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NONSTATIONARY PLANE CONTACT PROBLEM IN THEORY OF ELASTICITY FOR CONFORMAL CYLINDRICAL SURFACES

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ABSTRACT A numerical-analytical approach is described to investigate the process of impact interaction between a long smooth rigid body and the surface of a circular cylindrical cavity in elastic space. A non-stationary mixed initial boundary value problem is formulated with a priori unknown boundaries moving with variable velocity. The problem is solved using the methods of the theory of integral transforms, expansion of desired variables into a Fourier series, and the quadrature method to reduce the problem to solving a system of linear algebraic equations at each time step. Some concrete numerical computations are presented. The cylindrical body mass and radius impact on the profile of the transient process of contact interaction has been analysed.

KEYWORDS non-stationary mixed problem, cylindrical cavity in elastic medium, rigid body, contact interaction, Laplace transform, Fourier expansion

I. INTRODUCTION

In mechanics of contact interaction, which embraces the problems of elastic impact of bodies, investigators distinguish between cases of interaction of bodies whose shapes are conformal and non-conformal [1]. The interacting bodies are commonly considered non-conformal if their profiles, at least in the place where they contact another body, do not match. For such bodies, as a rule, the contact zone is significantly smaller than their characteristic sizes. When simulating the impact problem for such bodies, this zone can be approximated by a plane surface [2–5]. A conformal contact, as a rule, is inherent to "inner" contact problems. It occurs when the surfaces of both bodies in the contact zone have sufficiently close or conformal profiles at the initial moment. In engineering practice, in particular, such a contact occurs between the shaft (axle) neck and the bearing part surface, between the teeth of Novikov's mesh gears, or in other cases [6, 7]. The inapplicability of Hertz's theory to solving the above application problems due to commensurability of the sizes of the contact zone with the radii of curvature of mating surfaces, in particular, of cylindrical form, has sparked interest in developing appropriate approaches to such investigations. Monographs [1, 6, 8] and papers [9–15] can be mentioned among a big variety of publications dealing with developing effective methods to solve the problems of contact interaction between conformal cylindrical bodies. Thereat recent publications have been focused on building approximate solutions to the problems in the static statement with the least number of independent parameters. At the same time, the impact contact interaction between conformal bodies has not been investigated adequately to date [16, 17].

This paper offers a numerical-analytical method in solving the non-stationary problem of impact "inner" contact between cylindrically shaped conformal bodies. The case is considered when a rigid body with a cross-section defined by a curve sufficiently smooth in the frontal part collides at a given initial velocity with the surface of a round cylindrical cavity in elastic space. The stress-strain state of elastic medium and the characteristics of body

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