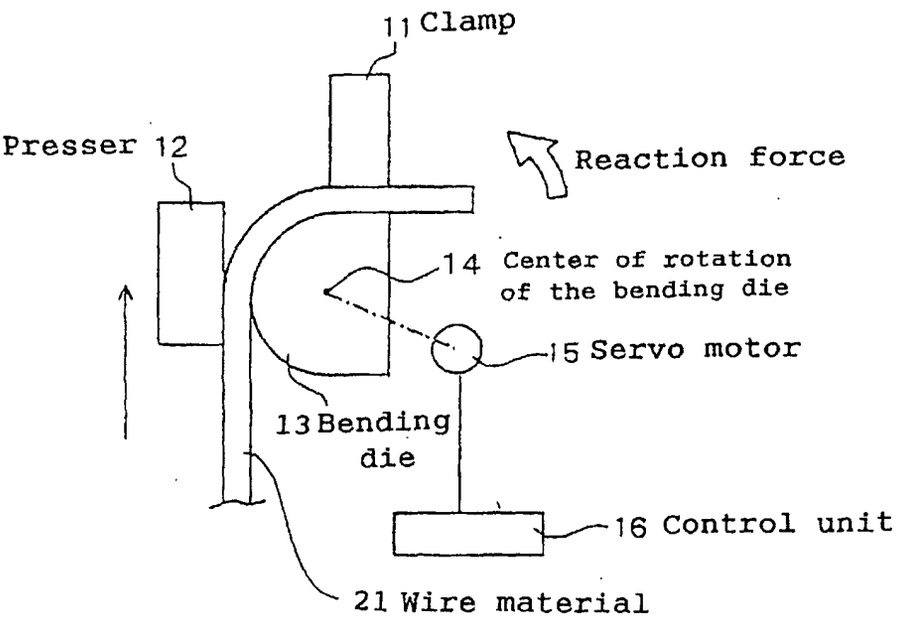
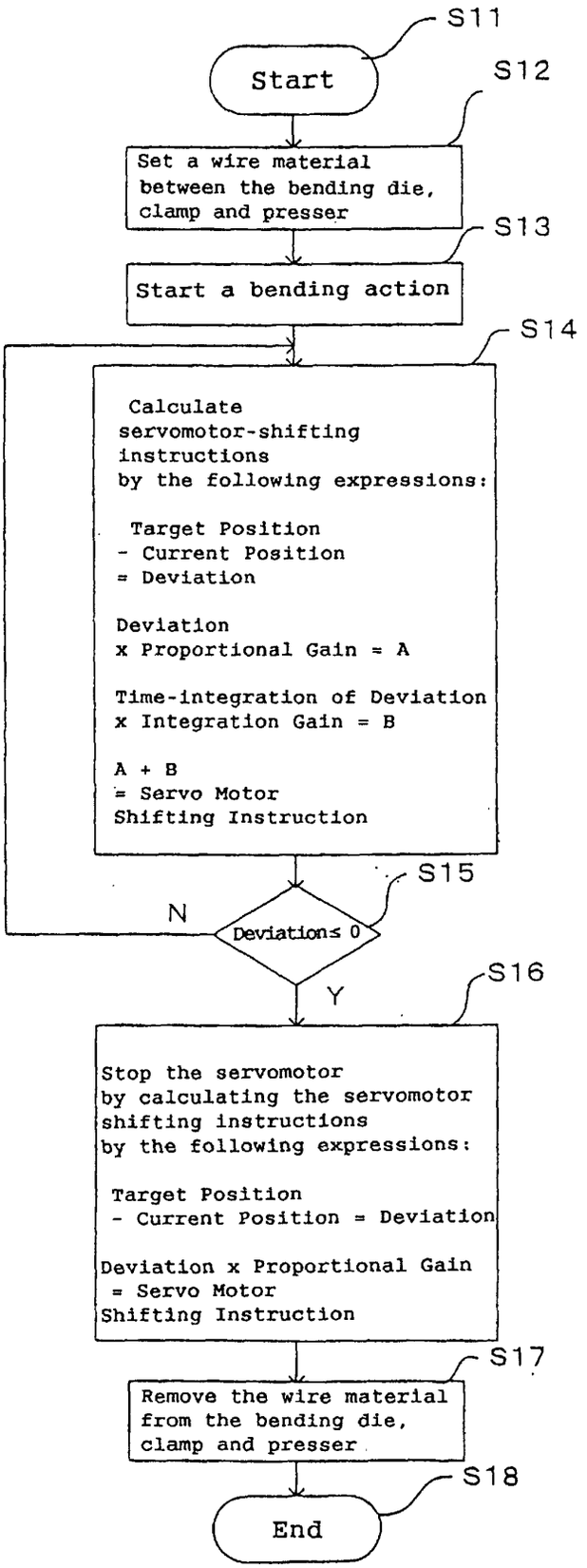

11 Clamp
Presser 12
Reaction force
14 Center of rotation of the bending die
15 Servo motor
13 Bending die
16 Control unit
21 Wire material

Fig. 3


S11
Start
S12
Set a wire material between the bending die, clamp and presser
S13
Start a bending action
S14
Calculate servomotor-shifting instructions by the following expressions:
Target Position - Current Position = Deviation
Deviation x Proportional Gain = A
Time-integration of Deviation x Integration Gain = B
A + B = Servo Motor Shifting Instruction
S15
Deviation≤ 0
N
Y
S16
Stop the servomotor by calculating the servomotor shifting instructions by the following expressions:
Target Position - Current Position = Deviation
Deviation x Proportional Gain = Servo Motor Shifting Instruction
S17
Remove the wire material from the bending die, clamp and presser
S18
End

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/03115

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B21F 1/00 , B21D 7/025

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B21F 1/00 , B21D 7/025 , G05D 3/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2000
Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 7-308718, A (Sumitomo Metal Industries, Ltd.), 28 November, 1995 (28.11.95) (Family: none)	1,2
A	JP, 6-250740, A (Hitachi, Ltd.), 09 September, 1994 (09.09.94) (Family: none)	1,2

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 August, 2000 (29.08.00)	19 September, 2000 (19.09.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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