

Article

Dynamics Modeling and Suspension Parameters Optimization of Vehicle System Based on Reduced Multibody System Transfer Matrix Method

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Abstract: This study introduces an innovative vehicle-modeling framework based on the Reduced Multibody System Transfer Matrix Method, incorporating wheel-ground contact and friction to analyze dynamic performance metrics, including vertical acceleration, suspension deflection, and angular acceleration. The model is applied to simulate vehicle behavior at 40 km/h on Class D road conditions. To enhance dynamic characteristics, suspension parameters were optimized using the NSGA-II algorithm. The optimization process achieved significant reductions in vertical acceleration (24.12%), suspension deflection (25.98%), and angular acceleration (4.93%). The Pareto frontier facilitated the selection of a representative solution that balances smoothness, stability, and suspension performance. Frequency, PSD, and RMS analyses were performed under different road conditions and speeds to verify the robustness of the optimization results. The application of the transfer matrix method is extended to vehicle suspension modeling and optimization, offering valuable insights into improving ride comfort and stability. Additionally, it highlights the effectiveness of advanced multi-objective optimization techniques in improving vehicle dynamics and provides a robust methodology for practical applications.

Keywords: vehicle dynamics; transfer matrix method; NSGA-II; suspension optimization



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1. Introduction

The automotive industry is currently undergoing a period of transformation, primarily driven by digitalization, the principles of a circular economy, and sustainable development goals. Additionally, manufacturers are striving to address these challenges in an intensely competitive and rapidly evolving market environment. Against this backdrop, the intelligent manufacturing of the automotive sector has seen rapid development in recent years, facilitated by the application of CAE software [1]. This approach aims to evaluate the dynamic behavior of vehicles during the design, development, and prototyping phases. Compared to traditional experimental procedures, it helps reduce costs, shorten design and production timelines, and simultaneously maximize vehicle performance, comfort, environmental characteristics, quality, and safety.

The suspension system has consistently been a focal area of research within the field of vehicle dynamics. Comprising a set of rigid bodies capable of relative motion, the suspension system plays a crucial role in handling performance, stability, and comfort [2]. The function of a suspension system is to maximize the friction between the tires and the road surface, provide good steering stability, and ensure passenger comfort. Despite

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Proceedings of the 9th International Conference on Mechanical Manufacturing Technology and Material Engineering Jiang Guo,Alam Md. Mahbub,Ying-Ren Chien,2025-04-28 This book offers a comprehensive examination of the latest advancements in mechanical manufacturing technology and material engineering as presented at the 9th International Conference on Mechanical Manufacturing Technology and Material Engineering MMTME 2024 It delves into the forefront of research in areas like intelligent manufacturing process and structure optimization intelligent mechanical design and simulation analysis The book is structured to highlight significant innovations that are poised to redefine manufacturing processes enhance material performance and drive sustainability in production Each chapter provides in depth analysis of emerging technologies and their practical applications backed by recent case studies and expert insights Key topics such as the integration of AI and IoT in manufacturing advancements in 3D and 4D printing technologies and the development of new sustainable materials are explored These are critical for pushing the boundaries of what is possible in manufacturing and materials science today This book is significant as it not only encapsulates state of the art research but also provides a vision for future directions in the field It sets out to solve problems related to efficiency cost effectiveness and environmental impact in manufacturing offering new perspectives and solutions to researchers and professionals The target audience includes academic researchers industry professionals and engineers in the fields of mechanical manufacturing and material engineering

The 9th International Conference on Advances in Construction Machinery and Vehicle Engineering Halgamuge Saman,Yan Peng,Dingxuan Zhao,Yongming Bian,2025-09-30 This open access book presents the proceedings of the 9th International Conference on

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Dynamics of Vehicles on Roads and Tracks Vol 2 Maksym Spiryagin, Timothy Gordon, Colin Cole, Tim McSweeney, 2017-12-06 The International Symposium on Dynamics of Vehicles on Roads and Tracks is the leading international gathering of scientists and engineers from academia and industry in the field of ground vehicle dynamics to present and exchange their latest innovations and breakthroughs Established in Vienna in 1977 the International Association of Vehicle System Dynamics IAVSD has since held its biennial symposia throughout Europe and in the USA Canada Japan South Africa and China The main objectives of IAVSD are to promote the development of the science of vehicle dynamics and to encourage engineering applications of this field of science to inform scientists and engineers on the current state of the art in the field of vehicle dynamics and to broaden contacts among persons and organisations of the various countries engaged in scientific research and development in the field of vehicle dynamics and related areas IAVSD 2017 the 25th Symposium of the International Association of Vehicle System Dynamics was hosted by the Centre for Railway Engineering at Central Queensland University Rockhampton Australia in August 2017 The symposium focused on the following topics related to road and rail vehicles and trains dynamics and stability vibration and comfort suspension steering traction and braking active safety systems advanced driver assistance systems autonomous road and rail vehicles adhesion and friction wheel rail contact tyre road interaction aerodynamics and crosswind pantograph catenary dynamics modelling and simulation driver vehicle interaction field and laboratory testing vehicle control and mechatronics performance and optimization instrumentation and condition monitoring and environmental considerations Providing a comprehensive review of the latest innovative developments and practical applications in road and rail vehicle dynamics the 213 papers now published in these proceedings will contribute greatly to a better understanding of related problems and will serve as a reference for researchers and engineers active in this specialised field Volume 2 contains 135 papers under the subject heading Rail

Advances in Dynamics of Vehicles on Roads and Tracks III Wei Huang, Mehdi Ahmadian, 2024-10-31 This book offers a timely snapshot of research and development in rail vehicle dynamics Gathering a set of peer reviewed contributions to the 28th Symposium of the International Association of Vehicle System Dynamics IAVSD which was held on August 21 25 2023 in Ottawa Canada this first volume of the proceedings covers a broad range of topics relating to rail vehicles Topics covered include modelling and simulation as well as design control and monitoring of rail vehicles and strategies to improve

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