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VISCOUS LUBRICATION

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Viscous lubrication – the most common type of lubricant – its structure, composition, basic properties, as well as advantages and disadvantages are studied in this paper.

Viscous lubrication (greases) is used to reduce friction and wear of those units which cannot be treated by forced oil circulation. Easily penetrating into the contact friction parts, greases hold on the friction surfaces and do not flow down from them, as is the case of oil. Greases are also used as protective or tightening materials.

Viscous lubricants or consistent greases are pasty lubricants produced by introducing solid thickeners in liquid petroleum or synthetic oils and mixtures thereof. Generally, viscous lubricants are colloidal ternary systems containing a dispersion medium (liquid base), discontinuous phase (thickener), and structure modifiers, additives (fillers, additives). Due to the high concentration of colloidal particles greases form a thickener spatial structural framework, where oil is firmly held in its cells. Most viscous lubricants have a fibrous structure. The high degree of structuring of the dispersed phase gives greases elasticity and other useful properties which distinguish them significantly from the liquid lubricants. At low loads or in their absence greases exhibit the properties of solids, do not spread under their own weight, hold on vertical surfaces, and cannot be easily discharged from moving parts by inertial forces. However, at some critical pressure (typically of 0,1 – 0,5, rarely of 2 – 3 kPa) exceeding the tensile strength of the structural frame, the so-called thixotropic transformation takes place: greases get destroyed and begin to deform (to flow) as though plastic body without discontinuities. After removing the load the flow stops, the deformed frame restores itself and greases acquire the properties of solids again.

Oil is a base of lubrication (see below), and the former accounts for 70 – 90% of its weight. Oil properties define the basic properties of the grease.

Thickener creates a lubrication space frame. Simply put, it can be compared with foam, holding oil by its cell. The thickener constitutes from 8 to 20% of the mass of lubricant.

To improve the performance properties of viscous lubricants the following preparations are needed:

• additives are mostly the same as those used in commercial oils (motor oils, transmission oils, etc.); additives constitute oil-soluble surfactants and comprise 0,1 – 5% of the weight of lubricant;

• fillers improve anti-friction and tightening properties; they are solids, usually inorganic, insoluble in oil (molybdenum disulfide, graphite, mica, etc.) constitute 1 – 20% of the weight of lubricant;

• structure modifiers contribute to a more durable and elastic structure lubrication; represent surfactants (acids, alcohols, etc.) constitute 0,1 – 1% of the weight of lubricant.

Assessment of the quality of viscous lubricants includes defining properties that underlie the selection and application of lubricants (e.g. shear strength, minimum load, causing a transition from elastic-plastic deformation to the flow of lubricant). With temperature increase, lubricant generally reduces. The temperature at which the strength limit of material approaches zero, characterizes the upper limit of viscous lubricant performance. Strength assessment is made with a rheometer: shift lubrication is carried out in a special finned capillary under the pressure of thermally expanding fluid. For most viscous lubricants shear strength constitues 0,1 – 1,0 kPa (at 200°C). Lubricant viscosity determines pumpability at low temperatures and the possibility of filling with it friction units. For viscosity measurements capillary viscometers are used. Rheological properties of lubricants, that is their ability to recover from destruction, are characterized by mechanical stability. Mechanical stability – change of the strength of the viscous lubricant during its deformation – is measured with a taximeter.

Penetration is an indicator of the strength of lubricants. The immersion depth of the standard weight cone for 5 seconds in the lubricant, expressed in tenths of millimeters, is called a penetration number. The softer lubricant, the deeper the immersion of the cone in it, and the greater penetration number of the cone. This indicator is used to establish the identity of recipes and compliance with production technology of lubricants. Penetration number of the viscous lubricant is 170 – 420.

Colloidal stability describes the ability of greases to resist oil separation (due to temperature, pressure and other factors, or due to structural changes, such as its own weight) during storage and operation period. Colloid stability of greases is determined by the perfection of their structural frame and viscosity of the dispersion medium: the higher the viscosity of oil, the more difficult it flows out of a lubricant volume. Many industrial lubricants based on low viscosity oils or with a low content of thickeners are not colloidally stable enough. To prevent or reduce oil separation out from the greases, the latter are packed in small containers. Colloid stability is measured by the share of oil (%) in mass of the molded grease at room temperature for 30 min; for viscous lubricant it should not exceed 30% in order to avoid a sharp hardening, violation of its normal admission to the lubricated surfaces and deterioration of viscosity and lubricity.

Chemical stability is a grease resistance to oxidation by atmospheric oxygen (in a broad sense – the absence of changes in the properties of lubricants when exposed to acids, alkalis, etc.). Oxidation leads to the formation and accumulation of oxygenated compounds in lubricants, reducing their strength and deterioration of colloid stability, and other factors. Chemical stability of viscous lubricants can be promoted by careful selection of base oil and thickeners, introduction of antioxidant additives, and technological change in production modes. Resistance to oxidation is particularly important for those lubricants which are tucked in friction units 1-2 times in 10–15 years, operate at a high temperatures in thin layers and contact with ferrous metals. Most methods for determining this index are based on viscous lubricant oxidizability blocked in a thin layer on the surface (glass, steel, copper) at a high temperature, and measured by the induction period and rate of oxygen uptake.

Thermal stability is the ability of lubricants not to change their properties and not reinforce themselves by a short-term exposure to high temperatures. Thermostrengthening hampers the delivery of lubricants to friction units, impairs their adhesive properties. Thermal stability of a viscous lubricant is measured with an instrument called strength meter by changing the limit of the strength before and after it exposure to high temperature.

Volatilization is an indicator of stability of lubricants during storage and use. It depends primarily on the volatility of the oil: the higher the volatility, the lower the chemical stability of the lubricant, and the thinner and larger its surface. Quantitative assessment of volatility of greases is based on measuring the loss of mass (in %) of the sample which is maintained under standard conditions for a specified time at a constant temperature.

Microbiological stability is a resistance to change of lubricant composition and properties under the action of microorganisms. To prevent the microbiological destruction, in lubricants can be introduced microbicides, antiseptics (e.g., salicylic acids, phenols, organic derivatives of *Hg*, *Sn*, etc.) and some additives. This index is evaluated by the absence or growth, for example, fungi on the surface of the grease in Petri dishes or on metal plaques.

Radiation resistance is an indicator of the stability of greases under the influence of high-energy radiation (α- and β-particles, γ-quanta, free electrons). Resistance to radiation of greases is largely determined by the composition of the dispersion medium. Depending on the type of thickeners, greases can acquire "induced" radioactivity. Most easily become radioactive *Na*-greases. Radiation resistance of grease can be assessed by changing its properties after irradiation with certain intensity.

Dropping point is the minimum temperature at which the fall of the first drop of the heated grease occurs; it conventionally characterizes the melting temperature of thickener. Maximum application temperatures of greases are usually taken at 15–200°C lower than the dropping temperatures. However, maximum application temperature does not allow all greases to be properly assessed in respect to their high temperature properties. Thus, the dropping temperatures of *Li*-greases are different from the temperature of the upper limit of their performance at 40–70°C.

To evaluate the anticorrosive properties of greases, metal plate was immersed therein at high temperature depending on the dropping temperature. About the aggressiveness of lubricants can be judged by a change in state of the surface of the plate. Antiwear properties of a viscous lubricant are defined with a four-ball wear test machine. Limit values of wear beads are set depending on the purpose of greases and their operating conditions. Protection (conservation) properties of a viscous lubricant can be evaluated when it deposited on a metal plate and exposed to high humidity and temperature, fog and other corrosives. The evaluation of properties of viscous lubricants also includes determination of water content, the free acids and alkalis therein.

The advantages include their ability to hold on surfaces, not to leak and not to be squeezed out of the unsealed friction nodes, as well as wider temperature operating range than that of oil. These advantages allow to simplify the design of friction units and, therefore, to reduce their metal content and cost. Some grease has good sealing ability and good conservation properties.

The main drawbacks of greases are confining in them the products of mechanical retention and corrosion, which increases the rate of destruction of the rubbing surfaces, and poor heat transfer from the lubricated parts.

A favorable combination of properties of liquids and solids in viscous lubricants can be used in a variety of friction units: open, unsealed, hard-to-reach, angled toward the horizon, and operating in a wide range of temperatures and speeds. Viscous lubricants operate effectively in a vacuum; in the mechanisms, where greases can be rarely changed; in media in which there is a need of specific environmental precautions in respect; in situations of forced contact with water, etc.

REFERENCES

1. Pshibilski, V.V. Technology of superficial plastic treatment / V.V. Pshibilski. – M.: Metallurgy, 1991. – 479 p.
2. Livshitz, L.S. Physical metallurgy of welding and heat treatment of the weld-fabricated connections / L.S Livshi, A.H. Hakimov. – the 2nd publ., reused and added. – M.: Engineer, 1989. – 336 p.