Main Influencing Factors of Hydraulic Oil Performance for Construction Machinery

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Abstract. The influencing factors of hydraulic oil performance are systematically analyzed, and a technical study is proposed to investigate the selection, use and service life of hydraulic oil by establishing a reasonable comprehensive performance evaluation method of hydraulic oil.

1. Introduction
The hydraulic system of construction machinery uses hydraulic oil as the fluid lubricating medium. Hydraulic oil has good incompressibility and good fluidity. It can not only transmit power but also has six functions of lubrication, cooling, protection, sealing and filterability in hydraulic system.

2. Main Factors Affecting Hydraulic Oil Performance

2.1. Air release and foam resistance
The so-called "air entrainment" caused by the air entering the hydraulic system easily affects the performance of the liquid. The compressibility of hydraulic oil increases, and air bubbles are compressed, which causes the hydraulic cylinder to lag behind and shake, and may cause the working temperature of the system to be too high. When air bubbles enter the hydraulic circuit from the oil tank, the efficiency of the system will be greatly reduced. As the foam does not have the characteristics of hydraulic fluid, it cannot form a continuous oil film on the surface of the components, resulting in excessive wear of the components due to lack of lubrication. In order to avoid this phenomenon, hydraulic fluid must have good air release and foam resistance. Highly refined low viscosity mineral oil is usually selected to meet this requirement, and appropriate amount of anti-foam agent can be added when necessary. However, such additives may not be conducive to the air release ability of hydraulic fluid, and appropriate types and amounts of additives need to be selected to balance this contradiction.
2.2. Viscosity and viscosity index

Viscosity is one of the most important characteristics of hydraulic oil. The hydraulic oil must have a high enough viscosity to ensure that the hydraulic system can be fully lubricated and have a good sealing performance, and to avoid leakage from the gaps of pumps, valves, motors and other components during operation. At the same time, in order to ensure the working efficiency of the hydraulic system, the viscosity of the hydraulic oil must not be too high, so as to avoid unsmooth flow in the system circuit and reduce the mechanical efficiency of the system. Selecting high viscosity hydraulic oil can reduce the leakage in the hydraulic system and ensure the volumetric efficiency of the hydraulic system, but the cooling performance of high viscosity hydraulic oil is lower than that of low viscosity hydraulic oil. Weighing the working efficiency of the hydraulic system [1], the choice of hydraulic oil viscosity is more likely to choose hydraulic oil with low viscosity and high viscosity. In practical application, people often take the guarantee of the lubrication performance of the pump as the reference as the standard for hydraulic oil selection [2].

![Viscosity-Efficiency Trend](image2.png)

**Figure 2.** Viscosity-Efficiency Trend.

![Sticky Finger-Temperature Trend](image3.png)

**Figure 3.** Sticky Finger-Temperature Trend.

Viscosity index reflects the change degree of oil viscosity with temperature. The higher the viscosity index, the less the viscosity is affected by temperature. The hydraulic oil should have high enough viscosity during use to ensure the lubricity of the system, but the high viscosity of the hydraulic oil will easily cause flow obstruction or failure to start at low temperature. The viscosity
index of most hydraulic oils is about 100, but with the expansion of working environment and working temperature range of construction machinery and equipment, the viscosity index of hydraulic oils used may reach 130 or higher [3].

2.3. Wear resistance
An anti-wear additive [4] is present in most hydraulic oils to improve the bearing capacity of hydraulic oils. The anti-wear additive forms a layer of chemical film on the surface of the hydraulic pump when the hydraulic pump operates at high speed, thus protecting the equipment to reduce the degree of wear and prolong the service life.

2.4. Demulsibility (water splitting)
Water often enters the hydraulic system during the working process, and the working temperature of the hydraulic system is generally not more than 60, so water cannot evaporate from the hydraulic oil, which requires that the hydraulic oil must have water separation, i.e. good demulsibility. The presence of other additives such as dispersants and detergents in lubricating oil will also reduce the demulsibility of hydraulic oil.

![Eulsifying phenomenon](image)

**Figure 4.** Eulsifying phenomenon.

2.5. Thermal oxidation resistance
Oxidation resistance determines the service life of hydraulic oil. Under high temperature and high pressure environment, hydraulic oil is prone to oxidation, and its color will darken and thicken, which will be converted into sludge to block the filter. Acid substances generated by oxidation will accelerate equipment corrosion and generate paint films. Anti-oxidation additives are usually added to select hydraulic oil in these systems to slow down the oxidation speed and prolong the service life of hydraulic oil. Sufficient thermal stability of hydraulic oil can reduce high-temperature oxidative deterioration or sludge formation.

![Sludge-time trend chart](image)

**Figure 5.** Sludge-time trend chart.

2.6. Pollution of hydraulic oil [5]
The three major pollutants of hydraulic oil are mainly water, solid particles and mixed oil. According to the source, it can be divided into external and internal. External refers to solid impurities, moisture
and other oils. Internal refers to the pollution caused by the wear of parts and components that move relative to each other during the use of the hydraulic system and changes in the physical and chemical properties of the hydraulic oil, in addition to the pollution caused by the original new oil. According to its invasion mode, it can be divided into three categories:

2.6.1. Potential pollution. Potential pollution also becomes residual pollutants, which are the residual pollutants in components and systems of hydraulic components or parts of hydraulic systems during processing, assembly, testing, storage, transportation, etc. There are mainly casting core sand cores, chips, abrasives, welding slag, rust flakes, paint peeling flakes, rubber flakes, broken ends of cotton fibers, dust, oil for assembly and cleaning (antirust oil, lubricating oil, etc.) and harmful substances such as moisture, which have been lurking in the hydraulic system before it starts working.

2.6.2. Invasion of contaminated. Hydraulic System During installation, storage and transportation, foreign pollutants (such as dust, solid particles, moisture, air, environmental gas, heterogeneous oil, etc.) invade the system, such as oil injected into the system through the oil tank vent and oil filler, air flowing in the oil tank, splashed or condensed water droplets, leaked oil flowing back into the oil tank, pollutants entrained during oil change, etc. invade the system, thus causing pollution.

2.6.3. Regenerative pollution. Regenerative pollution is also called product pollution, which refers to the pollutants produced by hydraulic oil in the working process of hydraulic system. For example, residual rust of parts and particles and fine pieces worn off by metal elements, peeling paint pieces, worn particles and fine pieces of sealing materials, particles or fibers dropped off from filter materials, precipitated asphalt sludge, water leakage from cooler, air sucked into system under negative pressure and environmental corrosive gas, etc.; The products of physical, chemical or biological changes in hydraulic oil can cause metal corrosion to produce particle rust flakes, which can cause regeneration pollution. Hydraulic oil or products of biological changes can cause regeneration pollution such as metal corrosion and particle rust. Under the action of high temperature and high pressure, the hydraulic oil generates pollutants such as oxides and resin grease due to the action of water, air, copper, iron and other media, thus causing pollution.

2.7. Hazards caused by hydraulic oil pollution
Contaminated hydraulic oil will directly affect the performance of hydraulic transmission, such as working reliability, sensitivity, stability, system efficiency and service life. The hazards of different pollutants to the system are as follows:

2.7.1. Harmfulness of solid particles. Solid particles mixed in oil have the greatest harm. When these impurities enter the mating clearance of relative moving parts, they will scratch the mating surface, destroy the accuracy and surface roughness of the mating surface, increase leakage and even cause component failure. Once the damping hole is blocked, the hydraulic components cannot work normally. For example, the moving surfaces of hydraulic pump, hydraulic motor and hydraulic cylinder are worn more seriously, thus increasing leakage, reducing volumetric efficiency, increasing oil temperature and oxidation, and further accelerating deterioration; Some valves, such as directional valves, pressure valves and flow valves, are difficult to wear, jam or move, which can also cause filter clogging, make oil absorption difficult, generate cavitation, and the filter screen even loses its filtering function due to excessive pressure drop and rupture on both sides.

2.7.2. Hazards of water and air. Water in hydraulic oil will emulsify the oil, causing rust spots on the surface of components and deterioration of the oil. Water can also form acid with additives in the oil, thus accelerating corrosion. Mixing air into oil not only increases the compressibility of oil, but also causes noise, cavitation, impact, vibration, crawling, etc. The presence of air in the oil will also destroy the continuity of the oil flow, and even produce "air plugs" in small-diameter pipelines,
hindering the normal operation of the valve. The air in the oil will also accelerate the oxidation of the oil.

3. Conclusion
(1) By analyzing the influencing factors of hydraulic oil performance index, it is the focus of the next step to develop a reasonable comprehensive performance evaluation method for hydraulic oil. It has practical guiding significance for the selection, use and life evaluation of hydraulic oil. Especially for the pollution control and analysis technology of hydraulic oil, it is suggested to specifically analyze the cleanliness test, infrared test, element test, ferrography test, oil membrane filtration test, non-tolerance test, acid value, moisture and other items, and design a test method to form a closed loop control for the analysis and test of in-use oil.

(2) Using fuzzy evaluation method, expert scoring method, analytic hierarchy process, clustering analysis, grey system theory, neural network evaluation method and the comprehensive method of several methods to investigate the comprehensive performance of hydraulic oil, and put forward reasonable suggestions on the use of hydraulic oil.

(3) Strengthen the use and management of hydraulic oil from the selection of base oil and additives and the control of the sources of pollutants to ensure the normal operation of the hydraulic system.

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