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WORKING FLUID VOLUME COMPENSATION SYSTEM

Abstract. The article describes a working fluid volume compensation system developed and realized by OBRUM. The problem is presented and a solution is proposed by the author. The principles of the system operation are explained with the help of a block diagram. It discusses the main unit of the system, a patented electrically operated directional valve. The summary characterizes the benefits of using the proposed compensation system.

Keywords: DAGLEZJA group bridges, telescopic actuator, compensation system, MS-20, MS-40

1. INTRODUCTION

In each hydraulic system, there are elements that are essential for its operation by providing a sufficient amount (volume) of the working fluid, usually an oil, in the circuit. These elements include: oil tank, pump,, conduits, valves, manifolds, etc. The oil is forced by the pump to flow from the tank through the conduits (discharge or pressure line) to terminal units, i.e. the final control elements (e.g. actuators). The terminal unit converts the energy of the oil stream into mechanical energy, i.e. the movement of the piston rod of the actuator. The working fluid (oil) is recycled to the tank via another conduit, the return line. In the process of use, depending on the type of the terminal unit, there may be a disturbance in the amount of oil flowing out and flowing in. This situation occurs in the case of MS-40 (DAGLEZJA) bridge, where one of the terminal units is a hydraulic double-acting telescopic actuator.

2. ORIGIN OF THE COMPENSATION SYSTEM

In the OBRUM projects involving the DAGLEZJA bridges, in order to unify the applied solutions, a principle was adopted on the interchangeability of tractor units with built-in tanks of hydraulic systems with connection elements. This principle applies to the MS-20 (DAGLEZJA) bridge on truck chassis and the MS-40 (DAGLEZJA-S) support bridge where, according to the tactical and technical objectives, "the MS-40 bridge tractor units should be interchangeable with the MS-20 bridge tractor unit".

The limited space available on the tractor allows for the installation of a main tank of the hydraulic system with a total capacity of 200 dm^3. The tank of such capacity is sufficient only for the hydraulic system of the DAGLEZJA bridge. The hydraulic system of the DAGLEZJA-S support bridge, on the other hand, is characterized by a much higher demand for the working fluid, which is due to the need for more terminal units and the installation of double-acting hydraulic telescopic actuators with a demand of around 300 dm^3. This is much more than the total capacity of the tank installed on the tractor. Hence the problem of insufficient quantity of hydraulic oil in the tank. Deficient amount of oil in the tank limits the functionality of the DAGLEZJA-S support bridge. In addition, the risk of excessive heating of oil increases. To ensure proper operation of the hydraulic system of the support bridge, the hydraulic system is supplied from an external source. This solution caused a number of inconveniences, and one of

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them required the operator to continuously control the oil level in the tank to ensure uninterrupted operation of the system.

As a result of extensive analytical work, a supplementary hydraulic system has been introduced, which acts as a buffer to eliminate the oil volume difference during the work and return movement of the actuators in the DAGLEZJA-S support bridge laying cycles. In order to satisfy the requirement for interchangeability of tractor units, a working fluid volume compensation system was installed on the trailer frame of this bridge.

2.1 Characteristics of the compensation system

Additional hydraulic system - compensation system mounted on the frame of the trailer of the DAGLEZJA-S bridge-laying vehicle is equipped with its own hydraulic pump drive with integrated overflow valve, which protects the pump against damage after excessive pressure increase. The pump is driven by an electric motor powered by a bank of batteries in the tractor unit.

The main components of the working fluid volume compensation system is shown in Fig. 1.

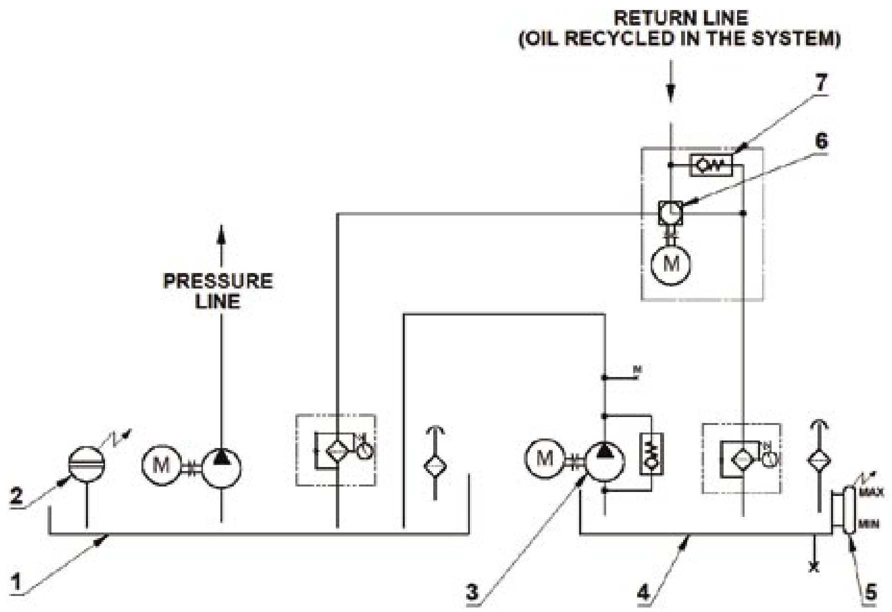

Fig. 1. Block diagram of the compensation system
1-main tank, 2-sensor for continuous level monitoring, 3-additional pump, 4-additional tank, 5-min/max level sensor, 6-electrically operated directional valve, 7-check valve

2.1.1. Operating principle of the system

As shown in fig. 1, when the oil level in the main tank (item 1) falls to the minimum level (below the critical value), which is indicated by the oil level sensor (item 2), the additional pump (item 3) is activated. The pump draws oil from the additional tank (item 4) to replenish the oil in the main tank. At this time, the oil in the return line is fed to the main tank by means of an electrically operated directional valve (item 6). When the oil level in the main tank reaches the optimum value (lower than the maximum), the additional pump is switched off (item 3).

The level of oil in the main tank is continuously monitored by a sensor (item 2). The maximum, minimum and optimum levels can be changed. When the oil level in the main tank reaches the maximum value, the directional valve (item 6) is switched to feed the oil from the return line to the additional tank.

In the event of an electrical failure and after complete filling of the main tank, the check valve (item 7) directs the oil flow to the additional tank. In this way, the main tank is protected against receiving excessive amount of oil, i.e. against overfilling.

In the event of a power failure, it is possible to manually override the directional valve (Fig.1, item 6) and to balance the oil levels in both tanks. If the oil level in the main tank or in the additional tank falls below the minimum, the hydraulic system is deactivated.

3. DIRECTIONAL VALVE

One of the important components of the compensation system is the electrically operated directional valve. This valve has been designed specifically for this system. The valve design (Figs. 1 and 2) being innovative, a patent application has been filed with the Polish Patent Office.

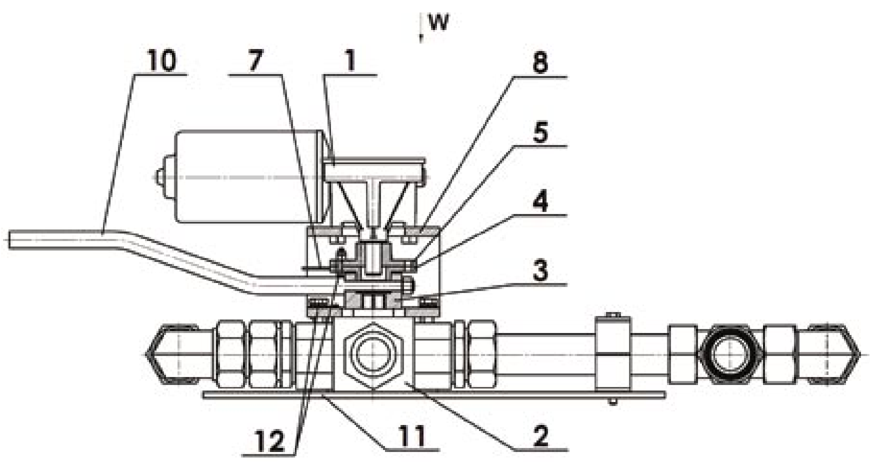

Fig. 2. Directional valve – front view
1-ball valve, 2-gear motor, 3-link, 4-coupling-bottom part, 5-coupling-top part, 6-inductive sensors, 7-disc, 8-bracket, 9-check valve, 10-lever, 11-bracket, 12-fixing bolt, 13-hydraulic connectors

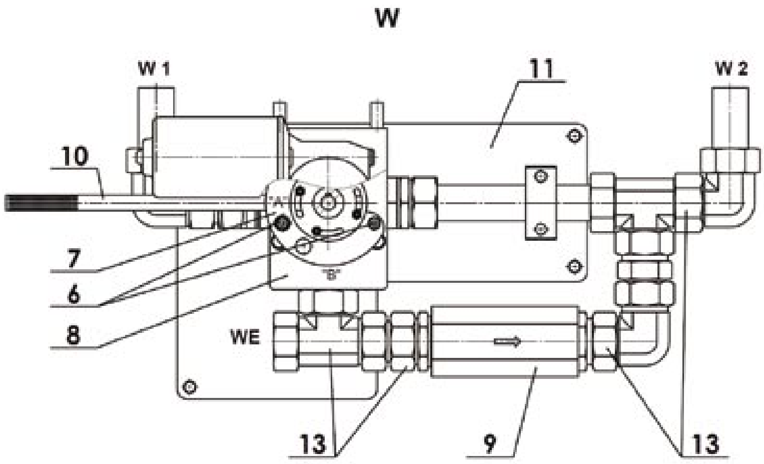

Fig. 3. Directional valve – top view
1-ball valve, 2-gear motor, 3-link, 4-coupling-bottom part, 5-coupling-top part, 6-inductive sensors, 7-disc, 8-bracket, 9-check valve, 10-lever, 11-bracket, 12-fixing bolt, 13-hydraulic connectors

The valve has a lever (item 10) that enables manual override of the valve in the event of a power failure.

The analysis of the characteristics of the flow through directional ball valves shows that the flow through the valve measured from start to end of valve position change (flow in the function of time) is not constant - this is related to pressure drop and change in flow velocity (due to change in the size of the gap through which the working fluid flows). In order to eliminate this phenomenon, i.e. reducing the uneven flow velocity at the moment of ball valve actuation (item 1) and momentary increase of pressure between the inlet and outlets of the directional valve, a check valve (item 9) is installed in series with the directional valve to minimize the pressure increase resulting from the ball valve position change. In addition, the check valve prevents blocking of the flow through the directional valve if the latter is in an intermediate position due to a failure.

4. SUMMARY

The additional working fluid volume compensation system developed by OBRUM was installed on a DAGLEZJA-S support bridge-laying vehicle and has successfully passed functional tests and factory tests. The design of the compensation system enabled increasing the volume of hydraulic oil to meet the current needs resulting from the performed functions (tasks). Eliminating the need to periodically replenish hydraulic oil from an external source minimizes the risk of feeding improper, i.e. insufficient, amount of oil to the hydraulic system, of possible contamination, or of oil overheating during the segmental bridge laying. The presented design of the directional valve is protected by a patent.

The adopted design of the working fluid volume compensation system described in the article provides for full interchangeability of tractor units in MS-20 (DAGLEZJA) and MS-40 (DAGLEZJA-S) bridges.

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