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HUMAN EXPLORATION OF THE SOLAR SYSTEM SYMPOSIUM (A5)
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DESIGN OF A HIGH TRACTION FLEXIBLE WHEEL FOR A MANNED LUNAR ROVER: DEFINING THE WHEEL REQUIREMENTS

Abstract

Foreseeing a permanent settlement on the moon, the astronauts will need a rover to explore the lunar environment on a daily basis. The goal of this project is to develop a new wheel that is able to provide more control, comfort, and drawbar pull in order to safely reach remote areas. Following a thorough design method, a new concept of flexible wheel that aims to provide a higher drawbar pull while being sturdy and able to operate under the moon environment for a long time without maintenance was achieved. First, terramechanics principles, based on the Nepean Wheeled Vehicle Performance Model (NWVPM) by J.Y. Wong, were used to find the optimal dimensions and ground pressure of the wheel necessary to achieve the highest drawbar pull at a 20% slip ratio. The terramechanics optimization was done by covering the whole range of possible combinations of wheel diameter, width and ground pressure. The terramechanics model uses these combinations and the lunar soil parameters as inputs and then iterates to find the sinking of the wheel so that the static forces are balanced. For every combination, the thrust, the torque and the resistances (rolling, bulldozing and flexion) are computed, and a normalized drawbar pull value is calculated. Then, the wheel parameters giving the highest drawbar pull for a reasonable wheel flexion and sinkage are integrated within the requirements. The result is a high deflection wheel that deforms up to 10% of the wheel diameter under the static load of the vehicle. Second, a Matlab suspension optimization program was created to fine tune the stiffness and damping of the wheel and suspension system of the rover excited by a realistic moon surface profile. The lunar surface displacement power spectrum based on a National Aeronautics and Space Administration (NASA) research was used together with the harmonic superposition method to find the surface roughness in the forward direction. The quarter-car linear model was used to find which stiffness and damping coefficients of the wheel would optimize the vertical acceleration of the vehicle, the stroke length of the suspension and the force developed between the wheel and the ground. Finally, many wheel designs were analyzed and compared, and a coil type design using wire ropes to provide the necessary stiffness and damping was selected. The methodology used to determine the wheel requirements and specifications is presented and discussed.