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Method for reducing the gas factor in hydraulic fluids

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Method for reducing the gas factor in hydraulic fluids

A S Lunev, A A Nikitin, A S Kaverzina, A V Novik and V A Kramarenko

Siberian Federal University, 79, Svobodny Avenu, Krasnoyarsk, 660041, Russia

E-mail: Allynev@mail.ru

Abstract. This paper considers technologies for reducing the gas factor in hydraulic fluids used in a hydraulic system. Methods and means of reducing the gas factor include three main groups: gas relief, gas separation, and degasification. The work is important because the gas presence adversely affects the operational performance and dynamics of the all system. Finding the most effective way to reduce the gas factor is of primary importance.

1. Introduction

The hydraulic fluid plays a pivotal role in the hydraulic system, being both an energy carrier and a lubricant. Variable pressures, speeds, and temperatures produce an effect on it. The presence of gas in the hydraulic system adversely affects the operational performance, loading capacity, and dynamics of the system.

Undissolved air increases compliance of fluid drive and contributes to pressure rise retarding in actuating elements that exert a significant impact on the speed of operation of the controlling system. Researches are on dynamic processes of fluid-operated machines. Papers [1-5] give a fuller list of researches on the dynamic processes of fluid-operated machines. Paper [4] shows interdependence between modulus of compression of fluid drive and pressure, however dependence between modulus of compression and gas factor was not taken into consideration.

Figure 1 shows the classification of methods and means of reducing the gas factor in hydraulic fluids used in the hydraulic drives' systems. These methods and means can include three groups depending on the application:

- education of concentrated amounts of gas from the fluid;
- separation and education of gas dispersed in the fluid;
- separation and education of one or another part of the dissolved gas-air component.

According to the purpose, these groups respectively call gas relief, gas separation, and degasification

The problem of reducing the gas factor in hydraulic fluids is relevant to many industries. There are solutions to this problem for energy, chemical, oil, aviation, engineering, and other industries. These industries use the fluid as a working medium for various processes or as ware.

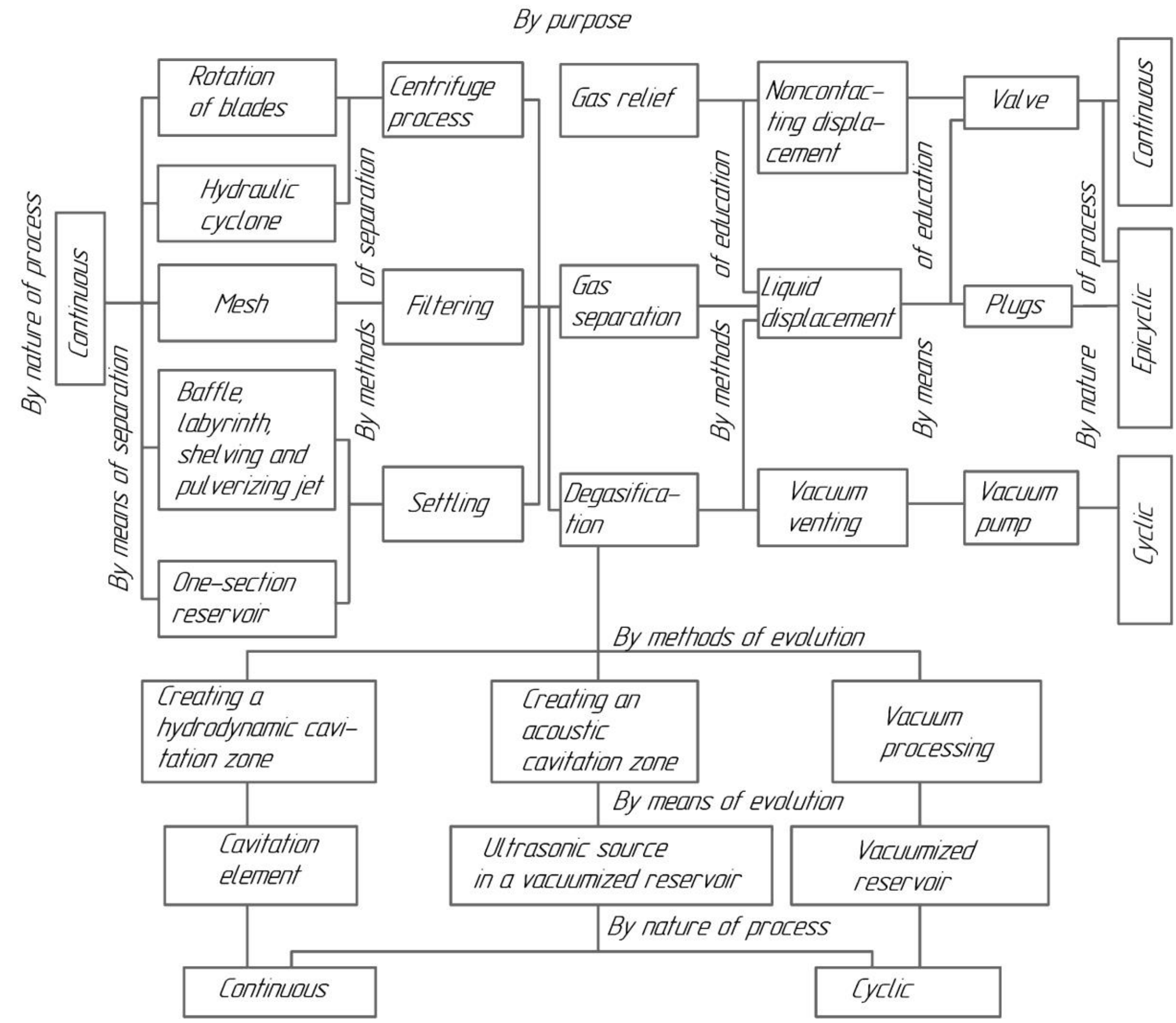

Figure 1. Classification of methods and means of reducing gas factor in hydraulic fluids.

2. Analysis of various methods and means of reducing gas factor

The fluid flow rate increased, its temperature decreases, and the cleaning efficiency decays. The reasons for that are reducing the time of the presence of fluid in the tank and the hoisting velocity of the gas bubble. When the gas factor in the fluid flowing in the tank increases, the cleaning efficiency rises due to the appearance of hydrodynamic coupling between bubbles in motion. At the same time, the hoisting velocity of a group of bubbles is more than twice or third as much as the hoisting velocity of an isolated bubble.

There is a technology that uses fluid drain in the tank by extended surface elements, such as baffles and flanges. It increases the efficiency of gas separation by reducing the time of floating up of gas bubbles. Inflow input can be carried out to these elements by the fluid drain on them, or by spraying. In either case, the thin film layer of fluid flows in the tank, which accelerates the separation of free gas from the fluid [2].

The separation of free gas bubbles grows significantly in intensity by filtration. Using this method, ninety percent or more of the amount of dispersed gas entering the filter element [3, 4] can split away.

In terms of construction, the filtration of bubbles can occur by assembly flat meshy baffles [5] or by connecting a self-supporting filter apparatus with conical meshwork to the drain tube in the hydraulic tank.

The separation of gas bubbles from the fluid can also occur in the field of centrifugal force. The fluid rotational motion generating this field can result from the energy of this fluid or using a rotor with blades driven from a supplementary power source. This rotation of fluid occurs by tangential admission of fluid flow into the gas separation cavity (hydraulic cyclone) [5] or by its admission using a helical port, as [6], at most of the prior art implementing the method of centrifuge process. The efficacy of this type of apparatus depends on the undissolved gas content in the fluid, the flow rate (velocity) of the fluid and its viscosity. Gas content increasing in the fluid, the value of gas separation significantly decreases [5]. An enhancement of the viscosity of the liquid causes an enhancement of the resistance force to the gas bubbles movement in it, the efficiency of gas separation decaying.

Besides, when the viscosity increases, the pressure loss increases significantly on the hydraulic cyclone. Thus, the hydraulic cyclone tests performed on MG-10 oil [7] shows that the increase of oil temperature from 21-23 °C to 40-45 °C causes a decrease in pressure losses from 1.2 MPa to 0.5 MPa. The dependence of the efficiency of centrifugal gas separation on the flow rate and, more precisely, the velocity of the fluid according to the data of works [5, 7] has a maximum. On the one hand, the field centrifugal force enhances with an increase in the velocity of the fluid flow in the hydraulic cyclone. On the other hand, the pressure increases too in the peripheral part and entrance of the hydraulic cyclone. These facts explain dependence. All bubbles could separate from the fluid at its optimal speed. Thus, If velocity is lower than the optimal one, only some of all free gas bubbles can separate. When the velocity is higher than the optimal one, some of the gas bubbles cannot separate due to the size reduction owing to additional compression and dissolving.

Theoretically, it is possible to decay the content of undissolved gas in the hydraulic fluid to zero if the possibility of the existence of transformation of the dissolved gas in the free state. This process occurs in the fluid compression release areas to a pressure lower than dissolved gas bubble point pressure exclude. So the free gas content of the fluid can be zero only if the dissolved gas bubble point pressure is lower than minimum pressure in the hydraulic system. The pressure being usually subatmospheric at fluid compression release areas, it is necessary to separate part of the dissolved gas from the fluid to decay its bubble point pressure to the required value. Only the degasification apparatus can provide. They are part of the third group of means to decay the gas content in the fluid. Means of this group differ from the gas separators considered above in that they maintain a subatmospheric pressure in the gas separation zone, which causes the release of dissolved gas from the liquid.

Gas release zones create in degassing devices by the following methods:

- vacuum degassing of the tank by vacuum venting from it simultaneously part of the hydraulic fluid and the gas escaped from it or only part of the fluid;
- creating a hydrodynamic cavitation zone in flow cavitation elements;
- creating an acoustic cavitation zone using an ultrasonic source that converts the energy of any other kind into the energy of the sound field.

The various electroacoustic transducer and hydrodynamic radiators usually use as an ultrasonic source. The electroacoustic transducer converts electrical energy into vibrational energy of a solid such as a blade, rod that pings acoustic waves into the environment. Hydrodynamic radiators convert the kinetic jet energy of a fluid into the energy of acoustic vibrations [8]. Creating acoustic cavitation in the fluid is usually an expedient method of degasification used with vacuum degassing of the tank to intensify the degassing process.

Some technology differs from the degassing apparatus considered above by only various known means of separation from the degassed fluid of the gas.

Some of the presented degassing means checked on mineral oils. Some parameters of the apparatus [10] and the graph of the process of degasification by it from Hydrol 30 oil give in paper [9]. The results of analytical and experimental studies of the apparatus [12] present in the paper [11].

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However, comparative analysis of the efficiency of degassing apparatus and recommendations on the optimality of their structure and work process-related parameters don't give in these and other papers.

3. Decrease of gas content by installing a pneumatic cylinder in the power supply unit of the hydraulic drive

The power supply unit of the hydraulic drive contains a sealed reservoir with suction and drainpipes connected to the suction and drain hydraulic lines, return valve. The unit has a pneumatic cylinder. Its reciprocating part connects through return valves with the atmosphere and with the sealed reservoir. A fixed member sets on the rod of the hydraulic cylinder and works with the rod of the pneumatic cylinder. The reciprocating part of the pneumatic cylinder has a spring. One end of spring connects with the piston, and another one connects with the end surface of the pneumatic cylinder.

The disadvantages of many similar apparatus are the lack of pipes for gas disposal from the tanks of the power unit of the transport. This gas contains oil vapors that can ignite contacting with the exhaust gas.

Construction of the hydraulic drive [13] with a pneumatic cylinder achieves the goal consisting of the decrease of gas. Figure 2 shows the basic diagram of the power supply unit of the hydraulic drive. The following offers describe of the power supply unit of hydraulic drive.

The power supply unit of the hydraulic drive contains a sealed reservoir 1, suction and drainpipes 2, 3, connected with the suction and drain lines 4, 5. The gas passage 6 connects the top part of the hydraulic tank 1 through the return valve 7 with the piston part of the pneumatic cylinder 9. The piston part of the pneumatic cylinder 9 connects through the return valve 8 with the atmosphere. A fixed member 12 sets at the end of the rod 10 of the hydraulic cylinder 11. It works with the rod 13 of pneumatic cylinder 9. A spring 14 install at the piston part of pneumatic cylinder 9. Any hydraulic cylinder of the pneumatic cylinder machine can use as a hydraulic cylinder 11 of the hydraulic drive.

The power supply unit of the hydraulic drive works as follows.

The hydraulic drive running, the flow of fluid with dissolved and undissolved gases continuously flows from the drain line 5 through the drainpipe 3 to the sealed reservoir 1. The amount of gas intensively separates from the free surface of the fluid in the reservoir 1. The subatmospheric pressure increases in it. Spring 14 extension makes this pressure.

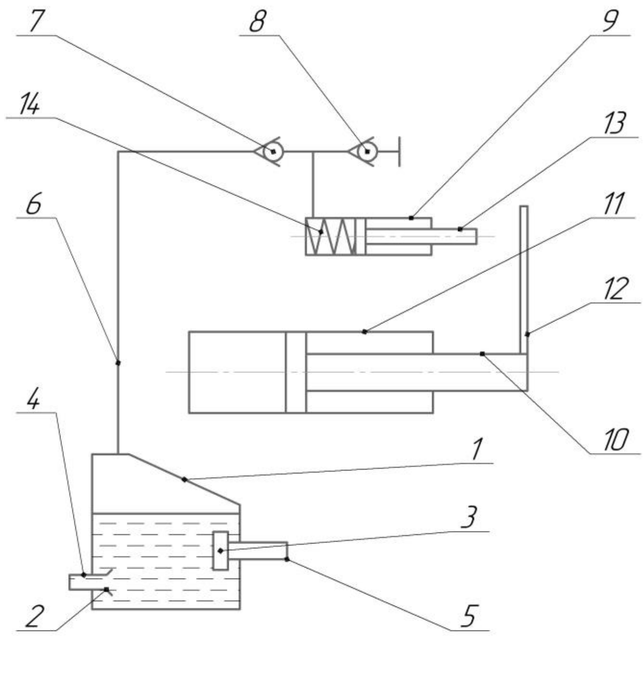

Figure 2. Basic diagram of power supply unit of the hydraulic drive: 1 - sealed reservoir; 2 - suction pipe; 3 - drain pipe; 4 - suction line; 5 - drain line; 6 - gas passage; 7 - return valve; 8 - valve; 9 - pneumatic cylinder; 10 - rod; 11 - hydraulic cylinder; 12 - fixed member; 13 - pneumatic cylinder rod; 14 - spring.

The gas-phase enters from the sealed reservoir 1 through a gas passage 6 and an opened return valve 7 to the head end of the pneumatic cylinder 9. The rod of the working hydraulic cylinder 9 moved in the opposite direction, the fixed member 12 and the rod of the pneumatic cylinder 9 work together. So the gas-phase is compressed in the head end of the pneumatic cylinder. At the same time, the closed return valve 7 prevents the gas-phase from invasion into the reservoir1, and the opened return valve 8 use to degasification of the pneumatic cylinder into the atmosphere.

Thus, the required efficiency of the degasification of the hydraulic fluid, which is not dependent on the oscillation of fluid flow value in the suction line, achieves, especially in a hydraulic drive of self-propelled road construction and agricultural machines characterized by the intense working of hydraulic cylinders.

4. Conclusion

Therefore, the most effective method of decrease the gas content in the hydraulic fluid of hydraulic systems is its degasification. The operating efficiency of it depends on the means that implement it. It has not been comprehensively analyzed yet.

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