

MATHEMATICAL ESTIMATION AND EXPERIMENTAL VALIDATION OF POWER AND MASS REQUIREMENTS FOR PERFORMANCE OPTIMIZATION IN FORMULA SAE ACCELERATION EVENT

Abstract. In Formula SAE, a university engineering competition, one of the dynamic events is the Acceleration Event, where prototypes are evaluated based on their ability to cover a 75m straight line in the shortest possible time. In this context, the engine's Wide Open Throttle (WOT) power is crucial for performance improvement. For the 2024 season, the Formula UFSM team aimed to surpass their personal record of 4.01 seconds, achieved in 2022. To achieve this, a mathematical estimate was developed to determine the power required to reach 3.9 seconds in the event. The forces acting on the car, both aiding and opposing motion, were thoroughly characterized, including tractive force, rolling resistance, aerodynamic drag, and inertia. The key environmental and vehicle parameters considered were initial and final speed, car mass, driver mass, frontal area, drag coefficient, and tire rolling resistance coefficient. The target final speed was set at 105 km/h, 10% higher than in 2022. Tire slip at the start was not considered, as the prototype's speed gain profile was assumed to be linear, allowing for constant acceleration. The general equation of motion was applied, integrating the drag force for a more accurate representation, resulting in a required tractive force of 2070 N, corresponding to 80 hp under the test conditions. During the validation phase, the FU-23 Galgo prototype's Powertrain team successfully extracted 80 hp at full load. To validate the estimate and prepare the car for competition, the team conducted several tests simulating the Acceleration Event, using real air density and total mass conditions. The best times stabilized at 3.94 seconds over 75 meters, with a top speed of 102 km/h. The mathematical model proved reliable, aiding in setting the power target and evaluating the impact of changes in vehicle characteristics on performance. For instance, the model indicated that an additional 1.5 hp would be needed for every extra 5 kg added to the car to maintain the same performance.

Keywords: Formula SAE. Acceleration. Power.