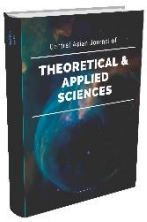

CENTRAL ASIAN JOURNAL OF THEORETICAL AND APPLIED SCIENCES

Volume: 05 Issue: 01 | Jan 2024 ISSN: 2660-5317
https://cajotas.centralasianstudies.org

Reaction Forces of an Non-Axisymmetric Wedge

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Received 28th Nov 2023, Accepted 9th Dec 2023, Online 30th Jan 2024

Abstract. *A mathematical expression for determining the reaction force of a non-axisymmetric wedge is obtained; it generalizes the formula, found in literature, for determining the reaction force of constraints of a given object under the action of a constant force. The research methods are based on the classical methods of theoretical mechanics for deriving the equilibrium state equation and the analytical method for determining the reaction force of constraints.*

Keywords: *reaction forces, wedge pairs, constant force, equilibrium state.*

Introduction

Wedge pairs are widely used in many industries. Determining the reaction forces of wedge pairs is the foundation for studying the dynamic processes of many mechanisms used in mechanical engineering. Agricultural machines are equipped with V-belts and wedge friction gears, wedge valves are used in oil products conveying lines, and freight car bogies are equipped with wedge spring-friction sets. Wedge pairs are widely discussed in the literature [1, 2].

Using the method of addition of forces between two infinitesimal sections of the rod, in accordance with the d'Alembert principle, a differential equation of longitudinal vibrations of a wedge pair was derived in [3]. The general and particular solutions of the differential equation of longitudinal oscillations of a wedge pair were presented and their propagation under the action of a constant force corresponding to the given initial and boundary conditions was studied.

A mathematical expression for determining the reaction force of an axisymmetric wedge pair was obtained which generalizes the formula (found in literature) for determining the reaction force of constraints of a given object under constant [4].

A generalized model of a spring-friction set of a freight car bogie was developed in [5]. Critically discussing the absence of methods of classical mechanics in numerous publications, according to the principle of release from constraints, an equation for the equilibrium of friction wedges was compiled and

an analytical expression for the reaction of a friction wedge was obtained in [6].

In the present article, a refined mathematical expression for reaction forces acting on a non-axisymmetric wedge pair in the wedge penetration medium was obtained.

Research methods

Research methods are based on classical methods of theoretical mechanics of deriving an equilibrium state equation and an analytical method for determining the reaction force of constraints.

Materials

Consider the statics of a non-axisymmetric wedge under constant force $\bar{P}$. It is necessary to determine the reaction forces of constraints on a wedge pair.

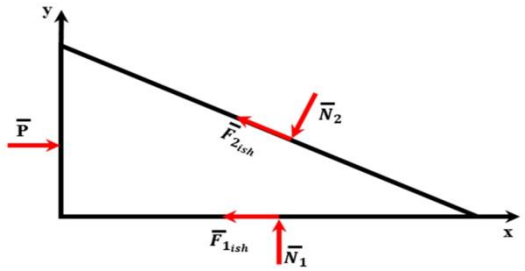

Fig.1. Acting forces

To determine the reaction force, we set a coordinate system and compose an equation for the equilibrium of the wedge along the axes of this coordinate system (Fig.1). Normal reaction forces $\bar{N}$ of the working planes are directed perpendicular to these planes. Friction forces $\bar{F}_{ish}$ of these surfaces lie in the working planes.

Let us set the coordinate axes and compose the equilibrium equation for the wedge pair. The sum of active forces and reaction forces for an equilibrium state must be zero [7, 8]. As seen from the figure, the sum of all projections of active forces and reaction forces along the *y*-axis is zero.

Let us compose the equilibrium equation of the wedge along the x and y axes:

$$\sum F_{kx} = 0 : P - F_{ish2}\cos\alpha - N_2\sin\alpha - F_{ish1} = 0. \quad (1)$$

$$\sum F_{ky} = 0 : N_1 - N_2\cos\alpha + F_{ish2}\sin\alpha = 0. \quad (2)$$

Taking into account ratio $F_{ish} = fN$ for the friction force, where f is the friction coefficient, from the last equation we obtain:

$$P - fN_2\cos\alpha - N_2\sin\alpha - fN_1 = 0, \quad (3)$$

$$N_1 - N_2\cos\alpha + N_2\sin\alpha = 0. \quad (4)$$

Hence, we determine the first reaction force:

$$N_1 = N_2(\cos\alpha - f\sin\alpha). \quad (5)$$

Introducing the found expression into (3), we obtain:

$$P - fN_2\cos\alpha - N_2\sin\alpha - fN_2\cos\alpha - fN_2\sin\alpha = 0,$$

or

$$P - N_2(f\cos\alpha + \sin\alpha + f\cos\alpha - f^2\sin\alpha) = 0.$$

Hence:

$$P = N_2(2f\cos\alpha + \sin\alpha - f^2\sin\alpha).$$

From this expression, we determine the second reaction force:

$$N_2 = \frac{P}{2f\cos\alpha + \sin\alpha - f^2\sin\alpha}. \qquad (6)$$

Introducing the found expression of the second reaction force N_2 into (5), we obtain the expression of the first reaction force:

$$N_1 = P\frac{\cos\alpha - f\sin\alpha}{2f\cos\alpha + \sin\alpha - f^2\sin\alpha}. \qquad (7)$$

Thus, analytical expressions (6) and (7) for the reaction forces of constraints on a non-axisymmetric wedge are obtained.

Conclusion

The resulting expressions, in contrast to the formulas found in the literature, more accurately express the nature of the reaction forces of a real constraint. Note that in the literature on the theory of mechanisms and machines [1, 2], the friction force is determined by the following formula

$$F_{ish} = \frac{Pf}{\sin\alpha},$$

According to this formula and considering $F_{ish} = fN$, the normal reaction force is determined by the following formula

$$N = \frac{P}{\sin\alpha},$$

here, for $\sin\alpha = 0$, the reaction force tends to infinity, which does not correspond to the physics of the phenomenon.

The analytical expressions obtained for determining the normal reaction forces of constraints acting on a non-axisymmetric wedge correspond to the physics of the phenomenon under any conditions of the application of active forces.

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