DESIGN AND EXPERIMENTAL TESTING OF AN INSTRUMENT TO EVALUATE THE WEAR RESISTANCE OF PARTS OF TRANSPORTATION EQUIPMENT

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Calculations are performed to determine the parameters for the adjustment of a friction dilatometer with allowance for local contact strains caused by impact against structural elements of the instrument. An analysis of the results of the calculations is used as a basis for proposing a method of adjusting it for specific test conditions. Experimental data is presented that demonstrates the feasibility of using the instrument to measure the linear wear of high-strength contacts.

Experience in the operation of different types of transportation equipment shows that the overwhelming majority of failures are attributable to mechanical systems. Approximately 85% of these failures are in turn connected to some extent with the wear of equipment parts. The failures lead to significant material losses from the work required to restore the parts to working order during scheduled and unscheduled repairs and servicing [1, 2]. One of the most effective methods of increasing the tribological reliability (wear resistance) of these parts is to conduct objective laboratory wear tests of the materials used to make them.

The accuracy of evaluations of the wear of rubbing parts can be improved significantly only by using an instrument designed especially for this purpose — the friction dilatometer [3, 4]. However, this instrument can be efficiently used only if it is properly adjusted and controlled. A simplified diagram of a friction dilatometer is shown in Fig. 1.

Information on the dilatation of the tribometric system is sent along a circuit that includes the following components: test specimen 8, 9; specimen holder 7; rod 5 with lateral stop 10; main rod 2; linear displacement sensor 1; amplifier, recorder, computer (not shown in Fig. 1). One of the main components is the device used to adjust the measurement circuit. It consists of parts 1, 2, 11, and 12 and is installed in the instrument's housing 4. With rotation of the abradant 9, which interacts with the specimen 8, the displacements caused by wear, thermal expansion, and radial vibration of the parts of the measurement system are transmitted to the adjustment device. A change in the working gap \( \delta \) between the stop 10 and the adjustment screw 11 reduces the effect of the radial vibrations on the accuracy of evaluation of the linear wear of the tribomechanical systems that are tested.

In adjusting the instrument for testing specific parts, it is necessary to optimize the force that tightens the friction clutches 3, 6, and the working gap in the adjustment device \( \delta \) for the specified test conditions.

The force which tightens the clutches 3 should be such that the movement of parts 1, 2, 11, and 12 does not continue after they are acted upon by the lateral stop 10 (such movement is possible if the stop is moved downward). If we ignore the compression of bodies 10 and 11, then the equation of motion of the adjustment device can be represented in the form

\[
m_1 a = F_{st} + m_1 g - F_{fr1},
\]

where \( m_1 \) is the mass of the adjustment device (\( m_1 = 0.1256 \) kg in the PCLW-01 dilatometer); \( a \) is the acceleration of points of the device; \( F_{st} \) is the force of interaction between the stop 10 and the screw 11; \( F_{fr1} \) is the total frictional force between the clutches 3 and the rod 2.

In the absence of relative displacements of components 6 and 5, the law of motion of the points of contact of bodies 10 and 11 can be written in the form

Fig. 1. Simplified diagram of friction dilatometer PCLW-01: 1) inductive transducer; 2) main rod; 3, 6) friction clutches; 4) housing; 5) rod; 7) specimen holder; 8) specimen (bushing); 9) abradant (shaft); 10) lateral stop; 11) adjustment screw; 12) lateral clamp.

\[ y = \frac{\delta_0}{2} \sin \omega t, \]

where \( \delta_0 \) is the radial vibration of the parts of the measurement system; \( \omega \) is the angular velocity of the abradant.

Since \( a = \ddot{y} = -\frac{\delta_0 \omega^2}{2} \sin \omega t \), it follows from Eq. (1) that

\[ F_{fr1} = F_{st} + m_1 g + m_1 \frac{\delta_0 \omega^2}{2} \sin \omega t. \]

The minimum theoretical value of friction corresponds to the moment the parts separate from one another, when \( F_{st} = 0 \) and \( \sin \omega t = 1 \):

\[ F_{fr \, min} = m_1 \left( g + \frac{\delta_0 \omega^2}{2} \right). \]

(2)

To determine the optimum values for the working gap \( \delta \) and the force on the clutches 6, we will examine the combined upward motion of the stop and the adjustment device. The equation of motion of bodies 1, 2, 11, and 12 (adjustment device) takes the form

\[ m_2 a = F_r - F_{fr \, min} - m_2 g. \]

(3)

The dynamic effects connected with the impact of the stop 10 against the lower part of rod 2 can be determined with allowance for the extent of deformation of the bodies in the contact region. At impact velocities lower than 1 m/sec, it can be assumed with a high degree of accuracy [5] that the contact force obeys Hertz' law

\[ F_k = k \alpha^{2/3}. \]