2nd INTERNATIONAL MULTIDISCIPLINARY CONFERENCE FOR YOUNG RESEARCHERS
Sustainable Development Trends and Challenges under COVID-19

Modeling the rolling of a rigid cylinder on the soil surface

Sokolik Serhii [1]*, Zubko Vladyslav [1], Zhyhylii Dmytro [2]

1 Department of Tractors, Agricultural Machinery and Transport Technologies, Faculty of Engineering and Technology, Sumy National Agrarian University, Herasyma Kondratieva Str. 160, 40000 Sumy; sokolik1009@gmail.com; zubkovladislav@ukr.net

2 Volodymyr Martsynkovskyy Computational Mechanics Department, Faculty of Technical Systems and Energy Efficient Technologies, Sumy State University, Rymskogo-Korsakova str. 2, 40007 Sumy; zhigiliy.d@gmail.com

* Correspondence sokolik1009@gmail.com

Background: Detection and removal of the plow sole is an important task. Modern contactless scanners are not available for most farms due to the high price, and our device will allow small farms to investigate soil compaction and take the necessary measures to loosen it. The peculiarity of the device we are developing is that its working body (disk or sphere) penetrates the soil to a small depth. The aim of this study is, within the framework of the used model of the viscoelastic layer, to obtain the force factors of the impact on the cylinder, ensuring its uniform rolling when penetrating the uncompacted viscoelastic soil layer. **Methods**: This work solves the problem of rolling a rigid cylinder on a viscoelastic layer of uncompacted soil, interlocked with a non-deformable half-plane that simulates a plow sole, in the presence of adhesion and slippage zones in the contact area. When formulating the problem, the compliance of the cylinder and half-plane is not taken into account, and to describe the properties of the soil layer, the Kelvin model is used, which has a limited viscoelastic creep. **Results**: A model has been built to analyze the influence of the mechanical characteristics of the intermediate viscoelastic soil layer on the contact characteristics and the friction force during the rolling of a rigid cylinder on a rigid base. The viscoelastic behavior of the soil in the normal and tangential directions is described using the Kelvin model. The existence of adhesion zones and relative slippage of the surfaces of interacting bodies in the area of their contact is taken into account. As a result of solving the problem, the distributions of normal and tangential stresses on the contact area, as well as the sizes and positions of the adhesion and slip zones in the contact area, were determined. It is shown that in the contact area, there can exist both two (slip-adhesion) and three (slip-adhesion-slip) zones. The analysis of the influence of mechanical and geometric characteristics of a thin viscoelastic soil layer, rolling speed, cylinder radius, and sliding friction coefficient on the distribution of normal and tangential stresses on the contact area is carried out. **Conclusions**: The 2D contact problem for a rigid cylinder rolling on a thin viscoelastic layer bonded to a rigid half-plane is considered. The Kelvin model is used to describe the viscoelastic properties of the soil layer. The method to calculate the normal and shear stresses within the contact area is presented. The contact stress distributions and the dependence of the traction coefficient on the relative slip are studied for various values of the coefficient of sliding friction and the layer viscosity parameters.

Keywords: plow sole, viscoelastic layer, Kelvin model, relative slip, rolling friction, friction coefficient, traction coefficient.