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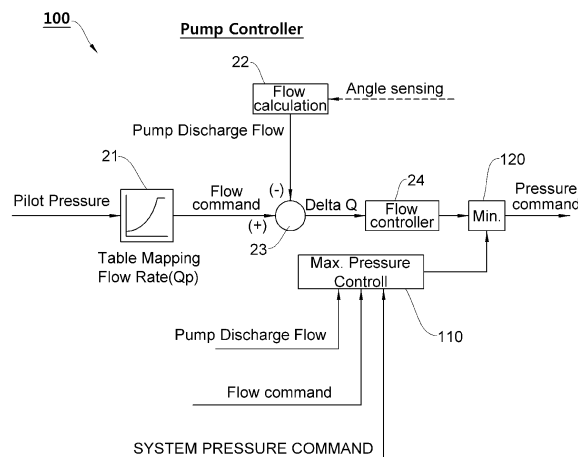
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(54) **PRESSURE OVERSHOOTING PREVENTION SYSTEM FOR ELECTRONIC HYDRAULIC PUMP IN HYDRAULIC SYSTEM**

(57) The present disclosure relates to a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system, in which a flow rate command is added (+), a discharge flow rate is subtracted (-), a displacement flow rate (Delta Q) is calculated, a first pressure command corresponding to the displacement flow rate (Delta Q) is generated, a working fluid pressure value corresponding to the discharge flow rate is generated, a limit pressure command is generated to limit an increasing gradient of the working fluid pressure

value, a stall is determined based on a first rate of change of the flow rate command, and a second rate of change of the discharge flow rate, and the limit pressure command is set to a second pressure command when the stall is determined, and a small value of the first pressure command and the second pressure command is selected as a final pressure command so as to control an electronic proportional control valve, thereby reducing overshooting of the electronic hydraulic pump.

Fig 5.



## Description

### CROSS-REFERENCE TO RELATED APPLICATION

[0001] This Application is a Section 371 National Stage Application of International Application No. PCT/KR2012/011352, filed December 24, 2012 and published, not in English, as WO 2013/100509 on July 4, 2013.

### FIELD OF THE DISCLOSURE

[0002] The present disclosure relates to a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system, and more particularly, to a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system, capable of preventing pressure overshooting by controlling a pressure command to an electronic hydraulic pump in a hydraulic system in a state in which an actuator cannot be operated any more.

### BACKGROUND OF THE DISCLOSURE

[0003] In general, in a hydraulic system, a working fluid is discharged from an electronic hydraulic pump, and the working fluid is on standby at an inlet of a main control valve. A plurality of spools is provided in the main control valve, and a plurality of actuators is connected outside the main control valve. In addition, pilot pressure is generated in a flow rate requiring unit such as a joystick and a pedal, and the pilot pressure is provided to the main control valve. A specific spool of the main control valve is opened and closed by the pilot pressure, and the working fluid is provided to the actuator associated with the corresponding spool by the operation of opening and closing the corresponding spool.

[0004] That is, by manipulating the joystick, the working fluid discharged from the electronic hydraulic pump is provided to the actuator through the main control valve, and as a result, the actuator is operated.

[0005] The actuator has a piston rod provided in a cylinder, and the piston rod is operated by pressure of the working fluid in a direction in which the piston rod is extended or retracted. The piston rod may reach an end point at which the piston rod cannot be extended any more, or the piston rod cannot be extended or retracted any more due to large external loads. The situation in which physical resistance is applied to the piston rod so that the piston rod cannot be operated may be defined as a stall.

[0006] When the stall occurs as described above, a worker may still manipulate the joystick or the pedal regardless of the worker's intention. In this situation, because a required flow rate is constantly required, the electronic hydraulic pump constantly discharges the working fluid to provide the working fluid to the actuator, and as a result, there is a risk that hydraulic pressure in the hy-

draulic system may be raised to a dangerous level.

[0007] In order to prepare for the aforementioned risk, a safety device is provided in the hydraulic system, and as the safety device, for example, there is a variable relief valve that is opened to discharge the working fluid when pressure is set to be higher than allowable pressure.

[0008] In addition, among the hydraulic systems, there is a hydraulic system that has a main control valve in which a center bypass line is blocked, and a pressure control type electronic hydraulic pump, and there is a technology that reduces a flow rate by decreasing a swash plate angle of the electronic hydraulic pump to a minimum level when the actuator stalls in this hydraulic system.

[0009] However, in the aforementioned situation in which the actuator stalls, the working fluid is constantly discharged from the electronic hydraulic pump even in a case in which the hydraulic pressure is being stabilized while being decreased to safe pressure by opening the variable relief valve or adjusting the swash plate angle to a minimum level, and in this case, a pressure peak instantaneously occurs due to the flow rate of the discharged working fluid. There is a problem in that the pressure peak weakens durability of the hydraulic system.

[0010] Hereinafter, a hydraulic system having an electronic hydraulic pump will be described with reference to the attached FIG. 1.

[0011] The attached FIG. 1 is a view for explaining a hydraulic system having a pressure control type electronic hydraulic pump.

[0012] As illustrated in FIG. 1, the hydraulic system includes a flow rate requiring unit 10 which is configured as a joystick, a pedal, or the like, an electronic hydraulic pump 50 which discharges a working fluid, and a main control valve 60 which provides the working fluid to an actuator 70 by opening and closing a spool.

[0013] When the worker manipulates the joystick or the pedal, pilot pressure is generated by the flow rate requiring unit 10, and the pilot pressure is provided to the main control valve 60.

[0014] The main control valve 60 has a plurality of spools therein, the spools are operated by the pilot pressure, and the main control valve 60 allows the working fluid to pass therethrough when the spools are opened, and shuts off a flow of the working fluid when the spools are closed.

[0015] The actuator 70 has a piston rod provided in a cylinder, and a piston head side and a tail side are connected with the main control valve 60, and supplied with the working fluid. The piston rod is extended or retracted in accordance with a direction in which the working fluid is supplied, and a direction in which the working fluid is discharged. A stall occurs in a case in which the piston rod cannot be moved any more. That is, the actuator 70 stalls in a case in which the piston rod cannot be moved any more.

[0016] The electronic hydraulic pump 50 discharges the working fluid in which hydraulic pressure is formed.

The hydraulic pressure of the working fluid may be determined by a swash plate angle. For example, assuming that the shaft of the electronic hydraulic pump 50 is rotated with the same number of revolutions, high pressure is formed and the flow rate is increased as the swash plate angle is increased, and low pressure is formed and the flow rate is decreased as the swash plate angle is decreased. Meanwhile, when the swash plate angle is changed, a period of time is required to set a desired swash plate angle because there are physical dynamic characteristics.

**[0017]** The swash plate angle of the electronic hydraulic pump 50 is adjusted by a pump regulator 40, and the pump regulator 40 is operated by an electronic proportional control valve 30.

**[0018]** The electronic proportional control valve 30 is operated by a pressure command, and the pressure command is provided from a pump control unit 20.

**[0019]** The pump control unit 20 receives a pressure value of pilot pressure formed by the flow rate requiring unit 10, and a swash plate angle value of the electronic hydraulic pump 50, and calculates the pressure command.

**[0020]** The pressure command from the pump control unit 20 is applied to the electronic proportional control valve 30 as an electrical signal, the electronic proportional control valve 30 operates the pump regulator 40, and the pump regulator 40 adjusts the swash plate angle of the electronic hydraulic pump 50 so as to discharge the working fluid at a flow rate that corresponds to a required flow rate.

**[0021]** Meanwhile, allowable pressure may be set in the hydraulic system, and in a case in which pressure, which is higher than the allowable pressure, is formed, the variable relief valve 80 is opened to allow the working fluid to maintain the set pressure. In addition, the allowable pressure set in the hydraulic system is variable, and may be varied and set depending on a capacity of the hydraulic system.

**[0022]** An operation of the pump control unit 20 will be described in more detail with reference to the attached FIG. 2.

**[0023]** The attached FIG. 2 is a view for explaining control logic of the pressure control type electronic hydraulic pump in the hydraulic system in the related art.

**[0024]** The pump control unit 20 receives a pressure value of pilot pressure formed by the flow rate requiring unit 10, and a swash plate angle value of the electronic hydraulic pump 50, and calculates the pressure command.

**[0025]** When the flow rate requiring unit 10 is manipulated, the pilot pressure is formed, and a pressure value of the pilot pressure may be understood as a required pressure value.

**[0026]** When the required pressure value is input, a flow rate command is generated in the flow rate command generating unit 21 at a set rate. The flow rate command generating unit 21 may be the data that has been input

by a manufacturer of the hydraulic system in advance. That is, an electric current signal corresponding to the required pressure value is generated, and the electric current signal becomes the flow rate command.

**[0027]** The current discharge flow rate can be seen when a value of the swash plate angle of the electronic hydraulic pump 50 is recognized.

**[0028]** In a flow rate command calculating unit 23, the flow rate command is added (+), the discharge flow rate is subtracted (-), and then a displacement flow rate ( $\Delta Q$ ) is calculated.

**[0029]** The displacement flow rate ( $\Delta Q$ ) is converted into the pressure command by the flow rate control unit 24. The pressure command is used to control the electronic proportional control valve 30, as described above.

**[0030]** When the pressure command is changed, the pressure according to the pressure command is changed, and this process will be described with reference to FIG. 3.

**[0031]** The attached FIG. 3 is a view for explaining pressure in control logic of the pressure control type electronic hydraulic pump in the related art, and a mapping line drawing of a pressure command.

**[0032]** As illustrated in FIG. 3, when second pressure command differential pressure  $P_x$  is changed, the pressure of the working fluid is changed by the displacement pressure ( $\Delta P$ ).

**[0033]** That is, when the pressure command is changed in the electronic proportional control valve 30, the pressure transmitted to the pump regulator 40 is changed depending on the pressure command of the electronic proportional control valve 30. In this case, because there are physical dynamic characteristics, there is a time interval until the pressure of the pump regulator 40 is actually changed depending on the pressure command after the electronic proportional control valve 30 is operated.

**[0034]** The flow rate is changed with a delay due to the aforementioned time interval, and an abnormal peak  $P$  is generated in a situation in which a stall occurs, and this process will be described with reference to the attached FIG. 4.

**[0035]** The attached FIG. 4 is a line drawing illustrating a variation in flow rate according to variation in time for explaining an example in which a peak is generated at a discharge flow rate by the pressure control type electronic hydraulic pump in the related art.

**[0036]** As illustrated in FIG. 4, when the joystick of the flow rate requiring unit 10 is manipulated, the required flow rate and the required hydraulic pressure are increased from a time point  $t_0$  when manipulating the joystick. In this case, the pump pressure command is also increased, and the discharge flow rate of the working fluid of the electronic hydraulic pump 50 is increased.

**[0037]** When a state in which the joystick is constantly manipulated is maintained, the actuator 70 is extended or retracted.

**[0038]** At a time point t1 when the actuator 70 stalls at any moment, the piston rod of the actuator 70 cannot be moved any more, and the actuator 70 does not receive the working fluid any more from this time point, such that the pressure of the working fluid in the hydraulic system is increased.

**[0039]** In addition, a variation in flow rate occurs as the displacement flow rate ( $\Delta Q$ ) from the time point t1 when a stall occurs.

**[0040]** Regarding the pump pressure command, the pressure command of the electronic proportional control valve 30 is increased to a time point t2 when the swash plate angle is completely moved to a minimum level with a gradient a when the pressure is increased. In addition, the pressure in the pump regulator 40 is rapidly increased with a gradient b1 that is greater than the gradient a so as to form a peak p, and thereafter, the pressure is decreased with a gradient b2, and depends on the pressure of the electronic proportional control valve 30.

**[0041]** That is, in a situation in which a stall occurs, the working fluid is discharged at the flow rate that is substantially discharged from the electronic hydraulic pump 50, and the flow rate is excessive by an area indicated by a c region in FIG. 4. Accordingly, there is a problem in that the overshoot working fluid degrades durability of the hydraulic system.

**[0042]** The discussion above is merely provided for general background information and is not intended to be used as an aid in determining the scope of the claimed subject matter.

## SUMMARY

**[0043]** This summary and the abstract are provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. The summary and the abstract are not intended to identify key features or essential features of the claimed subject matter, nor are they intended to be used as an aid in determining the scope of the claimed subject matter.

**[0044]** Therefore, a technical problem to be resolved by the present disclosure is to provide a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system, which more quickly reduces a discharge flow rate of an electronic hydraulic pump when a stall occurs such that the actuator does not receive a working fluid, thereby stabilizing the hydraulic system.

**[0045]** A technical problem to be achieved in the present disclosure is not limited to the aforementioned technical problems, and any other not-mentioned technical problem will be obviously understood from the description below by those skilled in the technical field to which the present disclosure pertains.

**[0046]** In order to achieve the aforementioned technical problem, a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the present disclosure includes: a flow rate

command calculating unit 23 which adds (+) a flow rate command corresponding to required pressure, subtracts (-) a discharge flow rate discharged from an electronic hydraulic pump 50, and calculates a displacement flow rate

**[0047]** ( $\Delta Q$ ); a flow rate control unit 24 which generates a first pressure command corresponding to the displacement flow rate  $\Delta Q$ ; a stall determining unit 114 which determines a stall based on a first rate of change of the flow rate command, and a second rate of change of the discharge flow rate; a flow rate pressure generating unit 115 which generates a working fluid pressure value corresponding to the discharge flow rate; a gradient limiting unit 116 which generates a limit pressure command so as to limit an increasing gradient of the working fluid pressure value; a selecting unit 117 which sets the limit pressure command to a second pressure command when a stall is determined by the stall determining unit 114; and a minimum pressure setting unit 120 which selects a small value of the first pressure command and the second pressure command as a final pressure command so as to control an electronic proportional control valve 30.

**[0048]** The stall determining unit 114 of the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the present disclosure may determine the stall when the second rate of change is greater than the first rate of change.

**[0049]** In the limit pressure command of the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the present disclosure, a second pressure command gradient a2 after a time point t4 when the stall is determined may be smaller than a first pressure command gradient a1 before the time point t4 when the stall is determined.

**[0050]** The selecting unit 117 of the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the present disclosure may set a system pressure command to the second pressure command when the stall determining unit 114 determines that the stall is released.

**[0051]** Specific items of other exemplary embodiments are included in the detailed description and the drawings.

**[0052]** The pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the present disclosure, which is configured as described above, more quickly changes the pressure command which is used to control the electronic hydraulic pump when a stall occurs, such that the swash plate angle in the electronic hydraulic pump may be more quickly moved, thereby remarkably reducing the working fluid flow rate that is overshoot in the electronic hydraulic pump. That is, the overshooting working fluid is reduced, thereby improving durability of the hydraulic system.

## DESCRIPTION OF THE DRAWINGS

**[0053]**

FIG. 1 is a view for explaining a hydraulic system having a pressure control type electronic hydraulic pump.

FIG. 2 is a view for explaining control logic of the pressure control type electronic hydraulic pump in the hydraulic system in the related art.

FIG. 3 is a view for explaining pressure in control logic of the pressure control type electronic hydraulic pump in the related art, and a mapping line drawing of a pressure command.

FIG. 4 is a line drawing illustrating a variation in flow rate according to variation in time for explaining an example in which a peak is generated at a discharge flow rate by the pressure control type electronic hydraulic pump in the related art.

FIG. 5 is a view for explaining control logic of a pressure control type electronic hydraulic pump in a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to an exemplary embodiment of the present disclosure.

FIG. 6 is a view for explaining logic of a maximum pressure limiting unit in the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure.

FIG. 7 is a line drawing illustrating a variation in flow rate according to a variation in time for explaining an example that prevents a peak at a discharge flow rate in the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure.

## Description of Main Reference Numerals of Drawings

### [0054]

10: Flow rate requiring unit  
 20, 100: Pump control unit  
 21: Flow rate command generating unit  
 22: Discharge flow rate calculating unit  
 23: Flow rate command calculating unit  
 24: Flow rate control unit  
 30: Electronic proportional control valve  
 40: Pump regulator  
 50: Electronic hydraulic pump  
 60: Main control valve  
 70: Actuator  
 80: Variable relief valve  
 110: Maximum pressure limiting unit  
 111: Flow rate calculating unit  
 112, 113: First and second flow rate variation calculating units  
 114: Stall determining unit  
 115: Flow rate pressure setting unit  
 116: Gradient limiting unit  
 117: Flow rate selecting unit

120: Minimum pressure setting unit

t0: Time point when manipulating joystick

t0 ~ t1 : Actuator operation (movement) section

t1 : Time point when stall occurs

t2: Time point when pump swash plate angle is completely moved to a minimum level in the related art

t3: Time point when pump swash plate angle is completely moved to a minimum level

t4: Time point when stall is determined

a1, a2: First and second pressure command gradients

b1, b2: First and second actual pressure line drawings

c: Discharge flow rate

p: Peak point

## DETAILED DESCRIPTION

[0055] Advantages and features of the present disclosure and methods of achieving the advantages and features will be clear with reference to exemplary embodiments described in detail below together with the accompanying drawings.

[0056] Like reference numerals indicate like elements throughout the specification, constituent elements identical to constitute elements in the related art will be indicated by the same reference numerals, and detailed descriptions thereof will be omitted.

[0057] Meanwhile, the terms used in the description are defined considering the functions of the present disclosure and may vary depending on the intention or usual practice of a manufacturer. Therefore, the definitions should be made based on the entire contents of the present specification.

[0058] In the specification of the present disclosure, a stall means a phenomenon in which an actuator 70 is stopped when a piston rod of the actuator 70 reaches an end point when the piston rod is extended or retracted, or when the piston rod cannot be moved any more by an external load.

[0059] In addition, in the specification of the present disclosure, overshooting means a phenomenon in which a working fluid is discharged from an electronic hydraulic pump 50 for a period of time that is physically delayed due to dynamic characteristics when a pump regulator 40 responds to a pressure command made by an electronic proportional control valve 30.

[0060] Hereinafter, a pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to an exemplary embodiment of the present disclosure, and control logic of a pressure control type electronic hydraulic pump will be described with reference to FIGS. 1 and 5.

[0061] The attached FIG. 1 is a view for explaining a hydraulic system having the pressure control type electronic hydraulic pump. The attached FIG. 5 is a view for explaining control logic of the pressure control type electronic hydraulic pump in the pressure overshooting pre-

vention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure.

**[0062]** As illustrated in FIG. 5, a pump control unit 100 is operated by control logic of an electronic hydraulic pump.

**[0063]** The pump control unit 100 controls the electronic hydraulic pump 50 suitably for a required flow rate by adding and subtracting the required flow rate and a flow rate at which the working fluid is discharged from the electronic hydraulic pump 50.

**[0064]** The aforementioned required flow rate is generated by manipulating a flow rate requiring unit 10. In more detail, when the flow rate requiring unit 10 is manipulated, required pressure is generated, and a required flow rate is determined as a set rate by the flow rate command generating unit 21 according to the required pressure. The required flow rate is used to control a flow rate control unit 24 as a required flow rate command. The flow rate control unit 24 controls an electronic proportional control valve 30 as a pressure command corresponding to flow rate control is converted.

**[0065]** The aforementioned electronic hydraulic pump 50 may output a value of a swash plate angle, and the swash plate angle value is provided to a discharge flow rate calculating unit 22 so that the current flow rate of the working fluid discharged from the electronic hydraulic pump 50 may be calculated.

**[0066]** A flow rate command calculating unit 23 receives the aforementioned flow rate command and information on a discharge flow rate. In the flow rate command calculating unit 23, when a required command is added (+), and the discharge flow rate is subtracted (-), a displacement flow rate ( $\Delta Q$ ) which indicates whether to change the flow rate to any extent is calculated.

**[0067]** The displacement flow rate ( $\Delta Q$ ) is converted into the pressure command by the flow rate control unit 24. The pressure command is used to control the electronic proportional control valve 30, as described above.

**[0068]** The hydraulic system according to the exemplary embodiment of the present disclosure further includes a minimum pressure setting unit 120 between the flow rate control unit 24 and the electronic proportional control valve 30.

**[0069]** In addition, the minimum pressure setting unit 120 receives the pressure command from the maximum pressure limiting unit 110.

**[0070]** That is, the minimum pressure setting unit 120 selects a small pressure command of a first pressure command input by the flow rate control unit 24 and a second pressure command input by the aforementioned maximum pressure limiting unit 110, and controls the electronic proportional control valve 30.

**[0071]** The aforementioned maximum pressure limiting unit 110 will be described with reference to FIG. 6.

**[0072]** The attached FIG. 6 is a view for explaining logic of a maximum pressure limiting unit in the pressure over-

shooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure.

**[0073]** As illustrated in FIG. 6, the maximum pressure limiting unit 110 receives a pump discharge flow rate and the flow rate command so as to generate the second pressure command.

**[0074]** The second pressure command limits and is generated a gradient a raised pump pressure command in accordance with a map of a gradient limiting unit 116 which allows maximum pressure to be set depending on the current discharge flow rate.

**[0075]** The above description will be further described below.

**[0076]** The flow rate calculating unit 111 calculates the required flow rate by receiving and adding and subtracting the flow rate command and a value of the pump discharge flow rate. The required flow rate may be varied depending on an amount of manipulation of the flow rate requiring unit 10, and the required flow rate may be rapidly varied, or slowly varied, and the extent of the variation is calculated by a first flow rate variation calculating unit 112, and a rate of change of the required flow rate is calculated.

**[0077]** In addition, a second flow rate variation calculating unit 113 receives a value of the pump discharge flow rate, and calculates a second rate of change of the discharge flow rate of the working fluid that is actually discharged from the electronic hydraulic pump 50.

**[0078]** A stall determining unit 114 compares a first rate of change of the flow rate command with the second rate of change of the discharge flow rate, and determines whether the actuator 70 stalls. That is, when the second rate of change is greater than the first rate of change, a situation in which a stall occurs is determined.

**[0079]** The stall state will be further described. Since the stall state is a state in which the piston rod of the actuator 70 is not moved even though a driver manipulates the joystick, the flow rate command is present, but the actuator 70 does not receive the flow rate of the working fluid, such that a flow path of the hydraulic system is shut off, and the swash plate angle of the electronic hydraulic pump 50 is quickly reduced. That is, the stall state is determined when a variation value with respect to a difference between the flow rate command and the pump discharge flow rate is greater than a set value, and a variation value of the discharge flow rate of the electronic hydraulic pump 50 is smaller than the set value.

**[0080]** In addition, a working fluid pressure value corresponding to the current pump discharge flow rate is set by the flow rate pressure generating unit 115 depending on the pump discharge flow rate value. The aforementioned working fluid pressure value is increased with a gradient value set by the gradient limiting unit 116.

**[0081]** Meanwhile, a selecting unit 117 receives a limit pressure command set from the aforementioned gradient value, and a system pressure command set by the hydraulic system, outputs the limit pressure command

when the aforementioned stall determining unit 114 determines the stall, and outputs the system pressure command when there is no stall.

**[0082]** That is, when the stall state is released, the limit pressure command is deselected by the selecting unit 117, such that the system pressure command is output.

**[0083]** The pressure command output from the aforementioned selecting unit 117 is set as the aforementioned second pressure command.

**[0084]** Hereinafter, the minimum pressure setting unit 120 finally outputs a small pressure command of the first pressure command provided from the flow rate control unit 24, and the second pressure command provided from the aforementioned selecting unit 117.

**[0085]** Accordingly, in the stall state, the pressure command having the limited gradient is provided to the pressure electronic proportional control valve 30, the flow rate of the working fluid discharged from the electronic hydraulic pump 50 is more quickly reduced, thereby resolving the problem that the working fluid is overshot.

**[0086]** An operation of reducing a discharge peak of the working fluid using the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure will be described with reference to FIG. 7.

**[0087]** The attached FIG. 7 is a line drawing illustrating a variation in flow rate according to a variation in time for explaining an example that prevents a peak at a discharge flow rate in the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure.

**[0088]** As illustrated in FIG. 7, when the joystick of the flow rate requiring unit 10 is manipulated, the required flow rate and the required hydraulic pressure are increased from the time point  $t_0$  when manipulating the joystick. In this case, the pump pressure command is also increased, and the discharge flow rate of the working fluid of the electronic hydraulic pump 50 is increased.

**[0089]** When a state in which the joystick is constantly manipulated is maintained, the actuator 70 is extended or retracted.

**[0090]** At the time point  $t_1$  when the actuator 70 stalls at any moment, the piston rod of the actuator 70 cannot be moved any more, and the actuator 70 does not receive the working fluid any more from this time point, such that the pressure of the working fluid in the hydraulic system is increased.

**[0091]** In addition, a variation in flow rate occurs as the displacement flow rate ( $\Delta Q$ ) from the time point  $t_1$  when a stall occurs.

**[0092]** When the pressure is raised, the pressure command of the electronic proportional control valve 30 is varied regarding the pump pressure command. By the initial pressure command, the swash plate angle is varied with the first pressure command gradient  $a_1$  corresponding to the first pressure command, and the swash plate

angle of a second pressure command gradient  $a_2$  corresponding to the second pressure command is varied from the time point  $t_4$  when the stall is determined by the stall determining unit 114.

**[0093]** As described above, the second pressure command has a limited gradient in comparison with the first pressure command, such that the second pressure command gradient  $a_2$  is formed to be small in comparison with the first pressure command gradient  $a_1$ .

**[0094]** Meanwhile, when the first pressure command is changed to the second pressure command, the electronic hydraulic pump 50 depends on the pressure command, such that an initial first actual pressure line drawing  $b_1$  depends on the first pressure command gradient  $a_1$  at the time point  $t_1$  when a stall occurs, is reduced as exemplified by a second actual pressure line drawing  $b_2$  immediately after being changed to the second pressure command gradient  $a_2$ , and then is stabilized.

**[0095]** That is, the pressure overshooting prevention system according to the exemplary embodiment of the present disclosure reduces the pressure command much earlier, thereby remarkably lowering the flow rate peak  $p$ .

**[0096]** Accordingly, the time point  $t_3$  when the swash plate angle of the electronic hydraulic pump 50 is completely moved to a minimum level may be advanced, thereby reducing the flow rate  $c$  of the working fluid that is discharged while the swash plate angle is moved to a minimum level as a stall occurs.

**[0097]** Therefore, the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure finally outputs a small value of output values of the maximum pressure limiting unit 110 and the flow rate control unit 24 as the pressure command, thereby reducing the pressure peak in the stall state.

**[0098]** As described above, the pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system according to the exemplary embodiment of the present disclosure more quickly changes the pressure command which is used to control the electronic hydraulic pump 50 when a stall occurs, such that the swash plate angle in the electronic hydraulic pump 50 may be more quickly moved, thereby remarkably reducing the working fluid flow rate  $c$  that is overshoot in the electronic hydraulic pump 50. That is, the overshooting working fluid is reduced, thereby improving durability of the hydraulic system.

**[0099]** The exemplary embodiment of the present disclosure have been described with reference to the accompanying drawings, but those skilled in the art will understand that the present disclosure may be implemented in any other specific form without changing the technical spirit or an essential feature thereof.

**[0100]** Accordingly, it should be understood that the aforementioned exemplary embodiment is described for illustration in all aspects and are not limited, and the scope of the present disclosure shall be represented by the claims to be described below, and it should be con-

strued that all of the changes or modified forms induced from the meaning and the scope of the claims, and an equivalent concept thereto are included in the scope of the present disclosure.

**[0101]** The pressure overshooting prevention system for an electronic hydraulic pump of a hydraulic system according to the present disclosure quickly reduces the discharge flow rate of the electronic hydraulic pump when a stall occurs so that the actuator cannot be operated, and may be used to improve durability of the hydraulic system.

## Claims

1. A pressure overshooting prevention system for an electronic hydraulic pump in a hydraulic system, comprising:
  - a flow rate command calculating unit which adds (+) a flow rate command corresponding to required pressure, subtracts (-) a discharge flow rate discharged from an electronic hydraulic pump, and calculates a displacement flow rate;
  - a flow rate control unit which generates a first pressure command corresponding to the displacement flow rate;
  - a stall determining unit which determines a stall based on a first rate of change of the flow rate command, and a second rate of change of the discharge flow rate;
  - a flow rate pressure generating unit which generates a working fluid pressure value corresponding to the discharge flow rate;
  - a gradient limiting unit which generates a limit pressure command so as to limit an increasing gradient of the working fluid pressure value;
  - a selecting unit which sets the limit pressure command to a second pressure command when a stall is determined by the stall determining unit;
  - and
  - a minimum pressure setting unit which selects a small value of the first pressure command and the second pressure command as a final pressure command so as to control an electronic proportional control valve.
2. The pressure overshooting prevention system of claim 1, wherein the stall determining unit determines the stall when the second rate of change is greater than the first rate of change.
3. The pressure overshooting prevention system of claim 1, wherein in the limit pressure command, a second pressure command gradient after a time point when the stall is determined is smaller than a first pressure command gradient before the time point when the stall is determined.

4. The pressure overshooting prevention system of claim 1, wherein the selecting unit sets a system pressure command to the second pressure command when the stall determining unit determines that the stall is released.

Fig 1.

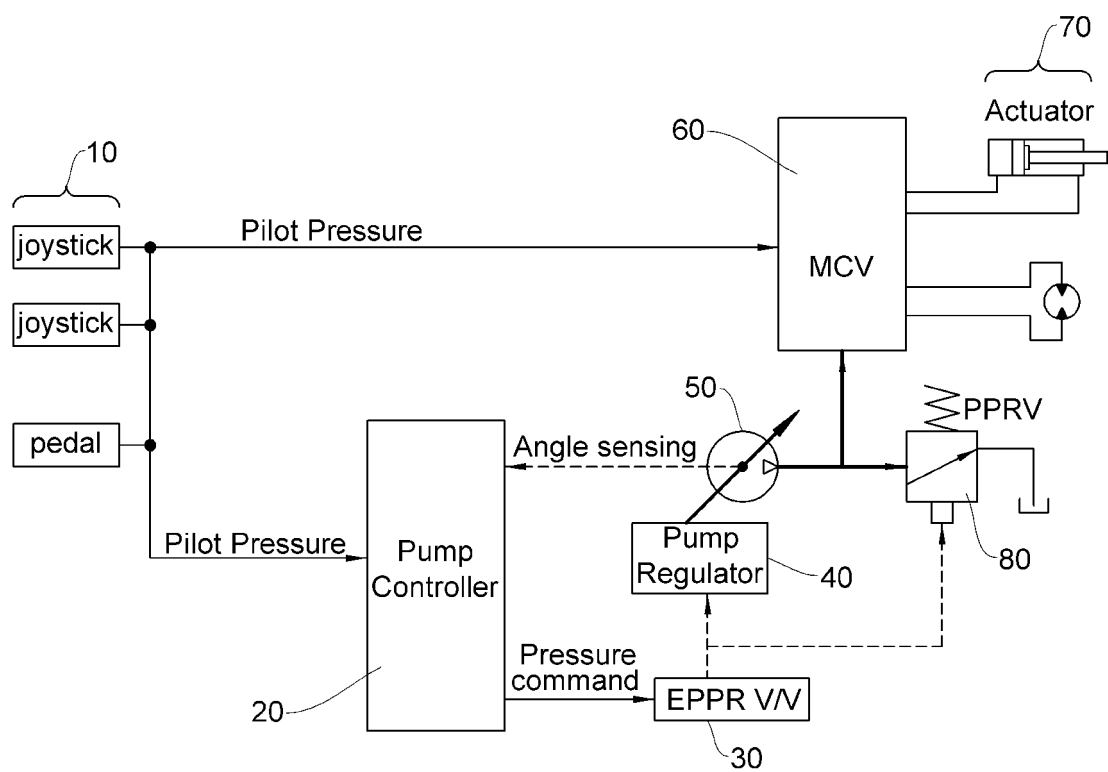


Fig 2.

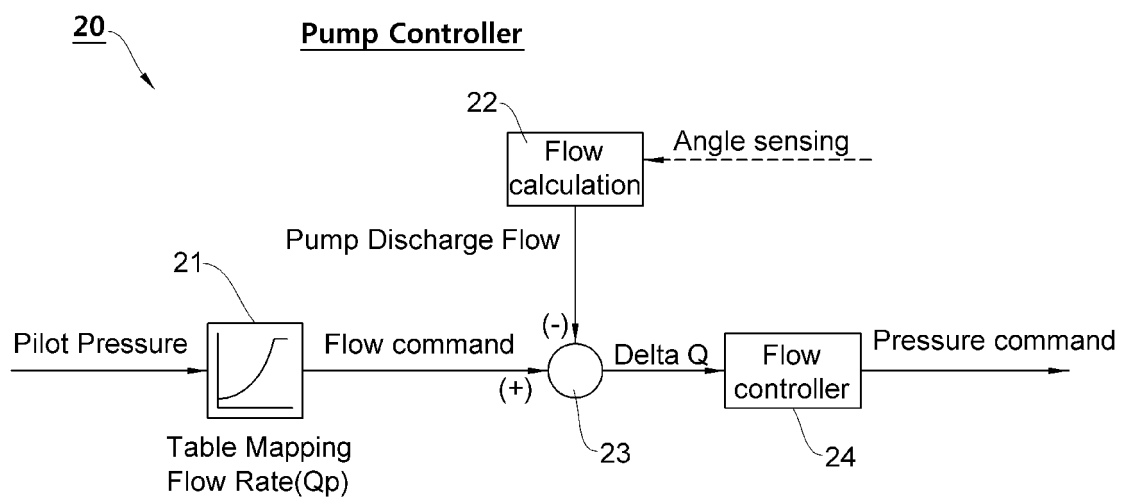


Fig 3.

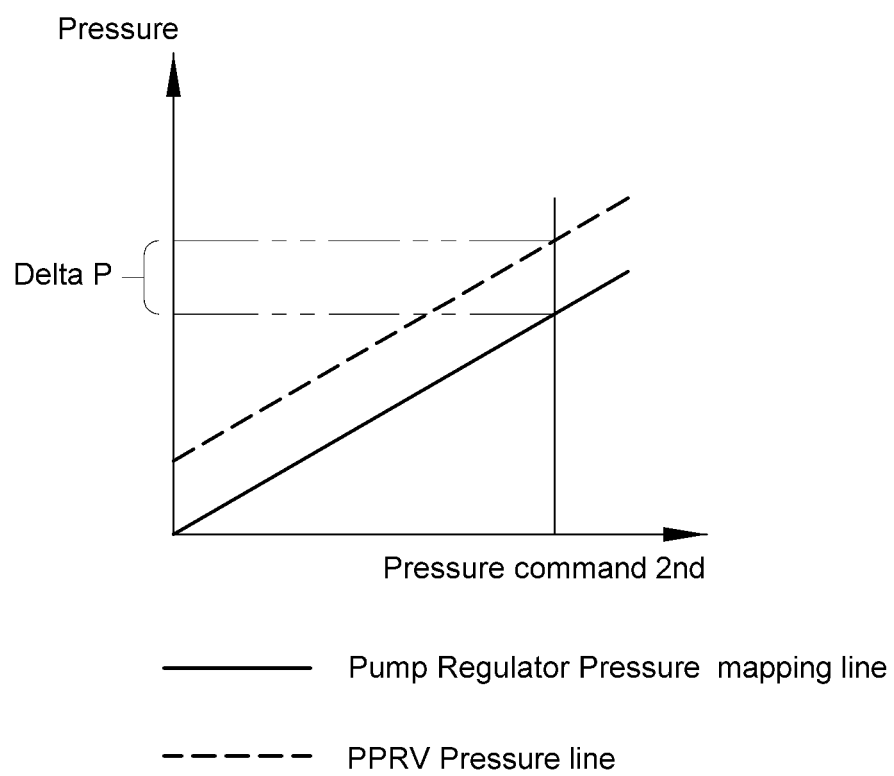
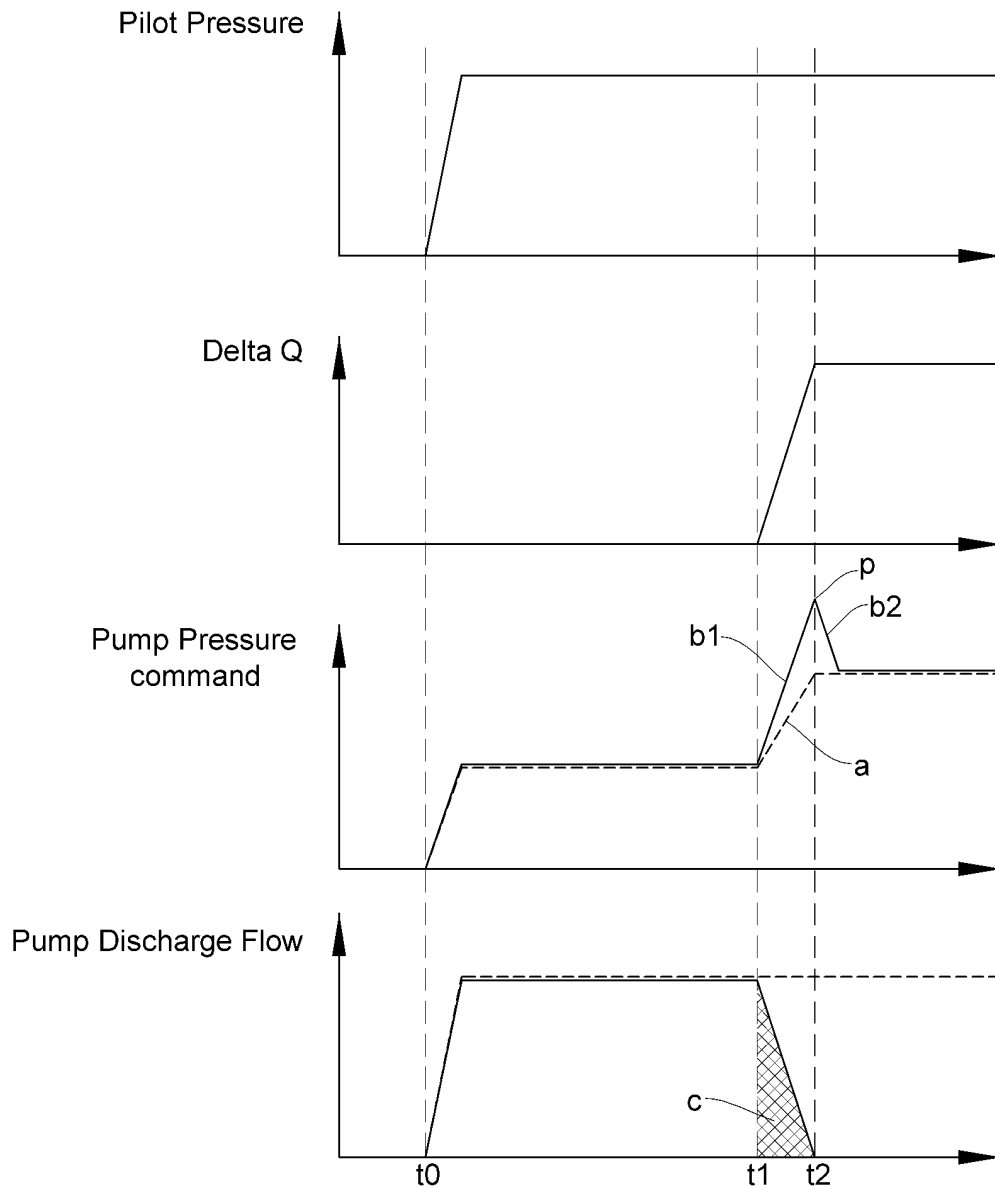


Fig 4.



$t_0$ : Time point when manipulating joystick

$t_0 \sim t_1$ : Actuator operation (movement) section

$t_1$ : Time point when stall occurs

$t_2$ : Time point when pump swash plate angle is completely moved to a minimum level in related art

———— Pump Regulator Pressure mapping line

----- PPRV Pressure line

Fig 5.

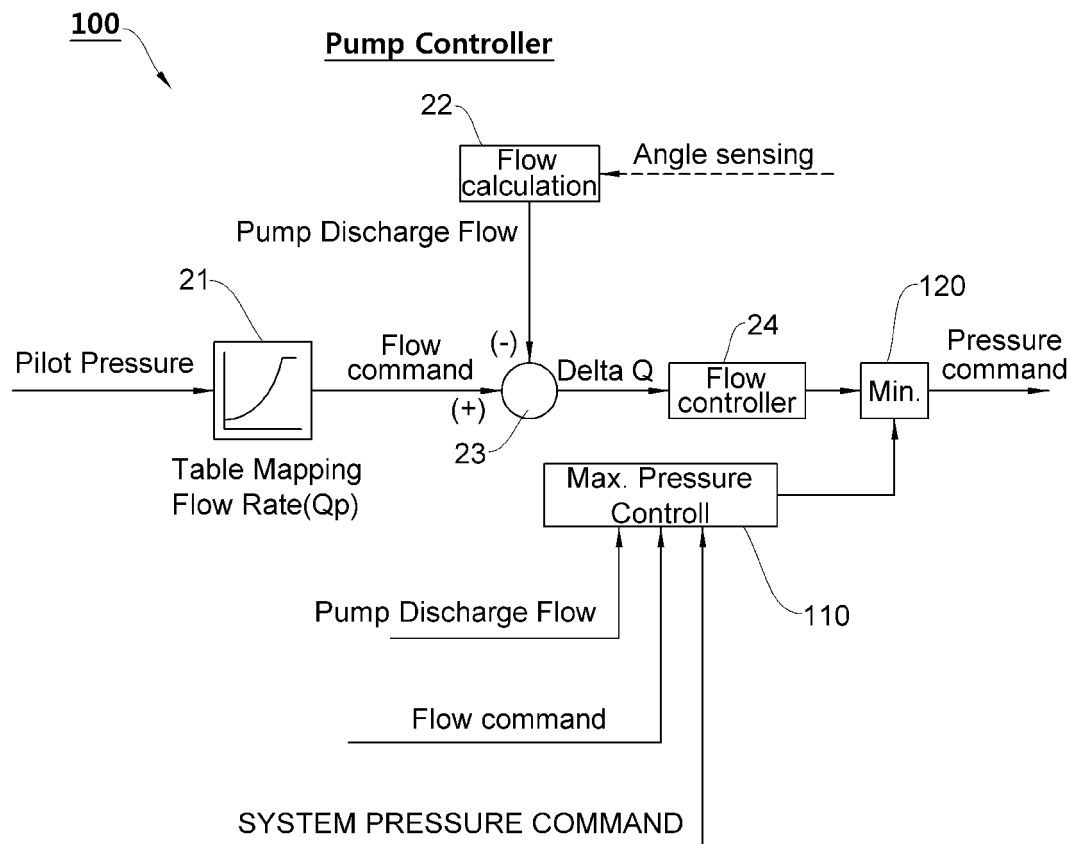


Fig 6.

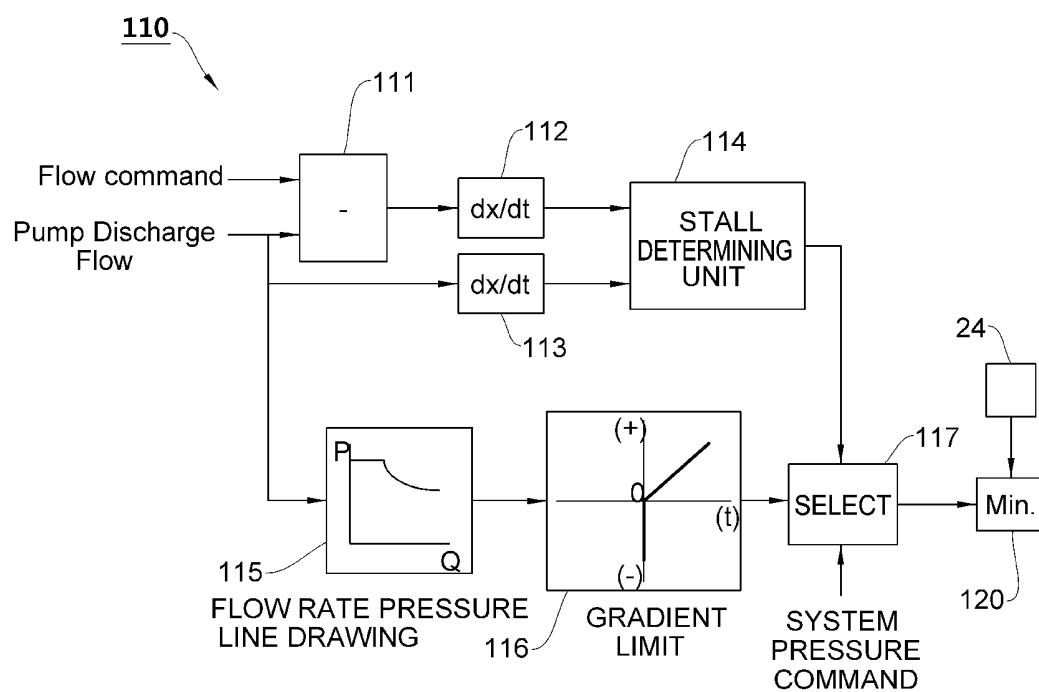
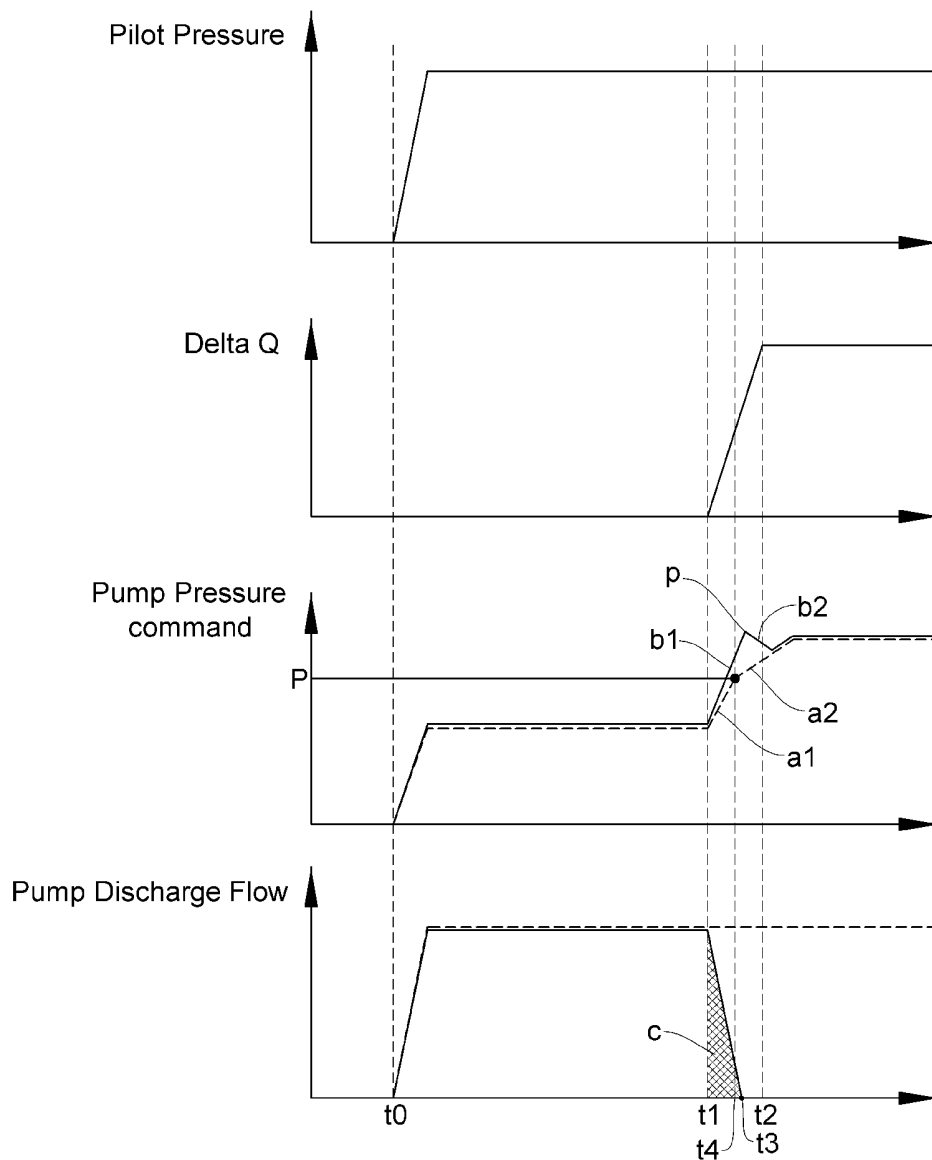


Fig 7.



$t_0$ : Time point when manipulating joystick  
 $t_0 \sim t_1$ : Actuator operation (movement) section  
 $t_1$ : Time point when stall occurs  
 $t_2$ : Time point when pump swash plate angle is completely moved to a minimum level in related art  
 $t_3$ : Time point when pump swash plate angle is completely moved to a minimum level  
 $t_4$ : Time point when stall is determined

——— Pump Regulator Pressure mapping line  
 - - - - - PPRV Pressure line

## INTERNATIONAL SEARCH REPORT

International application No.

**PCT/KR2012/011352**

## A. CLASSIFICATION OF SUBJECT MATTER

**F04B 49/08(2006.01)i, F15B 20/00(2006.01)i, F15B 13/044(2006.01)i, F04B 49/10(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)

**F04B 49/08; F15B 11/02; F04B 49/06; F04B 27/04; F15B 7/02; F15B 11/00; E02F 9/22**

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

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

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

**eKOMPASS (KIPO internal) & Keywords: hydraulic pressure, stall, overshooting, hydraulic, pump, stall, overshoot**

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                | Relevant to claim No. |
|-----------|-------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | KR 10-2011-0073082 A (DOOSAN INFRACORE CO., LTD.) 29 June 2011<br>See paragraph [0020] and figures 1-2.           | 1-4                   |
| A         | KR 10-2010-0072482 A (DOOSAN INFRACORE CO., LTD.) 01 July 2010<br>See paragraph [0014] and figure 1.              | 1-4                   |
| A         | JP 2005-265002 A (KOBELCO CONSTRUCTION MACHINERY LTD.) 29 September 2005<br>See paragraph [0029] and figures 1-2. | 1-4                   |
| A         | JP 2009-144505 A (VOLVO CONSTRUCTION EQUIPMENT AB) 02 July 2009<br>See paragraph [0020] and figure 2.             | 1-4                   |
| A         | JP 2002-195164 A (TOKIMEC INC.) 10 July 2002<br>See paragraph [0021] and figure 1.                                | 1-4                   |

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

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"P" document published prior to the international filing date but later than the priority date claimed

"I" 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

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"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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

**21 MARCH 2013 (21.03.2013)**

Date of mailing of the international search report

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Name and mailing address of the ISA/KR


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## INTERNATIONAL SEARCH REPORT Information on patent family members

International application No.

**PCT/KR2012/011352**

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member                                                                                                                                                       | Publication<br>date                                                                                                                      |
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| JP 2002-195164 A                          | 10.07.2002          | NONE                                                                                                                                                                          |                                                                                                                                          |

Form PCT/ISA/210 (patent family annex) (July 2009)

**REFERENCES CITED IN THE DESCRIPTION**

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