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(54) Low-load start-up hydraulic system for controlling rotation of a railroad car body

Hydraulisches System mit Start unter niedriger Last zum Steuern der Neigung eines
Eisenbahnwagenkastens

Système hydraulique avec démarrage sous faible charge pour contrôler l'inclinaison d'une caisse d'un
véhicule ferroviaire

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Description

[0001] The present invention relates to a hydraulic system for controlling rotation of a railroad car body.

[0002] Variable-trim railroad cars are known to present a body supported on trucks and rotatable about a longitudinal axis. When cornering, the body is rotated inwards of the curve to at least partially compensate the centrifugal force produced and so provide for improved passenger comfort.

[0003] The body is rotated by means of a hydraulic system substantially comprising a tank; a motor pump; a number of hydraulic actuators, normally two for each truck; and a solenoid valve for controlling supply to the actuators, and which in turn is controlled by an electronic processing unit on the basis of input signals from sensors on the car.

[0004] Downstream from the motor pump assembly, a bypass start valve is normally provided, which, being open during start-up of the system, provides for low-load start-up of the pump motor. More specifically, the valve is a timed solenoid valve, which closes after a predetermined time sufficient for the motor to reach the steady-state condition, to enable pressurization of the system to the given operating values.

[0005] It is an object of the present invention to provide a system presenting a bypass start valve requiring no electric control, and which is therefore extremely straightforward and reliable, and provides for low-load starting the motor pump in any operating situation.

[0006] According to the present invention, there is provided a hydraulic system for controlling rotation of a railroad car body, and comprising:

- a hydraulic fluid tank;
- a motor pump assembly connected to the tank and to a supply line;
- a number of hydraulic actuators for exerting mechanical force on the body to rotate it;
- a solenoid valve for selectively connecting said hydraulic actuators to the supply line or to a drain, in response to electric control signals; and
- a bypass start valve for depressurizing the supply line during start-up of the motor pump assembly; characterized in that said bypass start valve is a purely hydraulically operated, normally-open valve, which switches automatically when supply from said motor pump assembly reaches a predetermined threshold value.

[0007] A preferred, non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying hydraulic diagram.

[0008] Number 1 in the accompanying drawing indicates a hydraulic system for controlling rotation of a railroad car body 2 about a longitudinal axis A of the car.

[0009] System 1 substantially comprises a first pair of front hydraulic cylinders 3a, 3b; a second pair of rear

hydraulic cylinders 4a, 4b; and a hydraulic unit 5 for generating hydraulic power and operating said cylinders. As shown schematically for front cylinders 3a, 3b only, the cylinders in each pair are located on either side of body 2, on the left and right side respectively, and are interposed between the body and a structural element 6 supported, conveniently by means of an elastic suspension, on the truck (not shown) of the car. Cylinders 3a, 3b, 4a, 4b are all single-acting types.

[0010] Rotation axis A is defined by a known articulated parallelogram mechanism (not shown) connecting body 2 to structural element 6.

[0011] Hydraulic unit 5 substantially comprises a hydraulic fluid tank 7; a motor pump assembly 8 for generating hydraulic power; and a hydraulic assembly 9 for controlling cylinders 3a, 3b and 4a, 4b.

[0012] More specifically, motor pump assembly 8 comprises a three-stroke, asynchronous electric motor 10; a pressure-compensated, variable-displacement main pump 12 and a fixed-displacement auxiliary pump 13, both driven by motor 10 and intake-connected to tank 7.

[0013] A supply line 14 for supplying assembly 9 is connected to pump 12, which presents a pressure compensator for reducing its displacement on reaching a predetermined operating pressure of, say, 30 MPa. Pump 12 also presents a drain line 15 drain-connected to tank 7 and fitted with a low-pressure filter 16 presenting an electric clogging indicator 17 and a bypass valve 18. A conduit 19 for loading the system is connected to drain line 15, and presents a one-way valve 20 and an inlet filter 21.

[0014] The delivery side of pump 13 is connected by a recirculating line 31 to a heat exchanger 32 presenting a power fan 33, and then to tank 7; and pump 13 provides for circulating a large quantity of fluid, but for a low pressure of, say, 0.3 MPa.

[0015] Control assembly 9 is connected to motor pump assembly 8 by supply line 14, and comprises, at the inlet and in series along line 14, a high-pressure filter 24 with an electric clogging indicator 25, and a non-return valve 23.

[0016] Control assembly 9 also comprises a four-way, open-center, electrohydraulic servovalve 26, which presents an inlet 27 connected to supply line 14, a drain 28 connected to a drain line 29 in turn connected to tank 7, and two outlets 30a, 30b connected respectively to left cylinders 3a, 4a and right cylinders 3b, 4b, so that the two cylinders on each side are operated in parallel with the work chambers constantly at the same pressure. Servovalve 26 provides for selectively connecting cylinders 3a, 4a and 3b, 4b to supply line 14 and drain line 29 in response to electric signals from a control unit C.

[0017] A diaphragm accumulator 34 is connected to supply line 14, between non-return valve 23 and inlet 27 of servovalve 26, by a line 35, which is fitted with a pressure switch 36 for generating an enabling signal when

the pressure along supply line 14 exceeds a predetermined minimum threshold value sufficient to ensure correct operation of system 1.

[0018] Upstream from inlet 27 of servovalve 26, a depressurizing conduit 37 with a calibrated orifice 38 extends from supply line 14; and, upstream from orifice 38, conduit 37 is connected to drain line 29 by a conduit 39 fitted with a hand-operated drain valve 40.

[0019] Downstream from orifice 38, conduit 37 is connected to drain line 29 by two parallel conduits 43, 44. Conduit 43 is fitted with a pressure regulating valve 45 set to open when the inlet pressure reaches a predetermined threshold value; and conduit 44 is fitted with a two-way, two-position, normally-open electric distributor 46 which closes in the presence of an electric enabling signal received from unit C and indicating correct operation of the system.

[0020] Control assembly 9 also comprises a pair of disabling valves 47, which are substantially hydraulically-operated bypass valves, with respective inlets 48 connected by calibrated orifices 49 to respective outlets 30a, 30b of servovalve 26, and respective outlets 50 connected to drain line 29.

[0021] More specifically, each disabling valve 47 comprises a hollow body 53 presenting, at axial end 54, inlet 48 surrounded coaxially by a substantially conical sealing seat 55; and a movable member 56 sliding axially inside body 53. At the opposite axial end 57, body 53 also presents an auxiliary drive inlet 58 connected by a drive conduit 59 to conduit 37 downstream from orifice 38. Member 56 is movable between a closed position in which it cooperates with seat 55, and an open position in which it is detached from seat 55 to hydraulically connect inlet 48 and outlet 50.

[0022] Movable member 56 is pushed into the open position by the elastic force of a spring 60 interposed between member 56 and end 54 of body 53, and is also subjected to hydraulic force in the opening direction, due to the pressure at inlet 48, and to hydraulic force in the closing direction, due to the pressure at drive inlet 58. In use, the resultant of the hydraulic forces is normally opposite and prevails over the elastic force to keep the valve in the closed position.

[0023] Electric distributor 46 and valves 47 define a device 61 for simultaneously depressurizing actuators 3a, 3b, 4a, 4b.

[0024] Finally, control assembly 9 also comprises a two-way, normally-open valve 64 for bypass starting motor pump assembly 8, and which is located along a conduit 63 connecting supply line 14, immediately downstream from filter 24, to drain line 29. Valve 64 comprises a body 65 presenting an inlet 67 and an outlet 68 communicating respectively with supply line 14 and drain line 29; and a ball 69 movable inside body 65 and cooperating in sealing manner with a seat 66 interposed between inlet 67 and outlet 68. Ball 69 is loaded and detached from seat 66 by a spring 70, and is subjected to the resultant of the hydraulic forces exerted by

flow through valve 64; which resultant, as a consequence of the load loss through the valve, tends to push ball 69 against seat 66, and increases in intensity alongside an increase in flow. Spring 70 is so sized that valve 64 switches from open to closed when the flow through it reaches a predetermined threshold value equal to the maximum-displacement flow of pump 12 at close to the rated speed (e.g. 75%) of motor 10.

[0025] System 1 operates as follows.

[0026] Initially, accumulator 34 is discharged; distributor 46 is de-energized and connects supply line 14 to drain line 29; and valve 64 is opened by spring 70.

[0027] When power is supplied to turn on electric motor 10, this operates pumps 12 and 13 connected to it; and pump 12, which is in the maximum-displacement condition, supplies line 14 with a quantity of fluid increasing alongside an increase in the speed of motor 10. Since the pumped fluid is recirculated into tank 7 via distributor 46 and valve 64, the pressure in supply line 14 remains low, and, since the hydraulic resistance of valve 64 is less than that of distributor 46, the fluid pumped by pump 12 flows mainly through valve 64. When, as the speed of the motor increases, the flow through valve 64 reaches the above threshold value, the valve closes, and the pressure along supply line 14 increases to help keep valve 64 closed.

[0028] In the presence of an electric enabling signal from the system control unit, distributor 46 also closes; the supply line is pressurized further; and, servovalve 26 being in the central position, accumulator 34 is charged. This stage continues until the set pressure of the compensator of pump 12 is reached, at which point, the displacement of the pump is reduced to the minimum value required to compensate for leakage of the system and maintain a constant operating pressure.

[0029] In the above description of the start-up transient condition, distributor 46 is assumed to close after valve 64. In actual practice, however, the opposite may occur, with no substantial change in the operation of the system, the only difference being that, in the event distributor 46 closes before valve 64, the flow generated by pump 12 flows entirely through valve 64 and closes it when the above flow threshold value is reached.

[0030] Since motor 10 also powers fixed-displacement pump 13, this also contributes towards the loading torque demanded of the motor. As pump 13, however, operates permanently at low pressure, very little torque is required to operate it, so that motor 10 may be low-load started at all times.

[0031] Under normal operating conditions, when the car is cornering, control unit C of system 1 calculates an optimum or reference angular position of body 2, and supplies servovalve 26 with a control signal as a function of the error between the reference position and the actual angular position of body 2 as detected by sensors on the body; the control signal shifts the slide valve in the required direction from the center position to regulate flow to and from the hydraulic cylinders and rotate

the body; and, as the actual angular position, as detected by the sensors on the body, nears the reference value, the error and consequently the flow regulated by servovalve 26 are gradually reduced, until flow is eventually cut off when the body reaches the required angular position.

[0032] Under normal operating conditions, distributor 46 and pressure regulating valve 45 are closed; and disabling valves 47 are closed by virtue of the drive pressure of the valves being equal to the supply pressure. This is always greater than the pressure of outlets 30a, 30b of servovalve 26, and the resultant of the pressure forces on movable member 56 of disabling valves 47 is always greater than the opening force generated by spring 60.

[0033] During operation, the delivery of pump 12 is filtered by high-pressure filter 24 to ensure clean fluid is supplied to control assembly 9 and cylinders 3a, 3b, 4a, 4b; and filter 16 is fitted to drain line 15 of pump 12, which is the major source of contamination.

[0034] Pump 13 pumps a continuous flow of hydraulic fluid from tank 7 through heat exchanger 32 to dispose of the heat generated by the system.

[0035] In the event of a temporary power failure - e.g. when traveling along a stretch of line with no electricity supply, due to a breakdown or repair or maintenance work - motor pump assembly 8 stops, non-return valve 23 closes, and the part of the system downstream from valve 23 is pressurized by accumulator 34, thus enabling correct operation of the system until the pressurized fluid reserve in accumulator 34 runs out.

[0036] Since pump 12 is idle at this stage, the part of system 1 upstream from non-return valve 23 is depressurized due to internal leakage of the pump; and bypass start valve 64 opens to permit depressurized start-up when electric motor 10 is again supplied.

[0037] To disable system 1, power supply to electric motor 10 is cut off and electric distributor 46 is de-energized; the part of the system upstream from non-return valve 23 is therefore depressurized as described above, and valve 64 opens to prepare the system for the next start-up; and, at the same time, the opening of distributor 46 connects accumulator 34 to drain line 29 to depressurize the system as a whole. More specifically, drive lines 59 of disabling valves 47 are also connected to the drain, so that valves 47 open to drain all four cylinders 3a, 3b, 4a, 4b. The system may be disabled under normal operating conditions, at the end of the duty period, or in the event of a breakdown, e.g. in the event of the slide valve of servovalve 26 jamming, thus ensuring the body is restored to the upright position.

[0038] The advantages of system 1 according to the present invention will be clear from the foregoing description.

[0039] Bypass start valve 64 provides for low-load start-up of electric motor 10 by depressurizing the supply line until the motor reaches a conveniently large percentage of its rated speed; the valve is closed

automatically, thus enabling pressurization of the supply line, in response to an increase in the delivery of the motor pump assembly, with no external electric enabling signal required; and, since valve 64 is opened automatically when the system is disabled at the end of the duty period or in the event of a breakdown, system 1 is made ready at all times for the next low-load start-up of the electric motor.

[0040] Employing low-pressure filter 16 on drain line 15, as opposed to the return line, provides for filtering a small but continuous amount of hydraulic fluid, and so filtering a greater total volume. Moreover, since the drain flow of the pump is the most contaminating, this provides for more effective overall cleaning of the hydraulic fluid using a filter which, being subjected to a small amount of fluid, may be small and lightweight without creating unacceptable counterpressures.

[0041] Using a fixed-displacement, low-pressure, auxiliary pump 13 for circulating the fluid through the heat exchanger provides for effective heat exchange with only a small load on the electric motor.

[0042] Clearly, changes may be made to system 1 as described and illustrated herein without, however, departing from the scope of the present invention.

[0043] In particular, servovalve 26 may be replaced by a proportional solenoid valve.

Claims

1. A hydraulic system (1) for controlling rotation of a railroad car body (2), and comprising:
 - a hydraulic fluid tank (7);
 - a motor pump assembly (8) connected to the tank (7) and to a supply line (14);
 - a number of hydraulic actuators (3a, 4a; 3b, 4b) for exerting mechanical force on the body (2) to rotate it;
 - a solenoid valve (26) for selectively connecting said hydraulic actuators (3a, 4a; 3b, 4b) to the supply line (14) and to a drain (29), in response to electric control signals; and
 - a bypass start valve (64) for depressurizing the supply line (14) during start-up of the motor pump assembly (8);
 characterized in that said bypass start valve (64) is a purely hydraulically operated, normally-open valve, which switches automatically when supply flow from said motor pump assembly (8) reaches a predetermined threshold value.
2. A system as claimed in Claim 1, characterized in that said bypass start valve (64) comprises a shutter member (69) cooperating in sealing manner with a seat (66) to define the closed position of the valve (64); and elastic means (70) for forcing said shutter member (69) into the open position in opposition to

the resultant of the hydraulic forces due to the difference in pressure up- and downstream from said shutter member (69).

3. A system as claimed in Claim 2, characterized in that said shutter member (69) is a ball. 5
4. A system as claimed in one of the foregoing Claims, characterized in that said motor pump assembly (8) comprises a main pump (12) connected to said supply line (14); and an auxiliary pump (13) for circulating hydraulic fluid through a heat exchanger (32); said pumps (12, 13) being driven by a single electric motor (10). 10
5. A system as claimed in Claim 4, characterized in that said main pump (12) is a variable-displacement pump; and said auxiliary pump (13) is a fixed-displacement pump operating at a much lower pressure than the main pump (12). 15
6. A system as claimed in Claim 4 or 5, characterized in that it comprises a low-pressure filter (16) along the drain line (31) of said main pump (12). 20

Patentansprüche

1. Hydraulisches System (1) zum Steuern der Drehung eines Schienenfahrzeugaufbaus (2) umfassend: 25
 - einen Tank für ein hydraulisches Fluid (7);
 - eine mit dem Tank (7) und mit einer Zuleitung (14) verbundene Pumpmotorbaugruppe (8);
 - eine Anzahl hydraulischer Stellantriebe (3a, 4a; 3b, 4b) zum Beaufschlagen des Aufbaus (2) mit einer mechanischen Kraft, um ihn zu drehen; 30
 - ein Sperrventil (26) zum selektiven Verbinden der hydraulischen Stellantriebe (3a, 4a; 3b, 4b) mit der Zuleitung (14) und mit dem Abfluß (29) als Folge elektrischer Steuerungssignale und
 - ein Umgehungsstartventil (64) zum Druckabbau in der Zuleitung (14) während des Startens der Pumpmotorbaugruppe (8) 40

dadurch gekennzeichnet, daß das Umgehungsstartventil (64) ein rein hydraulisch betriebenes, normalerweise geöffnetes Ventil ist, das selbsttätig schaltet, wenn der Zufluß von der Pumpmotorbaugruppe (8) einen vorbestimmten Schwellenwert erreicht. 45
2. System gemäß Anspruch 1, dadurch gekennzeichnet, daß das Umgehungsstartventil (64) ein Schließteil (69), das in abdichtender Art und Weise mit einem Auflageteller (66) zur Festlegung der geschlossenen Stellung des Ventils (64) zusammenwirkt, und elastische Mittel (70) umfaßt, um das 50

Schließteil (69) entgegen dem Resultierenden der hydraulischen Kräfte, die aufgrund der Druckunterschiede oberhalb und unterhalb des Schließteils (69) entstehen, in die geöffnete Stellung zu zwingen.

3. System gemäß Anspruch 2, dadurch gekennzeichnet, daß das Schließteil (69) eine Kugel ist.
4. System gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Pumpmotorbaugruppe (8) eine mit der Zuleitung (14) verbundene Hauptpumpe (12) und eine Hilfspumpe (13) zum Zirkulieren des hydraulischen Fluids durch einen Wärmeaustauscher (32) aufweist, wobei die Pumpen (12, 13) durch einen einzigen Elektromotor (10) angetrieben sind.
5. System gemäß Anspruch 4, dadurch gekennzeichnet, daß die Hauptpumpe (12) eine Pumpe mit variabler Förderleistung und die Hilfspumpe (13) eine Pumpe mit konstanter Förderleistung ist, die mit einem viel geringeren Druck als die Hauptpumpe (12) arbeitet.
6. System gemäß Anspruch 4 oder 5, dadurch gekennzeichnet, daß es einen Tiefdruckfilter (16) entlang der Abflußleitung (31) der Hauptpumpe (12) aufweist. 25

Revendications

1. Système hydraulique (1) pour commander le pivotement d'une caisse de véhicule ferroviaire (2) et comprenant: 30
 - un réservoir de fluide hydraulique (7);
 - un groupe moto-pompe (8) raccordé au réservoir (7) et à une conduite d'alimentation (14);
 - plusieurs actionneurs hydrauliques (3a, 4a; 3b, 4b) destinés à exercer une force mécanique sur la caisse (2) afin de la faire pivoter;
 - une électrovanne (26) destinée à raccorder, de façon sélective, lesdits actionneurs hydrauliques (3a, 4a; 3b, 4b) à la conduite d'alimentation (14) et à un conduit de purge (29), en réponse à des signaux électriques de commande; et
 - une soupape de dérivation au démarrage (64) destinée à relâcher la pression dans la conduite d'alimentation (14) au cours du démarrage du groupe moto-pompe (8); 35

caractérisé en ce que ladite soupape de dérivation au démarrage (64) est une soupape normalement ouverte, à actionnement purement hydraulique, qui se commute automatiquement lorsque le débit d'alimentation délivré par ledit groupe moto-pompe (8) atteint une valeur de 40

seuil prédéterminée.

2. Système selon la revendication 1, caractérisé en ce que ladite soupape de dérivation au démarrage (64) comprend un élément obturateur (69) coopérant, d'une façon étanche, avec un siège (66), afin de définir la position fermée de la soupape (64); et des moyens élastiques (70) destinés à repousser ledit élément obturateur (69) dans la position ouverte, en opposition à la résultante des forces hydrauliques engendrées par la différence des pressions en amont et en aval dudit élément obturateur (69). 5 10
3. Système selon la revendication 2, caractérisé en ce que ledit élément obturateur (69) est une bille. 15
4. Système selon l'une des revendications précédentes, caractérisé en ce que ledit groupe moto-pompe (8) comprend une pompe principale (12), raccordée a ladite conduite d'alimentation (14), et une pompe auxiliaire (13) destinée a faire circuler du fluide hydraulique à travers un échangeur de chaleur (32), lesdites pompes (12, 13) étant entraînées par un seul moteur électrique (10). 20 25
5. Système selon la revendication 4, caractérisé en ce que ladite pompe principale (12) est une pompe à cylindrée variable et ladite pompe auxiliaire (13) est une pompe à cylindrée fixe, fonctionnant à une pression nettement inférieure à celle de la pompe principale (12). 30
6. Système selon la revendication 4 ou 5, caractérisé en ce qu'il comprend un filtre basse pression (16) le long du conduit de purge (15) de ladite pompe principale (12). 35

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