Validating Aerodynamic Downforce and Reducing Suspension Unsprung Weight

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Company/Institute: Clemson University Formula SAE

Industry/Application Area: Stress Measurement

Products Used:

- Strain Gages, 125UT Rosette and 062UT Rosette
- Installation Kit GAK-2-200
- 4 Conductor Wire 426-DFW

The Challenge

The 2016 season for the Clemson University Formula SAE racing team marks the second year in a three-year program to implement a full aerodynamic package. This year's package on our car, Tiger 18, includes a three element diffuser and underbody tray. Computational fluid dynamics (CFD) analysis shows the design is good for 209 N of downforce at 20 m/s, a significant improvement of 239 N when compared to the car without the package (-30 N, or lift). In order to fine tune the car and optimize its performance accordingly, it is necessary to be able to validate these numbers and measure the real world performance of the diffuser.

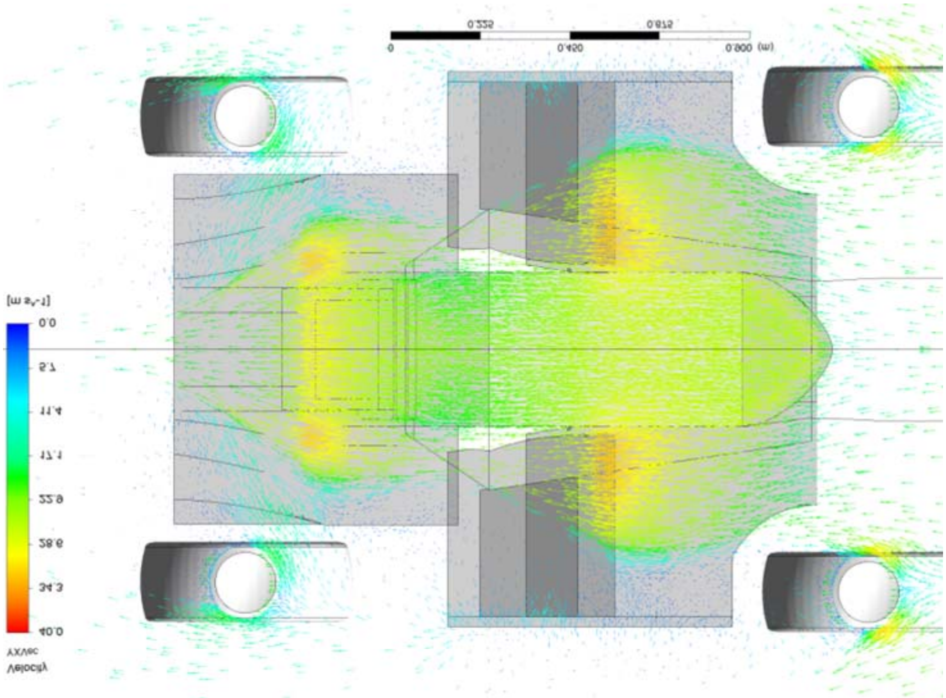

Fig 1: Computational fluid dynamics (CFD) analysis model of Tiger 18

Another goal for 2016 is optimization of the existing suspension design. Tiger 18 features an equal length double wishbone suspension with pullrods in the front and pushrods in the rear. Reducing the unsprung weight of the car, which means anything not directly supported by the springs, helps the suspension react faster to driver inputs and changes in the road surface. The weight reduction improves weight transfer characteristics and helps increase lateral acceleration. By reducing suspension link size and thickness, we can significantly reduce unsprung weight, however, excess reduction will result in links that are unable to handle the loads seen in a race situation and will lead to structural failure.

The Solution

Strain gages were attached to all suspension links on last year's Tiger 17 in a Wheatstone Bridge configuration to measure loads with maximum accuracy. Strain gages specifically on the push- and pullrods were used to measure aerodynamic loads on Tiger 18.

Fig 2: Rear pushrod suspension for Tiger 18

Fig 3: Front pullrod suspension for Tiger 18

The User Explains

The push- and pullrods transfer vertical tire forces into the spring and damper assembly. Calculating the difference between vertical loads with and without the diffuser enables us to see how much downforce is felt at each corner of the car. The tests validated the expected real-world performance of the diffuser, and provided a better understanding of the center of pressure and the distribution of the downforce. This valuable information enables tuning the suspension rates for optimal performance with the aero package.

All of Tiger 17's suspension links were tested to provide a clear picture of how much load can be expected in each individual link. Our suspension members are made with Chromoly 4130 steel, and the material properties combined with expected loads gave us the information we needed to reduce the link sizes as much as possible while still maintaining sufficient structural integrity. We successfully shaved 1.7 pounds off of the unsprung weight of the car, resulting in an 8.5% total weight reduction of the entire suspension and steering assembly of Tiger 18.

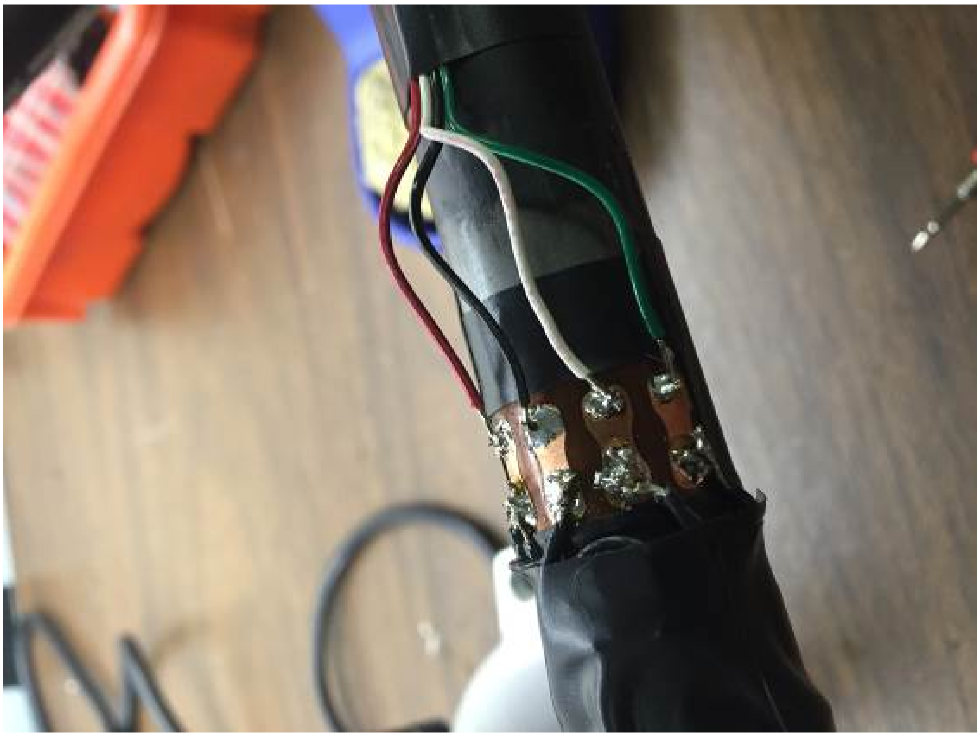

Fig 4: Wiring the connections on the gages to form a Wheatstone Bridge configuration

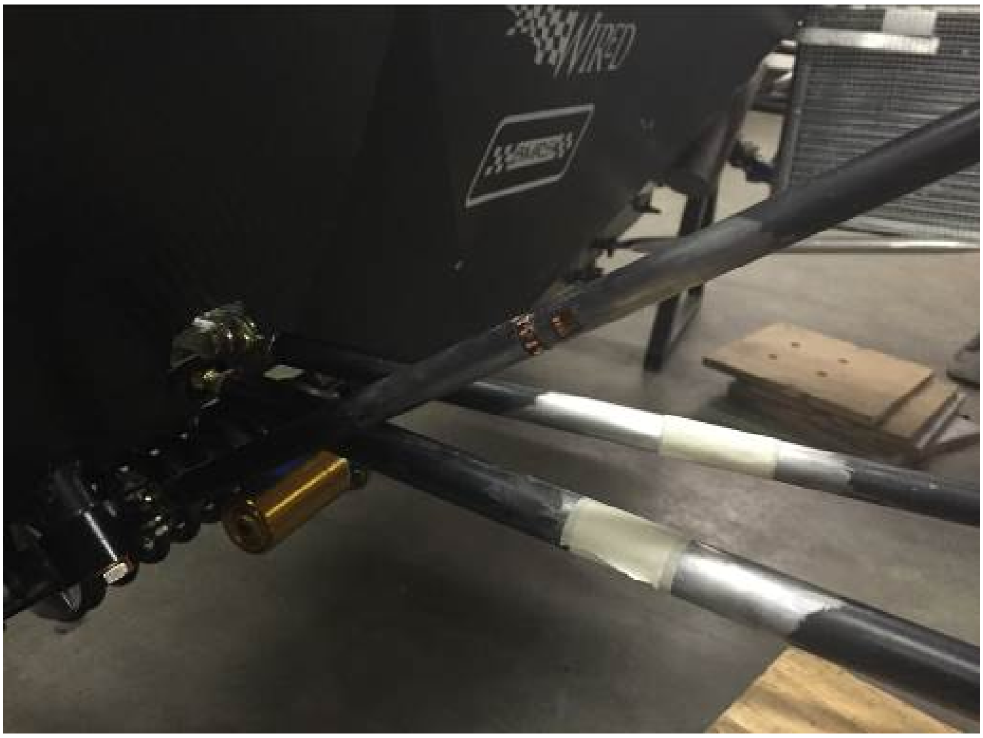

Fig 5: Gages as seen when installed on the car

Clemson Formula SAE is incredibly grateful for Micro-Measurements' support and technical expertise to aid us in our data acquisition endeavors. The use of strain gages allowed us to reduce maximum unsprung weight, as well as provide us with the information necessary to optimize the Tiger 18 suspension tuning with our new aerodynamic package. The result was a lighter car that could accelerate quicker, respond to inputs quicker, and corner at higher speeds. This was instrumental in helping us improve our results from 84th place overall in 2015 to 51st in 2016. This is only the beginning, as this information will continue to help us. Next year the full aero package will include a front and rear wing, and we are planning to switch to carbon fiber for suspension components.

Fig 6: Tiger 17 test run with strain gages installed

"The evaluation of our race car structure and aerodynamics using strain gages allowed us to build a more competitive car: lighter, quicker accelerating, better responding to inputs, and cornering at higher speeds."

Acknowledgement:

The Clemson Formula SAE team was founded in 1998 under the Clemson University Mechanical Engineering Department. Since then we have prided ourselves every year in working tirelessly and passionately to make the finest racecar possible. In 2016 the team is made up of 7 divisions (Powertrain, Chassis, Aerodynamics/Composites, Electrical, Suspension, Outboard, Business), giving members the opportunity to specialize in what they are truly most passionate about. Every day of the week our shop is open, giving members the opportunity to work as much as they want, and when their busy student schedules permit. The formula team is a source of pride for all of its members, and represents the pinnacle of the capabilities of Clemson University's engineering students. The end result is a testament to what is possible when passion, dedication, and expertise come together in equal amounts to create sophisticated and exciting machinery. For more information, visit our website at www.cufsae.com.

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