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DEVELOPMENT OF A PASSENGER TRAIN SEAT STRUCTURE USING FINITE ELEMENT ANALYSIS AND DESIGN OPTIMIZATION ALGORITHMS

Frederico Alves[(1)], João Marques[(2)], José Aguilar Madeira[(3)], Ricardo Baptista[(4)], Virgínia Infante[(5)]

[(1)]IST, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal; IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
[(2)]Escola Superior de Tecnologia de Setúbal, Instituto Politécnico de Setúbal, Setúbal, Portugal; Atlantica – Instituto Universitário, Fábrica da Pólvora de Barcarena, 2730-036 Barcarena, Portugal
[(3)]IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal; ADM, Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, Rua Conselheiro Emídio Navarro, 1, 1959-007 Lisboa, Portugal
[(4)]IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal; Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, Rua Conselheiro Emídio Navarro 1, 1959-007 Lisboa, Portugal
[(5)]IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

frederico.alves@tecnico.ulisboa.pt, joao.ribeiro@estsetubal.ips.pt, aguilarmadeira@tecnico.ulisboa.pt, ricardo.baptista@isel.pt, virginia.infante@tecnico.ulisboa.pt

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Summary: The transport sector is a major contributor to environmental impacts due to its dependence on non-renewable resources, high energy consumption, and substantial greenhouse gas emissions. Rail transport, which accounts for 11% of freight and 8% of passenger movement in Europe, offers significant potential for enhanced sustainability. This study targets the multiobjective challenge of reducing the weight of suburban train seat structures while preserving stiffness and complying with production, ergonomic, and aesthetic requirements.
By employing optimization techniques like Siemens NX Nastran's SOL200 optimization solver and the Direct MultiSearch method, a newly designed seat structure was obtained resulting in a mass reduction of over 50% without sacrificing mechanical performance.
The design remained compatible with traditional manufacturing processes, including welding, riveting, and bending. Finite element analysis guided the optimization by identifying key parameters for improvement. This weight reduction allows for increased passenger capacity without affecting the train's total mass or energy consumption, ultimately improving energy efficiency per passenger. Beyond advancing sustainability in rail transport, this study provides a scalable framework for optimizing passenger seat designs across different transport modes, contributing to more efficient and competitive sustainable mobility systems.