European Journal of Emerging Technology and Discoveries
ISSN (E): 2938-3617
Volume 1, Issue 1, April, 2023.

Antifriction Properties of Lubricants and Their Effect on the Viscosity of Oils

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Abstract
In this paper, the antifriction properties of lubricants and their effect on friction forces are considered. The antifriction properties of oils are understood as their ability to reduce the cost of mechanical energy for external friction. The loss of friction energy in a modern piston engine from the indicator power is 6-8% in the cylinder piston group, and 1-2% in bearings. With an increase in the viscosity of the oil, the hydraulic resistance increases, as a result of which the power costs for the oil pump drive increase, the supply decreases and the oil does not flow well to the friction units lubricated under pressure.

Keywords: friction, viscosity, power, wear, mechanical energy, antifriction properties.

Introduction

The antifriction properties of oils are understood as their ability to reduce the cost of mechanical energy for external friction. External friction occurs at the points of contact of solids. It consists in the mechanical interaction of these bodies, preventing their relative movement in the direction lying in the plane of contact.

There is a distinction between rest friction (between stationary bodies) and kinematic friction (between moving bodies).

Depending on the type of movement of one body on the surface of another, kinematic friction is divided into sliding friction and rolling friction. External friction is caused by processes occurring in the surface layers at the interface of bodies in the zones of actual contact.

The friction force depends on the physico-chemical properties of the surface layers located in the depth of the material, it is not explained by the symmetry of the binding forces of atoms on the surface, where particles cannot occupy a position that corresponds to the minimum energy value characteristic of particles located in the volume of matter.

The structure of the surface layers is also affected by the mechanical treatment of the surface, its deformation during friction and as a result of temperature changes.

The force field created by the atoms of the surface layer has a high adsorption capacity, so the ions of the environmental molecule are actively adsorbed on the surface of solids and interact chemically with them (the phenomenon of chemisorption). As a result, the surface is usually covered with films of chemical compounds (usually oxides). Water and gas vapors are adsorbed on the films in the presence of atmospheric air. Ultimately, solids, even in the absence of lubrication, interact with each other during friction by means of films covering their surface,

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and the magnitude of the friction forces depends on the mechanical properties of the solids, the degree of processing of the contacting surfaces and the presence of oxide films on them.
Between the rubbing parts, the coefficient of friction without lubrication is 0.1–0.5. This coefficient decreases with an increase in the hardness of the body and the purity of the surface treatment when oxide films occur and increases with an increase in the duration of contact, reaching a maximum value at rest friction.
When using a lubricant, when direct contact of solids (liquid friction) is excluded, the friction coefficients are equal:
sliding friction coefficients – 0.001÷0.1,
rolling friction coefficients –0.005÷0.1.
In the presence of lubrication, the coefficient of friction of rolling bearings is:
coefficient of friction of a rolling ball bearing – 0.0015;
coefficient of friction of the rolling roller bearing – 0.005÷0,008;
friction coefficient of needle rolling bearing – 0.01.
In engineering, external friction plays a dual role: on the one hand, it creates the possibility of movement of all knee and track devices, as well as for the transmission of forces through friction clutches, belt gears, etc. On the other hand, kinematic friction causes wear andheating of the rubbing parts of the mechanism. Lubricating oils are used in thisconnections to reduce energy costs during sliding friction, reduce the wear rate and heating of parts.
The loss of friction energy in a modern piston engine from engine power is 6÷8% in the cylinder piston group, and 1÷2% in bearings.
In general, the losses are distributed as follows:
the details of the crank mechanism – 60%,
the valve timing mechanism –10%,
the drive of water, oil and fuel pumps – 20%,
the oil mist in the crankcase of the engine -10%.
The antifriction properties of lubricating oils are mainly characterized by viscosity. Viscosity is the property of a liquid to resist the mutual movement of its layers under the influence of an external force, including gravity.
There are dynamic and kinematic viscosity. According to GOST 26098-84, dynamic viscosity is a measure of internal friction (η) equal to the ratio of tangential stress to the shear rate gradient in the laminar flow of a Newtonian fluid:

$$\eta = fx \frac{ds}{du}$$

Where:
fx- the internal friction force of the fluid, equal to the magnitude and inverse to the direction of the force applied from the outside;
ds - the area of the liquid layer to which the force is applied, m^2;
du - the gradient of the shear rate, s^{-1}.
Kinematic viscosity (ν) with dynamic viscosity (η) is related through the density of the liquid at the temperature of the experiment (ρ) by the expression:

$$\nu = \frac{\eta}{\rho}$$

The unit of kinematic viscosity in the SI system is 10^{-4} m^2/s.

At the same time, when choosing an oil of the required viscosity, along with the need to ensure minimal energy consumption for friction and the bearing capacity of the oil layer, pumpability, cooling of parts, the need to seal friction units, as well as cleaning of parts from contamination are taken into account.

With an increase in the viscosity of the oil, the hydraulic resistance increases, as a result of which the power costs for the oil pump drive increase, the supply decreases and the oil does not flow well to the friction units lubricated under pressure. The amount of lubricating oil is especially important during the engine start-up and the start of movement, the higher the viscosity of the engine oil, the more reliable the seal of the cylinder piston group is, for this reason, high viscosity oils are recommended for a worn engine. The higher the viscosity of the oil, the lower its consumption. However, oil of lower viscosity removes heat better and removes contamination and wear products from the friction zone.

When choosing a lubricating oil and using it, knowing the viscosity value at a certain temperature is not enough, it is necessary to know how much the viscosity of the oil changes from temperature, since the actual lubrication mode at different temperatures will depend on this. The specific pressures in the friction nodes have a significant effect on the antifriction properties of oils, since at elevated pressures, the viscosity of the oil changes and the hydrodynamic lubrication regime changes.

The influence of pressure is most strongly affected at low temperatures and in high-viscosity oils. A noticeable increase in the viscosity of the oil is already observed at 5 MPa, and at pressures of 200÷300 MPa increases hundreds of times. At even higher pressures, the oil loses the properties of a liquid and turns into a plastic, and then a solid.

The minimum pressure at which the oil solidifies depends on the nature of the oil and the temperature. The change in oil viscosity from pressure is described by the empirical formula:

$$\nu_p = \nu_0 + 0{,}005\ P,$$

where: ν_p– the viscosity of the oil at a pressure of P, mm^2/s;

P – pressure in the friction nodes, MPa;

ν_0– oil viscosity at atmospheric pressure, mm^2/s

Thus, the operational value of the viscosity of the lubricating oil is ambiguous: to ensure the bearing capacity of the oil layer, sealing parts, reducing consumption, high viscosity oil is required, otherwise lower viscosity oil is preferable.

Therefore, for the lubrication of engines and machinery, an oil of as low viscosity as possible is chosen, but such that it reliably provides liquid friction in the main nodes. The strength of the boundary film increases with increasing viscosity or molecular weight of hydrocarbons.

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ISSN (E): 2938-3617
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