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CHARACTERIZING THE VERTICAL RIDE DYNAMICS OF THE IRINGS WHEEL

Abstract

In 2009, a new class of energy absorbing non-pneumatic, non-rubber wheels was introduced. The design consists of a fabric tire carcass filled with rigid spherical particles, mounted on a rim in a manner similar to its rubber analog. It was dubbed iRings in reference to the chain-mail tire material, chosen for space worthiness, durability, and traction on loose soil.

At a critical wheel rotational velocity, the primary sustained acceleration experienced by the particles in the iRings wheel transitions from gravitational to centripetal. As the wheel nears its critical speed, the particulates begin to orbit the rim, held together by the chain mail. Normal external forces no longer have a continuous path from the contact patch to the rim and must now be transmitted via particle collisions. Beyond this critical speed, the wheel exhibits an increase in stiffness along with a reduction in contact area with the soil. Below the critical speed, the particulate layer compresses to conform to terrain features. This property of the iRings wheel enables two desired operating scenarios: low speed/high traction for excavation, and high speed/high efficiency for astronaut transportation.

Our aim is to characterize the vertical ride dynamics of the iRings wheel at varying speeds. To do this, we devise an empirical model capable of matching experimental frequency response spectra of iRings.

First, experimental data is obtained with an instrumented test-rig. It allows iRings to freefall from a set height onto a smooth rigid surface while rotating at 0, 5, 10 or 15 km/hr. Second, a viscoelastic model is defined based on the continuous normal contact force approach. Third, using the Nelder-Mead simplex method, the model's five contact parameters are chosen to minimize the power of the error.