COMBINED SYSTEM DEGASSING WORKING LIQUID AND REFILL PUMP

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The proposed scheme deaerating devices with vacuum working fluid without damage for pump feed.

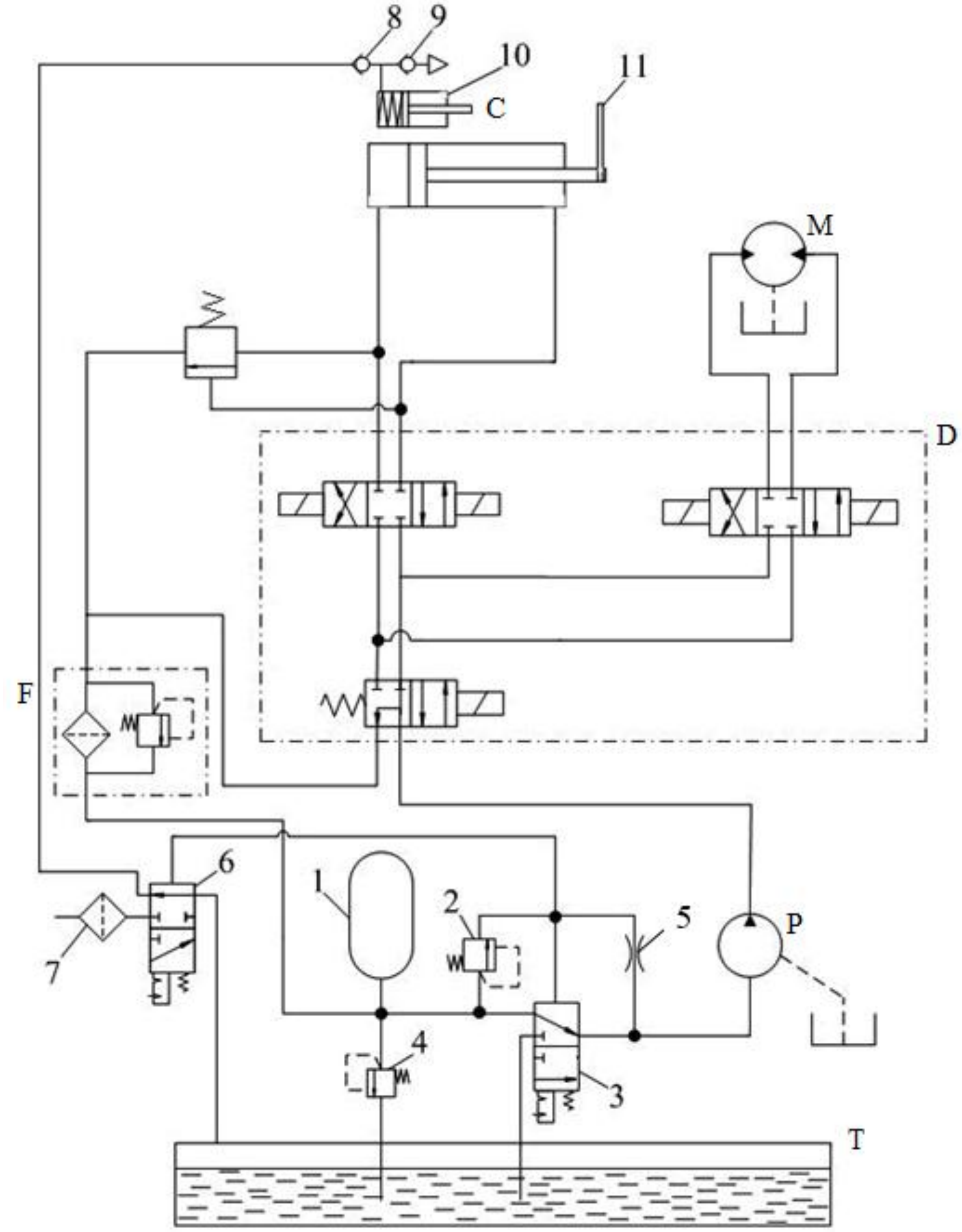
Most modern self-propelled machines of various technological purposes are equipped with a hydraulic drive propulsion or working equipment. Currently, there is a tendency to increase the nominal pressure and power of hydraulic actuators, the cost of fuel and lubricants is constantly increasing. All this imposes new increased requirements on the performance of hydraulic actuators and the service life of the working fluid. It is known that the main factors affecting the performance of hydraulic actuators are: temperature, contamination of the working fluid and the presence of dissolved and undissolved gas phase in it. The presence of gas phase in working fluids is the main cause of their oxidation, the formation of acids, the corrosion of hydraulic equipment, the deterioration of the suction capacity of the pump, cavitation phenomena and the diesel effect. The gas phase in the working fluids is one of the reasons for the intensification of the aging of the working fluid, as a result - the frequent replacement of the working fluid, which ultimately reduces the efficiency and performance of hydraulic machines.

There are a number of ways to degas the working fluid by physical methods, these include: sludge fluid in hydraulic tanks, mechanical destruction of bubbles, filtration, vacuuming, cavitation, centrifugal and other methods. Each of these methods has its drawbacks. The most acceptable way from the point of view of efficiency, low cost and maintenance costs is vacuuming with the installation of the drain pipe closer to the level of the working fluid in the hydraulic tank. We propose a method of significantly reducing the negative effect of the gas phase contained in the working fluid, by applying a closed hydraulic system with an accumulator feed system in combination with a degassing device.

Hydraulics with closed circulation, battery feed and degassing device have several advantages. During the operation of such hydraulic systems in areas with a cold climate, it is particularly possible to highlight the improvement of the pump suction conditions by creating an overpressure at its inlet with a rechargeable battery. The amount of gas phase of the working fluid decreases, the feed coefficient of the main pump increases.

The basis of the refill system will be hydroaccumulator 1, control valve 2, control valve 3, and safety valve 4.

The degassing device consists of a pneumatic distributor 6, an air filter 7, check valves 8 and 9, a pneumatic cylinder 10 as a vacuum pump and a rack 11. Hydraulic systems with working elements in the form of hydraulic cylinders and accumulator charging systems are shown in fig. 1.



T - hydraulic tank, M - hydraulic motor, P - pump, D - distributor, C - hydraulic cylinder, F - filter

Fig.1. Hydraulic system with closed circulation, accumulator feed and degassing device of the working fluid: 1 - hydraulic accumulator, 2 - control valve, 3 - hydraulic valve, 4 - safety valve, 5 - throttle, 6 - pneumatic valve, 7 - air filter, 8, 9 - check valves, 10 - pneumatic cylinder, 11 - rack

The battery 1 is installed on the drain line, which is connected to the suction line of the pump through the valve 3. The valve 3 has two fixed positions. From one end of the distributor spool there is a control cavity connected through a throttle 5 to the suction line of the pump, as well as to the output of the control valve 2 and the control cavity of the pneumatic distributor 6. At the other end, a spring acts on the valve, which, at a certain pressure in the pump suction line, moves the valve to the position corresponding to charging the battery. In this case, the fluid from the control cavity is forced through the choke into the suction line of the pump. At the same time, under the action of the spring, the valve of the pneumatic valve 6 moves to the position in which the hydraulic tank is communicated with the atmosphere through the air filter 7. In this case, a vacuum pressure is created in the piston cavity of the pneumatic cylinder 10 by alternately opening / closing the check valves 8, 9 and the reciprocating motion of the rod of the pneumatic cylinder 10, after which the rod of the pneumatic cylinder 10 remains in the retracted position. Degassing is not carried out.

The system of feed and degassing operates cyclically. At a pressure below the set, the drain line after the battery is blocked by the valve 3, while charging the battery 1, and the pump sucks the fluid from the hydraulic tank. When the pressure in the accumulator 1 increases to a value corresponding to its sufficient charge, the control valve 2 switches the hydraulic distributor 3 and the pneumatic distributor 6. This position of the pneumatic distributor 6 connects the gas chamber of the tank with the pneumatic cylinder 10. During operation of the machine's cylinder rod, reciprocating movement by means of the stand 11 is transferred to the pneumatic cylinder rod, thereby vacuuming the working fluid in the hydraulic tank. As a consequence, there is an intense separation of the gas phase from the working fluid. At the same time, the valve of the hydraulic distributor 3 moves to the position corresponding to the connection of the drain and suction lines of the hydraulic system. The reverse flow of fluid into the hydraulic tank from the suction line is prevented by the check valve or directly by the distributor. Leaks in the system and fluctuations in the flow of the drain are compensated by the battery. With an excessive increase in pressure in the feed system, its value is limited by the safety valve 4. The working fluid enters the hydraulic tank only through the drainage lines of the hydraulic machines and hydraulic equipment. This fluid is a mixture of oil and air, which effectively deaerates the degassing device.

Due to the cyclical nature of the system, degassing does not affect the process of suction of the working fluid by the pump, which will allow to apply more vacuum and thus increase the efficiency of degassing.

The working volume of the battery of the makeup system is determined on the basis of the following expression, m^3:

$$V_b = \Delta V_{hc.max} + \sum V_l,$$

where $\Delta V_{hc.max}$– maximum change in the volume of hydraulic cylinder cavities in the cycle; $\sum V_l$ – total leakage of pumps and motors through drainage lines during the cycle. Thus, when a single operation of each cylinder during the operating cycle, the minimum working volume of the accumulator will be equal to, m^3:

$$V_b = \sum_{i=1}^{n} \frac{\pi d_i^2}{4} l_i + \sum V_l,$$

where n – the number of working cylinders during the full cycle; i - number of the hydraulic cylinder operating in the cycle, d и l – diameter and stroke of the hydraulic cylinder, respectively. Battery charging time when the spool is in neutral is determined as follows:

$$t_{ch} = \frac{V_b}{Q_p - Q_l},$$

where t_{ch} – battery charging time, s; V_b – battery capacity, m^3; Q_p – pump flow rate, m^3/s; Q_l – leakage rate in hydraulic equipment, m^3/s.

When the pressure in the system is lower than the allowable pressure, it will automatically switch to charging mode of the accumulator, while the function of the volume of fluid in the battery when it is charging and subsequent operation taking into account leaks in the pump and idling the hydraulic system, m^3:

$$V_{b.id}(t) = V_b(t)(0 \le t \le t_{ch}) + V_a(t_{ch})(t > t_{ch}) - V_{ут}(t)\big(0 \le t \le t_{cyc}\big),$$

where $V_a(t)$ и $V_l(t)$ – the volume of fluid entering the battery from the pump and the amount of leakage in the hydraulic system during time t, respectively, t_{ch} – battery charging time.

For complex hydraulic duty cycles, the required battery capacity can be determined using the function of changing the fluid volume in the battery during the duty cycle, m^3:

$$V_{b.hc}(t) = V_{b.id}(t) - Q_p \sum_{i=1}^{n} \sum_{j=1}^{m} (1 - c_{i,j}) \Big((t - a_{i,j})(a_{i,j} < t \le b_{i,j}) + \big(b_{i,j} - a_{i,j}\big)\big(b_{i,j} < t \le t_{cyc}\big) \Big),$$

where i – hydraulic cylinder number, j – the sequence number of the inclusion of the i-th cylinder in the cycle, $c_{i,j}$ – parameter of the forward or reverse stroke of the hydraulic cylinder, with the forward stroke of the hydraulic cylinder $c_{i,j} = \psi_i^{-1}$, with the reverse $c_{i,j} = \psi_i$, where $\psi_i = S_p/S_{p.s}$ – the ratio of the areas of the piston in the piston and rod cavities, $a_{i,j}$ и $b_{i,j}$ – the time of the beginning and end of the movement of the rod of the *i*-th hydraulic cylinder during the *j*-th activation, respectively, t_{cyc} – hydraulic drive cycle time. The last formula was obtained under the assumption that the beginning of the working cycle is synchronized with the beginning of the battery charging period. In general, it is possible to unsynchronize the time in the battery charging cycle and the duty cycle, thus obtaining an arbitrary picture of the joint operation of the makeup and hydraulic drive system. Also, when modeling, it is necessary to take into account that the maximum battery capacity is limited structurally and cannot be exceeded.

For hydraulic systems that have hydraulic cylinders with one-sided rods as working bodies, the working volume of the accumulator must be further increased and not fully charged, but taking into account the possible increase in the discharge flow during the return stroke of the hydraulic cylinders according to the operating cycle of the hydraulic drive. If the charging pressure of the charging system is set correctly and the battery volume is not sufficiently charged, the increase in pressure in the charging system above the allowable one can be completely eliminated, which will prevent energy losses when draining the liquid through the safety valve of the refill system.

It is preferable to use rechargeable battery systems in high-pressure hydraulic systems, where compared with low-pressure hydraulic systems with the same power, the pumps will have less power, and therefore a smaller battery is required.

At that time, when the working fluid enters the pump from the refill system, and not from the hydraulic tank, vacuuming occurs, which allows to increase the amount of suction in the hydraulic tank without affecting the suction capacity of the pump. In these schemes, the system does not require intervention in the work of the operator - the process of feeding and degassing occurs automatically. Also in this scheme of feeding there are no mechanical drive and throttling, which will allow more efficient use of drive energy.

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