Validation of Suspension Link Loads for Formula SAE Race Car Design Using Micro-Measurements' Strain Gages

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The 2015-2016 Cal Poly Formula SAE team would like to thank Micro-Measurements!

Strain gages from Micro-Measurements, a brand of Vishay Precision Group (VPG), are used by the Cal Poly Racing Formula SAE team to validate its suspension link load calculator. This will, in turn, create a useful tool that can be passed down to future students for the design of suspension components such as A-arms, uprights, tie rods, and push and pull rods. Knowing how close the load calculator is to being accurate allows the team to more confidently lower weight by reducing the safety factor on designs. Reducing weight and having sufficient stiffness are major factors in giving the school's Formula SAE cars a competitive advantage.

Company/Institute: Cal Poly Racing, California Polytechnic State University San Luis Obispo, Society of Automotive Engineers (SAE), Formula SAE

Industry/Application Area: Force measurement

Products Used:

- Tee Rosette strain gages, CEA-06-125UT-350
- GAK-2-200 gage application kit

The Challenge

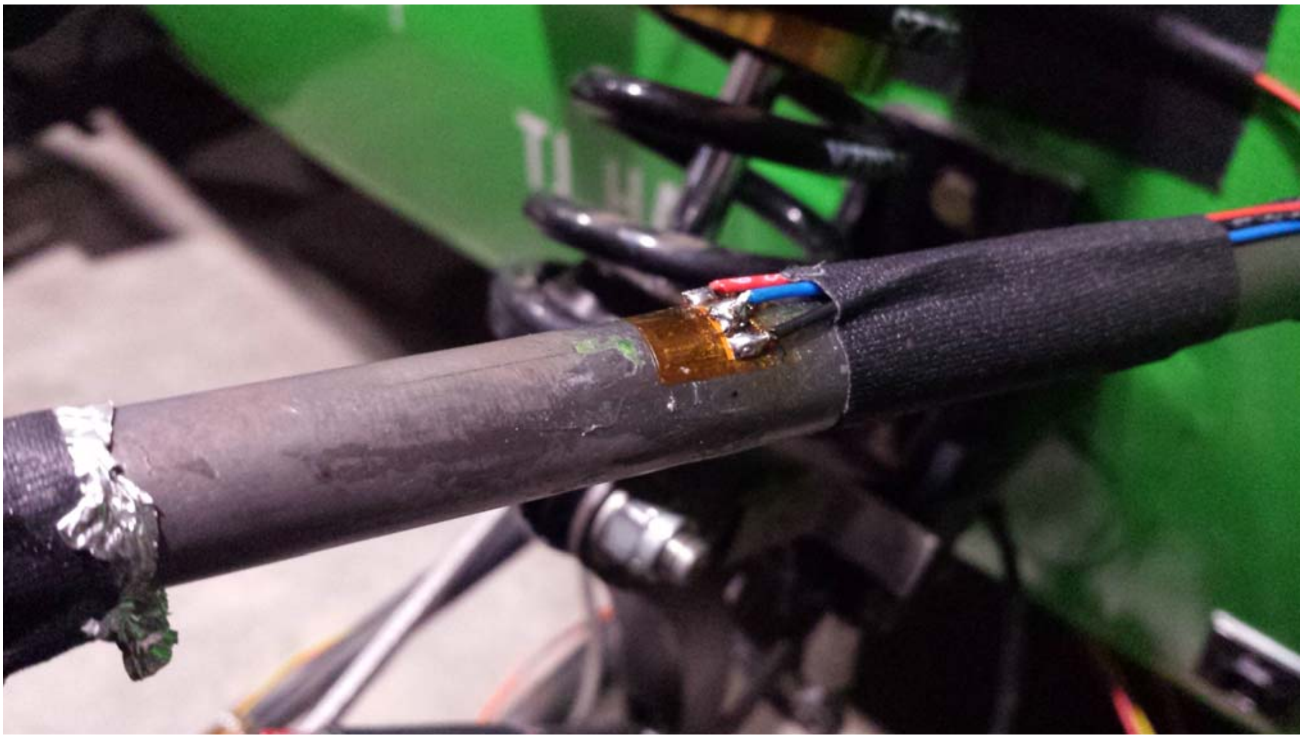
The 2015-2016 Formula SAE team at Cal Poly SLO has been looking for areas to shave weight and increase stiffness in its continuing drive to be competitive at events in Michigan and Lincoln. The heaviest subsystem of the car in previous years has been the suspension, so this year a senior project team is focusing on the design of boxed steel uprights. The team has had a load calculator that models the car through a 1.6 g turn; however, it was decided to actually gather strain measurements to back up the force measurements. This will validate the load calculator and ensure the senior project team is designing under realistic loading conditions.

The Solution

The Tee Rosette strain gages provided by Micro-Measurements were bonded to the 4130 steel round tubing of the suspension links using the application kit provided. The team wanted to use a half bridge to ensure temperature compensation for measuring axial loads. Using the Tee Rosettes minimized the amount of strain gages that needed to be bonded, thus reducing the number of potential installation errors.

Jim Johnson, technical sales manager at Micro-Measurements, comments, “In this configuration, the measurement includes tension / compression, as well as possible bending. Using pairs of Tee Rosette gages allows for the cancellation of bending strains and the measurement of pure tension / compression.”

Wire lengths were determined on the car and soldered on, but the suspension components were then removed to bring to the Instron for tensile loading. The team used an Instron to build a calibration curve that was linear within the desired range of expected loading. The components were then reinstalled for testing at the Buttonwillow Raceway Kart Track. Due to a limiting number of differential outputs on its DAQ, the team had to split tests up into six groups to log the data. The driver would drive three laps in one direction and turn around so that any wedging errors could be eliminated.



An example of how the Formula SAE team at Cal Poly SLO bonded the strain gages onto the suspension links, ensuring strain relief of wires as well. There were 25 other links to do.

The User Explains

Without the help of Micro-Measurements, the team would not have been able to follow the design process that our university and the Formula SAE try to teach us: design, build, and test. With the data we gathered from the previous year's car that went to competition, we felt confident that our designs would be ready to meet the rigorous tests of Formula SAE Michigan and Lincoln events in 2016.

The table below summarizes our results and compares them to our theoretical model. The strain gage measurements are calculated using 95% confidence in a two-sample t-test and uncertainty propagation at ~1.26 g. In addition, a video is available here.

Suspension component	Load calculator [lbf]	Strain gage [lbf]	% Difference
Front pull rod	455.62	551.97, ±68.49	17.5%
Steering tie rod	57.31	279.62, ±20.24	79.5%
Rear push rod	248.25	551.10, ±77.93	55.0%
Front upper control arm	122.27	311.06, ±18.44	60.7%

"With Micro-Measurements strain gages, we were able to validate stiffness and justify weight savings on this year's design. The data we gathered even validated our suspension load calculator, which will be a legacy to pass on to future engineers who come to Cal Poly SLO."

Acknowledgement

The Society of Automotive Engineers equips students with valuable experience that closely reflects what they will see in the industry. Throughout the course of a year, each SAE team designs, builds, and tests a race-prepped vehicle that competes on an international level. In order to succeed, students must cooperate in researching, decision making, project planning, manufacturing, and validating their vehicle. The process is no easy task, pushing undergraduates to apply classroom knowledge in an industry setting with real deadlines and tangible deliverables.

Experience gained in the SAE makes participants some of the most sought-after candidates for positions in the automotive and aeronautical industries. When asked how to get a job at SpaceX, Dolly Singh, the Head of Recruiting at SpaceX for six years, said:

"If your school has an SAE team, join it; if it doesn't, try to start one."

The SAE helps teach the process of bringing a product to market, a skill not taught in most classes. It takes a vast amount of commitment and teamwork to build a competitive vehicle, but participants who succeed will stand out among a vast array of other job candidates.

Furthermore, Cal Poly students seek out sponsorships from industry leaders to complete over half of their cars. By communicating with generous suppliers, students are given access to cutting-edge technologies and industry connections to spur their professional growth — suppliers are given international promotion along with notoriety among a future generation of engineers.

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