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DESIGN, VALIDATION AND PRODUCTION OF SMALL-SIZE ROVER ELASTIC WHEELS: A SOLUTION TO PLASTIC DEFORMATIONS

Abstract

This work proposes a new concept of elastic wheels for Lunar and Mars small-size rover applications, which aims to reduce criticality related to plastic deformations. Design and validation were achieved through the utilization of advanced finite element modelling and experimental test campaigns.

The wheel is composed of an elastic and a rigid part. Utilizing a combination of high-elasticity steel and aluminium, the rigid part works as the hub of the wheel, guaranteeing structural integrity and an interface with the rover's rocker-bogie suspension. The elastic part is mounted around the hub and contributes to the adaptability to the terrain. As a driving requirement, enhancing durability and performance, the wheel shall be able to work in the elastic field without undergoing any plastic deformation during its life cycle.

The design of the elastic part first followed a preliminary trade-off analysis to select the best configuration possible, taking into account parameters such as weight, cost-effectivity, reliability, and manufacturability. Two possible Design Configurations were selected and a series of analyses and tests were performed to verify which solution would have satisfied the requirements.

The elastic behaviour is entrusted in both configurations to highly thin-wall structural elements, the first cylindrical shaped and the second sinusoidal. Next, the solution with elastic cylinders was chosen and a full physical mock-up was produced. A preliminary test campaign was conducted to obtain a correlation with the numerical analyses. For this purpose, different non-linear FEM analyses were performed using Hexagon MSC Nastran with Patran. The wheel is designed to act as a vibration damper, attenuating medium-to-high frequency oscillations induced by obstacles encountered during rover traversal. Consequently, the wheel damps out transient dynamic loads transmitted to the rover chassis, promoting enhanced ride quality, and enabling higher operating speeds while maintaining stability.

To assess the performances of the designed wheels operative tests were conducted at the Altec Mars Terrain Simulator (MTS Facility), developed for the ESA ExoMars programme under Thales Alenia Space Italy contract.