National Aviation University

RESEARCH OF TRIBOTECHNICAL CHARACTERISTICS OF MODERN AVIATION OILS

Performed

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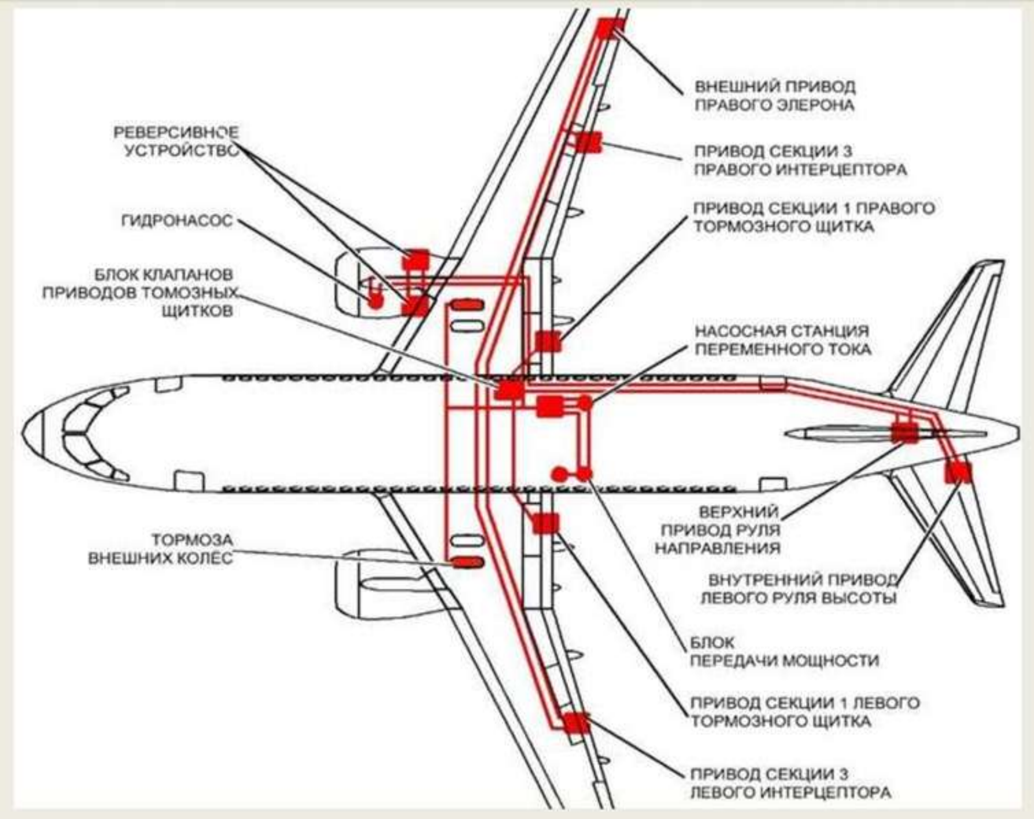
INTRODUCTION

Routes to increase the wear resistance of triboconjuction elements are based on modification of contact surfaces via selecting lubricant compositions and finding optimal operating modes for friction pairs. An important factor in ensuring a high efficiency of friction units is a high-quality choice of lubricants with high lubricating, antifriction and antiwear characteristics.

Among various producers of commercial oil batches, it is important to choose a lubricant that meets not only required physical and chemical characteristics, but also has effective tribological properties. However, tribological indicators have not yet been standardized for a wide range of lubricants. Therefore, the development of methods for evaluating the quality of lubricants in tribological contact is an important area of research, the results of which can make it possible to provide valuable recommendations on oil workabity in certain operation modes.



The aviation hydraulic system is designed to control the mechanisms and systems responsible for flight safety. Its durability, operational survivability and reliability provide perfection of the design of units. Aviation hydraulic systems include forced hydraulic pumps. Ensuring their efficiency requires a high level of tribological properties of oils.

In particular, oils for aviation hydraulic systems must have an optimal level of viscosity, high viscosity-temperature properties in a wide temperature range and resistance to oxidation and foam formation. Oils must also have a sufficient level of tribological characteristics and be compatible with the structural and sealing materials of the components and units of the hydraulic system. A reduced viscosity of hydraulic oils causes the most intense manifestation of fatigue wear of the contacting parts of the hydraulic system. An increased viscosity significantly increases the mechanical losses of the drive, complicates the relative movement of pump parts and valves as well as makes it impossible for hydraulic systems to operate at low temperatures.

OBJECTS OF RESEARCH AND EXPERIMENTAL CONDITIONS

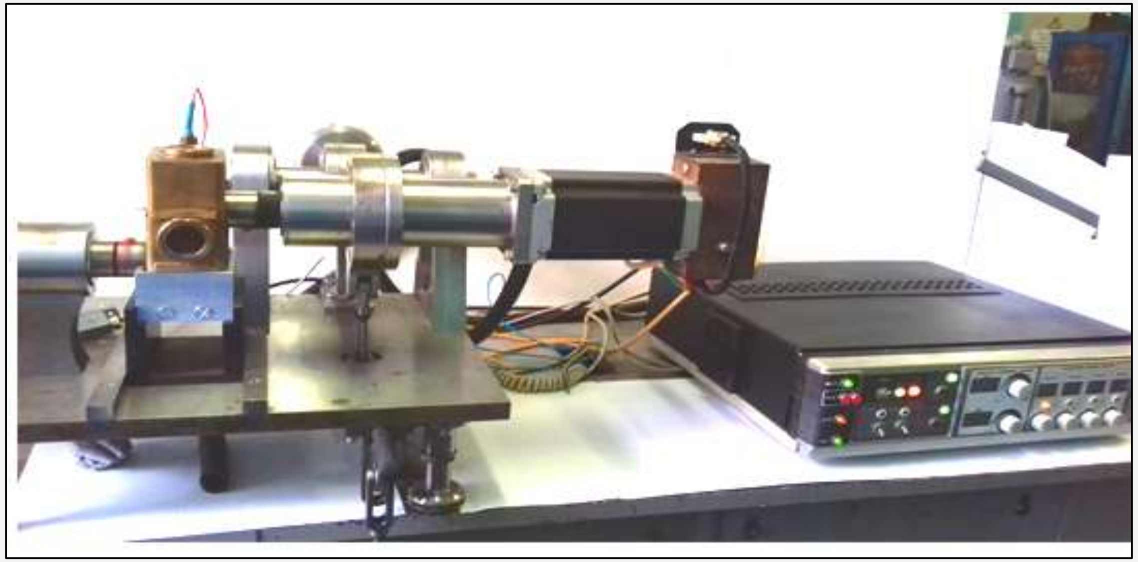


Fig. 1. Device for evaluation of tribological characteristics of triboelements

Oils to be studied:

- Sample 1 is oil "Bora B" AMG-10 according to TU U 19.2-38474081-010: 2016 with change 1 (produced by the LLC “Bora B”, Ukraine);

- Sample 2 is oil AMG-10 according to GOST 6794-75 with changes 1 - 5 (produced by the LLC “NPP Kvalitet”).

The study of the samples was carried out on a software-hardware complex to evaluate the tribological characteristics of triboelements (Fig. 1), for which a special software had been developed for stepper motor control and online visual evaluation of the kinetics of changes in the main tribological parameters of tribocontact.

Work of gears in the conditions of rolling with sliding was modeled using the software-hardware complex by means of a roller analogy. Testing was conducted in nonstationary conditions, which provide for the cyclicity of repetition in the start-up – stationary operation – braking – stop mode (Fig. 2). The total duration of the cycle was 80 s.

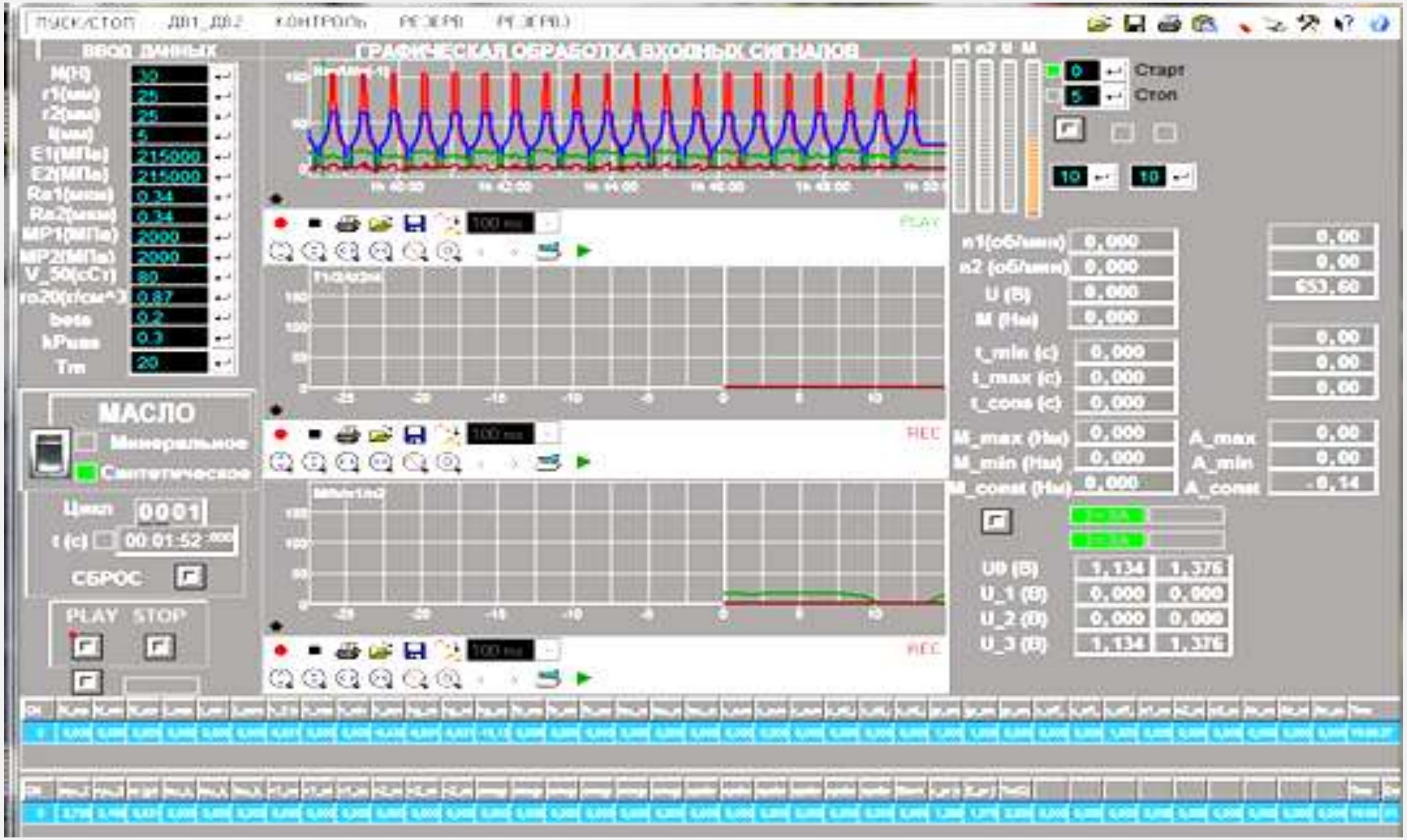


Fig. 2. Interface of subprogram for data processing during tribosystem operation in nonstationary friction conditions

ANALYSIS OF THE MAIN RESULTS

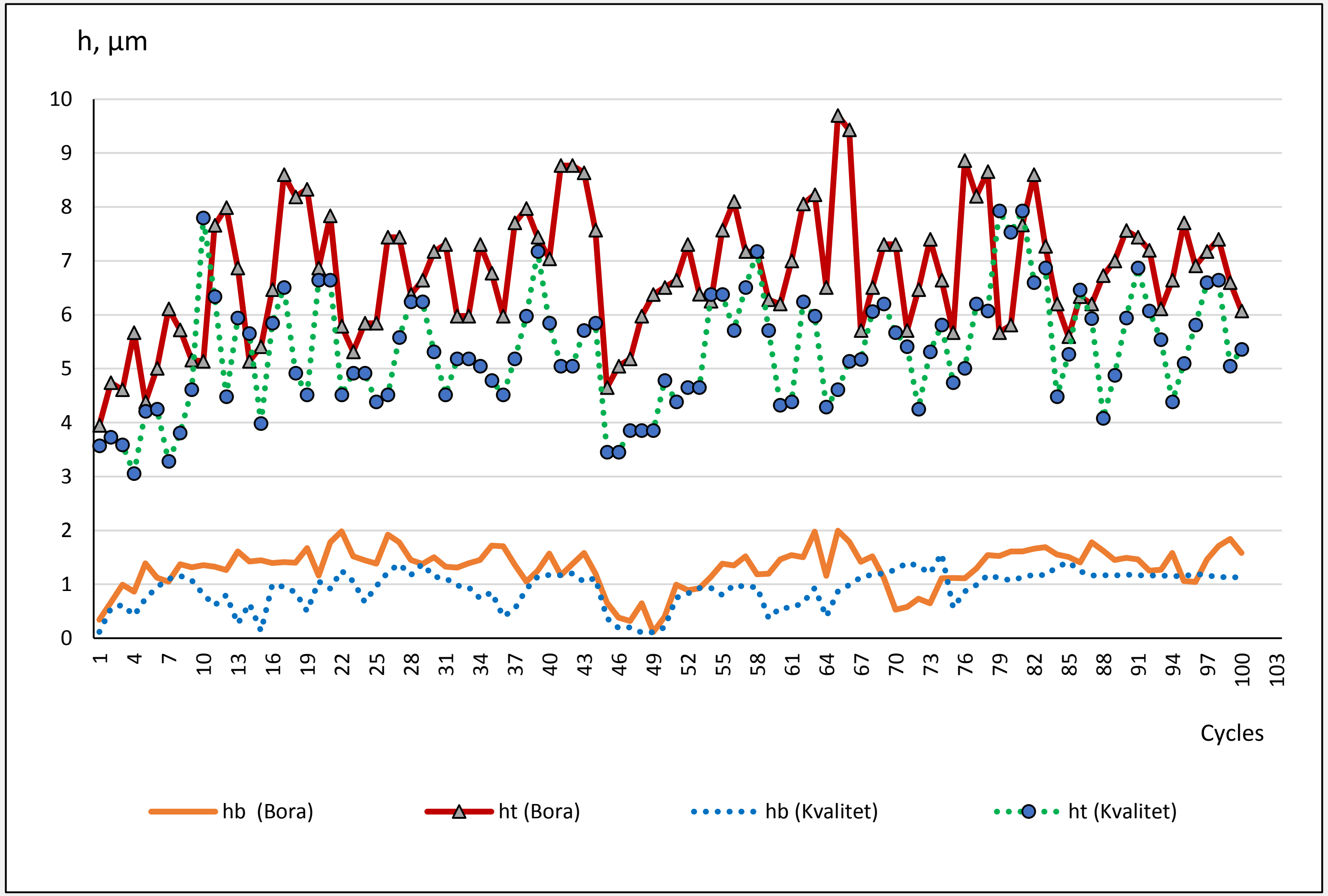


Fig. 3. The kinetics of change in the thickness of the boundary adsorption layers (h_b) and the total thickness of the lubricating layer (h_t) in the contact in the course of operation

The investigated oil "Bora B" AMG-10 (Sample 1) is characterized by effective lubricating properties both during start-up and at the maximum rotation speed (Fig. 3). With increasing temperature in the tribological contact there is observed a decrease in the thickness of boundary adsorption layers due to changes in their nature: boundary layers of predominantly physical nature are replaced by boundary layers of chemical nature characterized by more effective antiwear properties.

At start-up, a mixed lubrication mode dominates regardless of the lubricant temperature, which indicates the effective starting properties of Sample 1 (Fig. 4).

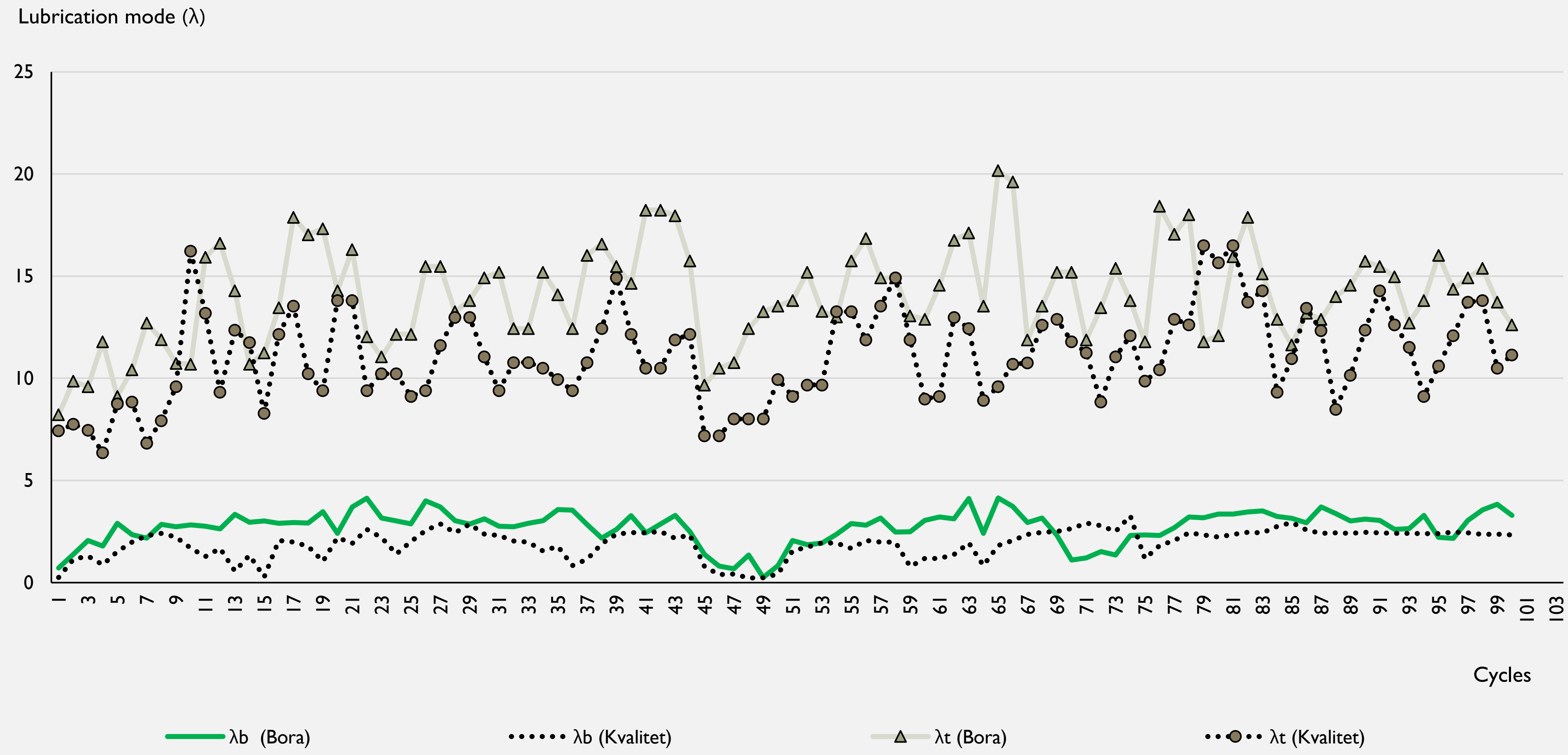


Fig. 4. The kinetics of change in lubrication modes in tribological contact (Classification of lubrication modes by λ: semidry (λ = 0…1); boundary (λ = 1…1.5); mixed (λ = 1.5…3); elastic-hydrodynamic (contact-hydrodynamic) (λ = 3…4); hydrodynamic (λ ≥ 4))

Despite the high shear rate gradients in the contact lubricating layer, from $5.63 \cdot 10^3$ to $5.73 \cdot 10^5$ s^{-1}, which occur at a maximum sliding speed of 0.71 m/s in the conditions of rolling with sliding, the lubricant is characterized by effective viscosity, on average, 4249 and 5039 Pa·s at a volumetric oil temperature of 20 and 100 ^{0}C, respectively (Fig. 5). This indicates good resistance of the oil components to destruction under conditions of increasing shear rate gradient.

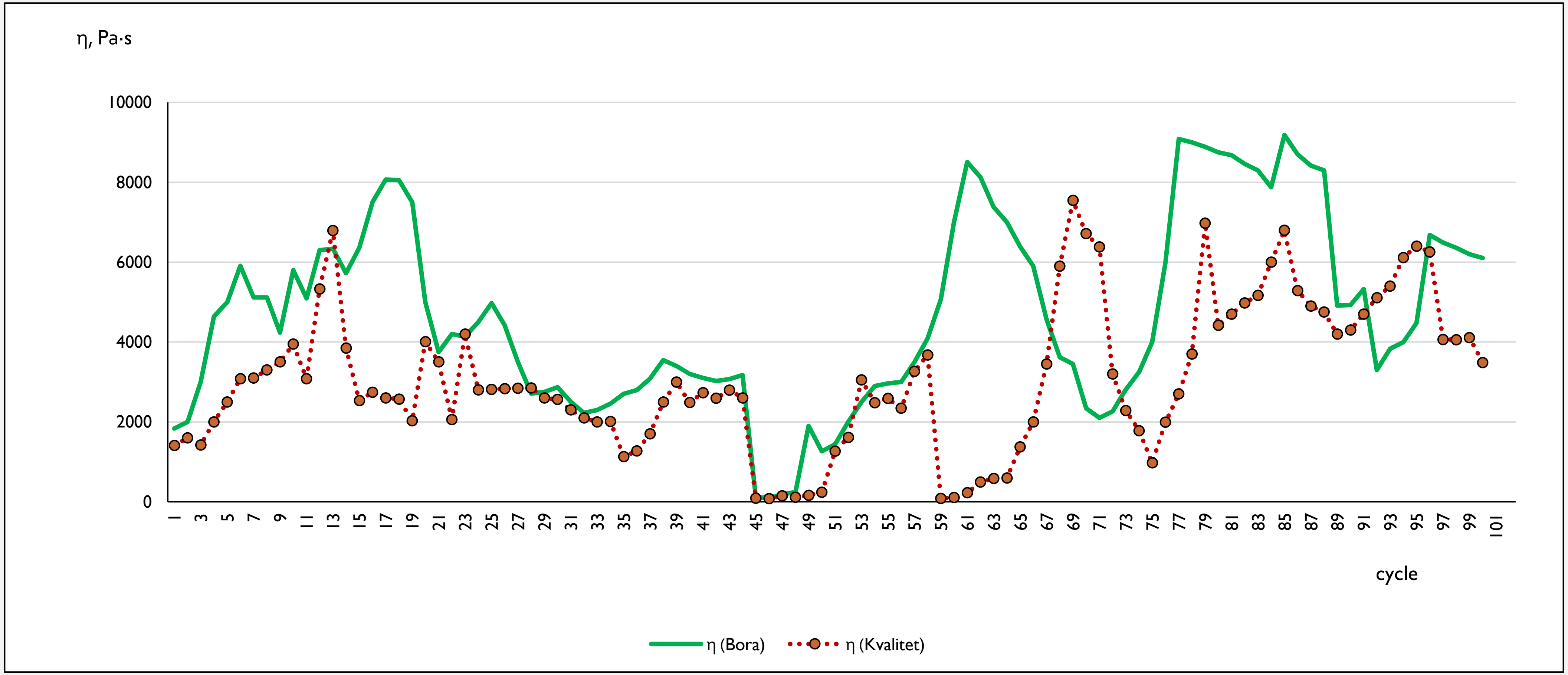


Fig. 5. The kinetics of change in the effective viscosity (η) of oils in the contact

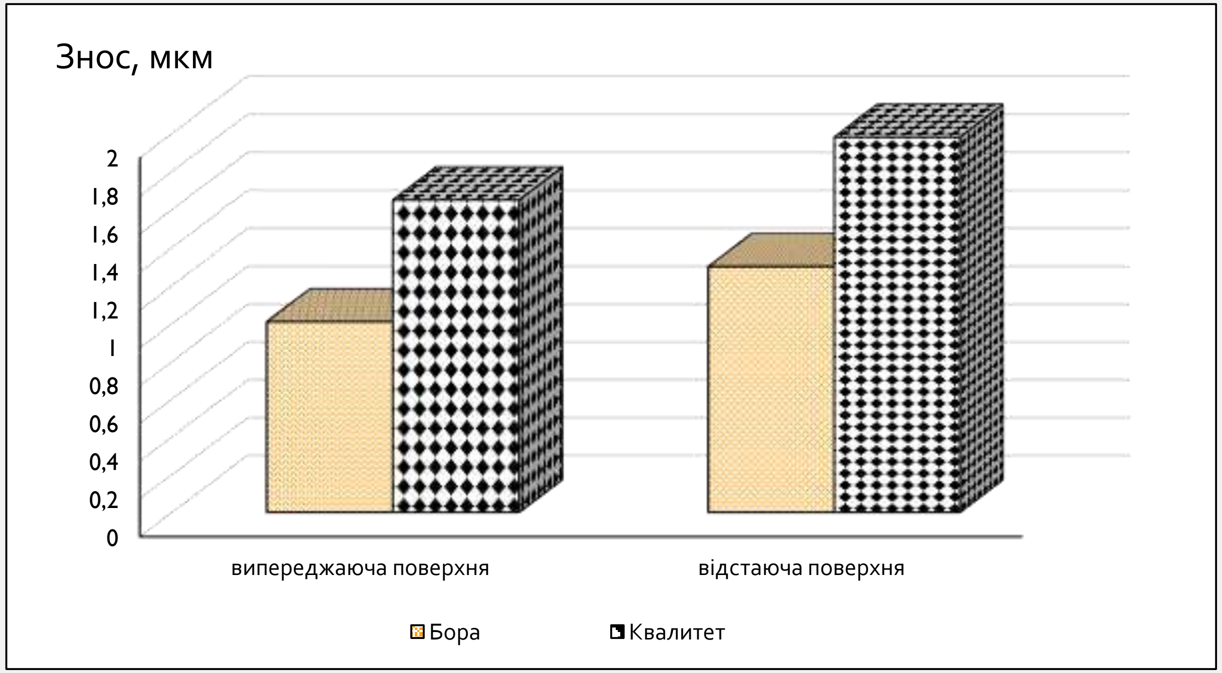


Fig.6 Wear of contact surfaces during operation (reduction of the parameter has a positive effect on the operation of friction pairs).

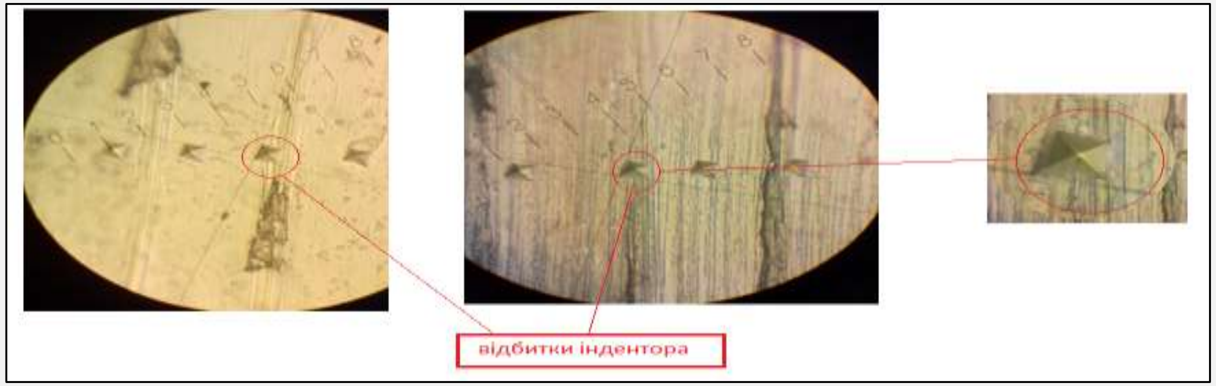


Fig.7 Photos of measuring the diagonal of the indenter imprint when calculating the microhardness

Analysis of changes in microhardness of the surface layers of steel 30KhHSA after 100 cycles revealed the dependence of this parameter on the type of test material. When using Sample 1 as a lubricant, strengthening of both leading and lagging surfaces was fixed. In particular, microhardness of the surface layers of the metal was increased by 512 and 517 MPa for the leading and lagging surfaces, respectively. In the case of using Sample 2, the leading surface of the metal was softened (decrease in microhardness upon testing was 696 MPa), while the lagging surface was strengthened (increase in microhardness was 444 MPa).

CONCLUSIONS

Sample 1 of oil "Bora B" AMG-10 (production: LLC "Bora B", TU U 19.2-38474081-010: 2016 with change 1) is characterized by more effective lubricating and rheological characteristics in nonstationary conditions of friction in the rolling with 30% sliding mode as compared to Sample 2 of AMG-10 oil (production: LLC NPP Kvalitet, GOST 6794-75 with changes1 - 5) according to the following criteria.

1. With Sample 1, there was not fixed any failure of the lubricating layer during start-up and direct metal contact of the friction surfaces. A semidry lubrication mode was only for a short time, during the periods of running-in and initial temperature rise. At start-up, regardless of the temperature of the lubricant, a mixed lubrication mode dominates, while at the maximum rotation speeds of the investigated samples a hydrodynamic lubrication mode dominates.

2. At a volumetric oil temperature of 20 and 100 ^{0}C, the thickness of boundary adsorption layers is 1.44 times that for Sample 2.

3. Sample 1 is characterized by low shear stresses, on average 9.4 MPa, regardless of oil temperature, and high effective viscosity, on average, 4249 and 5039 Pa·s at volumetric oil temperature 20 and 100 ^{0}C, respectively.

4. Additives present in “Bora B” AMG-10 oil (Sample 1) are characterized by more effective antiwear properties and increase wear resistance of contact surfaces in the conditions of rolling with sliding due to strengthening of surface layers of metal during operation, while in Sample 2 hardening-softening processes have been established, which cause a decrease in wear resistance of friction pairs.

THANK YOU FOR YOUR ATTENTION!