

ABSTRACT

The operation of heavy vehicles such as mining dump trucks in extreme terrains often generates large-amplitude vibrations that negatively impact operator comfort, component structural fatigue, and vehicle lifespan. Conventional passive suspension systems are frequently suboptimal and unable to adapt effectively to these varying road roughness conditions. This study aims to model and analyze the comparison of the dynamic response of a quarter-car suspension system on a mining dump truck (CAT 773E) before and after the implementation of a Magnetorheological (MR) damper as a semi-active system. This research employs a quantitative computational simulation method using a 2-DOF quarter-car model approach. Three parametric MR damper models—Bingham, Modified Hyperbolic Tangent, and Modified Bouc-Wen—were identified using Genetic Algorithm optimization from experimental data, which were then scaled up to match the heavy equipment's capacity. The results of this study indicate that the application of MR dampers significantly reduces body acceleration and limits suspension deflection across various road conditions (Class A, B, and C) compared to passive suspensions. The Modified Hyperbolic Tangent model proved to be the most optimal representation, providing the highest level of comfort with the most minimal tire deflection (road holding) trade-off.

Keywords: MR Damper, Quarter-Car, Dump Truck, Semi-Active Suspension, Parametric Model

INTI SARI

Operasional kendaraan berat seperti *dump truck* tambang di medan yang ekstrem seringkali menimbulkan getaran dengan amplitudo besar yang berdampak negatif pada kenyamanan operator, kelelahan struktural komponen, dan umur pakai kendaraan. Sistem suspensi konvensional yang bersifat pasif seringkali kurang optimal dan tidak mampu beradaptasi dengan baik terhadap variasi kekasaran jalan tersebut. Penelitian ini bertujuan untuk memodelkan dan menganalisis perbandingan respons dinamis sistem suspensi *quarter-car* pada *dump truck* tambang CAT 773E sebelum dan sesudah menggunakan *Magnetorheological (MR) damper* sebagai sistem semi-aktif. Penelitian ini menggunakan metode simulasi komputasional kuantitatif dengan pendekatan model *quarter-car* 2-DOF. Tiga model parametrik MR *damper* yaitu *Bingham*, *Modified Hyperbolic Tangent*, dan *Modified Bouc-Wen* diidentifikasi menggunakan optimasi Algoritma Genetika dari data eksperimental, yang kemudian diskalakan (*scale-up*) menyesuaikan kapasitas alat berat. Hasil penelitian ini menunjukkan bahwa penerapan MR *damper* secara signifikan mampu mereduksi akselerasi bodi dan membatasi defleksi suspensi pada berbagai kondisi jalan (Kelas A, B, dan C) dibandingkan suspensi pasif. Model *Modified Hyperbolic Tangent* terbukti sebagai representasi paling optimal karena memberikan tingkat kenyamanan tertinggi dengan kompromi defleksi ban (*road holding*) yang paling minimal.

Kata Kunci: MR *Damper*, *Quarter-Car*, *Dump Truck*, Suspensi Semi-Aktif, Model Parametrik