Validation of Analytical Model of Formula SAE Race Car Suspension During Driving Events Using Strain Gages

Authors: Nicholas Cardwell, Robert West Jr.

The Virginia Tech Motorsports Formula SAE Team developed MATLAB code to evaluate the loadings acting through the suspension. The team has never fully validated the loading seen during driving conditions. Validation of the Suspension analyzer code is the main goal of using the Micro-Measurements' strain gages. By validating this model, it assures the team that the design choices made using simulation correlate with experiment and are representative of the operational load scenarios used for designing the race car. The team is constantly looking for ways to validate models so better designs can be made that decrease weight and increase handling of the car during competition.

The 2014-2015 Virginia Tech Motorsports Formula SAE Team and the car used for testing

Company/Institute: Virginia Tech Motorsports, Formula SAE

Industry/Application Area: Stress Measurement (Automotive/Suspension)

Product Used:

- C2A-06-031WW-120 Strain Gages
- GAK-2-200 Gage Application Kit

The Challenge

The use of a computer simulation model has been invaluable for designing the suspension components on the Formula SAE racecar. The model uses the known geometry and weight distributions to calculate how vehicle motion will translate to forces acting through each suspension member. There are a number of assumptions made during this process and that is why there is a need for validation. The team uses the strain gages on each of the control arms of the suspension to determine the actual loading that these members will see during the dynamic events.

The Solution

Micro-Measurements provided the team with forty (40) stacked rosette gages. These gages were bonded to the tubing using the application kit that was sent with the gages. Each suspension member had a full-bridge wired to measure axial loading with temperature compensation. This bridge type was chosen because the suspension members are designed with the assumption that the suspension members are only subjected to compression and tension loading and no bending loads. The team's plan is to validate this type of loading condition.

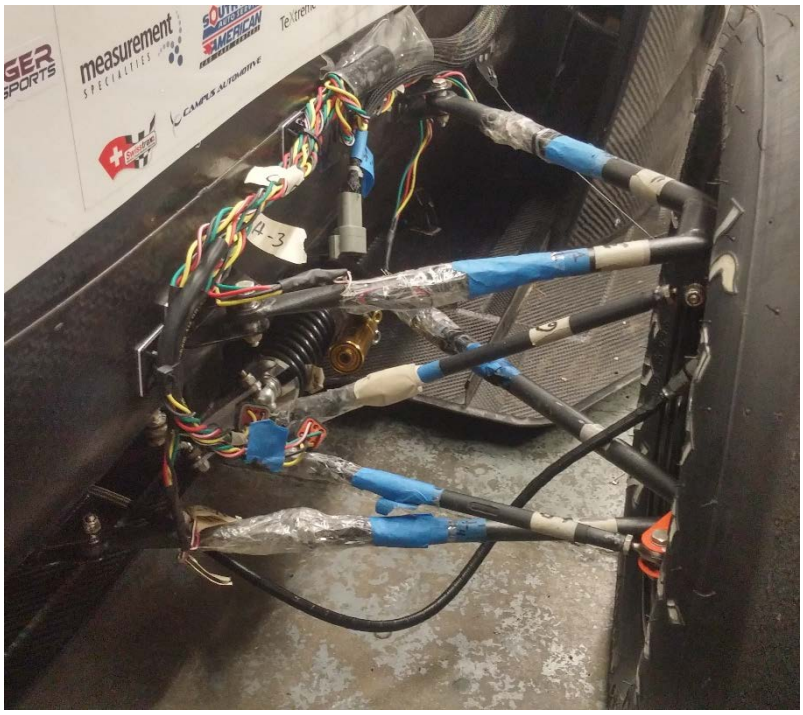

Figure 1: This image depicts the suspension corner used for testing. Under each blue taped area is a full-bridge circuit to measure loading in that member. The wiring harness can be seen running from the gages to the DAQ.

The six full-bridges were connected to an NI DAQ using its strain gage specific input cards, and NI 9237 strain gage module. The DAQ was also used to measure inputs from three shock potentiometers and an accelerometer measuring lateral acceleration of the vehicle. The shock potentiometers were used to ensure the loading of the pull rods was consistent with the loading

seen in the shock absorber. The accelerometer was used to capture the acceleration of the vehicle during the events and find the times at which the car behavior matched the prediction of the suspension analyzer.

The User Explains

The accelerometer data collected unfortunately had noise induced on the signal that made the data unusable. This meant that the strain gauge data could not be compared to the estimates from the suspension analyzer. There was a separate data logger onboard the vehicle that collected data from a separate accelerometer. Unfortunately, the time stamps could not be lined up between the two data sets. Refinements are being made to sensor installation and the data acquisition so accelerometer and strain gauge data will correlate in future testing.

While this testing run was not initially fruitful toward providing data needed to validate the car's suspension model, the team is currently planning on redoing the test with the 2016 year car using the remaining gages. Even though the data from the accelerometer was unusable, the team made improvements to be able to collect accurate loading data in each of the suspension components while the car is being driven. A few changes have been made to the data collection process and instrumentation to ensure the acceleration data will not be corrupted. The team also plans to create a finite element model of the suspension that will replace the MATLAB model. The next testing cycle performed by the team will also be conducted to validate that vehicle's dynamics model in the suspension analyzer.

"While the data from the accelerometer was not correct, the team made a step in the right direction by being able to collect accurate loading data in each of the suspension members while the car is driving."

Acknowledgement:

VT Motorsports would not have been able to complete this task without the help of Micro-Measurements for providing the necessary materials. This helped the team develop expertise with strain gages and strain gage testing, which expanded our horizons and creates a stepping stone that will help others toward greater engineering developments of the vehicle. The team also thanks

the Society of Automotive Engineers for hosting this competition. The team would not have been able to experience hands-on work of this scale or collaborating on design compatability without this competition.

Contact Information

Robert West Jr, Faculty Advisor
Phone: +1 540-231-7185
Email: westrl@vt.edu
Web: VTMotorsports.com

Vishay Precision Group, Inc. (VPG)
Micro-Measurements
mm.us@vpgsensors.com