Case Studies

March, 2015

Validation of Suspension Component Stresses On the Cal Poly Pomona Baja Car using Strain Gauges

Authors:
Amani, Jim
Chano, Charles
Gromova, Alena
Quintana, Quinton

Institute:
Cal Poly Pomona, Baja SAE (Society of Automotive Engineers)

Baja SAE is a collegiate design series where student teams are tasked with designing, building, and competing a single-seat, enclosed off-road vehicle against universities internationally. Each year a new vehicle is made with attempts to improve the capabilities of the vehicle at a minimal cost.

Industry/Application Area:

Stress Measurement
Automotive/Suspension

Product Used:
Stacked Rosette (0,45,90): C2A-06-062WW-350
Rosette (0,45,90): CEA-06-120CZ-120
Linear Gages: CEA-06-240UZ-120

The Challenge

As stated in The 2016 Collegiate Design Series Baja SAE Rules, "all vehicles must use the same 10 Horsepower Briggs and Stratton Engine." It is this limitation which leads to the necessity to design a suspension system that is both as strong and as light as possible. Our vehicle must traverse through rough terrain with unexpected loading conditions, making component design crucial in terms of balancing the strength of a component versus the added weight. Any added weight to the suspension is unsprung mass, and unsprung mass can have adverse effects on steering and traction during acceleration, deceleration, and cornering. It can also have effects on ride comfort and can increase mechanical loads. The goal with our suspension components is to assure that they will not break under normal driving conditions, which entails the obstacles and tracks that are encountered in our competitions; excluding collisions. After the manufacturing of the vehicle is complete, testing is done to validate design assumptions. This is a difficult task when it comes to validating loading conditions the suspension components experience during operation. Attempting to simulate loading conditions onto the components cannot be done without making assumptions. Some of the most complicated loading situations the suspension experiences is seen by the lower A-arms and trailing arms, since they have tubular designs, finding a relatively accurate measurement is difficult.

The Solution

Strain gauges provide a solution for testing suspension components in dynamic conditions. They allow for non-destructive, direct measurements of our critical components without interfering with normal driving conditions. By conducting tests that closely resemble conditions experienced in competitions, we are able to confirm that our assumptions for expected loads are close to what we actually encounter.

Points of interest for adhering strain gauges to the suspension components were selected based on Finite Element Analysis. In our scenario, the pre-wired 350 Ohm stacked rosette (C2A-06-062WW-350) provided a solution to recording stresses of our lower A-arms and trailing arm, as the tubular geometry of these critical members made finding the principal stresses complicated. The equations used for calculating stresses from measured strain assume a small differential area, and using a small stacked rosette decreases any errors this assumption would create for a small tubular surface. Using a higher resistance of 350 Ohm allowed for greater excitation without introducing greater error due to temperature. This rosette also made installation easier by not having to deal with the difficulty of soldering small leads to the tiny solder pads of each gauge. For the upper A-Arm and upright, the 120 ohm rosette (CEA-06-120CZ-120) were sufficient for measurement along the flat faces of the surface. Lastly, all the suspension links were best measured by the 120 ohm linear gages (CEA-06-240UZ-120) as they only experienced tension and compression

Figure 1: (Top left) Lower A-Arm with a stacked rosette applied to each side with one covered by thermal reflecting tape. (Top right) FEA model of lower A-arm. (Bottom left) Stacked rosette applied to trailing arm. (Bottom right) FEA model of trailing arm.

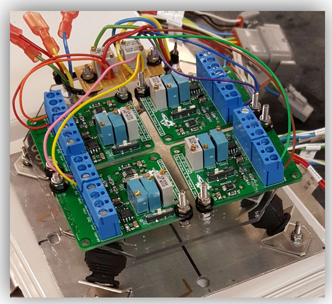

Figure 2: *Student made amplifiers on suspended mounting.*

A team member designed a wheat-stone bridge/amplifier system that fully integrates with our current data logging system. This system allowed for data collection on the testing track. Calibration was done with an Instron tensile tester for the overall system; which included the amplifier and the strain gauge used on a test sample made of AISI 4130.

The test conducted simulated obstacles we would encounter, such as a rock garden, steep incline, cornering, hard braking (all wheels locked), and bumps. A linear potentiometer was placed in conjunction with the strain gauges as to find the reaction forces from the air shocks.

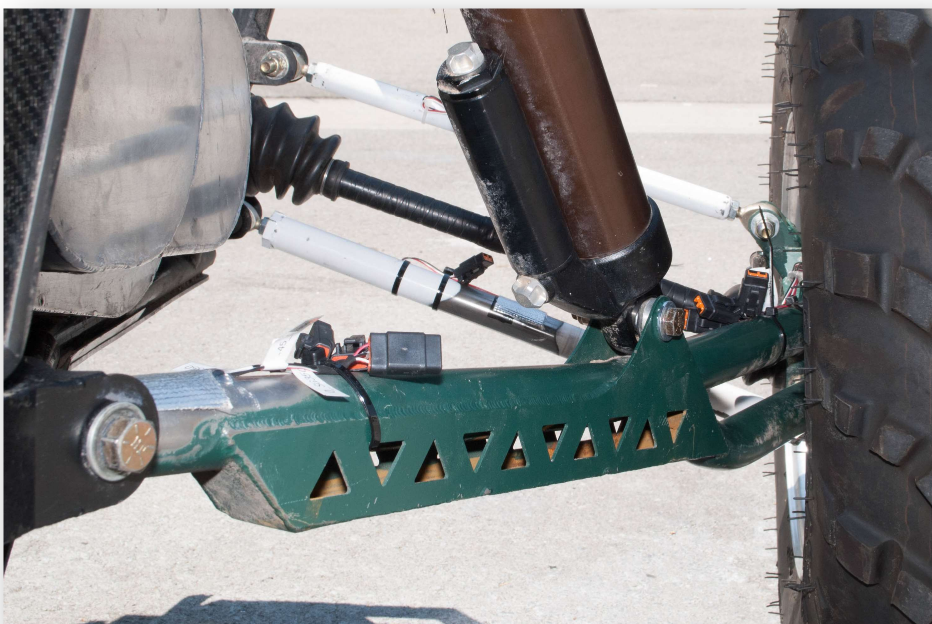

Figure 3: Rear suspension outfitted with strain gauges on linkages, trailing arm and integrated upright. All gauges are sealed with RTV and thermal reflecting tape.

The User Explains

Strain gauges validated that the true loading conditions were within 2% error of simulated loading conditions, done through FEA. This proves that our factor of safety values are valid assumptions and that our car is capable of handling said loading conditions.

Being able to complete the design cycle is important for any engineering application. Strain gauges provided us with a method for directly analyzing critical location on structural components. Their simplicity allows for greater versatility in application.

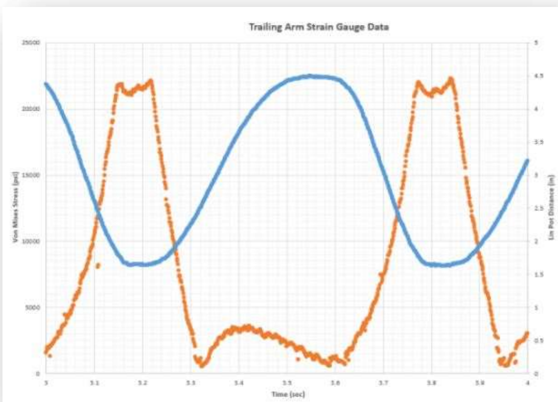

Figure 4: Trailing arm data. (Blue curve) Linear potentiometer linear displacement of distance versus time [in v. sec]. (Orange curve) Von Misses stress from strain gauge rosette versus time [psi v. sec].

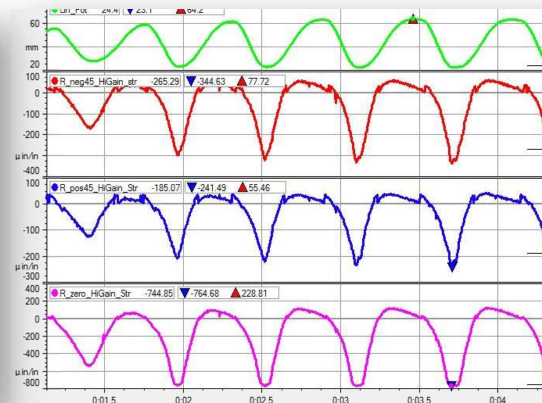

Figure 5: Trailing arm data collected from strain gauge rosette and linear potentiometer. (Top to bottom) 1) Linear potentiometer displacement versus time [mm v. sec]. 2) Strain gauge -45° from tube axis [in/in v. sec]. 3) Strain gauge parallel to tube axis [in/in v. sec]. 4) Strain gauge 45° from tube axis [in/in v. sec].

Acknowledgement:

The Cal Poly Pomona Baja team would like to thank Jim Johnson of Micro-Measurements for his guidance in the proper use of strain gauges.

Contact Information:

Cal Poly Pomona, Baja SAE

Web: http://cppbajasae.com/

Email: cppbajasae@gmail.com

Advisor:

Prof. Clifford M. Stover, P.E.

College of Engineering

California State Polytechnic University, Pomona

3801 W. Temple Ave, Pomona, CA 91768

Tel: (909) 869 4610 Fax: (909) 869 4341

CASE STUDIES: http://www.vishaypg.com/micro-measurements/related/
http://www.vishaypg.com/docs/25517/25517.pdf
http://www.vishaypg.com/docs/25507/25507.pdf
http://www.vishaypg.com/docs/25501/25501.pdf