Stock Car Suspension Stiffness Ratio Analysis

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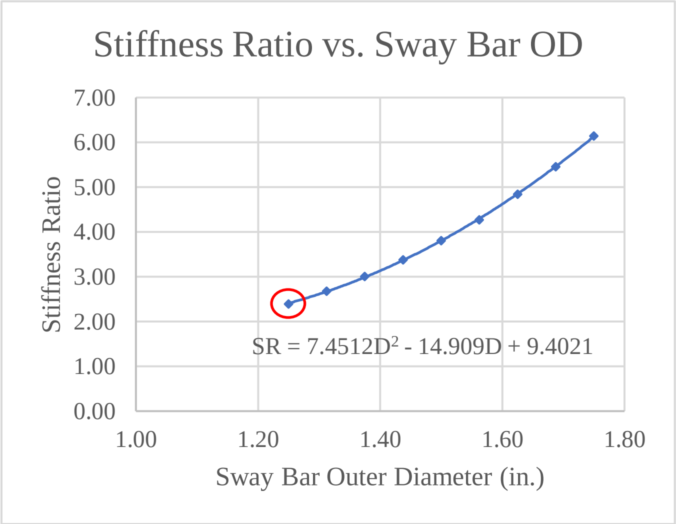
Background

A racecar's suspension is one of the key contributors to its performance on a track. Each component – springs, shocks, links, etc. – can be dealt with as a variable within a mathematical model. There are hundreds of combinations of these variables, with each change affecting the stiffness ratio. Using the sway bar as the variable of interest, data acquisition, and computer modeling, a mathematical was developed for predicting the stiffness ratio as a function of sway bar diameter. This model can simplify the time-consuming iterative process that is "racecar setup" by allowing a race team to plug numbers into an equation to make predictions instead of conducting on-track test sessions to determine the results of each component change.

Methodology

Using a data acquisition system with a variety of transducers, G-force values were measured from a test session at Kern County Raceway Park (Bakersfield, CA). During this test session, four on-track conditions were defined: braking into turn 1 (1), the center of turns 1 and 2 (2), accelerating out of turn 2 (3), full throttle on the back straightaway (4). Lateral and vertical G-force values were recorded for each of these conditions, allowing calculations to be carried out for each. Using a mathematical model created in Microsoft Excel, these G-forces were resolved to three-dimensional vector forces at each of the car's tires, which were then plugged into a CAD drawing of the car's suspension. Using FEA and altering the diameter of the sway bar within the model (1.25"-1.75", 0.0625" increments), different deflections, twists, and loads present on each suspension component was simulated.



Results

The numbers generated by the FEA were written into a .pth code file that was then plugged into a suspension geometry simulation software. For each theoretical sway bar diameter, the movement of the front suspension could be visualized through the progression of the four conditions. From these simulations, a different mathematical model that accounted for the other suspension component values was generated in Excel to determine the stiffness ratio of the car for each sway bar size. The stiffness ratio is effectively a measure of the dynamic load bearing capacity of the front suspension to that of the rear. It is not a measurable value, but rather a cumulative summation of each of the component values in the front and the rear and varies by track and driver preference. A higher ratio results in a tighter car, while a lower ratio results in a looser car. The "sweet spot" of stiffness ratio was approximately 2.5 at KCRP, and the calculated stiffness ratios for each experimental condition were plotted as a function of the sway bar outer diameter. A sway bar with an outer diameter of 1.25" yielded a stiffness ratio of 2.39, a clear choice to give the car its best shot at ideal performance.

Conclusions

The characteristic of the stiffness ratio versus the sway bar diameter was best modeled by the second-degree polynomial shown on the plot. This model allows for the ideal sway bar size to be predicted based on a desired stiffness ratio. This allows for a component change to be predicted, saving time and resources that are spent by the traditional "guess and check" method that includes changing one component at a time, sending the car onto the track, and hoping it works. The sway bar diameter is not the only component value that can be predicted in this manner; this sort of modeling is useful for the entire racecar. Ultimately, this project stresses the benefits of computer and mathematical modeling to stay competitive in the ever-evolving world of competitive motorsports.