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Inventor(s)	ITO; Satoru et al.

HYDRAULIC CIRCUIT CONTROL DEVICE AND MOLDING MACHINE

Abstract

A hydraulic circuit control device includes: a drive motor; a drive-side cylinder including a drive-side fluid chamber and a drive-side piston that is moved by the drive motor; a driven-side cylinder including a driven-side fluid chamber, a fluid path that connects the driven-side fluid chamber and the drive-side fluid chamber, and a driven-side piston that is moved by moving the drive-side piston to increase or reduce an amount of a working fluid in the driven-side fluid chamber through the fluid path; and a fluid path volume adjustment mechanism configured to increase or reduce a volume of the fluid path according to an increase or reduction in a volume of the working fluid.

Inventors:	**ITO; Satoru (Kariya-shi, Aichi-ken, JP), YOSHIDA; Takafumi (Kariya-shi, Aichi-ken, JP), NAKANISHI; Ken (Okayama-shi, Okayama-ken, JP), SEKIYAMA; Tokuzo (Okayama-shi, Okayama-ken, JP)**
Applicant:	**AISIN CORPORATION** (Kariya, Aichi, JP); **OKAYAMA NISSO ELECTRIC CORPORATION** (Okayama-shi, Okayama, JP)

Family ID:	**89191117**
Assignee:	**AISIN CORPORATION (Kariya, Aichi, JP); OKAYAMA NISSO ELECTRIC CORPORATION (Okayama-shi, Okayama, JP)**
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Background/Summary

TECHNICAL FIELD

[0001] This disclosure relates to a hydraulic circuit control device and a molding machine, and more particularly, relates to a hydraulic circuit control device and a molding machine, which include a drive-side cylinder and a driven-side cylinder driven by the drive-side cylinder.

BACKGROUND ART

[0002] In the related art, there is a hydraulic cylinder device including a drive-side cylinder and a driven-side cylinder driven by the drive-side cylinder. Such a hydraulic cylinder device is disclosed in, for example, JP 2000-356202A (Reference 1).

[0003] Reference 1 discloses a hydraulic cylinder device including a drive-side cylinder and a control cylinder (a driven-side cylinder) driven by the drive-side cylinder. An oil chamber in the drive-side cylinder and an oil chamber in the control cylinder are connected via a hydraulic hose (a fluid path). The hydraulic cylinder device is configured such that working oil in the oil chamber of the drive-side cylinder flows into the oil chamber of the control cylinder through the hydraulic hose as a piston of the drive-side cylinder moves forward and backward, thereby moving a piston of the control cylinder.

CITATION LIST

Patent Literature

[0004] PTL 1: JP 2000-356202A

SUMMARY

Technical Problem

[0005] However, in the hydraulic cylinder device disclosed in Reference 1, a volume of the working oil may vary due to a temperature change or leakage or the like of the working oil. In this case, since a movement amount of the piston of the control cylinder (the driven-side cylinder) relative to a predetermined movement amount of the piston of the drive-side cylinder changes (deviates from a set value) before and after the volume of the working oil varies, there is a problem that positional accuracy of the piston of the control cylinder (the driven-side cylinder) cannot be ensured.

[0006] This disclosure has been made to solve the above-described problems, and an object of this disclosure is to provide a hydraulic circuit control device and a molding machine capable of ensuring positional accuracy of a driven-side piston of a driven-side cylinder even when a volume of a working fluid varies due to a temperature change or leakage or the like of the working fluid.

Solution to Problem

[0007] In order to achieve the above object, a hydraulic circuit control device according to a first aspect of this disclosure includes: a drive motor; a drive-side cylinder including a drive-side fluid chamber and a drive-side piston that is moved by the drive motor; a driven-side cylinder including a driven-side fluid chamber, a fluid path that connects the driven-side fluid chamber and the drive-side fluid chamber, and a driven-side piston that is moved by moving the drive-side piston to increase or reduce an amount of a working fluid in the driven-side fluid chamber through the fluid path; and a fluid path volume adjustment mechanism configured to increase or reduce a volume of the fluid path according to an increase or reduction in a volume of the working fluid.

[0008] As described above, the hydraulic circuit control device according to the first aspect of this disclosure is provided with the drive-side cylinder including the drive-side piston, the driven-side cylinder including the driven-side piston that is moved by moving the drive-side piston to increase or reduce the amount of the working fluid in the driven-side fluid chamber through the fluid path, and the fluid path volume adjustment mechanism configured to increase or reduce the volume of the fluid path according to the increase or reduction in the volume of the working fluid. Accordingly, even when the volume of the working fluid is increased or reduced due to a temperature change or leakage or the like of the working fluid inside the fluid path, the driven-side fluid chamber, and the drive-side fluid chamber, the fluid path volume adjustment mechanism can increase or reduce the volume of the fluid path according to the increase or reduction in the volume of the working fluid. Therefore, the increase or reduction in the volume of the working fluid can be balanced by increasing or reducing the volume of the fluid path by the fluid path volume adjustment mechanism, so that the increase or reduction in the volume of the working fluid does not affect the movement amount of the driven-side piston. That is, the movement amount of the driven-side piston can be corrected such that the movement amount of the driven-side piston relative to a predetermined movement amount of the drive-side piston is maintained substantially constant. As a result, even when the volume of the working fluid varies due to a temperature change or leakage or the like of the working fluid, positional accuracy of the driven-side piston of the driven-side cylinder can be ensured.

[0009] In the hydraulic circuit control device according to the first aspect, it is preferable that the fluid path includes a main fluid path portion through which the working fluid flows between the driven-side fluid chamber and the drive-side fluid chamber, and an adjustment fluid path portion connected to the main fluid path portion, and the fluid path volume adjustment mechanism includes a volume adjustment motor configured to move an inner wall surface of the adjustment fluid path portion, and the inner wall surface is moved to increase or reduce a volume of the adjustment fluid path portion.

[0010] According to this configuration, since the inner wall surface of the adjustment fluid path portion can be moved by the volume adjustment motor to increase or reduce the volume of the adjustment fluid path portion, the movement amount of the driven-side piston can be easily corrected, and positional accuracy of the driven-side piston of the driven-side cylinder can be easily ensured.

[0011] In the hydraulic circuit control device according to the first aspect, it is preferable that the fluid path volume adjustment mechanism includes a movement adjustment detection unit configured to detect at least one of positions of the driven-side piston and the drive-side piston and a state of the working fluid in order to adjust the movement amount of the driven-side piston relative to movement of the drive-side piston, and the fluid path volume adjustment mechanism is configured to increase or reduce the volume of the fluid path based on a detection result of the movement adjustment detection unit.

[0012] According to this configuration, since the movement amount of the driven-side piston can be corrected based on a result obtained by detecting at least one of the positions of the driven-side piston and the drive-side piston and the state of the working fluid by the movement adjustment detection unit, it is possible to more reliably ensure positional accuracy of the driven-side piston of the driven-side cylinder according to the positions of the driven-side piston and the drive-side piston and the state of the working fluid.

[0013] In this case, it is preferable that the movement adjustment detection unit includes at least one of a position detection unit configured to detect the positions of the drive-side piston and the driven-side piston, a fluid temperature detection unit configured to detect a temperature of the working fluid, and a fluid pressure detection unit configured to detect pressure of the working fluid, and the fluid path volume adjustment mechanism increases or reduces the volume of the fluid path based on a detection result of at least one of the position detection unit, the fluid pressure detection unit, and the fluid temperature detection unit.

[0014] According to this configuration, the movement amount of the driven-side piston can be appropriately corrected according to various situations by detecting the positions of the drive-side piston and the driven-side piston indicating a movement amount change (deviation from a set value) of the driven-side piston and either the temperature or the pressure of the working fluid that affects the movement amount change of the driven-side piston.

[0015] In the hydraulic circuit control device according to the first aspect, it is preferable that the fluid path volume adjustment mechanism includes a volume adjustment piston provided in the fluid path, and a volume adjustment ball screw mechanism that includes a volume adjustment ball screw to which the volume adjustment piston is attached, and that increases or reduces the volume of the fluid path by moving the volume adjustment piston together with the volume adjustment ball screw.

[0016] According to this configuration, since the volume adjustment piston can be moved by the volume adjustment ball screw mechanism, the volume adjustment piston can be moved more accurately, and the volume of the adjustment fluid path portion can be adjusted accurately.

[0017] It is preferable that the hydraulic circuit control device according to the first aspect further includes a drive-side ball screw mechanism that includes a drive-side ball screw to which the drive-side piston is attached and that is driven by the drive motor to move the drive-side piston together with the drive-side ball screw, and a drive-side ball screw cooling path that is provided inside the drive-side ball screw and through which a coolant for cooling the drive-side ball screw flows.

[0018] According to this configuration, since the drive-side ball screw to which the drive-side piston is attached can be cooled by the drive-side ball screw cooling path, a temperature rise of the working fluid caused by the drive-side ball screw and the drive-side piston can be prevented, and a volume change of the working fluid caused by the temperature rise of the working fluid can be prevented.

[0019] In the hydraulic circuit control device according to the first aspect, it is preferable that the fluid path volume adjustment mechanism is configured to increase or reduce the volume of the fluid path based on at least one of a state index value directly indicating an increase or reduction in the volume of the working fluid and a state index value indirectly indicating an increase or reduction in the volume of the working fluid.

[0020] According to this configuration, the volume of the working fluid can be increased or reduced with higher accuracy in consideration of at least one of the state index value directly indicating the increase or reduction in the volume of the working fluid and the state index value indirectly indicating the increase or reduction in the volume of the working fluid. As a result, positional accuracy of the driven-side piston of the driven-side cylinder can be improved.

[0021] A molding machine according to a second aspect of this disclosure includes a fixed portion to which a fixed mold is attached, a movable portion to which a movable mold is attached, and a hydraulic circuit control device that is provided in the movable portion and configured to move the movable portion relative to the fixed portion, in which the hydraulic circuit control device includes a drive motor, a drive-side cylinder including a drive-side fluid chamber and a drive-side piston that is moved by the drive motor, a driven-side cylinder including a driven-side fluid chamber, a fluid path that connects the driven-side fluid chamber and the drive-side fluid chamber, and a driven-side piston that is moved by moving the drive-side piston to increase or reduce an amount of a working fluid in the driven-side fluid chamber through the fluid path, and a fluid path volume adjustment mechanism configured to increase or reduce a volume of the fluid path according to an increase or reduction in a volume of the working fluid.

[0022] As described above, the molding machine according to the second aspect of this disclosure is provided with the drive-side cylinder including the drive-side piston, the driven-side cylinder

including the driven-side piston that is moved by moving the drive-side piston to increase or reduce the amount of the working fluid in the driven-side fluid chamber through the fluid path, and the fluid path volume adjustment mechanism configured to increase or reduce the volume of the fluid path according to the increase or reduction in the volume of the working fluid. Accordingly, even when the volume of the working fluid is increased or reduced due to a temperature change or leakage or the like of the working fluid inside the fluid path, the driven-side fluid chamber, and the drive-side fluid chamber, the fluid path volume adjustment mechanism can increase or reduce the volume of the fluid path according to the increase or reduction in the volume of the working fluid. Therefore, the increase or reduction in the volume of the working fluid can be balanced by increasing or reducing the volume of the fluid path by the fluid path volume adjustment mechanism, so that the increase or reduction in the volume of the working fluid does not affect a movement amount of the driven-side piston. That is, the movement amount of the driven-side piston can be corrected such that the movement amount of the driven-side piston relative to a predetermined movement amount of the drive-side piston is maintained substantially constant. As a result, even when the volume of the working fluid varies due to a temperature change or leakage or the like of the working fluid, it is possible to provide a molding machine that can ensure positional accuracy of the driven-side piston of the driven-side cylinder.
[0023] The hydraulic circuit control device according to the first aspect and the molding machine according to the second aspect may have the following configurations.
Appendix 1
[0024] That is, the hydraulic circuit control device and the molding machine described above further include a working fluid cooling path that is provided in the fluid path and through which a coolant for cooling the working fluid in the fluid path flows.
[0025] According to this configuration, since the working fluid can be cooled by the working fluid cooling path, a temperature rise of the working fluid can be prevented, and a volume change of the working fluid caused by the temperature rise of the working fluid can be prevented.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0026] FIG. **1** is a front view illustrating a press molding machine including a hydraulic circuit control device according to an embodiment;
[0027] FIG. **2** is a view illustrating an overall configuration of the hydraulic circuit control device according to the embodiment;
[0028] FIG. **3** is a view illustrating a fluid path volume adjustment mechanism of the hydraulic circuit control device according to the embodiment; and
[0029] FIG. **4** is a view illustrating a fluid path volume adjustment mechanism of a hydraulic circuit control device according to a modification.
DESCRIPTION OF EMBODIMENTS
[0030] Hereinafter, an embodiment will be described with reference to the drawings.
Embodiment
(Configuration of Press Molding Machine)
[0031] A configuration of a press molding machine **100** (an example of a “molding machine” in the claims) including a hydraulic circuit control device (a hydraulic cylinder device) **101** according to an embodiment will be described with reference to FIGS. **1** to **3**.
[0032] As illustrated in FIG. **1**, the press molding machine **100** includes a fixed portion **100***a* (a bolster) to which a fixed mold M**1** is attached, a movable portion **100***b* (a slide) to which a movable mold M**2** is attached, and the hydraulic circuit control device **101** provided in the movable portion **100***b*.

[0033] The press molding machine **100** opens and clamps the fixed mold M**1** and the movable mold M**2** when the hydraulic circuit control device **101** moves, relative to the fixed portion **100***a*, the movable portion **100***b* forward and backward in an up-down direction (a B direction) from above.

(Configuration of Hydraulic Circuit Control Device)

[0034] As illustrated in FIG. **2**, the hydraulic circuit control device **101** includes a drive servomotor **1** (an example of a "drive motor" in the claims), a drive-side ball screw mechanism **2**, a drive-side ball screw cooling path **3**, a drive-side cylinder **4**, a driven-side cylinder **5** including fluid paths **50** and **51** connected to the drive-side cylinder **4**, a working fluid cooling path **6** (see FIG. **3**), and fluid path volume adjustment mechanisms **7**. The fluid path volume adjustment mechanism **7** is provided for each of the fluid paths **50** and **51**.

[0035] The drive-side cylinder **4** and the driven-side cylinder **5** send a working fluid to each other through the fluid paths **50** and **51** when the movable portion **100***b* is moved forward and backward. The hydraulic circuit control device **101** moves a driven-side piston **53** of the driven-side cylinder **5** forward (backward) by moving a drive-side piston **41** of the drive-side cylinder **4** forward (backward). The driven-side cylinder **5** is configured such that the movable portion **100***b* of the press molding machine **100** is attached to a tip end of the driven-side piston **53** in a forward direction (a B**1** direction), and generates a propulsive force for finally moving the movable portion **100***b* forward and backward in the hydraulic circuit control device **101**. The working fluid described above is an example, and may be a fluid such as oil and water.

[0036] Here, a cross-sectional area of the driven-side cylinder **5** in a cross section orthogonal to a moving direction of the driven-side piston **53** is larger than a cross-sectional area of the drive-side cylinder **4** in a cross section orthogonal to a moving direction of the drive-side piston **41**. Therefore, the hydraulic circuit control device **101** is configured to be able to generate a large propulsive force for moving the movable portion **100***b* by performing boosting using the drive-side piston **41** and the driven-side piston **53**. The cross-sectional area of the driven-side piston may be equal to or smaller than the cross-sectional area of the drive-side piston. When the cross-sectional area of the driven-side piston is smaller than the cross-sectional area of the drive-side piston, a moving speed (a movement amount) of the driven-side piston is larger than a moving speed (a movement amount) of the drive-side piston.

[0037] In each drawing, the moving direction of the drive-side piston **41** is indicated by an A direction, a forward direction of the A direction is indicated by an A**1** direction, and a backward direction of the A direction is indicated by an A**2** direction. An axis located at the center of the drive-side piston **41** and the center of a drive-side ball screw **21** is indicated by a central axis a, and the drive-side piston **41** and the drive-side ball screw **21** extend in the A direction.

[0038] In each drawing, the moving direction of the driven-side piston **53** is indicated by the B direction, a forward direction of the B direction is indicated by the B**1** direction, and a backward direction of the B direction is indicated by a B**2** direction. The B direction is also a moving direction of the movable portion **100***b* of the press molding machine **100**.

[0039] In each drawing, a moving direction of a volume adjustment piston **72** of the fluid path volume adjustment mechanism **7** is indicated by a C direction, a forward direction of the C direction is indicated by a C**1** direction, and a backward direction of the C direction is indicated by a C**2** direction. When the volume adjustment piston **72** moves in the C**1** direction, a volume of the fluid path **50** (**51**) is reduced, and when the volume adjustment piston **72** moves in the C**2** direction, the volume of the fluid path **50** (**51**) increases.

(Configuration of Drive Servomotor)

[0040] The drive servomotor **1** moves the drive-side piston **41** of the drive-side cylinder **4** forward and backward in the A direction via the drive-side ball screw mechanism **2**. The drive-side cylinder **4** is provided with a position detection unit **73***a* (an example of a "movement adjustment detection unit" in the claims) that detects a position of the drive-side piston **41**. The drive servomotor **1** is provided with a control unit **1***a* that controls driving of the drive servomotor **1**. The control unit **1***a* acquires a detection result of the position detection unit **73***a* through feedback and adjusts the driving of the drive servomotor **1**. In short, the fluid path volume adjustment mechanism **7** increases or reduces volumes of the fluid paths **50** and **51** based on a piston position which is a state index value directly indicating an increase or reduction in a volume of a working fluid. The fluid path volume adjustment mechanism **7** increases or reduces the volumes of the fluid paths **50** and **51** based on a temperature of the working fluid which is a state index value indirectly indicating an increase or reduction in a volume of the working fluid. The state index value directly indicating the increase or reduction in the volume of the working fluid is not limited to the piston position. The state index value indirectly indicating the increase or reduction in the volume of the working fluid is not limited to the temperature of the working fluid, and may be pressure of the working fluid or the like.

[0041] The control unit **1***a* includes a computer numerical control (CNC) device that generates a pulse signal for driving the drive servomotor **1**, and a servo amplifier (a driver) that drives the drive servomotor **1** based on the pulse signal.

[0042] The drive servomotor **1** includes a motor body **10** having a core, and a rotation shaft **11** (an output shaft) that is rotated about the central axis a by the motor body **10**. A through hole **12** extending along the central axis a is formed in the motor body **10** and the rotation shaft **11**. A coolant supply pipe **3***a* for supplying a coolant to the drive-side ball screw cooling path **3** and a coolant discharge pipe **3***b* for discharging the coolant from the drive-side ball screw cooling path **3** are disposed inside the through hole **12**.

(Configuration of Drive-Side Ball Screw Mechanism)

[0043] The drive-side ball screw mechanism **2** connects the drive servomotor **1** and the drive-side piston **41** of the drive-side cylinder **4**. The drive-side ball screw mechanism **2** includes a drive-side rotation nut **20** and the drive-side ball screw **21**. The drive-side ball screw mechanism **2** is driven by the drive servomotor **1** to move the drive-side piston **41** forward and backward in the A direction together with the drive-side ball screw **21**.

[0044] The drive-side rotation nut **20** is attached to the rotation shaft **11** of the drive servomotor **1**. Therefore, the drive-side rotation nut **20** rotates about the central axis a together with the rotation shaft **11** while maintaining a position in the A direction without moving in the A direction. The drive-side ball screw **21** extends in the A direction in a state of being constantly screwed to the drive-side rotation nut **20**. The drive-side piston **41** is attached to an end portion of the drive-side ball screw **21** in the A**1** direction. The drive-side ball screw **21** is disposed coaxially (on the central axis a) with the drive-side piston **41** of the drive-side cylinder **4**. The drive-side ball screw **21** moves in the A direction without rotating when the rotation shaft **11** rotates.

(Configuration of Drive-Side Ball Screw Cooling Path)

[0045] The drive-side ball screw cooling path **3** is provided inside the drive-side ball screw **21**. The drive-side ball screw cooling path **3** is configured such that a coolant for cooling the drive-side ball screw **21** flows through the drive-side ball screw cooling path **3**. As an example, the drive-side ball screw cooling path **3** is an elongated U-shaped path extending along a longitudinal direction (the A direction) of the drive-side ball screw **21**. The drive-side ball screw cooling path **3** is formed such that the coolant supply pipe **3***a* and the coolant discharge pipe **3***b* are connected to an end portion in the A**2** direction of the drive-side ball screw **21**, and the drive-side ball screw cooling path **3** is folded back in the vicinity of the end portion in the A**1** direction of the drive-side ball screw **21**.

[0046] A temperature of the drive-side ball screw **21** may greatly rise when the drive-side ball screw **21** is moved at a high speed together with the drive-side piston **41**. In such a case, the drive-side ball screw cooling path **3** cools the drive-side ball screw **21** and prevents expansion of the drive-side ball screw **21**, thereby preventing movement of the drive-side ball screw **21** from being hindered by the drive-side rotation nut **20** to which the drive-side ball screw **21** is screwed. Further, the drive-side ball screw cooling path **3** prevents an increase in a temperature of the working fluid around the drive-side piston **41** due to an increase in a temperature of the drive-side ball screw **21** via the drive-side piston **41** attached to the drive-side ball screw **21**.

(Configuration of Drive-Side Cylinder)

[0047] The drive-side cylinder **4** includes a drive-side tube portion **40**, the drive-side piston **41** that is moved by the drive servomotor **1**, and drive-side fluid chambers **42***a* and **42***b*. The drive-side tube portion **40** and the drive-side piston **41** are provided with oil seals S**1** that avoid (prevent) leakage of a working fluid.

[0048] The drive-side tube portion **40** is a hollow housing that houses the drive-side piston **41** therein in a state in which the drive-side piston **41** is movable in a front-rear direction (the A direction), and in which the drive-side fluid chambers **42***a* and **42***b* are provided. The position detection unit **73***a* that detects the position of the drive-side piston **41** is provided inside the drive-side tube portion **40**. The position detection unit **73***a* is, for example, a non-contact detection unit that detects a distance from the position detection unit **73***a* to the drive-side piston **41** using light or magnetism.

[0049] The drive-side piston **41** partitions an internal space of the drive-side tube portion **40** into the drive-side fluid chamber **42***a* on the A**1** direction side and the drive-side fluid chamber **42***b* on the A**2** direction side. Therefore, a working fluid in the drive-side fluid chamber **42***a* and a working fluid in the drive-side fluid chamber **42***b* do not mix with each other.

[0050] When the drive-side piston **41** is moved forward (in the A**1** direction), the working fluid flows out from the drive-side fluid chamber **42***a* to the driven-side cylinder **5** (a driven-side fluid chamber **54***b*) through the fluid path **50**, and the working fluid flows into the drive-side fluid chamber **42***b* from the driven-side cylinder **5** (a driven-side fluid chamber **54***a*) through the fluid path **51**.

[0051] When the drive-side piston **41** is moved backward (in the A**2** direction), the working fluid flows into the drive-side fluid chamber **42***a* from the driven-side cylinder **5** (the driven-side fluid chamber **54***b*) through the fluid path **50**, and the working fluid flows out from the drive-side fluid chamber **42***b* to the driven-side cylinder **5** (the driven-side fluid chamber **54***a*) through the fluid path **50**.

(Configuration of Driven-Side Cylinder)

[0052] The driven-side cylinder **5** includes the fluid paths **50** and **51**, a driven-side tube portion **52**, the driven-side piston **53**, and the driven-side fluid chambers **54***a* and **54***b*. The driven-side tube portion **52** and the driven-side piston **53** are provided with oil seals S**2** that avoid (prevent) leakage of a working fluid.

[0053] The fluid path **50** connects the drive-side fluid chamber **42***a* and the driven-side fluid chamber **54***b*. The fluid path **50**, the drive-side fluid chamber **42***a*, and the driven-side fluid chamber **54***b* form a closed circuit that allows the working fluid to flow between the drive-side fluid chamber **42***a* and the driven-side fluid chamber **54***b* without changing a total amount of the working fluid inside the fluid path **50**, the drive-side fluid chamber **42***a*, and the driven-side fluid chamber **54***b*. The closed circuit is filled with the working fluid. However, the total amount of the working fluid inside the fluid path **50**, the drive-side fluid chamber **42***a*, and the driven-side fluid chamber **54***b* may be reduced over time due to leakage of the working fluid through oil seals S**1** to S**3**.

[0054] The fluid path **51** connects the drive-side fluid chamber **42***b* and the driven-side fluid chamber **54***a*. The fluid path **51**, the drive-side fluid chamber **42***b*, and the driven-side fluid chamber **54***a* form a closed circuit that allows the working fluid to flow between the drive-side fluid chamber **42***b* and the driven-side fluid chamber **54***a* without changing a total amount of the working fluid inside the fluid path **51**, the drive-side fluid chamber **42***b*, and the driven-side fluid chamber **54***a*. The closed circuit is filled with the working fluid. However, the total amount of the working fluid inside the fluid path **51**, the drive-side fluid chamber **42***b*, and the driven-side fluid chamber **54***a* may be reduced over time due to leakage of the working fluid through the oil seals S**1**

to S**3**. The fluid paths **50** and **51** are each provided with a plug V (see FIG. **3**) for replenishing the working fluid that is reduced due to leakage.
[0055] The fluid path **50** includes a main fluid path portion **5***a* through which the working fluid flows between the driven-side fluid chamber **54***b* and the drive-side fluid chamber **42***a*, and an adjustment fluid path portion **5***b* (see FIG. **3**) connected to the main fluid path portion **5***a*. The adjustment fluid path portion **5***b* is disposed outside the driven-side tube portion **52** and the drive-side tube portion **40**.
[0056] The main fluid path portion **5***a* is formed by an elongated pipe path through which the working fluid passes. The main fluid path portion **5***a* is a flow path in which an inner wall surface is fixed without moving, and a volume of the main fluid path portion **5***a* does not increase or reduce.
[0057] A part of an inner wall surface W of the adjustment fluid path portion **5***b* can be moved, and a volume of the adjustment fluid path portion **5***b* is increased or reduced as the inner wall surface W is moved. The inner wall surface W of the adjustment fluid path portion **5***b* is formed by a front surface (a surface on the fluid path **50** side) of the volume adjustment piston **72** (to be described later) of the fluid path volume adjustment mechanism **7**. The adjustment fluid path portion **5***b* is connected to the main fluid path portion **5***a* from a lateral side (in an intersecting direction), and is a convex space protruding from the main fluid path portion **5***a* to the lateral side. The adjustment fluid path portion **5***b* extends in the C direction while maintaining a cross-sectional shape orthogonal to the C direction. That is, an extending direction of the adjustment fluid path portion **5***b* and an extending direction of the main fluid path portion **5***a* are substantially orthogonal to each other. As an example, the adjustment fluid path portion **5***b* is a cylindrical hollow space extending in the C direction. Further, the fluid path **51** is configured in a similar manner to the fluid path **50**, and includes the main fluid path portion **5***a* and the adjustment fluid path portion **5***b*.
[0058] The driven-side tube portion **52** is a hollow housing that houses the driven-side piston **53** therein in a state in which the driven-side piston **53** is movable in the front-rear direction (the B direction) and in which the driven-side fluid chambers **54***a* and **54***b* are provided. A position detection unit **73***b* that detects a position of the driven-side piston **53** is provided inside the driven-side tube portion **52**. The position detection unit **73***b* is, for example, a non-contact detection unit that detects a distance from the position detection unit **73***b* to the driven-side piston **53** using light or magnetism.
[0059] The driven-side piston **53** partitions an internal space of the driven-side tube portion **52** into the driven-side fluid chamber **54***a* on the B**1** direction side and the driven-side fluid chamber **54***b* on the B**2** direction side. Therefore, a working fluid in the driven-side fluid chamber **54***a* and a working fluid in the driven-side fluid chamber **54***b* do not mix with each other. The driven-side piston **53** is moved by moving the drive-side piston **41** to increase or reduce an amount of the working fluid in the driven-side fluid chambers **54***a* and **54***b* through the fluid paths **50** and **51**.
[0060] Specifically, when the drive-side piston **41** is moved forward (in the A**1** direction), the working fluid flows into the driven-side fluid chamber **54***b* from the drive-side fluid chamber **42***a* through the fluid path **50** to increase an amount of the working fluid in the driven-side fluid chamber **54***b*, and the working fluid flows out from the driven-side fluid chamber **54***a* to the drive-side fluid chamber **42***b* through the fluid path **51** to reduce an amount of the working fluid in the driven-side fluid chamber **54***a*. As a result, the driven-side piston **53** is moved forward (in the B**1** direction) together with the movable portion **100***b* of the press molding machine **100**. Accordingly, the fixed mold M**1** (see FIG. **1**) and the movable mold M**2** are clamped.
[0061] When the drive-side piston **41** is moved backward (in the A**2** direction), the working fluid flows out from the driven-side fluid chamber **54***b* to the drive-side fluid chamber **42***a* through the fluid path **50** to reduce an amount of the working fluid in the driven-side fluid chamber **54***b*, and the working fluid flows into the driven-side fluid chamber **54***a* from the drive-side fluid chamber **42***b* through the fluid path **51** to increase the amount of the working fluid in the driven-side fluid

chamber **54***a*. As a result, the driven-side piston **53** is moved backward (in the B**2** direction) together with the movable portion **100***b* of the press molding machine **100**. Accordingly, the fixed mold M**1** and the movable mold M**2** are opened.

(Configuration of Working Fluid Cooling Path)

[0062] The working fluid cooling path **6** (see FIG. **3**) is provided on the fluid paths **50** and **51**, and a coolant for cooling the working fluid in the fluid paths **50** and **51** flows through the working fluid cooling path **6**. The working fluid cooling path **6** is disposed outside the fluid paths **50** and **51** in a state of being in contact with the fluid paths **50** and **51**. The working fluid cooling path **6** is spirally wound around the fluid paths **50** and **51**. The working fluid cooling path **6** is formed of a material having a high heat transfer coefficient. As an example, the working fluid cooling path **6** is formed of copper.

(Configuration of Fluid Path Volume Adjustment Mechanism)

[0063] The fluid path volume adjustment mechanism **7** increases or reduces the volume of the fluid path **50** (**51**) according to an increase or reduction in a volume of the working fluid. As a result, the fluid path volume adjustment mechanism **7** performs control to keep a movement amount of the driven-side piston **53** relative to a predetermined movement amount of the drive-side piston **41** substantially constant. The increase or reduction in the volume of the working fluid is caused by leakage of the working fluid from the oil seals S**1** to S**3**, expansion or contraction of the working fluid due to a temperature change of the working fluid, or the like.

[0064] As an example, a forward (B**1** direction) movement amount of the driven-side piston **53** relative to a forward (A**1** direction) movement amount of the drive-side piston **41** of 100 mm is set to 50 mm. When an actual forward (B**1** direction) movement amount of the driven-side piston **53** is 52 mm instead of 50 mm, which is caused by expansion of the working fluid, the fluid path volume adjustment mechanism **7** moves backward the volume adjustment piston **72** (the inner wall surface W) to increase the volume of the adjustment fluid path portion **5***b*. Accordingly, an amount of a volume of the expanded working fluid is balanced by the enlarged adjustment fluid path portion **5***b*, and thus the movement amount of the driven-side piston **53** relative to the predetermined movement amount of the drive-side piston **41** is maintained substantially constant.

[0065] The fluid path volume adjustment mechanism **7** includes a volume adjustment servomotor **70** (an example of a "volume adjustment motor" in the claims), a volume adjustment ball screw mechanism **71**, the volume adjustment piston **72**, the position detection unit **73***a*, the position detection unit **73***b* (an example of a "movement adjustment detection unit" in the claims), a fluid temperature detection unit **73***c* (an example of a "movement adjustment detection unit" in the claims), a fluid pressure detection unit **73***d* (an example of a "movement adjustment detection unit" in the claims), and a control unit **74**.

[0066] The volume adjustment piston **72** is provided in the adjustment fluid path portion **5***b* of the fluid path **50** (**51**). The position detection unit **73***a*, the position detection unit **73***b*, the fluid temperature detection unit **73***c*, and the fluid pressure detection unit **73***d* are detection units for adjusting the movement amount of the driven-side piston **53** relative to movement of the drive-side piston **41**. The fluid path volume adjustment mechanism **7** adjusts the volume of the fluid path **50** (the adjustment fluid path portion **5***b*) based on detection results of the position detection unit **73***a*, the position detection unit **73***b*, the fluid temperature detection unit **73***c*, and the fluid pressure detection unit **73***d*.

[0067] As illustrated in FIG. **3**, the volume adjustment servomotor **70** moves the volume adjustment piston **72** forward and backward in the C direction via the volume adjustment ball screw mechanism **71**. The driving of the volume adjustment servomotor **70** is controlled by the control unit **74**.

[0068] The volume adjustment ball screw mechanism **71** connects the volume adjustment servomotor **70** and the volume adjustment piston **72**. The volume adjustment ball screw mechanism **71** includes a volume adjustment rotation nut **71***a* and a volume adjustment ball screw **71***b*.

[0069] The volume adjustment ball screw mechanism **71** is driven by the volume adjustment servomotor **70** to move the volume adjustment piston **72** forward and backward in the C direction together with the volume adjustment ball screw **71***b*. The volume adjustment rotation nut **71***a* is attached to a rotation shaft **70***a* (an output shaft) of the volume adjustment servomotor **70**. Therefore, the volume adjustment rotation nut **71***a* rotates together with the rotation shaft **70***a* while maintaining a position in the C direction without moving in the C direction.
[0070] The volume adjustment piston **72** is attached to an end portion in the C**1** direction of the volume adjustment ball screw **71***b*. The fluid path volume adjustment mechanism **7** increases or reduces the volume of the fluid path **50** (**51**) by moving the volume adjustment piston **72** (the inner wall surface W) in the C direction together with the volume adjustment ball screw **71***b*.
[0071] The volume adjustment ball screw **71***b* extends in the C direction in a state of being constantly screwed to the volume adjustment rotation nut **71***a*. The volume adjustment piston **72** is attached to the end portion in the C**1** direction of the volume adjustment ball screw **71***b*. A front surface (a surface on the C**1** direction side) of the volume adjustment piston **72** constitutes the inner wall surface W of the adjustment fluid path portion **5***b*. The volume adjustment piston **72** is provided with the oil seal S**3**.
[0072] The volume adjustment piston **72** partitions into the adjustment fluid path portion **5***b* that is a C**1**-direction-side space filled with the working fluid and a C**2**-direction-side space into which no working fluid flows. The volume adjustment piston **72** moves the inner wall surface W in the C direction to increase or reduce the volume of the adjustment fluid path portion **5***b*.
[0073] For example, when the volume adjustment rotation nut **71***a* rotates in one rotation direction (an R**1** rotation direction indicated by a white arrow), the volume adjustment piston **72** moves in the C**2** direction, and thus the volume of the adjustment fluid path portion **5***b* is increased. Since a volume of the main fluid path portion **5***a* does not change, a volume of the entire fluid path **50** (**51**) is increased by an amount at which the adjustment fluid path portion **5***b* is increased.
[0074] When the volume adjustment rotation nut **71***a* rotates in the other rotation direction (an R**2** rotation direction indicated by a black arrow), the volume adjustment piston **72** moves in the C**1** direction, and thus the volume of the adjustment fluid path portion **5***b* is reduced. Since the volume of the main fluid path portion **5***a* does not change, the volume of the entire fluid path **50** is reduced by an amount at which the adjustment fluid path portion **5***b* is reduced.
[0075] The position detection unit **73***b* illustrated in FIG. **2** detects the position of the drive-side piston **41**. As described above, the position detection unit **73***b* is provided inside the drive-side tube portion **40**. A detected value of the position detection unit **73***b* is acquired by the control unit **1***a* and the control unit **74**.
[0076] The position detection unit **73***a* detects the position of the driven-side piston **53**. The position detection unit **73***a* is provided inside the driven-side tube portion **52**. A detected value of the position detection unit **73***a* is acquired by the control unit **74**.
[0077] The fluid temperature detection unit **73***c* detects a temperature (a state) of the working fluid. The fluid temperature detection unit **73***c* is provided in the fluid path **50** (**51**). A detected value of the fluid temperature detection unit **73***c* is acquired by the control unit **74**.
[0078] The fluid pressure detection unit **73***d* detects pressure (a state) of the working fluid. The fluid pressure detection unit **73***d* is provided in the fluid path **50** (**51**). A detected value of the fluid pressure detection unit **73***d* is acquired by the control unit **74**.
[0079] The control unit **74** acquires detection results of the position detection unit **73***a*, the position detection unit **73***b*, the fluid temperature detection unit **73***c*, and the fluid pressure detection unit **73***d* through feedback and adjusts driving of the volume adjustment servomotor **70**. The control unit **74** includes a computer numerical control (CNC) device that generates a pulse signal for driving the volume adjustment servomotor **70**, and a servo amplifier (a driver) that drives the volume adjustment servomotor **70** based on the pulse signal.
(Control Configuration of Control Unit)

[0080] A control configuration of the control unit **74** will be described.
[0081] In a case where there is no temperature change in the working fluid, when the control unit **74** determines that a movement amount of the driven-side piston **53** relative to a predetermined movement amount of the drive-side piston **41** is smaller than a set value (a reference value) based on detected values of the position detection unit **73***a* and the position detection unit **73***b*, the control unit **74** performs control to reduce the volume of the adjustment fluid path portion **5***b* by moving (moving forward) the volume adjustment piston **72** (the inner wall surface W) in the C**1** direction. That is, the control unit **74** performs control to push the working fluid in the adjustment fluid path portion **5***b* into the main fluid path portion **5***a*. A reduction amount in the volume of the adjustment fluid path portion **5***b* in this case is substantially equal to a reduction amount in a volume of the driven-side fluid chamber **54***a* (the driven-side fluid chamber **54***b*) calculated based on the movement amount of the driven-side piston **53** that is smaller than the set value. As a result, the movement amount of the driven-side piston **53** relative to the predetermined movement amount of the drive-side piston **41** is corrected to be the set value. In the case where there is no temperature change in the working fluid, when the movement amount of the driven-side piston **53** relative to the predetermined movement amount of the drive-side piston **41** is smaller than the set value, for example, the reason may be leakage of the working fluid.
[0082] In a case where there is no leakage of the working fluid, when the control unit **74** determines that a temperature of the working fluid is lower than a set value based on a detected value of the working fluid temperature detection unit **73***c*, the control unit **74** performs control to reduce the volume of the adjustment fluid path portion **5***b* by moving (moving forward) the volume adjustment piston **72** (the inner wall surface W) in the C**1** direction in consideration of a contraction ratio of the working fluid caused by a temperature drop.
[0083] In a case where there is no leakage of the working fluid, when the control unit **74** determines that a temperature of the working fluid is higher than the set value based on a detected value of the working fluid temperature detection unit **73***c*, the control unit **74** performs control to increase the volume of the adjustment fluid path portion **5***b* by moving (moving backward) the volume adjustment piston **72** (the inner wall surface W) in the C**2** direction in consideration of an expansion rate of the working fluid caused by a temperature rise.
[0084] When the control unit **74** determines that pressure of the working fluid is (greatly) lower than a set value (when the control unit **74** determines that the pressure is lower than a predetermined threshold) or the like based on a detected value of the fluid pressure detection unit **73***d*, the control unit **74** performs control to increase the volume of the adjustment fluid path portion **5***b* by moving (moving forward) the volume adjustment piston **72** (the inner wall surface W) in the C**1** direction. When the pressure of the working fluid is (greatly) lower than the set value (when it is determined that the pressure is lower than the predetermined threshold), a propulsive force of the movable portion **100***b* that is moved together with the driven-side piston **53** is not sufficient, and a clamping force of the fixed mold M**1** and the movable mold M**2** is not sufficient.
Effects of Embodiment
[0085] In the present embodiment, the following effects can be obtained.
[0086] In the present embodiment, as described above, the hydraulic circuit control device **101** is provided with the drive-side cylinder **4** including the drive-side piston **41**, the driven-side cylinder **5** including the driven-side piston **53** that is moved by moving the drive-side piston **41** to increase or reduce the amount of the working fluid in the driven-side fluid chambers **54***a* and **54***b* through the fluid paths **50** and **51**, and the fluid path volume adjustment mechanism **7** that increases or reduces the volumes of the fluid paths **50** and **51** according to the increase or reduction in the volume of the working fluid. Accordingly, even when the volume of the working fluid is increased or reduced due to a temperature change or leakage or the like of the working fluid inside the fluid paths **50** and **51**, the driven-side fluid chambers **54***a* and **54***b*, and the drive-side fluid chambers **42***a* and **42***b*, the fluid path volume adjustment mechanism **7** can increase or reduce the volumes of the

fluid paths **50** and **51** according to the increase or reduction in the volume of the working fluid. Therefore, the increase or reduction in the volume of the working fluid can be balanced by increasing or reducing the volumes of the fluid paths **50** and **51** by the fluid path volume adjustment mechanism **7**, so that the increase or reduction in the volume of the working fluid does not affect the movement amount of the driven-side piston **53**. That is, the movement amount of the driven-side piston **53** can be corrected such that the movement amount of the driven-side piston **53** relative to a predetermined movement amount of the drive-side piston **41** is maintained substantially constant. As a result, even when the volume of the working fluid varies due to a temperature change or leakage or the like of the working fluid, positional accuracy of the driven-side piston **53** of the driven-side cylinder **5** can be ensured.
[0087] In the present embodiment, as described above, each of the fluid paths **50** and **51** includes the main fluid path portion **5***a* through which the working fluid flows between the driven-side fluid chambers **54***a* and **54***b* and the drive-side fluid chambers **42***a* and **42***b*, and the adjustment fluid path portion **5***b* connected to the main fluid path portion **5***a*, and the fluid path volume adjustment mechanism **7** includes the volume adjustment servomotor **70** that moves the inner wall surface W of the adjustment fluid path portion **5***b*, and the inner wall surface W is moved to increase or reduce the volume of the adjustment fluid path portion **5***b*. Accordingly, the inner wall surface W of the adjustment fluid path portion **5***b* can be moved by the volume adjustment servomotor **70** to increase or reduce the volume of the adjustment fluid path portion **5***b*, and thus a movement amount of the driven-side piston **53** can be easily corrected, and positional accuracy of the driven-side piston **53** of the driven-side cylinder **5** can be easily ensured.
[0088] In the present embodiment, as described above, the fluid path volume adjustment mechanism **7** includes the movement adjustment detection unit (the position detection units **73***a* and **73***b*, the fluid temperature detection unit **73***c*, and the fluid pressure detection unit **73***d*) that detects at least one of positions of the driven-side piston **53** and the drive-side piston **41** and a state of the working fluid in order to adjust a movement amount of the driven-side piston **53** relative to movement of the drive-side piston **41**, and increases or reduces volumes of the fluid paths **50** and **51** based on a detection result of the movement adjustment detection unit. Accordingly, the movement amount of the driven-side piston **53** can be corrected based on the result obtained by detecting at least one of the positions of the driven-side piston **53** and the drive-side piston **41** and the state of the working fluid by the movement adjustment detection unit, and thus it is possible to more reliably ensure positional accuracy of the driven-side piston **53** of the driven-side cylinder **5** according to the positions of the driven-side piston **53** and the drive-side piston **41** and the state of the working fluid.
[0089] In the present embodiment, as described above, the movement adjustment detection unit includes at least one of the position detection units **73***a* and **73***b* that detect the positions of the drive-side piston **41** and the driven-side piston **53**, the fluid temperature detection unit **73***c* that detects a temperature of the working fluid, and the fluid pressure detection unit **73***d* that detects pressure of the working fluid, and the fluid path volume adjustment mechanism **7** increases or reduces volumes of the fluid paths **50** and **51** based on a detection result of at least one of the position detection units **73***a* and **73***b*, the fluid pressure detection unit **73***d*, and the fluid temperature detection unit **73***c*. Accordingly, a movement amount of the driven-side piston **53** can be appropriately corrected according to various situations by detecting the positions of the drive-side piston **41** and the driven-side piston **53** indicating a movement amount change (deviation from a set value) of the driven-side piston **53** and either the temperature or the pressure of the working fluid that affects the movement amount change of the driven-side piston **53**.
[0090] In the present embodiment, as described above, the fluid path volume adjustment mechanism **7** includes the volume adjustment piston **72** provided in each of the fluid paths **50** and **51**, and the volume adjustment ball screw mechanism **71** that includes the volume adjustment ball screw **71***b* to which the volume adjustment piston **72** is attached, and that increases or reduces

volumes of the fluid paths **50** and **51** by moving the volume adjustment piston **72** together with the volume adjustment ball screw **71***b*. Accordingly, the volume adjustment piston **72** can be moved by the volume adjustment ball screw mechanism **71**, and thus the volume adjustment piston **72** can be moved accurately, and the volume of the adjustment fluid path portion **5***b* can be adjusted accurately.

[0091] In the present embodiment, as described above, the hydraulic circuit control device **101** is further provided with the drive-side ball screw mechanism **2** that includes the drive-side ball screw **21** to which the drive-side piston **41** is attached and that is driven by the drive servomotor **1** to move the drive-side piston **41** together with the drive-side ball screw **21**, and the drive-side ball screw cooling path **3** that is provided inside the drive-side ball screw **21** and through which a coolant for cooling the drive-side ball screw **21** flows. Accordingly, the drive-side ball screw **21** to which the drive-side piston **41** is attached can be cooled by the drive-side ball screw cooling path **3**, and thus a temperature rise of the working fluid caused by the drive-side ball screw **21** and the drive-side piston **41** can be prevented, and a volume change of the working fluid caused by the temperature rise of the working fluid can be prevented.

[0092] In the present embodiment, as described above, the hydraulic circuit control device **101** is further provided with the working fluid cooling path **6** that is provided on the fluid paths **50** and **51** and through which a coolant for cooling the working fluid in the fluid paths **50** and **51** flows. Accordingly, the working fluid can be cooled by the working fluid cooling path **6**, and thus a temperature rise of the working fluid can be prevented, and a volume change of the working fluid caused by the temperature rise of the working fluid can be prevented.

[0093] In the present embodiment, as described above, the fluid path volume adjustment mechanism **7** increases or reduces volumes of the fluid paths **50** and **51** based on both the state index value directly indicating the increase or reduction in the volume of the working fluid and the state index value indirectly indicating the increase or reduction in the volume of the working fluid. Accordingly, the volume of the working fluid can be increased or reduced with higher accuracy in consideration of both the state index value directly indicating the increase or reduction in the volume of the working fluid and the state index value indirectly indicating the increase or reduction in the volume of the working fluid. As a result, positional accuracy of the driven-side piston **53** of the driven-side cylinder **5** can be improved.

Modification

[0094] The embodiment disclosed herein should be considered to be illustrative and not restrictive in all respects. The scope of this disclosure is indicated not by the description of the above embodiment but by the claims, and includes all changes (modifications) within the meaning and scope equivalent to the claims.

[0095] For example, although the volume adjustment piston of the fluid path volume adjustment mechanism is directly attached to a tip end of the volume adjustment ball screw (an end portion in the C**1** direction) in the above embodiment, this disclosure is not limited thereto. In this disclosure, as in a hydraulic circuit control device **201** illustrated in FIG. **4**, a plate member **272***a* may be directly attached to a tip end (an end portion in the C**1** direction) of the volume adjustment ball screw **71***b*, and a spring member **272***b* may be provided between the plate member **272***a* and a volume adjustment piston **272**. The hydraulic circuit control device **201** can absorb (buffer) an impact applied to the driven-side piston using the spring member **272***b*.

[0096] Although the molding machine disclosed here is implemented by a press molding machine in the above embodiment, this disclosure is not limited thereto. In this disclosure, the molding machine may be an injection molding machine or a die casting machine.

[0097] Although the hydraulic circuit control device is provided in the press molding machine (the molding machine) in the above embodiment, this disclosure is not limited thereto. In this disclosure, the hydraulic circuit control device may be provided in a machine tool, an inspection device, or the like.

[0098] Although the drive-side fluid chamber on a front side of the drive-side piston and the driven-side fluid chamber on a rear side of the driven-side piston are connected by one fluid path, and the drive-side fluid chamber on a rear side of the drive-side piston and the driven-side fluid chamber on a front side of the driven-side piston are connected by the other fluid path in the above embodiment, this disclosure is not limited thereto. In this disclosure, the drive-side fluid chamber on the front side of the drive-side piston and the driven-side fluid chamber on the front side of the driven-side piston may be connected by one fluid path, and the drive-side fluid chamber on the rear side of the drive-side piston and the driven-side fluid chamber on the rear side of the driven-side piston may be connected by the other fluid path.

[0099] Although the working fluid cooling path is disposed outside the fluid path in the above embodiment, this disclosure is not limited thereto. In this disclosure, the working fluid cooling path may be disposed inside the fluid path so that the working fluid cooling path is in direct contact with the working fluid.

[0100] Although the drive motor disclosed here is implemented by a servomotor in the above embodiment, this disclosure is not limited thereto. In this disclosure, the drive motor may be implemented by a different type of motor such as a stepping motor.

[0101] Although the fluid path includes two types of portions of the main fluid path portion and the adjustment fluid path portion in the above embodiment, this disclosure is not limited thereto. In this disclosure, the fluid path may include only a fluid path portion (the main fluid path portion) through which the working fluid flows between the driven-side fluid chamber and the drive-side fluid chamber. That is, the fluid path volume adjustment mechanism may move an inner wall surface of the fluid path portion (the main fluid path portion) through which the working fluid flows between the driven-side fluid chamber and the drive-side fluid chamber.

[0102] Although the hydraulic circuit control device includes two fluid path volume adjustment mechanisms in the above embodiment, this disclosure is not limited thereto. In this disclosure, the hydraulic circuit control device may include one or three or more fluid path volume adjustment mechanisms.

[0103] Although the volume adjustment piston is attached to the volume adjustment ball screw and the volume adjustment piston is moved in the C direction together with the volume adjustment ball screw in the above embodiment, this disclosure is not limited thereto. In this disclosure, the volume adjustment piston may be attached to the volume adjustment rotation nut, and the volume adjustment piston may be moved in the C direction together with the volume adjustment rotation nut. In this case, the volume adjustment ball screw mechanism is configured such that the volume adjustment ball screw does not move in the C direction.

[0104] Although the fluid path volume adjustment mechanism increases or reduces the volume of the fluid path based on both the state index value directly indicating the increase or reduction in the volume of the working fluid and the state index value indirectly indicating the increase or reduction in the volume of the working fluid in the above embodiment, the fluid path volume adjustment mechanism may increase or reduce the volume of the fluid path based on only one of the state index value directly indicating the increase or reduction in the volume of the working fluid and the state index value indirectly indicating the increase or reduction in the volume of the working fluid.

REFERENCE SIGNS LIST

[0105] **1**: drive servomotor (drive motor) [0106] **2**: drive-side ball screw mechanism [0107] **3**: drive-side ball screw cooling path [0108] **4**: drive-side cylinder [0109] **5**: driven-side cylinder [0110] **5***a*: main fluid path portion [0111] **5***b*: adjustment fluid path portion [0112] **7**: fluid path volume adjustment mechanism [0113] **21**: drive-side ball screw [0114] **41**: drive-side piston [0115] **42***a*, **42***b*: drive-side fluid chamber [0116] **50**, **51**: fluid path [0117] **53**: driven-side piston [0118] **54***a*, **54***b*: driven-side fluid chamber [0119] **70**: volume adjustment servomotor (volume adjustment motor) [0120] **71**: volume adjustment ball screw mechanism [0121] **71***b*: volume adjustment ball screw [0122] **72**, **272**: volume adjustment piston [0123] **73***a*: position detection unit (for detecting position of drive-side piston) (movement adjustment detection unit) [0124] **73***b*: position detection unit (for detecting position of driven-side piston) (movement adjustment detection unit) [0125] **73***c*: fluid temperature detection unit (movement adjustment detection unit) [0126] **73***d*: fluid pressure detection unit (movement adjustment detection unit) [0127] **100**: press molding machine (molding machine) [0128] **100***a*: fixed portion [0129] **100***b*: movable portion [0130] **101**, **201**: hydraulic circuit control device [0131] M**1**: fixed mold [0132] M**2**: movable mold [0133] W: inner wall surface

Claims

1. A hydraulic circuit control device comprising: a drive motor; a drive-side cylinder including a drive-side fluid chamber and a drive-side piston that is moved by the drive motor; a driven-side cylinder including a driven-side fluid chamber, a fluid path that connects the driven-side fluid chamber and the drive-side fluid chamber, and a driven-side piston that is moved by moving the drive-side piston to increase or reduce an amount of a working fluid in the driven-side fluid chamber through the fluid path; and a fluid path volume adjustment mechanism configured to increase or reduce a volume of the fluid path according to an increase or reduction in a volume of the working fluid.
2. The hydraulic circuit control device according to claim 1, wherein the fluid path includes a main fluid path portion through which the working fluid flows between the driven-side fluid chamber and the drive-side fluid chamber, and an adjustment fluid path portion connected to the main fluid path portion, and the fluid path volume adjustment mechanism includes a volume adjustment motor configured to move an inner wall surface of the adjustment fluid path portion, and is configured to move the inner wall surface to increase or reduce a volume of the adjustment fluid path portion.
3. The hydraulic circuit control device according to claim 1, wherein the fluid path volume adjustment mechanism includes a movement adjustment detection unit configured to detect at least one of positions of the driven-side piston and the drive-side piston and a state of the working fluid in order to adjust a movement amount of the driven-side piston relative to movement of the drive-side piston, and is configured to increase or reduce the volume of the fluid path based on a detection result of the movement adjustment detection unit.
4. The hydraulic circuit control device according to claim 3, wherein the movement adjustment detection unit includes at least one of a position detection unit configured to detect positions of the drive-side piston and the driven-side piston, a fluid temperature detection unit configured to detect a temperature of the working fluid, and a fluid pressure detection unit configured to detect pressure of the working fluid, and the fluid path volume adjustment mechanism is configured to increase or reduce the volume of the fluid path based on a detection result of at least one of the position detection unit, the fluid pressure detection unit, and the fluid temperature detection unit.
5. The hydraulic circuit control device according to claim 1, wherein the fluid path volume adjustment mechanism includes a volume adjustment piston provided in the fluid path, and a volume adjustment ball screw mechanism that includes a volume adjustment ball screw to which the volume adjustment piston is attached, and that increases or reduces the volume of the fluid path by moving the volume adjustment piston together with the volume adjustment ball screw.
6. The hydraulic circuit control device according to claim 1, further comprising: a drive-side ball screw mechanism that includes a drive-side ball screw to which the drive-side piston is attached and that is driven by the drive motor to move the drive-side piston together with the drive-side ball screw; and a drive-side ball screw cooling path that is provided inside the drive-side ball screw and through which a coolant for cooling the drive-side ball screw flows.
7. The hydraulic circuit control device according to claim 1, wherein the fluid path volume adjustment mechanism is configured to increase or reduce the volume of the fluid path based on at least one of a state index value directly indicating an increase or reduction in the volume of the

working fluid and a state index value indirectly indicating the increase or reduction in the volume of the working fluid.

8. A molding machine comprising: a fixed portion to which a fixed mold is attached; a movable portion to which a movable mold is attached; and a hydraulic circuit control device provided in the movable portion and configured to move the movable portion relative to the fixed portion, wherein the hydraulic circuit control device includes a drive motor, a drive-side cylinder including a drive-side fluid chamber and a drive-side piston that is moved by the drive motor, a driven-side cylinder including a driven-side fluid chamber, a fluid path that connects the driven-side fluid chamber and the drive-side fluid chamber, and a driven-side piston that is moved by moving the drive-side piston to increase or reduce an amount of a working fluid in the driven-side fluid chamber through the fluid path, and a fluid path volume adjustment mechanism configured to increase or reduce a volume of the fluid path according to an increase or reduction in a volume of the working fluid.
