Data-Driven Analysis of Dynamic Characteristics in a Formula SAE Race Car

Abstract.*In competitive motorsports, particularly within the Formula SAE competition, the performance and reliability of a vehicle are crucial. Data analysis plays a critical role in understanding the strengths and weaknesses of a car, allowing teams to make informed decisions on design improvements. This paper presents a detailed examination of the dynamic parameters of the FU-24 prototype from the Formula UFSM team during the autocross tests of the 20th Formula SAE competition season. The primary objective is to identify optimization opportunities that can be implemented to improve the vehicle's stability and response on track. Data collection was carried out during a series of controlled track tests, where sensors installed in the car recorded the lateral accelerations, speed, and steering angle of the car. The test environment simulated typical competition conditions to ensure the relevance of the data, which were then processed and studied using the MATLAB and the MOTEC I2 pro softwares. The lateral forces were analyzed to determine the car's ability to maintain grip in corners, aiding in the analysis of the car's oversteer and understeer behavior. This analysis was done by comparing the data obtained from the steering angle sensor with the calculated kinematic steering angle, as well as comparing the yaw rate with its predicted values. The results showed that the vehicle had a peak of 1,749g of lateral forces in high-speed corners, indicating good cornering capability. However, it also revealed the occurrence of on average 13.58 degrees of understeer in tight corners and on average a 11.74 degrees per second difference between the predicted and actual yaw rates, which were identified as critical areas for future improvement. Those behaviors were linked to the weight distribution and suspension setup through further analysis on the curse of shock absorbers and the individual wheel loads, highlighting the need for adjustments on both in order to balance the car's performance. Therefore, based on this data, to optimize the vehicle's dynamic performance, adjustments are needed in weight distribution and suspension setup, along with developing new methods for fine-tuning the suspension. These modifications are essential to improving stability, predictability, and, consequently, the car's lap time in competition.*

Keywords: Vehicle Dynamics. Data analysis. Formula SAE.