(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 885 058 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.09.2021 Bulletin 2021/39

(21) Application number: **19902428.2**

(22) Date of filing: **18.09.2019**

(51) Int Cl.:
B21D 24/02 *(2006.01)* ***B30B 15/00*** *(2006.01)*
B30B 15/02 *(2006.01)*

(86) International application number:
PCT/JP2019/036506

(87) International publication number:
WO 2020/137032 (02.07.2020 Gazette 2020/27)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **26.12.2018 JP 2018243620**

(71) Applicant: **Daikin Industries, Ltd.**
Osaka 530-8323 (JP)

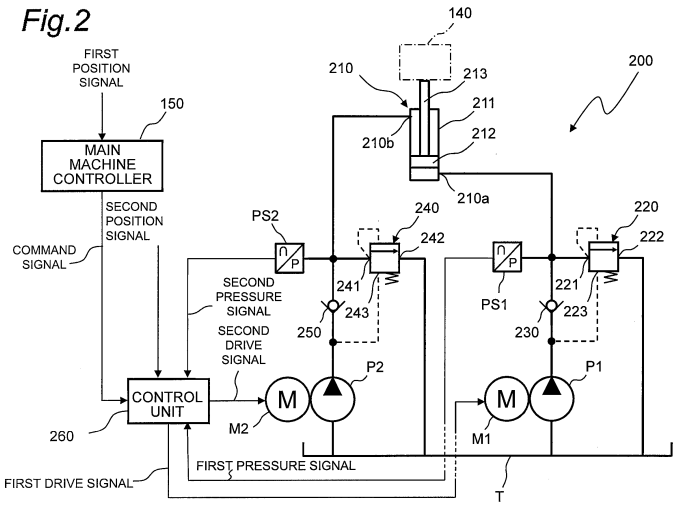
(72) Inventors:
- **KANBAYASHI, Atsuhiro**
  Osaka-shi
  Osaka 530-8323 (JP)
- **NAKAMURA, Hirokazu**
  Osaka-shi
  Osaka 530-8323 (JP)

(74) Representative: **Goddar, Heinz J.**
Boehmert & Boehmert
Anwaltspartnerschaft mbB
Pettenkoferstrasse 22
80336 München (DE)

(54) DIE-CUSHION DEVICE AND PRESS MACHINE

(57) A die cushion apparatus (200) includes: a double-acting hydraulic cylinder (210) configured to move a cushion pad (140) up and down; a first hydraulic pump (P1) configured to supply a hydraulic oil from an oil tank (T) to a first port (210a) of the hydraulic cylinder (210) and to drive a piston (212) of the hydraulic cylinder (210) upward; a second hydraulic pump (P2) configured to supply the hydraulic oil from the oil tank (T) to a second port (210b) of the hydraulic cylinder (210) and to drive the piston (212) of the hydraulic cylinder (210) downward; and a control unit (260) configured to control a rotation speed of the first hydraulic pump (P1) and a rotation speed of the second hydraulic pump (P2) and to control a flow rate and a pressure of the hydraulic oil which the first hydraulic pump (P1) supplies to the hydraulic cylinder (210) and a flow rate and a pressure of the hydraulic oil which the second hydraulic pump (P2) supplies to the hydraulic cylinder (210).

Fig.2



EP 3 885 058 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a die cushion apparatus and a press machine.

BACKGROUND ART

[0002] For example, JP 2007-075846 A (Patent Literature 1) discloses a die cushion apparatus in which a single-acting hydraulic cylinder is disposed below a cushion pad, and a die cushion pressure is controlled by a hydraulic oil discharged from a hydraulic pump.

CITATIONS LIST

PATENT LITERATURE

[0003] Patent Literature 1: JP 2007-075846 A

SUMMARY OF INVENTION

TECHNICAL PROBLEMS

[0004] In a press machine including the die cushion apparatus described above, the die cushion pad is supported at a low pressure in collision with a slide. This results in unsatisfactory reaction force to control a wrinkle in drawing and unsatisfactory pushing force for a molded product, failing to die cushion control with high accuracy and high rigidity.

[0005] The present disclosure proposes a die cushion apparatus capable of die cushion control with high accuracy and high rigidity, and a press machine including the die cushion apparatus.

SOLUTIONS TO PROBLEMS

[0006] The present disclosure is directed to a die cushion apparatus including:

a double-acting hydraulic cylinder configured to move a cushion pad up and down;
a first hydraulic pump configured to supply a hydraulic oil from an oil tank to a first port of the hydraulic cylinder and to drive a piston of the hydraulic cylinder upward;
a second hydraulic pump configured to supply the hydraulic oil from the oil tank to a second port of the hydraulic cylinder and to drive the piston of the hydraulic cylinder downward; and
a control unit configured to control a rotation speed of the first hydraulic pump and a rotation speed of the second hydraulic pump and to control a flow rate and a pressure of the hydraulic oil which the first hydraulic pump supplies to the hydraulic cylinder and a flow rate and a pressure of the hydraulic oil which the second hydraulic pump supplies to the hydraulic cylinder.

[0007] According to the present disclosure, the control unit controls the rotation speed of the first hydraulic pump and the rotation speed of the second hydraulic pump, thereby accurately and rapidly controlling the flow rate and pressure of the hydraulic oil which the first hydraulic pump supplies to the hydraulic cylinder and the flow rate and pressure of the hydraulic oil which the second hydraulic pump supplies to the hydraulic cylinder. The first and second hydraulic pumps therefore control the pressure near the first port in the hydraulic cylinder and the opposed pressure near the second port in the hydraulic cylinder. This configuration thus enables die cushion control with high accuracy and high rigidity.

[0008] An aspect of the present disclosure is directed to the die cushion apparatus, wherein
the first hydraulic pump is larger in amount of oil to be discharged per unit time than the second hydraulic pump.

[0009] According to the present disclosure, a hydraulic pump that is larger in amount of oil to be discharged per unit time than the second hydraulic pump is used as the first hydraulic pump. This configuration thus enables optimum selection of the first hydraulic pump and second hydraulic pump for the die cushion apparatus.

[0010] An aspect of the present disclosure is directed to the die cushion apparatus further including:

a first relief valve configured to return to the oil tank the hydraulic oil discharged from the hydraulic cylinder through the first port; and
a first pressure sensor configured to detect a pressure of the hydraulic oil as a first-port-side die cushion pressure of the hydraulic cylinder,
wherein
the control unit controls the rotation speeds of the first and second hydraulic pumps such that the pressure of the hydraulic oil detected by the first pressure sensor takes a die cushion pressure command value, and
the control unit rotates the first hydraulic pump reversely when the pressure of the hydraulic oil detected by the first pressure sensor is equal to or more than a set pressure for the first relief valve.

[0011] According to the present disclosure, in performing press molding using a press machine, the control unit controls the rotation speeds of the first and second hydraulic pumps in accordance with the pressure (i.e., a die cushion pressure) of the hydraulic oil near the first port in the hydraulic cylinder, the pressure being detected by the first pressure sensor. The control unit thus controls the flow rate and pressure of the hydraulic oil which the first hydraulic pump supplies to the hydraulic cylinder and the flow rate and pressure of the hydraulic oil which the second hydraulic pump supplies to the hydraulic cylinder. In die cushion control by the press machine, when a surge

pressure is generated in the hydraulic cylinder in performing the press molding, so that the pressure of the hydraulic oil as the die cushion pressure of the hydraulic cylinder becomes equal to or more than the set pressure for the first relief valve, the first relief valve is operated to return to the oil tank the hydraulic oil discharged from the hydraulic cylinder. In addition, when the pressure of the hydraulic oil detected by the first pressure sensor becomes equal to or more than the set pressure for the first relief valve, the control unit rotates the first hydraulic pump reversely. This configuration thus suppresses the surge pressure generated from the hydraulic cylinder in the die cushion control.

[0012] An aspect of the present disclosure is directed to the die cushion apparatus further including:

a first check valve disposed closer to the first hydraulic pump than a joint is, the joint being located on a flow path between the hydraulic cylinder and the first hydraulic pump and connected to the first relief valve, the first check valve being configured to regulate a flow of the hydraulic oil from the hydraulic cylinder to the first hydraulic pump,
wherein
the set pressure for the first relief valve is controlled by the pressure of the hydraulic oil discharged from the first hydraulic pump, and
the control unit rotates the first hydraulic pump reversely and opens the first relief valve when the pressure of the hydraulic oil detected by the first pressure sensor is equal to or more than the set pressure for the first relief valve.

[0013] According to the present disclosure, when the pressure of the hydraulic oil detected by the first pressure sensor is equal or more than the set pressure for the first relief valve, the control unit rotates the first hydraulic pump reversely. The first relief valve is thus operated to return to the oil tank the hydraulic oil discharged from the hydraulic cylinder through the first port.

[0014] The present disclosure is also directed to a press machine for subjecting a workpiece to press molding by pressurizing the workpiece between an upper die and a lower die,

the press machine including:
the die cushion apparatus described above;
an actuator configured to drive the upper die; and
a control device configured to control the die cushion apparatus and the actuator.

[0015] The present disclosure achieves a press machine that enables die cushion control with high accuracy and high rigidity.

[0016] An aspect of the present disclosure is directed to the press machine further including:

a first position sensor configured to detect a position of the upper die,
wherein
the control device controls the die cushion apparatus in accordance with the position of the upper die detected by the first position sensor, drives the cushion pad downward, and reduces a collision speed of the upper die with the lower die.

[0017] According to the present disclosure, the control device controls the die cushion apparatus, based on the position of the upper die detected by the first position sensor, drives the cushion pad downward, and reduces the collision speed of the upper die with respect to the lower die. This configuration therefore enables significant reduction in surge pressure to be generated from the hydraulic cylinder in performing the press molding.

BRIEF DESCRIPTION OF DRAWINGS

[0018]

FIG. 1 is a side view of a press machine including a die cushion apparatus according to a first embodiment of the present disclosure.
FIG. 2 is a schematic block diagram of the die cushion apparatus.

DESCRIPTION OF EMBODIMENTS

[0019] Embodiments will be described below. In the drawings, identical reference signs indicate identical or corresponding portions. The dimensions, such as a length, a width, a thickness, and a depth, illustrated in the drawings are appropriately changed from actual scales for making the drawings clear and simple; therefore, the actual relative dimensions are not illustrated in the drawings.

[First embodiment]

[0020] FIG. 1 is a side view of a press machine 100 including a die cushion apparatus 200 according to a first embodiment of the present disclosure. A servo motor 116a is used as a power source for the press machine 100.

[0021] The press machine 100 according to the first embodiment includes: a bed 110 disposed upright on a base 101; a bolster 111 disposed on the bed 110; four uprights 112 (FIG. 1 illustrates two of the four uprights 112) extending upward from the bed 110; a crown 113 supported by the uprights 112; and a slide 114 disposed below the crown 113 so as to be movable up and down along the uprights 112. The press machine 100 also includes a cushion pad 140 incorporated in the bed 110, and a double-acting hydraulic cylinder 210 disposed below the bed 110 to move the cushion pad 140 up and down.

[0022] The press machine 100 also includes a die 103

for forming a workpiece 102 (an object to be processed) by molding. The die 103 of the press machine 100 includes an upper die 120 attached to a lower face of the slide 114, and a lower die 130 mounted on an upper face of the bolster 111. The press machine 100 subjects the workpiece 102 to press molding by pressurizing the workpiece 102 between the upper die 120 and the lower die 130.

[0023] The press machine 100 also includes a die cushion apparatus 200 (see FIG. 2) including the hydraulic cylinder 210 configured to move the cushion pad 140 up and down.

[0024] The press machine 100 according to the first embodiment includes four drive mechanisms 116 (FIG. 1 illustrates two of the four drive mechanisms 116) configured to drive the slide 114. The four drive mechanisms 116 each include a servo motor 116a and a servo cylinder 116b configured to convert rotation of the servo motor 116a into linear motion with ball screws. The servo cylinders 116b each have a lower end connected to an upper face of the slide 114. The slide 114 moves up as the servo motors 116a rotate. Each of the drive mechanisms 116 is an example of an actuator.

[0025] The press machine 100 also includes: a first position sensor 115 configured to detect a position of the upper die 120; and a main machine controller 150 (see FIG. 1) configured to receive a first position signal indicating the position of the upper die 120 detected by the first position sensor 115, thereby controlling the die cushion apparatus 200, the drive mechanisms 116, and the like. The main machine controller 150 is an example of a control device.

[0026] FIG. 2 is a schematic block diagram of the die cushion apparatus 200. As illustrated in FIG. 2, the die cushion apparatus 200 includes the double-acting hydraulic cylinder 210. The hydraulic cylinder 210 includes: a cylinder tube 211; a piston 212 configured to reciprocate in the cylinder tube 211; and a piston rod 213 having a lower end connected to the piston 212. The piston rod 213 of the hydraulic cylinder 210 has an upper end to which the cushion pad 140 is coupled. The cushion pad 140 is provided with a second position sensor 215 (see FIG. 1) configured to detect a position of the cushion pad 140. The second position sensor 215 outputs a second position signal indicating a position of the cushion pad 140.

[0027] The die cushion apparatus 200 also includes: a first hydraulic pump P1 configured to supply a hydraulic oil from an oil tank T to a first port 210a provided on a lower side of the hydraulic cylinder 210 and to drive the piston 212 of the hydraulic cylinder 210 upward; a first motor M1 configured to drive the first hydraulic pump P1; a first relief valve 220 configured to return to the oil tank T the hydraulic oil discharged from the hydraulic cylinder 210; a first pressure sensor PS1 configured to detect a pressure of the hydraulic oil as a die cushion pressure of the hydraulic cylinder 210; and a first check valve 230 configured to regulate a flow of the hydraulic oil from the first port 210a of the hydraulic cylinder 210 to the first hydraulic pump P1.

[0028] The first check valve 230 is disposed closer to the first hydraulic pump P1 than a joint is, the joint being located on a flow path between the hydraulic cylinder 210 and the first hydraulic pump P1 and connected to the first relief valve 220. The first port 210a of the hydraulic cylinder 210 is connected to the discharge side of the first hydraulic pump P1 via the first check valve 230.

[0029] The first pressure sensor PS1 is connected to the first port 210a of the hydraulic cylinder 210.

[0030] The first relief valve 220 has an inlet port 221 connected to the first port 210a of the hydraulic cylinder 210, and an outlet port 222 connected to the oil tank T. The first relief valve 220 is a pilot-operated relief valve, and has a pilot port 223 to which the discharge side of the first hydraulic pump P1 is connected. The first relief valve 220 is thus controlled in such a manner that a discharge pressure (a pilot pressure) of the first hydraulic pump P1 is supplied to the pilot port 223 of the first relief valve 220.

[0031] The die cushion apparatus 200 also includes: a second hydraulic pump P2 configured to supply the hydraulic oil from the oil tank T to a second port 210b provided on an upper side of the hydraulic cylinder 210 and to drive the piston 212 of the hydraulic cylinder 210 downward; a second motor M2 configured to drive the second hydraulic pump P2; a second relief valve 240 configured to return to the oil tank T the hydraulic oil discharged from the hydraulic cylinder 210; a second pressure sensor PS2 configured to detect a pressure of the hydraulic oil near the second port 210b in the hydraulic cylinder 210; and a second check valve 250 configured to regulate a flow of the hydraulic oil from the second port 210b of the hydraulic cylinder 210 to the second hydraulic pump P2.

[0032] The second check valve 250 is disposed closer to the second hydraulic pump P2 than a joint is, the joint being located on a flow path between the hydraulic cylinder 210 and the second hydraulic pump P2 and connected to the second relief valve 240. The second port 210b of the hydraulic cylinder 210 is connected to the discharge side of the second hydraulic pump P2 via the second check valve 250.

[0033] The second pressure sensor PS2 is connected to the second port 210b of the hydraulic cylinder 210.

[0034] The second relief valve 240 has an inlet port 241 connected to the second port 210b of the hydraulic cylinder 210, and an outlet port 242 connected to the oil tank T. The second relief valve 240 is a pilot-operated relief valve, and has a pilot port 243 to which the discharge side of the second hydraulic pump P2 is connected. The second relief valve 240 is thus controlled in such a manner that a discharge pressure (a pilot pressure) of the second hydraulic pump P2 is supplied to the pilot port 243 of the second relief valve 240.

[0035] A hydraulic pump that is larger in amount of oil to be discharged per unit time than the second hydraulic

pump P2 is used as the first hydraulic pump P1. This configuration thus enables optimum selection of the first hydraulic pump P1 and second hydraulic pump P2 for the die cushion apparatus 200.

[0036] The second hydraulic pump P2 drives the piston 212 of the hydraulic cylinder 210 downward to move the cushion pad 140 down. The second hydraulic pump P2 moves the cushion pad 140 down mainly using the load and gravity in performing press molding. Therefore, the amount of oil to be discharged from the second hydraulic pump P2 per unit time may be relatively smaller than the amount of oil to be discharged from the first hydraulic pump P1 per unit time. In contrast to this, the first hydraulic pump P1 drives the piston 212 of the hydraulic cylinder 210 upward to promptly move the cushion pad 140 up. Therefore, a hydraulic pump to be used as the first hydraulic pump P1 preferably discharges a large amount of oil per unit time.

[0037] The press machine 100 includes a control unit 260 configured to control a flow rate and a pressure of the hydraulic oil supplied from the first hydraulic pump P1 to the hydraulic cylinder 210 and a flow rate and a pressure of the hydraulic oil supplied from the second hydraulic pump P2 to the hydraulic cylinder 210.

[0038] The control unit 260 receives a command signal indicating a die cushion pressure command value from the main machine controller 150. The control unit 260 also receives a second position signal indicating a position of the cushion pad 140 from the second position sensor 215. The control unit 260 also receives a first pressure signal from the first pressure sensor PS1 and a second pressure signal from the second pressure sensor PS2. The control unit 260 then outputs a first drive signal for driving the first motor M1 and a second drive signal for driving the second motor M2. The control unit 260 thus controls a rotation speed of the first hydraulic pump P1 and a rotation speed of the second hydraulic pump P2.

[0039] In the press machine 100, any unit different from the main machine controller 150 may input the command signal to the control unit 260.

[0040] In the press machine 100 having the configuration described above, the main machine controller 150 controls the die cushion apparatus 200, based on the position of the upper die 120 detected by the first position sensor 115. In performing press molding using the press machine 100, the control unit 260 controls the rotation speed of the first hydraulic pump P1 and the rotation speed of the second hydraulic pump P2 in accordance with the pressure of the hydraulic oil detected by the first pressure sensor PS1 and the pressure of the hydraulic oil detected by the second pressure sensor PS2. The control unit 260 thus accurately and rapidly controls the flow rate and pressure of the hydraulic oil which the first hydraulic pump P1 supplies to the hydraulic cylinder 210 and the flow rate and pressure of the hydraulic oil which the second hydraulic pump P2 supplies to the hydraulic cylinder 210.

[0041] The control unit 260 thus controls the pressure near the first port 210a and the pressure near the second port 210b in the hydraulic cylinder 210, thereby controlling the position of the cushion pad 140 with high accuracy. In holding the cushion pad 140 at a predetermined position, the hydraulic cylinder 210 holds the cushion pad 140 at a higher pressure than a pressure which a conventional single-acting hydraulic cylinder applies to the cushion pad 140 from below, so as to adjust the balance between the pressure near the first port 210a and the pressure near the second port 210b in the hydraulic cylinder 210. This configuration thus enables die cushion control with high rigidity.

[0042] In holding the cushion pad 140 at a predetermined position while adjusting the balance between the pressure near the first port 210a and the pressure near the second port 210b in the hydraulic cylinder 210, the cushion pad 140 is supported at a lower pressure or is supported at a higher pressure to enhance the rigidity. This configuration thus extends a range of pressure level in die cushion control.

[0043] Immediately before generation of an external force at the action of the die cushion in the press molding using the press machine 100, the control unit 260 controls the rotation speeds of the first and second hydraulic pumps P1 and P2 to make the flow rates of the first and second hydraulic pumps P1 and P2 constant such that the pressure (die cushion pressure) of the hydraulic oil detected by the first pressure sensor PS1 takes a die cushion pressure command value. The control unit 260 thus sets the pressure of the pilot port 223 at the pressure corresponding to the die cushion pressure command value.

[0044] Next, when a surge pressure is generated in the hydraulic cylinder 210 by collision of the upper die 120 with the lower die 130 with the workpiece 102 interposed between the upper die 120 and the lower die 130, so that the pressure (die cushion pressure) of the hydraulic oil near the first port 210a in the hydraulic cylinder 210 becomes equal to or more than a set pressure Pp1 for the first relief valve 220, the first relief valve 220 is operated to return to the oil tank T the hydraulic oil discharged from the hydraulic cylinder 210. In addition, when the pressure (die cushion pressure) of the hydraulic oil detected by the first pressure sensor PS1 becomes equal to or more than the set pressure Pp1 for the first relief valve 220, the control unit 260 rotates the first hydraulic pump P1 reversely. This configuration thus suppresses the surge pressure generated from the hydraulic cylinder 210 in the die cushion control.

[0045] In returning the cushion pad 140 to an initial position after completion of one cycle of press molding, the control unit 260 rotates the first hydraulic pump P1 to drive the piston 212 of the hydraulic cylinder 210 upward. At this time, when the pressure of the hydraulic oil near the second port 210b in the hydraulic cylinder 210 becomes equal to or more than a set pressure Pp2 for the second relief valve 240, the second relief valve 240 is operated to return to the oil tank T the hydraulic oil

discharged from the hydraulic cylinder 210. When the pressure (die cushion pressure) of the hydraulic oil detected by the second pressure sensor PS2 becomes equal to or more than the set pressure Pp2 for the second relief valve 240, the control unit 260 may rotate the second hydraulic pump P2 reversely.

[0046] In the first embodiment, the first and second hydraulic pumps P1 and P2 control the pressure near the first port 210a and the opposed pressure near the second port 210b in the hydraulic cylinder 210 to improve the degree of freedom as to how to set a pressure for supporting the cushion pad 140. This configuration thus achieves the die cushion apparatus 200 capable of die cushion control with high accuracy and high rigidity while suppressing a surge pressure, and the press machine 100 including the die cushion apparatus 200.

[0047] In the press machine 100, the die cushion pressure level is settable freely. A user therefore achieves die cushion control at arbitrary and optimum settings, which largely extend the degree of freedom in press molding.

[Second embodiment]

[0048] A press machine including a die cushion apparatus according to a second embodiment of the present disclosure is identical in configuration to the press machine 100 according to the first embodiment except for the operation of the main machine controller 150 (the control device), and is therefore described with reference to FIGS. 1 and 2.

[0049] In the press machine according to the second embodiment, a main machine controller 150 controls a die cushion apparatus, based on a position of an upper die 120 detected by a first position sensor 115. The press machine has a preliminary acceleration function of reducing a collision speed of the upper die 120 with respect to a lower die 130.

[0050] According to the preliminary acceleration function of the press machine, immediately before collision of the upper die 120 with the lower die 130 in press molding, the main machine controller 150 controls the die cushion apparatus. The main machine controller 150 controls rotation speeds of first and second hydraulic pumps P1 and P2 to move a cushion pad 140 downward. The main machine controller 150 thus reduces the collision speed of the upper die 120 with respect to the lower die 130. This configuration thus significantly suppresses a surge pressure generated from a hydraulic cylinder 210.

[0051] The second embodiment thus achieves the die cushion apparatus capable of die cushion control and preliminary acceleration with high accuracy and high rigidity while suppressing a surge pressure, and the press machine including the die cushion apparatus.

[0052] The first and second embodiments each describe the press machine 100 in which the drive mechanisms 116 including the servo motors 116a each serve as an actuator. Alternatively, this invention may be applied to a hydraulic press machine in which a hydraulic cylinder serves as an actuator.

[0053] The foregoing description concerns specific embodiments of the present disclosure; however, the present disclosure is not limited to the first and second embodiments, and various modifications and variations may be made within the scope of the present disclosure.

[0054] An aspect of the present disclosure is directed to the die cushion apparatus 200 including:

the second relief valve 240 configured to return to the oil tank T the hydraulic oil discharged from the hydraulic cylinder 210 through the second port 210b; and

the second pressure sensor PS2 configured to detect the pressure of the hydraulic oil near the second port 210b in the hydraulic cylinder 210,

wherein

the control unit 260 rotates the second hydraulic pump P2 reversely when the pressure of the hydraulic oil detected by the second pressure sensor PS2 is equal to or more than the set pressure for the second relief valve 240.

[0055] An aspect of the present disclosure is directed to the die cushion apparatus 200 further including:

the second check valve 250 disposed closer to the second hydraulic pump P2 than the joint is, the joint being located on the flow path between the hydraulic cylinder 210 and the second hydraulic pump P2 and connected to the second relief valve 240,

the second check valve 250 being configured to regulate the flow of the hydraulic oil from the hydraulic cylinder 210 to the second hydraulic pump P2,

wherein

the set pressure for the second relief valve 240 is controlled by the pressure of the hydraulic oil discharged from the second hydraulic pump P2, and

the control unit 260 rotates the second hydraulic pump P2 reversely and opens the second relief valve 240 when the pressure of the hydraulic oil detected by the second pressure sensor PS2 is equal to or more than the set pressure for the second relief valve 240.

REFERENCE SIGNS LIST

[0056]

100	press machine
101	base
102	workpiece
103	die
110	bed
111	bolster
112	upright

113	crown
114	slide
115	first position sensor
116	drive mechanism (actuator)
116a	servo motor
116b	servo cylinder
120	upper die
130	lower die
140	cushion pad
150	main machine controller (control device)
200	die cushion apparatus
210	hydraulic cylinder
211	cylinder tube
212	piston
213	piston rod
215	second position sensor
220	first relief valve
230	first check valve
240	second relief valve
250	second check valve
260	control unit
M1	first motor
M2	second motor
P1	first hydraulic pump
P2	second hydraulic pump
PS1	first pressure sensor
PS2	second pressure sensor
T	oil tank

Claims

1. A die cushion apparatus (200) comprising:

a double-acting hydraulic cylinder (210) configured to move a cushion pad (140) up and down;
a first hydraulic pump (P1) configured to supply a hydraulic oil from an oil tank (T) to a first port (210a) of the hydraulic cylinder (210) and to drive a piston (212) of the hydraulic cylinder (210) upward;
a second hydraulic pump (P2) configured to supply the hydraulic oil from the oil tank (T) to a second port (210b) of the hydraulic cylinder (210) and to drive the piston (212) of the hydraulic cylinder (210) downward; and
a control unit (260) configured to control a rotation speed of the first hydraulic pump (P1) and a rotation speed of the second hydraulic pump (P2) and to control a flow rate and a pressure of the hydraulic oil which the first hydraulic pump (P1) supplies to the hydraulic cylinder (210) and a flow rate and a pressure of the hydraulic oil which the second hydraulic pump (P2) supplies to the hydraulic cylinder (210).

2. The die cushion apparatus (200) according to claim 1, wherein
the first hydraulic pump (P1) is larger in amount of oil to be discharged per unit time than the second hydraulic pump (P2).

3. The die cushion apparatus (200) according to claim 1 or 2, further comprising:

a first relief valve (220) configured to return to the oil tank (T) the hydraulic oil discharged from the hydraulic cylinder (210) through the first port (210a); and
a first pressure sensor (PS1) configured to detect a pressure of the hydraulic oil as a first-port (210a)-side die cushion pressure of the hydraulic cylinder (210),
wherein
the control unit (260) controls the rotation speeds of the first and second hydraulic pumps (P1, P2) such that the pressure of the hydraulic oil detected by the first pressure sensor (PS1) takes a die cushion pressure command value, and
the control unit (260) rotates the first hydraulic pump (P1) reversely when the pressure of the hydraulic oil detected by the first pressure sensor (PS1) is equal to or more than a set pressure for the first relief valve (220).

4. The die cushion apparatus (200) according to claim 3, further comprising:

a first check valve (230) disposed closer to the first hydraulic pump (P1) than a joint is, the joint being located on a flow path between the hydraulic cylinder (210) and the first hydraulic pump (P1) and connected to the first relief valve (220),
the first check valve (230) being configured to regulate a flow of the hydraulic oil from the hydraulic cylinder (210) to the first hydraulic pump (PI),
wherein
the set pressure for the first relief valve (220) is controlled by the pressure of the hydraulic oil discharged from the first hydraulic pump (P1), and
the control unit (260) rotates the first hydraulic pump (P1) reversely and opens the first relief valve (220) when the pressure of the hydraulic oil detected by the first pressure sensor (PS1) is equal to or more than the set pressure for the first relief valve (220).

5. A press machine (100) for subjecting a workpiece (102) to press molding by pressurizing the workpiece (102) between an upper die (120) and a lower die (130),
the press machine (100) comprising:

the die cushion apparatus (200) according to any one of claims 1 to 4;
an actuator (116) configured to drive the upper die (120); and
a control device (150) configured to control the die cushion apparatus (200) and the actuator (116).

6. The press machine (100) according to claim 5, further comprising:

a first position sensor (115) configured to detect a position of the upper die (120),
wherein
the control device (150) controls the die cushion apparatus (200) in accordance with the position of the upper die (120) detected by the first position sensor (115), drives the cushion pad (140) downward, and reduces a collision speed of the upper die (120) with respect to the lower die (130).

Fig.1

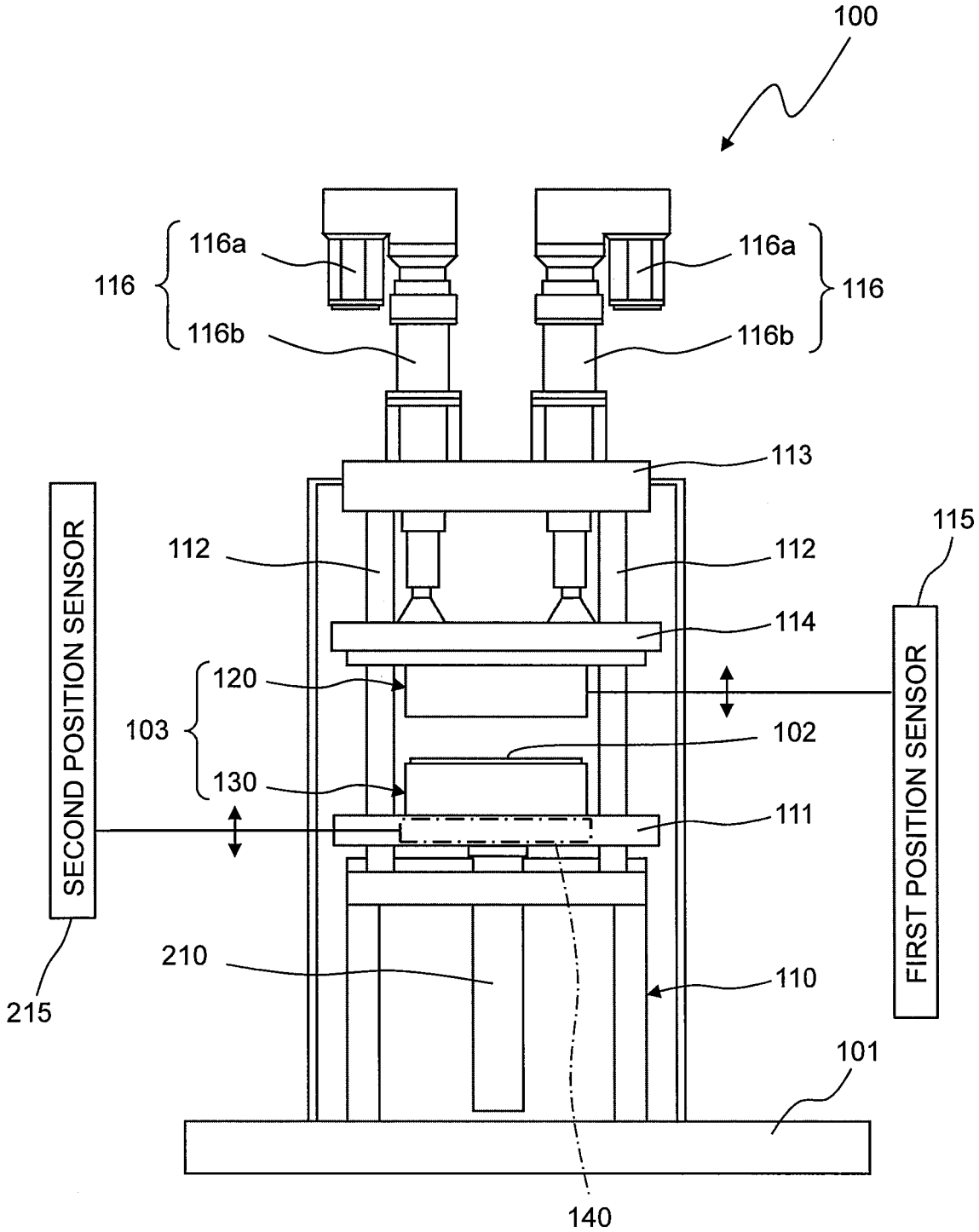
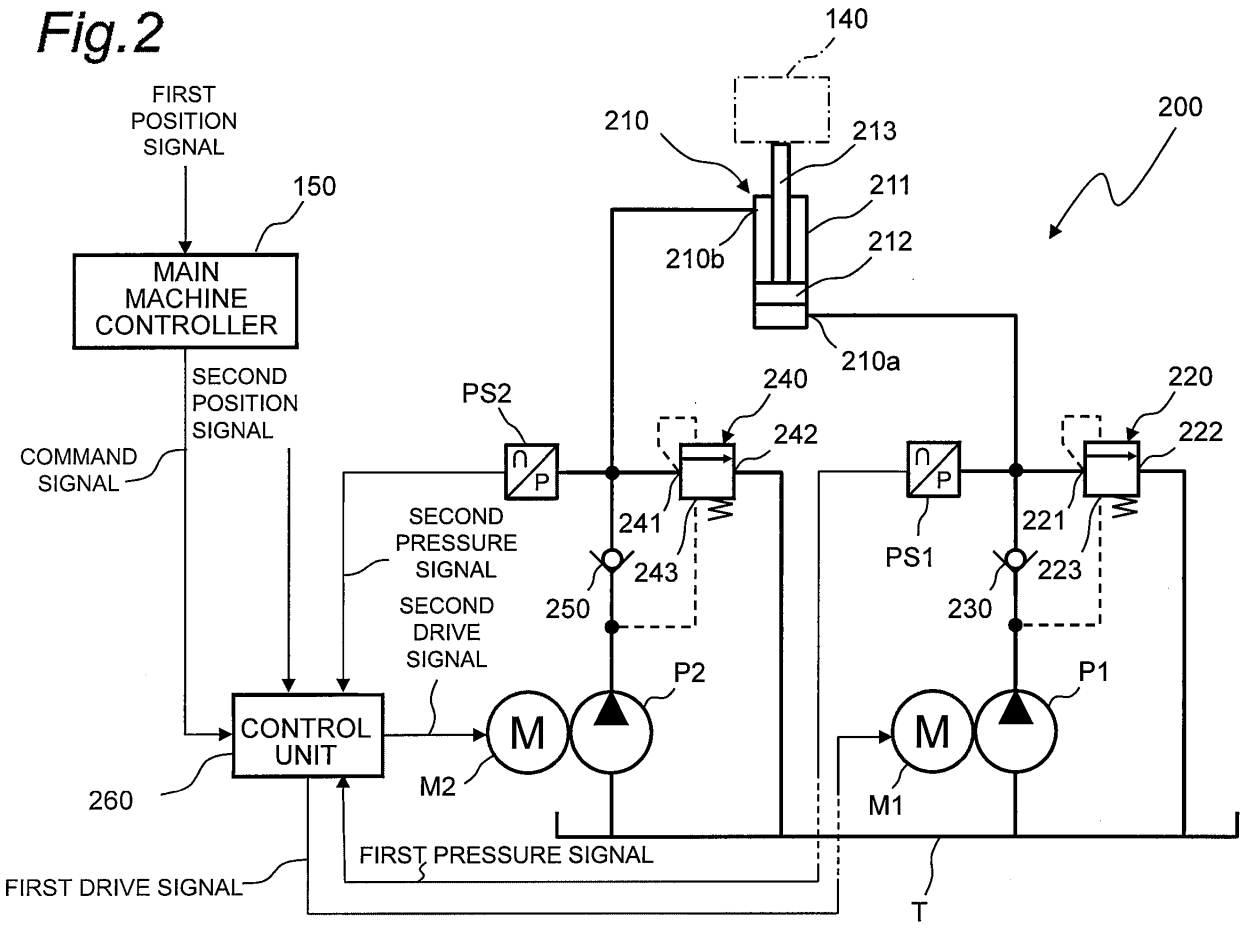

100
116
116a
116b
116a
116b
116
113
112
112
115
114
120
103
130
102
111
SECOND POSITION SENSOR
FIRST POSITION SENSOR
210
110
101
215
140

Fig.2


FIRST POSITION SIGNAL
150
MAIN MACHINE CONTROLLER
SECOND POSITION SIGNAL
COMMAND SIGNAL
CONTROL UNIT
260
FIRST DRIVE SIGNAL
SECOND PRESSURE SIGNAL
SECOND DRIVE SIGNAL
FIRST PRESSURE SIGNAL
PS2
PS1
M2
M1
M
P2
P1
T
140
210
213
211
212
210b
210a
200
240
242
241
243
250
220
222
221
223
230

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/036506

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B21D24/02(2006.01)i, B30B15/00(2006.01)i, B30B15/02(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)
Int.Cl. B21D24/02, B30B15/00, B30B15/02

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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.
X Y A	US 2014/0090441 A1 (SIEMENS AKTIENGESELLSCHAFT) 03 April 2014, paragraphs [0040]-[0050], fig. 1-3 & EP 2712688 A1	1, 2, 5 6 3, 4
Y	JP 63-273524 A (ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES CO., LTD.) 10 November 1988, page 3, upper left column, line 17 to upper right column, line 11 (Family: none)	6

☒ 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 application or patent 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
17.10.2019	29.10.2019

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/036506

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016/0271675 A1 (HANVIT INDUSTRIES CO., LTD.) 22 September 2016, paragraphs [0017]-[0022], [0032], [0033], fig. 1-3 & KR 10-1530608 B1 & CN 105984166 A	1, 5, 6
A	WO 2010/058710 A1 (AIDA ENG LTD.) 27 May 2010, paragraphs [0041]-[0077], fig. 1-4 & US 2011/0226141 A1, paragraphs [0056]-[0111], fig. 1-4 & EP 2377629 A1 & CN 102215996 A	1, 5

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2007075846 A **[0002] [0003]**