Grip and Sliding Friction Processes

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ABSTRACT
This article discusses the processes of adhesion and sliding friction. However, due to the extreme complexity of this physical and mechanical phenomenon and the difficulty of assessing numerous factors, influencing him, the exact general laws of friction have not yet been established. If necessary, it can be determined empirically and through approximate calculations.

Keywords: sliding friction, surface, clutch, friction and belt drives, rough surface, slip surface, harmful phenomenon, loss of energy, dry friction, liquid friction, lubrication layer, deformation of irregularities, engage oppositely.

Introduction

This article discusses sliding friction when the same surface areas of one body come into contact with different surface areas of another body. The processes of adhesion and sliding friction of parts have great importance in technology. For example, clutch forces are used in friction and belt drives [1-4].

At the same time, friction in some cases is a harmful phenomenon that causes unproductive energy losses in machines and mechanisms. It is no coincidence that the study of the phenomenon of friction is given great attention by specialists from all countries: up to 1/3 of the world's energy resources are spent on overcoming friction [5-9]. A scientific and technical discipline has been formed that studies this phenomenon - tribonics. Friction is classified as follows:

Dry friction- in which there is no lubrication between the contact surfaces of the links. The resistance to the relative movement of the links during dry friction arises as a result of mechanical engagement and deformation of individual protrusions of the rough surfaces, as well as the molecular interaction of the contacting surfaces [10-17].

Fluid friction- at which the contact surfaces of the links are completely separated by a lubricant layer. With this type of friction the thinnest layers of lubricant cover individual protrusions of rough surfaces. Consequently, their mechanical and molecular interaction disappears, and the resistance to relative motion is determined only by the shear resistance of individual layers of lubricant. Liquid friction resistance is much less than dry friction resistance.

However, very often in kinematic pairs, both dry and liquid friction are observed simultaneously. It happens in the case when the lubricant layer does not cover all the irregularities of the rough surfaces and, therefore, there is a partial contact of small protrusions. Such friction is called semi-dry. or semi-liquid, depending on which type of friction prevails. There is also boundary friction, in which there is a thin (of the order of 0.1 microns or less) layer of lubricant between the rubbing surfaces [18-24].

The main part

Consider dry friction slip. Figure 1 shows under high magnification the contacting surfaces of two links 1 and 2, which are at rest. Under the action of a vertical force G, link 1 is pressed against link 2. In this case, elastic-plastic deformation of the irregularities occurs, as a result of which it engages.

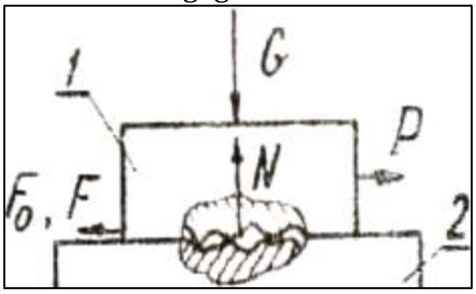

Fig.1

Normal force N acts on link 1 from side 2. If k link 1 applies a relatively small force P, then the movement of body 1 under the action of this force, the adhesion force F will prevent, caused in addition to elastic-plastic deformations of the protrusions as well as the forces of molecular interaction between them. If you increase the force P, then the adhesion force F_0 will increase, reaching the maximum value F_{0max}, before the start of the sliding link, which is called the maximum cohesive force (maximum static friction force) [25-18].

When the relative slip of link 1 appears, the resistance force abruptly decreases and becomes equal to the force F. This force is called the sliding friction force.

The force of sliding friction is always directed opposite to the relative speed of movement.

The maximum adhesion force and sliding friction force in most engineering calculations are determined by approximate formulas:

$$Fo_{max} = fo\,N; F = f\,N, \quad (1)$$

where N is the normal pressure force, f0 and f are the coefficients of adhesion and the coefficient of sliding friction, respectively;

Studies show that the coefficient of adhesion and sliding friction when two surfaces come into contact depends on the specific pressure (the ratio of normal pressure to the area of contact between two links), as well as on the material roughness of the contacting surfaces.

With an increase in the relative speed of movement, the coefficient of sliding friction for most materials decreases (the exception is, for example, leather).

Therefore, approximate calculations are carried out according to formula (1), substituting in them the average values of the coefficients f0 and f for the measurement ranges of the specific pressure and the relative sliding speed of the links, considering these coefficients to be constant.

Coefficients of adhesion and coefficients of sliding friction for various engineering materials at a relative speed of movement V=0.027 m/s and in the range of changes in specific pressure from 9x10 N/m to 15x10 N/m.

If necessary, it is possible to determine the sliding friction force (Fig. 2 of the device for determining the sliding friction force) that occurs when sample 1 slides over plate 2. The pressure force of sample 1 on the plate will be set using load 3 installed on the sample.

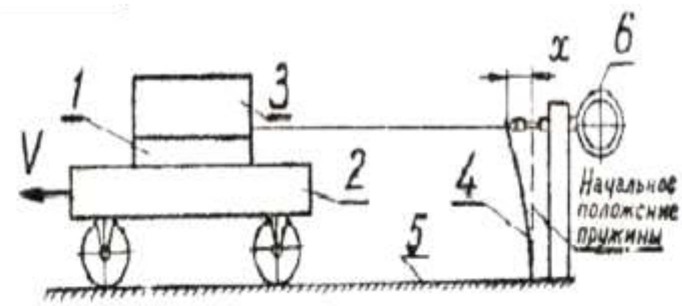

Fig. 2.

To measure the sliding friction force, sample 1 is connected by a thread (rod) to the free end of spring 4 installed on base 5.

If plate 2 is told to move to the left with some given speed V, then in the initial period sample 1 will move together with the plate due to the adhesion forces between them. In this case, the thread will be stretched, and the flat spring will bend. After a certain period, the action of the spring will stop in sample 1. Plate 2 will continue its movement. From the side of the plate, the sliding friction force will act horizontally on sample F. The friction force will be equal to the elastic force of a flat spring, that is $F=P_{ynp}$. For a flat spring 4, the elastic force is directly proportional to the deformation, that is

$$F = P_{упр} cx \quad (2)$$

where c is the coefficient of proportionality, called the stiffness of the spring (the spring is bent within the limits of elastic deformations), N/mm;

X- the value of the deviation of the end of the flat spring from the initial position, mm.

The deviation of the end of a flat spring from the initial position is measured using indicator 6, and knowing the stiffness from the spring, it is possible to determine the required friction force *F* by the formula:

$$F = cx. \quad (3)$$

The measurement of the maximum adhesion force can be determined using the same device as the sliding friction force, at the moment of time immediately preceding the start of the relative movement of plate 2 and sample 1. To do this, an intermediate spring of low rigidity is additionally installed between the thread and the end of the flat spring.

At the beginning of the movement of plate 2, sample 1 begins to move with it to the left. In this case, the intermediate spring is elongated and the flat spring is bent. Due to the low rigidity of the intermediate spring, the increase in the elastic force of a flat spring occurs much more slowly than when the sliding friction force changes. Therefore, the deformation of the flat spring will also occur slowly, which makes it possible to observe the movement of the indicator needle. For the tested materials, the maximum adhesion force is greater than the sliding friction force. It is enough to fix the maximum deviation of the end of the flat spring (maximum indicator reading). The desired adhesion force is determined by the formula:

$$F_0 = cx_{max}, \quad (4)$$

Where F_0 - the maximum grip force, and x_{max}- the maximum deviation of the end of the flat spring from the initial position.

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