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THE INFLUENCE OF FLUIDS ON THE OPTIMAL OPERATION OF THE HYDRAULIC SYSTEM

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Abstract: This paper indicates the importance of using adequate and high-quality fluid in hydraulic systems. Whether it is simple or more complex systems, the application of the appropriate hydraulic oil plays a decisive role in the optimal functioning of the system. In addition to a quality fluid, there must be a filter in the system, so that the separation of particles from the oil is effective and so that clean oil can circulate through the system again. In some cases, where there are high temperature areas, the installation of an oil cooler is necessary. Also in this work, examples of wear of certain components caused by harmful effects on the fluid, through the oxidation process, will be shown.
Key words: hydraulic systems, fluid.

INTRODUCTION

Hydraulic systems are characterized by the fact that the transmission of energy is carried out by a liquid under a certain pressure. Fluid pressure is evenly distributed on all sides in a closed system. Hydraulic oil is used as the working fluid in hydraulic systems. When it comes to energy transfer, it is necessary to distinguish between hydrostatic and hydrodynamic energy transfer. When the energy acting on the donor cylinder is transferred to the working cylinder by means of a column of liquid, then it is a question of hydrostatic energy transfer, while in hydrodynamic systems the pump produces working pressure which is transferred to the executive components of the system by means of the working fluid (hydraulic oil). These include hydraulic motors and hydraulic cylinders, [6].
The basic function of hydraulic oil is to act as a medium to transmit force from one point to another. In addition, the hydraulic oil must:

- Ensure adequate lubrication,
- Ensure proper sealing,
- Protects the system from rust and corrosion,
- Ensure adequate oil film strength in order to reduce wear,
- Has the ability to quickly settle and separate insoluble particles that enter the system,
- Dissipates heat well,
- It has good viscous-temperature characteristics,
- Compatible with sealing materials,
- It has good oxidation and thermal stability, which ensures a long replacement interval, [6].

The hydraulic fluid belongs to the components of the hydraulic system, in order to be able to fulfill the required functions of the criteria, it must meet the regulations that are defined according to the components of the system itself. At the very beginning of the development of hydraulic systems, the first fluid was water. Its main disadvantage is that it turns into a solid aggregate state at temperatures below 0 °C, forms corrosion on the surface, which indicates a poor lubrication function. After water, emulsions and rapeseed oil were used in hydraulics, but still the problems were not completely solved, but the harmful properties of water as a hydraulic fluid were only mitigated. After refining oil, and obtaining fuel and oil, the use of base oil in hydraulic systems began through the distillation process, [4].
Today there are several types of hydraulic fluids, and they can be divided into:

- Mineral hydraulic oils,
- Synthetic hydraulic oils,
- Plant-based hydraulic oils, [3].

The advantages of mineral oils are reflected in better lubrication ability, protection against corrosion, and can be used in the temperature range from -50 °C to 80 °C, and the disadvantages of mineral oils are large changes in viscosity depending on temperature and separation of resin at high temperatures, [1].
Plant-based hydraulic oils are obtained from renewable sources, such as vegetable oils or animal fats. Although they are environmentally acceptable due to their biodegradability, they still do not have good enough characteristics like mineral or synthetic oils. They are used with natural rubber gaskets, [4].
The efficiency of the hydraulic system largely depends on the properties of the working fluid used in the hydraulic system. The choice of an adequate working fluid has an important influence on the functionality, reliability, service life and economy of the hydraulic system, [3].
The tasks of the working fluid are:

- Energy transfer,
- Cooling,
- Lubrication,
- Sealing,
- Corrosion protection,
- Removal of impurities, [1].

CLEANLINESS OF HYDRAULIC OIL

High-quality hydraulic oil is characterized by high oxidation stability and guarantees a long working life of the fluid, it is incompressible, which means that it provides adequate protection against wear, has good temperature-viscosity characteristics, which is very important for mobile systems, quickly and completely separates water and air, protecting the pump from cavitation, has a low tendency to foam, effectively protects against rust and corrosion, is compatible with standard seals and has good filterability, [7].
Depending on the application, hydraulic oil may also be required to:

- Detergent properties,
- Biodegradability,
- Non-flammability,
- High oil purity due to small gaps in the system and the like, [3].

The use of low-quality hydraulic oils causes the appearance of corrosion, wear, oil degradation and the separation of sediment, contamination, filter blocking and valve clogging, and thus there is an increase in production costs caused by equipment damage, oil degradation and the need for premature replacement, the need for more frequent equipment servicing and the replacement of filters and other worn parts of the system, all of which is accompanied by expensive production stoppages, [8].
Regarding the definition of oil purity, there are several standards. The most frequently mentioned are:

- ISO 4406:2021,
- NAS 1638,
- SAE AS4059, [7].

Table 1. *Classification of oil purity by different standards, [7].*

	Standard designation		
	4406:2021	NAS 1638	SAE AS4059
Oil volumes	1ml	100ml	100ml
Recording in:	3 dimensions	2 dimensions	3 dimensions
Solid particle sizes	>4μm >6μm >14μm	5 - 15 μm 15 - 25 μm 25 - 50 μm 50 - 100 μm >100 μm	4 - 6 μm 6 - 14 μm 14 - 21 μm 21 - 38 μm 38 - 70 μm >70 μm
An example of marking oil purity	19/17/14	8	8

PROCESS OF OXIDATION AND WEAR OF HYDRAULIC SYSTEM COMPONENTS

The oxidation process of hydraulic oil changes its properties. This process is accelerated by increased temperature, the presence of air and sunlight. It has the greatest influence on the viscosity of the oil, and can be monitored by the change in color and smell. As a consequence of the content of solid particles in the oil, wear occurs on the surface of the hydraulic system, where a certain number of new particles are created, which causes more intensive wear of the system. In addition, metal particles have a catalytic effect on oil oxidation, [2].

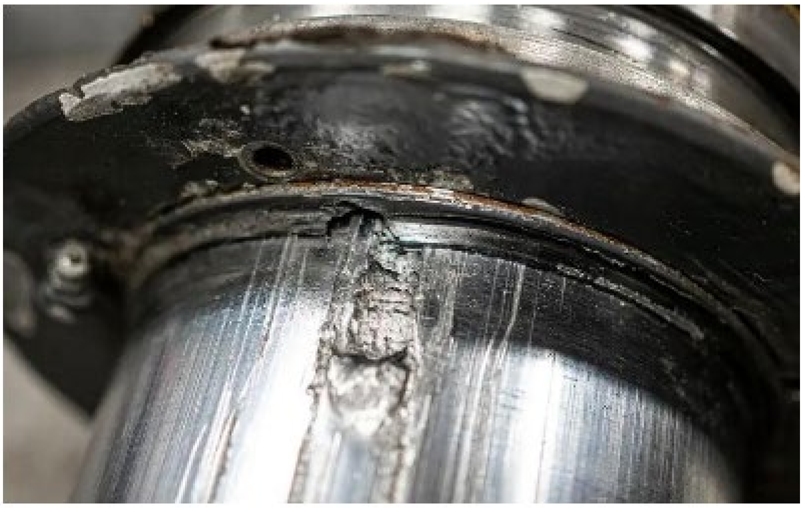

Fig. 1. *Cylinder piston rod exposed to the wear process[7].*

Mixing hydraulic oils is not recommended because hydraulic fluids consist of a base oil that makes up about 90% of the mixture and additives. The base oil can be of different origin, and in order to improve properties such as viscosity, resistance to wear, corrosion, foaming, it is necessary to add different additives to meet the needs of the hydraulic system, [9].
Possible causes of excessive wear of hydraulic system parts are:

- Abrasive substances circulate through the hydraulic oil pump, which means that an appropriate filter should be installed or the oil changed more often,
- Oil viscosity at operating conditions too low,
- Constantly high pressure above the maximum nominal characteristic of the pump, in which case the maximum set value of the safety or control valve should be checked,

- Air in the system worsens lubrication, i.e. increases wear of parts,
- Intensive wear of the sealing plug occurs if the cylinder is not well attached to the frame and vibrates, if the cylinder and connecting rod extension are not adjusted or if there is a large lateral pressure on the connecting rod, [7].

It is generally known that working at high pressures adversely affects the elements of vane pumps, especially when it comes to the stator ring and vanes. At the very beginning of the development of vane pumps, the use of unalloyed oils caused intensive wear of the pump components, and in order to improve the quality of lubrication, additives were added to the oil. Their basic role was to enable work at higher pressures while mitigating the wear process. The additive composition was in most cases based on zinc and phosphorus. The working fluid (oil) has the role of separating the points of contact between the tips of the blades and the surface of the stator. For this purpose, additives intended for operation at high pressure values are added to the oil. However, even the addition of additives did not completely solve the problem of wear of vane pump elements, so the leading pump manufacturers had to work on reducing the load, especially on the contact points in the areas of high mechanical pressure. One of the construction solutions was the production of wings that contain a double contact surface. The availability of newer materials in production has significantly reduced the wear of critical elements of the vane pump, [5].

Fig 2. *Example of vane pump surface wear, [10].*

CONCLUSION

This paper highlights the importance of oil within a hydraulic system. Also, this area indicates the possibility of accelerated development, bearing in mind that at the very beginning of the development of hydraulics, the working fluid was water. After the production of rapeseed oil, oil refining technology contributed to the creation of the fluids we have today. However, some disadvantages still exist due to the different requirements that the working fluid must meet, first of all, work at a wide range of temperature ranges, over the viscosity that should be within the permitted limits in different working conditions, and so on.

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