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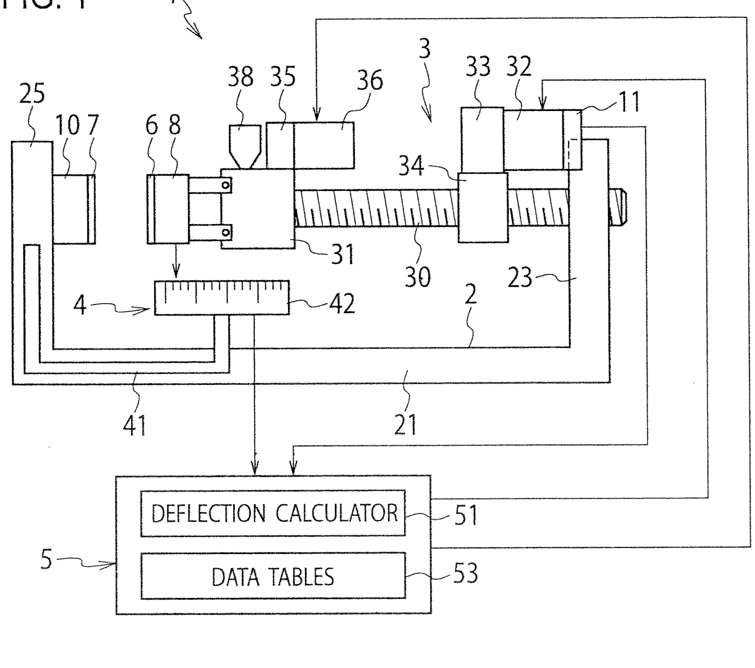
(54) **BENDING MACHINE**

(57) A bending machine (1) includes a frame (2) that has a punch-side frame section (23) and a die-side frame section (25), a punch holder (8) provided on the punch-side frame section (23), a die holder (10) provided on the die-side frame section (25), a pressing mechanism (3) for pressing a punch (6) toward a die (7), a first deflection detector (11) for detecting a displacement of the punch (6), a second deflection detector (42) for detecting an actual displacement of the punch (6), and a controller (5); and the controller (5) previously stores a relation between a deflection of the frame (2) and a bending length, material and a sheet thickness of a sheet material, calculates an actual deflection of the frame (2) by subtracting a detection value of the second deflection detector (42) from a detection value of the first deflection detector (11), gets a target deflection of the frame (2) for bending a sheet material to be bent based on the relation stored, and controls the pressing mechanism (3) so that the actual deflection becomes consistent with the target deflection.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a bending machine for bending sheet materials, especially, relates to a bending machine that requires no trial bending.

BACKGROUND ART

[0002] A Patent Document 1 listed below discloses a prior-art bending machine (press brake). In the bending machine, a punch-side table provided with a punch is disposed on its one side (upper side), and a die-side table provided with a die is disposed on its other side (lower side). A sheet material is bent between the punch and the die by stroking the punch to apply pressure to sheet material. A stroke of the punch is detected by a punch detector. The stroke may be changed by a thermal deformation of a frame. Therefore, when the stroke detected by the punch detector is not an expected amount, bending is done accurately by compensating the stroke.

[0003] In the above bending machine, a trial bending (s) is done for each specification [material, sheet thickness, shape (bending length)] of sheet materials to be bent. By setting a pressing force or a stroke according to the trial bending and then bending with the pressing force or the stroke that has been set, a bending work(s) can be automated.

[0004] As such a bending work, there are two types of working methods, air bending and coining. Note that air bending can be further classified into partial bending and bottoming. Namely, a bending work can be classified into three types working methods, partial bending, bottoming and coining.

Prior Art Document

Patent Document

[0005] Patent Document 1: Japanese Patent Application Laid-Open No. 2000-343128

SUMMARY OF INVENTION

[0006] Since air bending requires a small pressing force but brings a wide dispersion of a bent angle, its bending accuracy is not high. In order to improve accuracy of a bent angle by air bending with no trial bending for each specification of sheet materials to be bent, an angle sensor(s) is required. However, an automated bending machine is equipped with an automated tool changer, so that it is difficult to use an angle sensor(s). Therefore, it is required, for air bending, to set an adequate pressing force or an adequate stroke of a punch through a trial bending(s) for each specification of sheet materials to be bent. Coining is done with a ten to twelve times larger pressing force than a pressing force for air bending and thereby brings high accuracy, but it is problematic in that its pressing force becomes too large relative to a bending length.

[0007] As explained above, for the prior-art bending machine, a trial bending(s) is required for each specification of sheet materials to be bent to set an adequate pressing force or an adequate stroke (a good working condition), and thereby there are problems in view of working efficiency.

[0008] Therefore, an object of the present invention is to provide a bending machine that can improve working efficiency by rendering a trial bending unnecessary and can bring a good working condition.

[0009] An aspect of the present invention provides a bending machine that includes a frame that includes a base section, and a punch-side frame section and a die-side frame section that are extended from both sides of the base section in an identical direction, respectively, a punch holder that is provided on the punch-side frame section and to which a punch is attached, a die holder that is provided on the die-side frame section and to which a die is attached, a pressing mechanism that presses the punch toward the die to bend a sheet material between the die and the punch, a first deflection detector that is provided in the pressing mechanism and detects a displacement of the punch required for bending the sheet material, a second deflection detector that is supported by the die-side frame section and detects an actual displacement of the punch, and a controller operable to previously store a relation between a deflection of the frame 2 and a bending length, material and a sheet thickness of a sheet material, to calculate an actual deflection of the frame by subtracting a detection value of the second deflection detector from a detection value of the first deflection detector, to get a target deflection of the frame for bending a sheet material to be bent based on the relation stored, and to control the pressing mechanism so that the actual deflection becomes consistent with the target deflection.

[0010] According to the above aspect, the controller stores the relation between a deflection of the frame and a bending length, material and a sheet thickness of a sheet material, and the pressing mechanism is controlled so that the actual deflection of the frame that is calculated based on the detection values of the first deflection detector and the second deflection detector is made consistent with the target deflection associated with a sheet material to be bent (and retrieved based on the relation). Therefore, the sheet material can be bent under a good working condition, and, further, no trial bending is required. As a result, working labors for bending a sheet material can be reduced.

[0011] Here, it is preferable that the pressing mechanism includes a motor for pressing that moves the punch toward the die, the first deflection detector is an encoder that detects rotations of the motor, and the second deflection detector is a scale that is supported by the die-side frame section via a support frame.

[0012] According to this, since the first deflection detector is the encoder of the motor for moving the punch and the second deflection detector is the scale for detecting the displacement of the punch, the actual deflection of the frame can be directly detected while bending a sheet material. Therefore, the controller can be control the motor precisely.

[0013] In addition, it is preferable that the controller includes a deflection calculator that calculates the actual deflection of the frame from detection results of the first deflection detector and the second deflection detector, and a memory for storing a data table in which the relation is defined.

[0014] According to this, since the deflection calculator calculates the actual deflection of the frame and the data table in which the above relation is defined is stored in the memory, the relation between a deflection and a sheet material can be perceived accurately. Therefore, a sheet material can be bent successfully with no trial bending.

BRIEF DESCRIPTION OF DRAWINGS

[0015]

[Fig. 1] It is an overall front view of a bending machine according to an embodiment.

[Fig. 2] It is a block diagram of a controller in the bending machine.

[Fig. 3] It is a flowchart for a drive control for the bending machine.

[Fig. 4] It shows tables stored in the controller.

DESCRIPTION OF EMBODIMENTS

[0016] Hereinafter, a bending machine according to an embodiment will be explained. The bending machine 1 includes a frame 2, a pressing mechanism 3, a detection mechanism 4, and a controller 5.

[0017] The frame 2 is configured of a base section 21 having a given length, and a punch-side frame section 23 and a die-side frame section 25 that are integrally extended from both sides of the base section 21, respectively. The punch-side frame section 23 and the die-side frame section 25 are vertically extended from the base section 21 in an identical direction, respectively. A punch 6 and the pressing mechanism 3 are provided on the punch-side frame section 23. A die 7 is provided on the die-side frame section 25.

[0018] The pressing mechanism 3 includes a ball screw 30 supported on the punch-side frame section 23, and a motor 32 for pressing. The ball screw 30 can move linearly along its axial direction. A coupling bracket 31 is coupled to an end of the ball screw 30. A punch holder 8 is attached to the coupling bracket 31. The punch 6 is attached to an end of the punch holder 8. The punch 6 presses a sheet material due to a movement of the ball screw 30, and thereby the sheet material is bent between the punch 6 and the die 7. The punch 6 is moved by the motor 32.

[0019] The motor 32 has a reduction gear 33 on its output side. A nut 34 is coupled with the reduction gear 33. The ball screw 30 is meshed with the nut 34 to penetrate therethrough. When the nut 34 is rotated in its forward/backward direction by the motor 32, the ball screw 30 moves linearly in its feeding/reversing direction. Then, a sheet material is pressed due to the movement of the ball screw 30 in the feeding direction, and thereby the sheet material is bent. In this case, it is required to restrict a rotation of a screw of the ball screw 30 so that the screw is not passively rotated along with the rotation of the nut 34. Therefore, an anti-rotation unit 38 is provided in the pressing mechanism 3.

[0020] The rotation of the motor 32 is controlled by the controller 5. In addition, the number of rotations of the motor 32 is detected by an encoder 11. The encoder 11 is a first deflection detector, and an actual stroke of the punch 6 toward the die 7 is detected by detecting the number of rotations of the motor 32. Note that the stroke detected by the encoder 11 includes a deflection of the frame 2 caused by pressing a sheet material. A detection result of the encoder 11 is output to the controller 5.

[0021] Further, a motor 36 for high-speed feeding is provided in the pressing mechanism 3. The motor 36 moves the punch 6 at high speed to a position just before nipping a sheet material. The motor 36 is coupled to the coupling bracket 31 via a reduction gear 35.

[0022] The die 7 is attached to a die holder 10. Te die holder 10 is attached to the die-side frame section 25 of the frame 2. The die holder 10 is attached to the die-side frame section 25 so that the die 7 and the punch 6 face to each other. The detection mechanism 4 is disposed near the die holder 10 on the frame 2.

[0023] The detection mechanism 4 includes a support frame 41 supported by the die-side frame section 25, and a scale 42 attached to the support frame 41. The detection mechanism 4 is configured so that, even when a reactive force is generated against a pressing force for bending a sheet material, the reactive force doesn't act on the support frame 41. The scale 42 is disposed near the punch holder 8, and detects a relative position of the punch holder 8 to the die holder 10. The scale 42 is not directly fixed with the frame 2, but attached to the frame 2 via the support flame 41. Since the reactive force doesn't act on the support frame 41, the scale 42 can detect an actual displacement of the punch 6 without a deflection of the frame 2. Namely, the scale 42 is a second deflection detector that detects an actual displacement of the punch 6 when pressing a sheet material. A detection result of the scale 42 is output to the controller 5.

[0024] The controller 5 includes a deflection calculator 51, and data tables 53. The controller 5 controls the motor 32 and the motor 36. The deflection calculator 51 calculates a deflection of the frame 2 when pressing a sheet material. The deflection of the frame 2 can be calculated by subtracting a detection value of the scale 42 (the second deflection detector) from a detection value of the encoder 11 (the first deflection detector). Specifically, the deflection of the frame 2 can be obtained by (detection value of the encoder 11) - (detection value of the scale 42).

[0025] The data tables 53 are stored in a memory 56 (explained later) in the controller 5. In the data tables 53, recorded are relations between a calculated deflection of the frame 2 and a bending length, material and a sheet thickness of a sheet material. The controller 5 determines a deflection of the frame 2 associated with a bending length, material and a sheet thickness of a sheet material, and then controls the motor 32 so as to achieve the deflection.

[0026] Fig. 2 is a block diagram showing the controller 5. In the controller 5, an input interface 54, an output interface 55 and the memory 56 are connected with a CPU 58 by a data bus 57. It can be said that the above-explained deflection calculator 51 is configured of these components. In addition, the encoder 11, the scale 42, the motor 32 and the motor 36 that are explained above are also connected with the data bus 57.

[0027] The input interface 54 inputs various data to the CPU 58, and, for example, a keyboard and an external disk drive are connected to the input interface 54. The output interface 55 outputs data from CPU 58, and, for example, a display and a printer are connected with the output interface 55. Data and a work program that are input from the input interface 54 and the above-explained data tables 53 are stored in the memory 56. In addition, the detection results of the encoder 11 and the scale 42 are controlled by commands output from the CPU 58 via the data bus 57.

[0028] Next, a pressing control for bending by bottoming based on a deflection of the frame 2 will be explained.

[0029] First, a relation between a deflection δ of the frame 2 and a pressing force F is measured by a load sensor such as a load cell. Structural looseness and deformation become evident as the deflection δ of the frame 2 while the pressing force F is small, so that the relation between the deflection δ of the frame 2 and the pressing force F can be described by an exponential function $\delta = a \times F^b$ (a, b are constants). On the other hand, while the pressing force F is large, the relation between the deflection δ of the frame 2 and the pressing force F can be described by a linear function $\delta = c \times F + d$ (c, d are constants). Namely, the relation between the deflection δ and the pressing force F can be described by $\delta = a \times F^b$ [while F is small] or $c \times F + d$ [while F is large] ··· (I). Alternatively, the relation between the deflection δ and the pressing force F can be also described by $F = (\delta/a)^{1/b}$ [while F is small] or $(\delta\text{-}d)/c$ [while F is large] ··· (II).

[0030] A pressing force required for bottoming is determined thorough working tests separately from actual bendings. The working tests are done when initially setting the bending machine 1, and are not a trial bending (s) done for each specification of sheet materials. Fig. 4 shows the data tables 53 each of which indicates a relation between a sheet material [sheet thickness · material] and a deflection of the frame. In the working tests, a bending length (L1=0.5, L2=1.0, L3=2.0, ··· [unit: m]) is prepared for each sheet materials (A, B, ··) [specification: sheet thickness (t1, t2, ··) · material (m1, m2, ··)], and deflection(s) δ of the frame 2 that makes a bent angle after bending to 90° ± 15° is measured. In the present embodiment, as shown in Fig. 4, the data tables 53 are made for every sheet material, and the deflection δ is stored in the data tables 53 for each of the above sheet materials. Note that it may be possible to make one data sheet 53 by regarding types of sheet materials as a parameter.

[0031] The measured deflections δ of the frame 2 are converted to the pressing forces F by the above equation (II), respectively. For example, with respect to a sheet material A, F_{AL1}, F_{AL2}, ·· are calculated (similarly to a sheet material B). Further, the pressing forces F converted are further converted to converted pressing forces F' = F/L per unit length L [1m]. For example, with respect to the sheet material A, F_{AL1}, F'_{AL2}, ·· are calculated (similarly to a sheet material B). Then, calculated is an average value Z of all the pressing forces F' per unit length with respect to each bending length L (L1, L2, L3 ···) for each of the sheet materials (A, B, ··). For example, with respect to the sheet material A [(t1, m1)], calculated is an average Z_A of F'_{AL1}. F'_{AL2}, ··· F'_{ALn} (similarly to a sheet material B). These average values are stored, in the controller 5, for every sheet materials (A, B, ···) as the required pressing force Z (Z_A, Z_B, ···) per unit length.

[0032] Next, a control of bending (bottoming) by use of the above-explained data tables 53 will be explained with reference to a flowchart shown in Fig. 3.

[0033] First, data of a sheet material to be bent are input to the controller 5 (step S11). The data of the sheet material are a bending length, a sheet thickness and its material. The controller 5 calculates a target pressing force Ft required for bottoming based on an equation $F = Ld \times Z$. Here, Ld is the bending length in the data input in step S11. Z is the required pressing force for the sheet material [sheet thickness · material] of the data input in step S11, and is stored in the controller 5 through the above-explained working tests.

[0034] Subsequently, a target deflection δt of the frame 2 is calculated by the above equation (I) based on the calculated target pressing force Ft (step S12). In other words, the target deflection δt of the frame 2 is determined based on the target pressing force Ft calculated in step S11. Namely, when the frame 2 involves the deflection δt, it can be regarded that the target pressing force Ft is applied to the sheet material.

[0035] The controller 5 does pressing by driving the motor for pressing (step S13). At this time, the detection results of the encoder 11 and the scale 42 are output to the controller 5. The deflection of the frame 2 due to pressing is measured (step S14). The motor 32 is controlled with feedback based on the value calculated by subtracting the detection value of the scale 42 from the detection value of the encoder 11, i.e. the actual deflection δ. Specifically, the motor 32 is controlled with feedback so that the actual deflection δ of the frame 2 is made consistent with the target deflection δt.

[0036] When the deflection δ measured in step S14 becomes consistent with the target deflection δt determined in step S12, i.e. when the actual pressing force F becomes consistent with the target pressing force Ft, the controller 5 stops the motor 32 (step S15), and bending of the sheet material is finished. If the deflection δ measured in step S14 doesn't become consistent with the target deflection δt determined in step S12, the process flow returns to step S13 and driving of the motor 32 is continued by the controller 5.

[0037] In the present embodiment, the controller 5 stores data of relations between a deflection of the frame 2 and a bending length, material and a sheet thickness of a sheet material, and calculates, based on the stored data, a target deflection of the frame 2 associated with a bending length, material and a sheet thickness of a sheet material, and then controls the motor 32 so that an actual deflection of the frame 2 becomes consistent with the target deflection. Therefore, a sheet material can be bent under a good working condition, so that a trial bending (s) can be rendered unnecessary and working labors for bending a sheet material can be reduced.

[0038] In addition, since the deflection of the frame 2 is detected by the encoder 11 of the motor 32 for pressing and the scale 42 for detecting the displacement of the punch 6 in the present embodiment, the deflection of the frame 2 can be directly detected while bending a sheet material. Therefore, the controller 5 can control the motor 32 precisely.

[0039] Further, since the controller 5 includes the deflection calculator 51 and the data tables 53 that indicate relations between a deflection and a bending length, material and sheet thickness of a sheet material, a relation between deflection of the frame 2 and a sheet material can be perceived accurately and thereby a sheet material can be bent successfully with no trial bending.

Claims

1. A bending machine comprising:

a frame that includes a base section, and a punch-side frame section and a die-side frame section that are extended from both sides of the base section in an identical direction, respectively;
a punch holder that is provided on the punch-side frame section and to which a punch is attached;
a die holder that is provided on the die-side frame section and to which a die is attached;
a pressing mechanism that presses the punch toward the die to bend a sheet material between the die and the punch;
a first deflection detector that is provided in the pressing mechanism and detects a displacement of the punch required for bending the sheet material;
a second deflection detector that is supported by the die-side frame section and detects an actual displacement of the punch; and
a controller operable to previously store a relation between a deflection of the frame 2 and a bending length, material and a sheet thickness of a sheet material, to calculate an actual deflection of the frame by subtracting a detection value of the second deflection detector from a detection value of the first deflection detector, to get a target deflection of the frame for bending a sheet material to be bent based on the relation stored, and to control the pressing mechanism so that the actual deflection becomes consistent with the target deflection.

2. The bending machine according to claim 1, wherein the pressing mechanism includes a motor for pressing that moves the punch toward the die,
the first deflection detector is an encoder that detects rotations of the motor, and
the second deflection detector is a scale that is supported by the die-side frame section via a support frame.

3. The bending machine according to claim 1 or 2, wherein
the controller includes a deflection calculator that calculates the actual deflection of the frame from detection results of the first deflection detector and the second deflection detector, and a memory for storing a data table in which the relation is defined.

FIG. 1

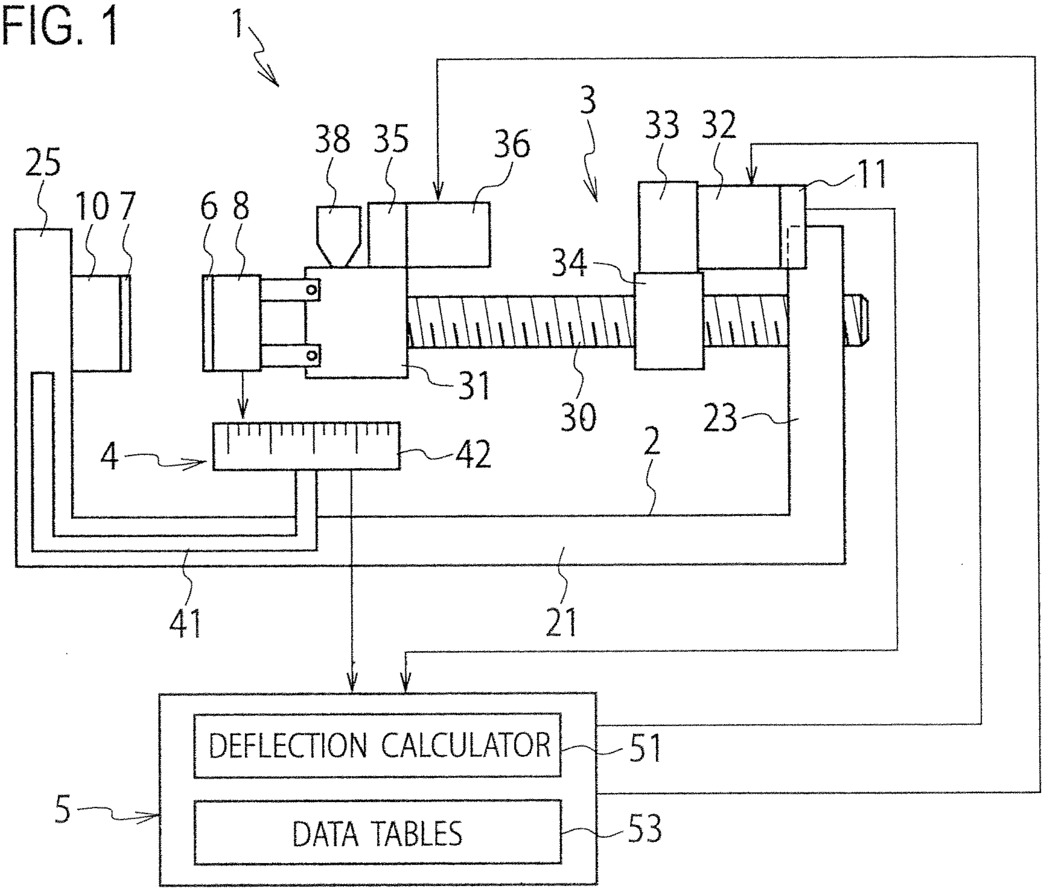
1
3
25
10 7
6 8
38 35
36
33 32
11
34
31
30
23
2
4
42
41
21
DEFLECTION CALCULATOR
51
5
DATA TABLES
53

FIG. 2

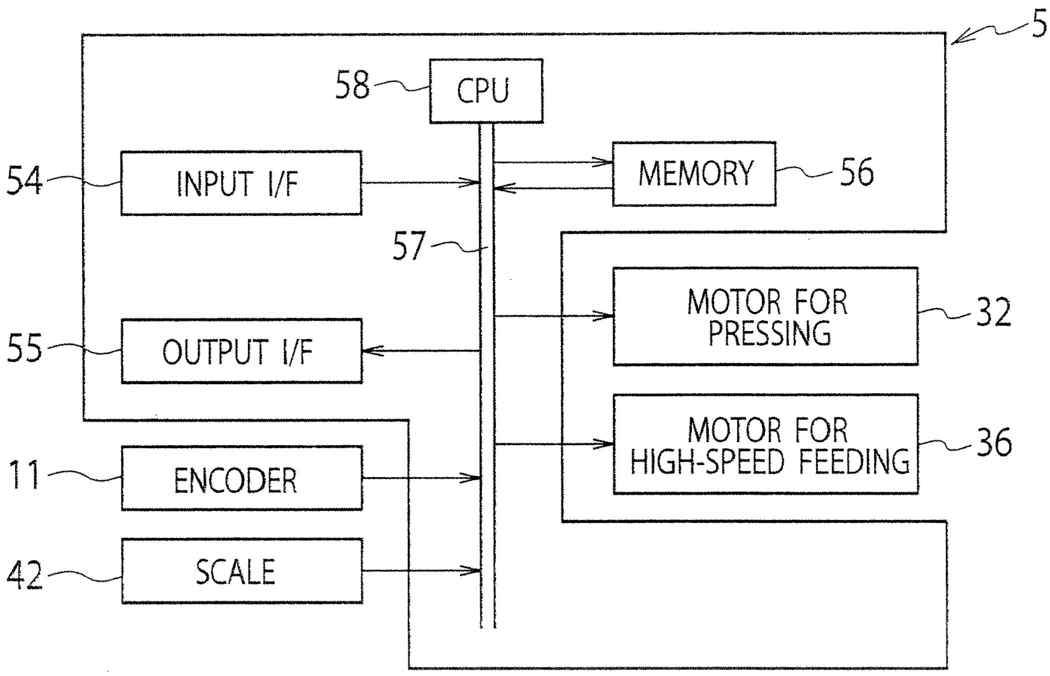
5
58
CPU
54
INPUT I/F
MEMORY
56
57
55
OUTPUT I/F
MOTOR FOR PRESSING
32
MOTOR FOR HIGH-SPEED FEEDING
36
11
ENCODER
42
SCALE

FIG. 3

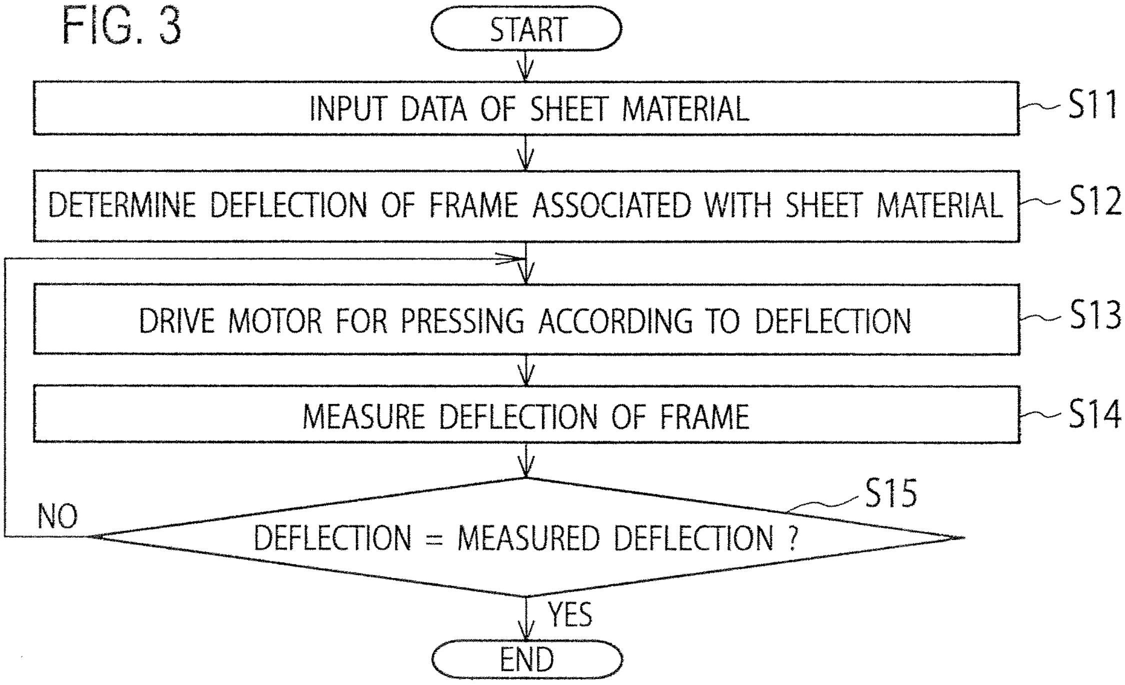

FIG. 4

SHEET MATERIAL A [SHEET THICKNESS : t1, MATERIAL : m1]

BENDING LENGTH	DEFLECTION OF FRAME δ	CONVERTED PRESSING FORCE F	CONVERTED PRESSING FORCE F' PER UNIT LENGTH	REQUIRED PRESSING FORCE Z
L1	δ_{AL1}	F_{AL1}	$F'_{AL1}=F_{AL1}/L1$	$Z_A=(F'_{AL1}+F'_{AL2}+F'_{AL3}+\cdots+F'_{ALn})/n$
L2	δ_{AL2}	F_{AL2}	$F'_{AL2}=F_{AL2}/L2$	
L3	δ_{AL3}	F_{AL3}	$F'_{AL3}=F_{AL3}/L3$	
⋮	⋮	⋮	⋮	

SHEET MATERIAL B [SHEET THICKNESS : t2, MATERIAL : m1]

BENDING LENGTH	DEFLECTION OF FRAME δ	CONVERTED PRESSING FORCE F	CONVERTED PRESSING FORCE F' PER UNIT LENGTH	REQUIRED PRESSING FORCE Z
L1	δ_{BL1}	F_{BL1}	$F'_{BL1}=F_{BL1}/L1$	$Z_B=(F'_{BL1}+F'_{BL2}+F'_{BL3}+\cdots+F'_{BLn})/n$
L2	δ_{BL2}	F_{BL2}	$F'_{BL2}=F_{BL2}/L2$	
L3	δ_{BL3}	F_{BL3}	$F'_{BL3}=F_{BL3}/L3$	
⋮	⋮	⋮	⋮	

⋮

SHEET MATERIAL X [SHEET THICKNESS : t1, MATERIAL : m2]

BENDING LENGTH	DEFLECTION OF FRAME δ	CONVERTED PRESSING FORCE F	CONVERTED PRESSING FORCE F' PER UNIT LENGTH	REQUIRED PRESSING FORCE Z
L1	δ_{XL1}	F_{XL1}	$F'_{XL1}=F_{XL1}/L1$	$Z_X=(F'_{XL1}+F'_{XL2}+F'_{XL3}+\cdots+F'_{XLn})/n$
L2	δ_{XL2}	F_{XL2}	$F'_{XL2}=F_{XL2}/L2$	
L3	δ_{XL3}	F_{XL3}	$F'_{XL3}=F_{XL3}/L3$	
⋮	⋮	⋮	⋮	

⋮

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/052761

A. CLASSIFICATION OF SUBJECT MATTER
B21D5/02(2006.01)i

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)
B21D5/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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 4-279220 A (Amada Co., Ltd.), 05 October 1992 (05.10.1992), entire text (Family: none)	1-3
A	JP 8-300047 A (Komatsu Ltd.), 19 November 1996 (19.11.1996), paragraphs [0021] to [0033]; fig. 1 to 2, 6 to 7	1-3
A	JP 2006-192498 A (Amada Co., Ltd.), 27 July 2006 (27.07.2006), paragraphs [0026] to [0029] & EP 1834712 A1 & WO 2006/054596 A1	1-3

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search 18 April, 2012 (18.04.12)	Date of mailing of the international search report 01 May, 2012 (01.05.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/052761

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-34965 A (National Institute of Advanced Industrial Science and Technology), 10 February 2005 (10.02.2005), claims (Family: none)	1-3

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000343128 A **[0005]**