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Abstract

Lubricants are either design materials or additional means for metalworking. In the first case, the lubricants should reduce friction and wear of working machines parts. In the second case, they should improve the machinability of the part material when machining this part by cutting or grinding. The paper studies the features of the solid lubricants based on stearic and oleic fatty acids. A comparative experimental study of both solid and liquid lubricants is carried out on a special friction stand. It is established that the solid lubricants provide a lower coefficient of friction and have the technological advantage in drilling small holes without the use of drilling fluid. The effect of molybdenum diselenide, sulfur, and serpentinite additives on drilling torque and axial cutting force, as well as on the increase in the life of drill bits, has been experimentally studied. The use of an electron microscope for chemical analysis made it possible to establish the solid lubricant components diffusion into the surface layer of the drill cutting blade. The solid lubricant formulations experimental studies are performed on modern CNC machine tools using a modern computer data acquisition system NI-DAQ$_{mx}$ (hardware) with NI-LabVIEW (software). Each experiment was repeated the required number of times to reduce the influence of random errors on the measurement results.

As it is known from experience, when drilling small holes with a diameter of less than 5 mm, the drill bit does not require additional cooling, since the heat released during cutting is absorbed by the workpiece being drilled. This can be explained as follows: around the rotating drill bit there is a metal environment of the material being drilled which takes heat from the drill off. For this case, SLs used in drilling have a significant effect on the lubricating, chemical and adsorption actions. Most often SL is applied to the working surface of the tool (drill bit, tap, abrasive wheel, etc.) with a mechanical touch and pressure. For the purpose of comparative tests of solid and liquid lubricants, an experimental setup in the form of a laboratory stand was created and used with the friction scheme of the ‘ring end face-plane’ (Fig. 1). The materials from which samples 6 and 7 (Fig. 1) were made corresponded to the pair of ‘instrumental material’ (R6M5, Germany analog 1.3343, HRC 60...63) – ‘processed material’ (steel 45, Germany analog C45E, HB 200...212). The coefficient of friction was calculated by the formula where T_f is the moment of friction, which is fixed by strain gauges, N·m; P is the axial load, which is given by the corresponding loads on the handle of the vertical feeding of the spindle, N; r is the average radius of friction ring, m. The inner r_1 and outer r_2 radiuses of the ring are 15 and 12 mm, respectively; therefore $r = 13.5$ mm.

For one hour in industrial oil I-20 a run-in of samples 6 and 7 (Fig. 1) was made (Fig. 2, a) with the registration of the friction moment and temperature of the oil. The axial load in the friction pair (470 N) creates the pressure 1.8 MPa in the contact area. The rotational speed of the moving sample 6 is 450 rpm. The axial load is equal to the average value from the possible range of its variation. It can be seen (in Fig. 2, a) that the friction coefficient increases from the initial value of about 0.14 within one hour and then stabilizes at the level of 0.22-0.23.

After the run-in was up, the dependence of the coefficient of friction on the axial load was determined using the following formulations of both the liquid and solid lubricants (Fig. 2, b):

- I-20 (industrial oil);
- I-20+2% ARC (antifriction regenerative composition of the company ‘Venture –N’ in the kind of tribo-polymer-forming additive EF-357);
- SL based on stearin (25% oleic acid, 10% chromium oxide, stearin – the rest).

Let’s analyze the results of the experiment on the stand, for example, at a load of 1100 N (Fig. 2, b). It can be seen that the highest friction coefficient (minimum value is f = 0.120) was obtained by testing the friction pair on I-20 oil, and the lowest (minimum value f = 0.04) – on SL. The intermediate result (f = 0.1) was obtained on the compound (I-20+ARC). In this regard, further studies were carried out to optimize the SL formulation.

Keywords

Metalworking fluid Friction coefficient Serpentinite powder

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