Ways to ensure the efficiency and improvement the efficiency of hydraulic machines

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Abstract. In this paper, the methods of designing hydraulic drives with minimal energy losses are considered. As well as ways to reduce energy losses in hydraulic systems. The importance of the work is due to the fact that methods have been proposed to improve the reliability and environmental friendliness of the hydraulic drive.

1. Introduction
The competitiveness of hydraulic drives and their elements is determined by a set of quality indicators and, above all, by efficiency, taking into account the cost of manufacturing and operating costs, reliability and environmental safety. For hydraulic drives of mobile machines, weight and overall dimensions are also important. These indicators determine not only the competitiveness of the developed hydraulic drives in the consumer market, but also their place among other well-known drives (mechanical, electrical, electromechanical, pneumatic, etc.) [1-3].

The economic indicators of a hydraulic drive are mainly determined by its purchase price (price) and operating costs. The first includes the costs of development, manufacture, purchase of components and components, as well as installation and commissioning. Operational costs include energy consumption, as well as maintenance and repair costs.

2. Analysis of various methods of designing hydraulic drives with minimal energy losses
Let's consider the main methods of designing hydraulic drives with minimal energy losses. It should be noted that these methods do not always reduce the cost of equipment, therefore, in each specific case, an analysis of a specific hydrofected equipment is necessary, taking into account its functional purpose.

Application of several pumps operating on one or more hydraulic lines. This mainly applies to a constant-flow pump driven by individual motors or to multi-section pumps (usually gear or sliding-vane) with a through shaft. In this case, the operating mode of each of the pumps can be more precisely coordinated with the operating modes of the actuators. The use of adjustable pumps with a pressure compensator that provide a constant or proportional pressure at the outlet and a supply corresponding to the flow rate of the power fluid (PF) can significantly reduce the power consumption [2].

Application of pumps with a constant working volume and flow regulated by changing the rotation speed of the drive induction motor using frequency converters. This method, which is widely used for regulating the speed of rotation of impeller pumps and fans, has good prospects. The use of this method has become possible due to the rapid development of semiconductor technology, including frequency converters, an increase in the power of frequency-controlled motors and a decrease in the prices of frequency converters.
The use of safety or reduction valves with electric discharge or proportional electric control, which allows you to remotely reconfigure the hydraulic drive to the required operating mode.

Selection of parameters of unregulated pumps with the minimum allowable margin for pressure and supply of PF.

The use of pump-battery hydraulic drives.

3. Ways to reduce energy losses in hydraulic systems

Using the possibility of energy storage. Of the known methods of accumulation, a special place is occupied by the hydropneumatic method based on the use of a pneumatic accumulator. A comparison of its energy characteristics with those of lead-acid batteries indicates its ability to give off more power in a short period of time. The use of such batteries, for example, for the recovery of braking energy of vehicles, allows you to save up to 30% (fuel).

A reasonable choice of pipeline diameters and conditional passages of hydraulic devices, taking into account the permissible hydraulic losses, which are usually taken as a fraction of the pressure in the pressure line. Sometimes it is possible to accurately take into account hydraulic losses only after the design or even testing of a prototype hydraulic drive is completed.

The use of working fluids with a gentle viscosity-temperature dependence. It is clear that when using high-viscosity rye, hydraulic losses in hydraulic lines and hydraulic devices increase, and the use of low-viscosity rye leads to an increase in internal leaks. In recent years, there have been reports of the use of clean water as PF, mainly for environmental reasons. Due to the low viscosity of water (50 times less than the viscosity of mineral oil) energy losses in the hydraulic system are reduced by several tens of percent. For self-propelled machines operating in the conditions of the far north, the task of reducing pressure losses during start-up is relevant, which is usually solved by pre-heating PF, for example, by throttling it through special hydraulic devices. The choice of the most economical type of throttle and its installation scheme for throttle speed control. For a group hydraulic drive, it is preferable to use two-line flow regulators, the cost of which differs little from the cost of throttles with the same conditional passage. In individual hydraulic drives, it is recommended to install a throttle in a branch or use three-line flow regulators that provide parallel removal of excess PF from the constant flow pump and change the working pressure in accordance with the load on the working body. At the same time, it is possible to reuse the drained PF flow to drive low-loaded actuators.

The use of a modular method of mounting hydraulic devices, which allows not only to simplify the manufacture of a hydraulic drive, but also to minimize the number of pipelines and, consequently, pressure losses in them.

Application of economical types of regulation of the supply and pressure of the power source in hydraulic drives with throttle control. For example, the use of the pulse-width modulation method of the control signal significantly increases the efficiency and dynamic accuracy of the hydraulic drive. It becomes possible to exclude distributors with compensation for the influence of the load on the hydraulic motor on the flow-drop characteristics of the spool pair.

4. Improving the reliability and environmental friendliness of the hydraulic drive

Reliability includes the concepts of reliability, durability, maintainability and persistence. The statistical analysis of failures of typical hydraulic throttle control drives is shown in figure 1.
Let's consider the main ways to improve the reliability of hydraulic drives:

Simplifying the structural scheme of the hydraulic drive, reducing the number of system elements, and the connections between them. The use of new highly reliable elements, the high level of reliability of which is confirmed by the results of operational tests. Special attention should be paid to typical "weak links" identified as a result of statistical analysis of failures of similar hydraulic drives.

Standardization and unification of hydraulic drive elements and their components.

Reservation. The main types of redundancy in the development of hydraulic drives: structural, informational, load, energy and functional. With structural redundancy, several elements performing the same function are introduced into the system, with information-additional information for the operation of the logic and computing system, with load redundancy, an increased safety margin of the element is provided, with energy, the use of spare energy sources in case of failures, so the latter is closely related to structural redundancy. Functional redundancy consists in the fact that in case of failure of one of the elements, its functions are transferred to another. Among the listed methods, the most effective is the method of structural redundancy, while the methods of its implementation depend on the purpose, design and operating conditions of the hydraulic drive [4].

The analysis of hydraulic drive failures showed that one of the "weakest links" is the seals of movable joints, and the physical process leading to failure is the thermal aging of rubber parts, so the choice of seals with increased wear resistance is an important task when designing hydraulic devices. One of the most effective ways to increase the reliability of the seal is to reserve the O-rings with the use of drainage of the inter-ring cavity.

The failure of spool devices, which are the most common element of many hydraulic drives, is mainly caused by contamination of the working fluid, which leads to increased friction forces and jamming of the cylindrical spool in the sleeve. A high degree of contamination with solid particles is a consequence of poor filtration. The selection of filters and their installation locations in the system should be carried out during the design process.

When designing a hydraulic drive, it is recommended to provide a diagnostic system that includes the installation of diagnostic information tools, monitoring of technical condition and troubleshooting. To do this, the hydraulic drive must have controllability and controllability. The first is understood as the ability to provide a reliable assessment of the technical condition, as well as the detection of failures and malfunctions. The controllability should be ensured by the design of the hydraulic drive and its technical diagnostics system [5-6].
Reduction of external PF leaks, mainly in hydraulic drives of mobile machines, is achieved by the correct choice of seals.

The use of environmentally friendly liquids and intensive scientific research conducted in this area are associated not only with an increase in a conscious attitude to the environment, but also with stricter laws adopted in a number of countries. Biologically degradable liquids can be divided into two groups. Plant-based rye and synthetic esters. As PF of vegetable origin, for example, rapeseed oil is used, which is obtained from the rapeseed plant culture, which is quite widespread in Europe. The advantage of synthetic esters - their long service life also contributes to environmental safety [7].

Since hydraulic drives are characterized by a high energy density, there is an intensive power exchange in them, and high noise levels occur. In many countries, there are regulatory documents on noise protection, the level of which in the workplace should not exceed 85-90 dB. It is known that noise occurs when high-frequency vibrations are excited in an elastic medium. In hydraulic drives, there are three forms of mechanical, hydrodynamic and aerodynamic vibrations. The first occur in pumps, shut-off and regulating elements of hydraulic devices and other devices. Hydrodynamic fluctuations are caused by wave processes, cavitation and turbulence of the PF, modes of operation of the hydraulic drive and depend on the correct installation of equipment, the presence of water and air in the PF. The sources of aerodynamic vibrations are fans of drive electric motors and air oil coolers. To reduce noise, it is possible to influence the exciting forces in order to reduce their intensity, to limit the propagation of noise through the air [8].

There are various ways to reduce noise in a hydraulic drive. Below are the most effective ways to reduce noise [9-10]:

• reduction of pressure and flow pulsations in pumps;
• the use of sound-proofing coatings;
• the correct choice of conditional passages of hydraulic devices to obtain the recommended fluid flow rates;
• reliable exclusion of the possibility of air entering the suction line of the pump;
• submerged location of the pump in the hydraulic tank;
• application of pumps with built-in electric motors;
• the use of noise dampers;
• the use of frequency-controlled constant-flow pumps.

5. Conclusion
The lack of control over the condition of the equipment, when designing a hydraulic drive, without a diagnostic system, including the installation of diagnostic information tools, monitoring of the technical condition and troubleshooting, reduces the durability of hydraulic equipment and the performance of hydrofected machines.

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