Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 206 (2017) 1388–1394

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2017

Application of the Laws of Mechanics of Granulated Solidsin Studies to Loader Bucket Interaction with Bulk Material Stack

Yu.M. Lyashenko[a], E.A. Revyakina[b,*], D.N. Shurygin[a]

[a] *Platov South-Russian State Polytechnic University (NPI), 132, St. Prosvescheniya, Rostov region, Novocherkassk 346428, Russia*
[b]*Don State Technical University, 1, Gagarina Sq., Rostov-na-Don 346000, Russia*

Abstract

Today the industrial complex needs sophisticated machines to perform loading operations. In the mechanized loading theory, one of the approaches to the description of the interaction processes between the bucket working bodies and the stockpile of bulk material, is the use of a static granular medium method developed in the papers by Ch. Coulomb, and S. S. Golushkevich's. Further development of progressive loading equipment is required to elaborate modern methods for research of physical and technological processes of interaction of executive bodies with the external environment through the use of the numerical methods such as the discrete element method.

Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering

*Keywords:*mechanized loading;resistance to implementation; static granular medium; graphic-analytical method.

1. Introduction

The resistance of the pile to introduce the working body is a characteristic that defines its basic parameters. Therefore, all the researchers involved in the study of loading in one way or another, concerned the question of determining the efforts in the implementation of the working body and the drawing of the goods [1-6]. To identify ways of further development of the studying of the interaction of loading machines with the external environment and improving the working bodies, the following is an analysis of existing analytical methods. In theory mechanized loading one of the approaches to the description of processes of interaction of working bodies of the bucket with the

* Corresponding author. Tel.: +7-918-515-1070; fax: +7-8636-22-3088.
E-mail address: revyelena@yandex.ru

1877-7058 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering.
10.1016/j.proeng.2017.10.650

stockpile bulk material is the use of the method is a static granular medium developed in the writings of Ch. Coulomb, and S. S. Golushkevich's [7-9].

2. Application of the Ch. Coulomb'smethod in studies of the process of loading packaged material bucket working body

The possibility of applying the Ch. Coulomb's method for describing the interaction of the front loader bucket to a stack tested in the works of I. V. Boyarkina [10]. According to the considered on the basis of the Ch. Coulomb's law interaction of the loader bucket with the pile of loose material at the first stage of introduction of the front wall of the bucket in a bulk material slip occurs cut the prism along the plane of the bucket (Fig. 1). At the same time there is a second sliding plane in an array of material on line *OB*, located at an angle ψ_2 with the horizontal. In the plane of the slides *OB* are the complex physical phenomena that require detailed consideration and study. In cake-stack material plane slip, line *OB*, is an imaginary plane. The real slide of the prism bounded by the cross section OA_1Bmay not occur on the line *OB*, since it is impossible to cut all pieces of material shown black fill (Fig. 1). In real conditions of digging the material is not subject to destruction. However, this does not mean that in this case the Ch. Coulomb's theory does not work. Shear volume of bulk material in its thickness occurs, the active layer separating the movable and fixed volume of material, having a thickness of d_{cp}. This layer is at an angle ψ_2 and acts as a Ch. Coulomb's slip plane. As a result of the phenomena in the slip plane OA_1 on the prism side of the bottom of the bucket is the force of sliding friction F_1 and the normal force N_1 and the sliding surfaces Ch. Coulomb's force: the frictional force F_2 of the soil on the ground, the force of cohesion of the soil $F_{CЦ}$ and normal force N_2. These forces are calculated values in the developed analytical calculation method:

$$N_2 = N_1(\psi_1, \psi_2, \mu_1, \mu_2, C, L_{BH}) \tag{1}$$

where μ_1, μ_2– accordingly, the coefficients of sliding friction of soil on the bottom of the bucket and the ground.

Modern computer technology allows the numerical method to determine the actual value of the slip angle ψ_2, which eliminates the necessity of finding the analytical formulas to determine the slip angle ψ_2 as complex functions of the parameters. The analytical method of power calculation of the process of interaction of the loader bucket with loose material based on the theory of grip and the limit Ch. Coulomb's equilibrium. In the process of thrusting the bucket into bulk material in the array of material when it is loading external shearing forces there is a shear plane at an angle ψ_2, which are the shear stress τ and normal stress σ and the coupling C, between which is established an analytical relationship for the Ch. Coulomb's law:

$$\tau = C + \sigma tg \rho_0 \tag{2}$$

At the beginning of the implementation process of the bucket the prism of material having a section OA_1B and the weight of *G* is free to slide along the flat wall of the bucket. The pressure of the front wall of the bucket on the soil, numerically coincident with the N_1 response, tends to move the prism OBA_1 parallel to the plane *OB* at an angle ψ_2, and the force of normal pressure from the slip plane *OB*, which is numerically coincident with the reaction N_2 is the force driving the prism OBA_1 inside of the bucket. Considered forces are distributed forces acting in the respective faces of the prism slides OA_1B.

In this case the normal forces N_1 and N_2 can be shown in the form of linear normal distributed strength with maximum values of intensity triangular plot $q_{1\max}$ and $q_{2\max}$(Н/м), which can be calculated by the formulas:

$$q_{1_{\max}} = 2N_1 \backslash OA_1,\ \ q_{2_{\max}} = 2N_1 \backslash OB \tag{3}$$

Mathematical models derived from Ch. Coulomb's laws, enabled a study of the process of implementation in a pile of bulk material flat front wall of the bucket.