Ground vehicles hydraulic system pneumatic hydraulic valve

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Abstract. Hydraulic systems equipped with working bodies hydraulic drives are widely used in ground vehicles. The researches show that one of the modern hydraulic drives problems is the destruction of flexible high-pressure hoses and the unauthorized pressure fluid discharge into the atmosphere. The analysis of the machines hydraulic drive protecting existing methods shows that the urgency of their improvement problem remains, since, for most of them the loss is between 3 and 10 l when operating, for example, pneumatic electric protection system - 6 ... 8 l., float protection system is up to 10 l. As can be seen from the analysis, after the protection system locking device actuation leakage of the pressure fluid is preserved. The hydromechanical hydraulic drive protection system is the closest in technical essence and the achieved technical result. However, it also has a disadvantage, for example, when the locking device is actuated a hydraulic shock occurs, and leads to an oscillatory process of the plunger, an increase in the overlap time of the damaged hydraulic line, a decrease in the speed of the locking device and its operational reliability. To eliminate these shortcomings, the authors propose a new technical solution.

The currently regulated working pressure (18-20 MPa) of the machine hydraulic system is accompanied by the pressure fluid volume increase (Figure 1), hydraulic drive power (Figure 2), and the destruction of flexible high-pressure hoses causes unauthorized pressure fluid discharge into the atmosphere.

In case of hydraulic drive malfunction each machine discharges from 46 to 335 liters [1-6] of the pressure fluid into the atmosphere, which causes significant damage to the environmental safety and bioresources irreplaceable loss.

For this reason, when using flexible high-pressure hoses, the further increase in the nominal pressure in the machines’ hydraulic systems is suspended. At the same time, the work on improving the reliability of high-pressure flexible hoses continues [8, 16].

Modern technologies made it possible to create metal-reinforced flexible pipelines, end reinforcement, bodywork basic structures made of high-strength polyester fiber and multi-layer reinforcement, but they are inferior in strength to all metal, and the latter, due to the complexity of highway layout in a multidimensional space, is economically impractical.

Another alternative to control the unauthorized pressure fluid discharge into the atmosphere is to develop ways to protect hydraulic systems [7, 9-15, 17, 18].

The design of the of the hydraulic drive with double overlap protection system locking device, developed and patented by the authors, is the closest to the known methods of the hydraulic drive protecting on the technical essence and the achieved result Figure 3 [19].
Figure 1. The pressure fluid volume in the hydraulic system, depending on the hydraulic drive power:
1 - hydroficated working bodies without taking into account aggregated trailers; 2 - the pressure fluid volume to power the rear hitch without taking into account the aggregated machines; 3 - the pressure fluid volume to power the machines’ hitch attachment and hydroficated working bodies without taking into account the aggregated trailers.

Figure 2. The change in working pressure in the hydraulic system:
1 - “Massey-Ferguson”; 2 - “Ford”; 3 - “MTZ-80 (82)”; 4 - “International-Harvester” 5-trailer K-701; 6 - other basic domestic models of machines; 7 - “John Deere”; 8 - “Deutz”; 9 - FIAT.
Figure 3. Hydraulic drive protection system: 1- pump, 2- hydraulic distributor, 3- hydraulic motor, 4,5,7,8, 24- pressure hydraulic line, 6, 22-discharge line, 9, 12- input cavity, 10- locking device, 11- spring-loaded plunger, 13- groove, 14- radial channel, 15, 23- spring, 16, 17- output cavity, 18- axial bore, 19- hydraulic tank, 20- drain adapter, 21- valve.
**Figure 4.** Hydraulic drive locking device with hydraulic head. 1- hydraulic tank, 2- pump, 3- pressure piping, 4- discharge line, 5- distributor, 6- hydraulic motor, 7- locking device, 8- housing, 9- inlet adapter, 10- outlet adapter, 11- drain adapter, 12- limit stop, 13- plunger, 14- ring groove, 15- radial bores, 16- axial bore, 17- taper-seat, 18- spring-loaded valve, 19- valve cone, 20- valve shoulder, 21,22- spring, 23- pneumonic cell, 24- cap, 25- hemisphere of the limit stop, 26- hemisphere of the cap, 27,28- membrane, 29- threaded joint, 30- plate, 31- ring, 32- pressure-actuated nipple, 33- screw, 34- hydraulic head.
The locking device (Figure 3) is equipped with a spring-loaded valve 21, as well as with a hydraulic head 24 from the pump. A functional purpose and its operational reliability in-depth analysis showed that such a constructive solution does not completely eliminate the hydraulic shock consequences that occur during the locking device actuation, lead to hard the valve 21 work, to the plunger 11 oscillatory process, to a decrease in the locking device operational speed and the damaged hydraulic line overlap reliability.

The patented by the authors (Figure 4) [20] new technical solution, allows to eliminate the mentioned disadvantages. Its design originality is in the fact that a pneumonic cell 23, which absorbs the energy of a hydraulic shock, is installed between the valve 18 and the hydraulic head 34.

The hydraulic drive protection system operates as follows. When a high pressure flexible hose ruptures in the outlet cavity B, the pressure of the pressure fluid decreases and, due to its differential in the cavities A and B, the plunger 13 of the inlet cavity, overcoming the resistance of the spring 21, moves rightwards and meets the valve 18, closes the flow section x. A pressure jump in the cavities A and B is accompanied by a hydraulic shock, which shock wave energy leads to the impact load on the valve 18 cone 19 and plunger 13 bore 16 taper-seat 17, and to the plungers 13 and valve 18 oscillatory process, their mutual repetitive impact loads during the shock wave damping period.

The negative process of hydraulic shock is neutralized by a pneumonic cell 23 located between the plunger 18 and the hydraulic head from the side of the high-pressure piping 3. The cavity D of the pneumonic cell 23, due to the high degree pressure fluid compressibility, absorbs the energy of the shock wave and smoothes the dynamic influence on the plunger 13 axial bore 16 taper-seat 17 and the valve 18 cone 19 contact surface. Specific pressure on the contact belt formed by the surface 17 and 19 when closing valve 18, reduces, which helps to reduce the impact load and, accordingly, the valve wear, and also contributes to the damaged pressure piping reliable overlapping.

Thus, the proposed technical solution in comparison with the prototype, increases the efficiency of the hydraulic drive protection system from unauthorized pressure fluid discharge from the hydraulic system, significantly increases the locking device operational speed, the operational reliability and environmental safety of the machine working bodies hydraulic drive.

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