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On the Friction Theory of Solids with Flat Contact Surface

I.V. Dobrov*

National metallurgical academy of Ukraine, Gagarina av., 4, Dnipropetorvsk, 49600, Ukraine

Abstract

The effect of the way of applying inclined external force pressing the bodies of translational friction pair with flat contact surface is analyzed based on theoretical and experimental research of the external friction processes. The relationship between the inclined external force and the contact stress considering external zone of the friction pair is analyzed. The conditions when it is necessary to consider the influence of external zone of friction pair, are determined. The reduced coefficient of friction based on the relationship between coefficient of sliding friction and the function of additional resistance to the relative displacement of the bodies of the friction pair is researched. It is shown that this resistance is caused by the external zone.

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Keywords: friction pair; static friction; sliding friction; force of friction; power of frition force.

It is developed and it is developing different laws (models) of friction based on the characteristics of these processes respectively to the other processes of friction with flat contact surface during analysis processes of friction with different conditions of external friction: the friction of solids; the friction of solid and elastic body; the friction of solid and plastically deformable body [1-4]. Then on the bases of assumptions and experimental research it is generalized the laws (models) of friction for solving of certain class of tasks and it is received specific laws (models) of friction in the mechanics of solids, in the mechanics of plastically deformable bodies and so on. The universalism of the mathematical equations that describe different tasks of mechanics of processes of external friction defines that the main laws of interaction of forces acting on contact surface of bodies in the different states of matter are common. This law may be determined by using the general assumptions and general methods of solving of different tasks of external friction first of all tasks of external friction (static friction and sliding friction) of solids with flat horizontal contact surface.

* Corresponding author. Tel.: +380562471501.
*E-mail address :*igordobrov@yahoo.com

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In this paper the question of friction forces is considered in accordance with the documentation [5] and its principles based on the papers [6,7]. In accordance with these papers the friction force $T_{1-2}^{(i)}$ acting between bodies 1 and 2 is an internal force of the system of bodies 1-2†.

The components of this force acting on the contact surface of the bodies 1 and 2 at the same point in space are the forces of friction $T_{21} = -T_{12}$ with the different directions and with the equal magnitudes. These forces act on the different bodies and these forces are the external forces for these bodies. The interaction of the external friction force ant its components with the external forces acting on the bodies of friction pair is defined by the Newton's laws at the law of conservation of energy.

Let us consider (fig.1) the process of external friction of solids‡ consisting of two bodies 1 and 2 with flat horizontal contact surface. These bodies are pressed to each other by the inclined external force P_1 applied in the center of the body 1 located in the fixed frame (body) 2. In accordance with Newton's third law the effect of the force $\overline{P}_1$ on the body 1 is balanced by the force $\overline{P}_{12}$ applied to the body 1 from the side of contact surface of the body 2

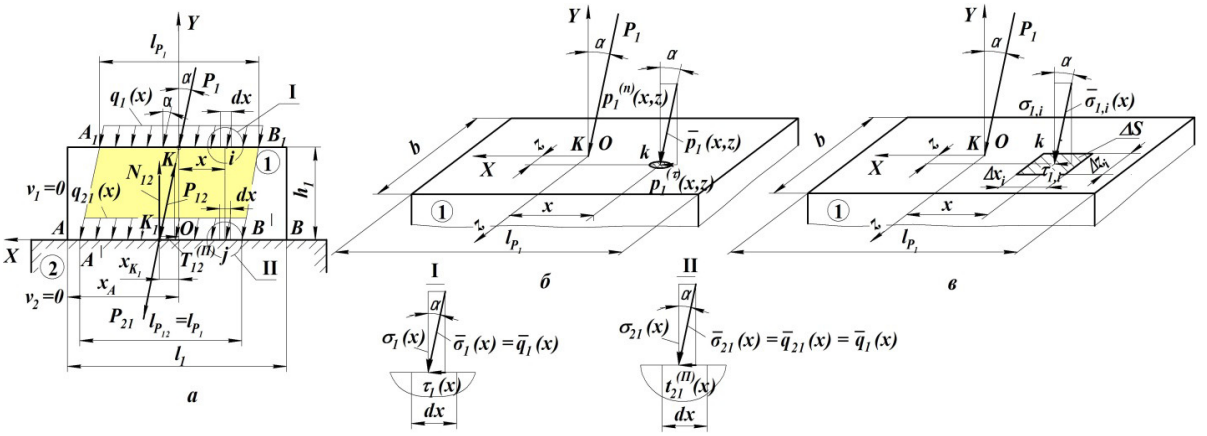

Fig. 1. The function of the distribution of the load on the contact surfaces of the friction pair during action of static friction forces (*a):* scheme for calculation during symmetric loading of the contact surface; (*b), (c):* pressure and stress distribution on the «free» surface of the body 1 of the friction pair

$$\overline{P}_{12} \equiv -\overline{P}_1 . \qquad (1)$$

This condition is fulfilled during static balancing of the body 1 when on the contact surface of the friction pair acting the static friction forces and when sliding of the body 1 with the forces of sliding friction act on the contact surface of the friction pair.

In the general case the force applied to the body 1 from the side of the body which is not shown on the fig. 1 acts in the form of distributed load $q_1(s)$ on the contact surface (S_{P1}) of these bodies

$$P_1 = \int_{S_{P1}} q_1(s)ds . \qquad (2)$$

† The internal force which defines the stresses inside a body and balance the effect of the external forces applied to the body contains superscript (i). The external force applied to the surface of the body does not contain superscript. The subscript near the symbol of force defines the number of a body to which this force is applied. If subscript near the symbol of force consists of two digits then: the first digit defines the body to which this force is applied; the second defines the body from the side of which this force is applied. If subscript near the symbol of force consists of two digits with dash then the subscript defines the bodies between which this force acts.

‡ Here and hereinafter the solid is a body with internal stresses far less than the elastic modulus of the body produced by the external forces applied to the body.