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Author: Mr. Robin Briend
McGill University, Canada, robin.briend@mail.mcgill.ca

Prof. Peter Radziszewski
McGill University, Canada, peter.radziszewski@mcgill.ca
Dr. Damiano Pasini
McGill University, Canada, damiano.pasini@mcgill.ca

STRUCTURE OPTIMIZATION OF A LUNAR ROVER WHEEL USING THE DISCRETE ELEMENT METHOD

Abstract

The structure of a wheel intended for lunar applications requires a completely new and innovative design because of the Moon's specific environment. As in-situ prototype testing is impossible, testing can only be conducted on lunar simulant soils, or through simulations. This study presents wheel-soil interaction simulations using the Discrete Element Method (DEM) software EDEM and their use in wheel structure optimization.

First, the DEM parameters coming into play in EDEM's contact-model are reviewed, and a systematic methodology for their calibration is presented. The first step consists in measuring key properties of the real soil with simple experiments and simulating these experiments for different values of the virtual soil's design variables. The soil's response surfaces for the targeted properties are then computed, and an optimization algorithm determines the optimum sets of design variables that would minimize the gap between virtual soil's and real soil's properties.

Then, the 3D wheel-soil simulation model used for wheel structure optimization is described. The wheel is modelled as an assembly of spheres and subjected to a parametric vertical load and driving torque. Data such as sinkage, slip, drawbar force and minimal torque for motion are extracted from the simulation. Repeatability and scale-model testing issues are explored.

Finally, this simulation model is run with various wheel grouser shapes, applied torques, applied loads, and on two types of soils – silica dry sand and lunar regolith. Results on wheel structure optimization and agreement with the semi-empirical Bekker equations of locomotion are presented.