Sensitivity analysis of the influence of particle interaction parameters and volume/shear work ratio on wear loss and friction force using DEM model of dry sand rubber wheel test

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In this study, the laboratory results of the dry sand rubber wheel test (DSRWT) wear loss and friction force were compared with those modelled by the DEM. To achieve model results similar to the experimental, the sensitivity of particle interaction parameters (dynamic friction of rubber-sand, dynamic friction of sand–steel, and rolling resistance of the particle) was evaluated by variance, regression, and Pareto statistical analyses. The wheel and sample contact stress analyses confirmed that employing the progressive volume/shear work ratio parameter is required during the simulation; this parameter increases/decreases the wear intensity of the tested material during the simulation.

Keywords: dry sand rubber wheel test; wear model; dynamic friction; rolling resistance; volume/shear work ratio.

1. Introduction

The discrete element method (DEM) incorporates abrasive particles to wear process. Abrasive material properties interaction are described by dynamic friction of steel–sand, rubber–sand and rolling resistance. Dynamic friction corresponds to the sliding on the contact when tangential force exceeds the normal force and static friction limit [1]. Rolling resistance describes the particle rolling or rotational movement in contact with a surface [2]. Volume/shear work ratio parameter directly affects abrasive wear resistance of tested material. All these parameters highly influencing wear loss and friction force results. This study aims to investigate the dynamic friction, rolling resistance (particle-sample), volume/shear work ratio sensitivity on wear loss, and friction force-related responses of the modelled DSRWT using DEM.

2. Methods.

Laboratory experiment and simulation of the DSRWT were made of the sample (Boron 27 steel). Analyses made at 17, 35, 57, 78 and 100 N loads. The Rocky DEM software used for simulation. To compare laboratory and simulation results volumetric wear loss was calculated from the ratio of mass loss before and after the test and density of the sample, as well as friction force was measured during the experiment.

2.1. DEM parameter calculation

The software evaluates wear loss using the Archard wear law [3]:

$$Q = \frac{k \cdot F \cdot L}{H} \quad (1)$$

where Q is the volume loss, F is the normal force, L is the sliding distance, H is the hardness, and k is the wear coefficient. In Eq. (1), wear coefficient k can be used as volume/shear work ratio parameter. The higher this parameter, the shorter calculation time (or wear track distance in simulation) can be achieved.
After some simulations, the results of wear loss and friction force were analysed using Statistica where general multiple linear regression model used for dynamic friction and rolling resistance sensitivity analysis.

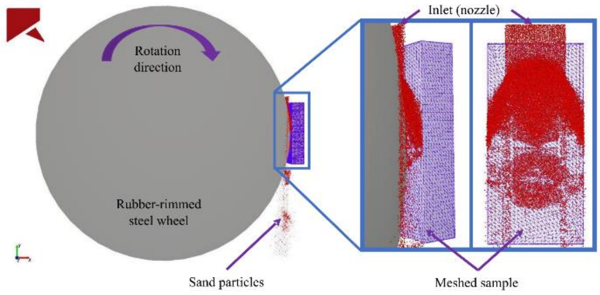

Figure 1: DSRWT model scheme used for DEM analysis.

3. Discussion

Wear model based on the DSRWT results helps to understand effect of k parameter. Variation of stresses acting the sample, inform us to necessity to use progressive k parameter during the simulation but not for all loads. This information can improve previously made wear investigation of agricultural tools, where constant k parameter was used through whole working depth but stresses (soil resistance) varied and wear loss did not showed high correspondence to measured wear loss.

4. References

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