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Modeling and Simulation of Active Suspension System for Road Vehicles and Sensitivity to Design Criteria for Energy Efficiency

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Objectives

Active suspension systems may become increasingly common in various automotive segments to improve in-vehicle comfort and reduce in-vehicle vibration, especially in light of the increasing electrification of road vehicles fostered by European climate agreements. Typical configurations of these systems incorporate Electric Motors (EMs) to drive the mechanical components, often using brushless motors that contain Critical Raw Materials (CRMs) in the Permanent Magnets (PMs), such as Neodymium, a Rare Earth Element (REE). While these systems can positively impact vehicle comfort and performance, they are responsible for direct and indirect energy consumption, so it is important to assess their potential environmental, social, and economic implications from a Circular Design perspective. This study contributes to this assessment by proposing a modeling and simulation approach for an active suspension system, analyzing its performance variations across different road profiles regarding energy consumption by the electric actuating motor. Model creation is part of a strategy to guide designers in implementing design for sustainability solutions relying on precise assessment of component performance.

Methods

The active suspension system is modeled by evaluating its energy consumption under different driving cycles and road conditions. This preliminary simulation framework is designed to analyze the sensitivity of system performance to changes in critical design parameters, focusing on the energy requirements of the electric motor used in the actuator system.

Results

The study produces a parametric simulation model to evaluate the performance variations of an active suspension system employing a permanent magnet electric motor. The model provides insight into how design choices affect the efficiency and energy consumption of the system under different operating conditions.

Conclusions

The model developed serves as a solid basis for creating a more comprehensive framework to evaluate and compare the performance and sustainability of industrial components using electric machines, such as active suspension in the automotive sector. This approach supports a broader assessment of the trade-offs between technological advances and sustainability challenges in designing next-generation automotive systems.

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