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Master Thesis Defense

Entitled

STUDY OF OPTIMIZATION IN A CHASSIS OF A HIGH-PERFORMANCE SPORTS CAR

by

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Abstract

This thesis is centered on the study of optimization for a sports car chassis developed and built by local entrepreneurs in the United Arab Emirates (UAE). The frame weighs 220 Kg (485 lbs) which is made of thin-walled tubes with 4130-alloyed steel. Nowadays, in automotive industry competitions arise, and corporations seek faster methods and techniques in designing to cut off the development period and to reduce the cost. The study utilized Patran and Nastran software to develop a finite element model of the chassis for computational studies assisted by the computer-aided design (CAD) model provided by the manufacturer. To gain insight into the static strength and understanding of the dynamic characteristics of the space frame chassis, static and modal analysis are conducted using Finite Element Analysis (FEA). It followed by sizing optimization analysis in Patran for the objective of weight reduction while constraining the torsional stiffness to 18,000 Nm/° and selecting the frames rectangular and square geometrical sections as the design variables. The chassis FE model is constructed using beam elements modeled with the auxiliary components mounted on the chassis, the driver, and the passenger that were all introduced as lumped masses. Various load cases have been studied in static analysis to evaluate the chassis strength when subjected to high loads. The modal analysis is computed for 5 natural frequencies and mode shapes that fall within a selected frequency range. The experimental test is conducted through modal testing of the real chassis and established a correlation and validation of the FE model with the actual chassis. The static analysis results concluded that the frame has a well-accepted strength and stiffness. The maximum Von Mises stress is 102 MPa (14,839 psi) which is below the material yield stress, and torsional stiffness of 17,630 N.m/^{o} (156,038 in-lbf/^{o}) which is in the range of the sports car category referred from literature. The modal analysis results have shown a global vibration behavior for the first two modes which are the bending and torsional that occur at 60 Hz and 65 Hz, respectively. Optimization results have provided a significant reduction of the weight along the longitudinal profiles that reflected in an increase in other profiles for structural reinforcement. The study has developed a methodology for characterization and design optimization for sports car chassis using cutting edge analysis software. This thesis introduces a knowledge-based estimation for key parameters including mass and stiffness.

Keywords: Sizing optimization, Static analysis, Automotive, Space frame chassis, Modal analysis, Torsional stiffness.