Validation of FEM and tyre models through measurement of suspension loads on a Formula SAE car

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This case study explains how we measured the force in the suspension arms of a Formula SAE car. The data obtained will be used for the validation of FEM models that will be used in the design of the suspension and tyre models for dynamic simulations, allowing improvements in future designs and model accuracy.

Company/Institute: University of Seville (Spain)

Industry/Application Area: Automotive competition, Formula SAE

Products Used:

- CEA-06-062UT-350
- Strain Gage Adhesive (M-Bond 200)

The Challenge

ARUS is a Spanish Formula student team composed of 90 highly motivated engineering students who design, manufacture and test a small racing Formula car. This season, we are in the process of

manufacturing our fifth combustion car and our first electric car. This feat represents a big challenge for us since we will be the first Spanish Formula student team to compete with two cars.

The objective of the study was to measure the suspension forces on a Formula SAE single-seater. Strain gauges were installed on four suspension links: two pullrods and two pushrods. The data obtained will be used to validate boundary conditions used for FEM analysis of the whole suspension and computer models of the tyre and vehicle, including Pacejka models of the tyre fitted to laboratory data.Because the measurement was taken during the tests, sources of electrical noise, such as vibrations of the engine and road, suspension movement and power supply to the different systems, was an important challenge that was faced.

The Solution

To measure the forces, strain gauges were bonded to four of the suspension bars. All of the tubes work on tension-compression uniaxial forces. As only axial efforts are of interest, all of the measurements were made using a full bridge configuration with Micro-Measurements® strain gauges in a distribution such that measurement of bending forces were cancelled, as shown in Figure 1.

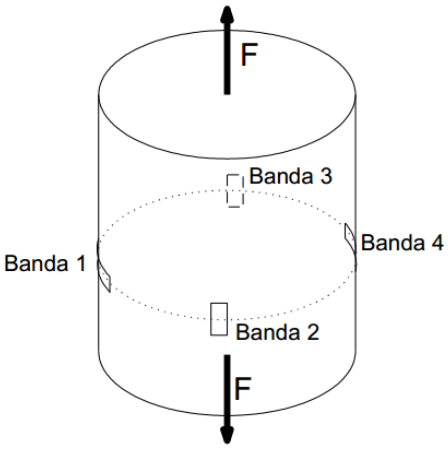

Fig. 1: Wheastone bridge configuration

Fig. 2: Front view of a part the car showing suspension arms

All data was collected with the Data Logger system inside the dashboard via CAN bus. The increments of millivolts provided by the strain gauge sensors was conditioned, managed and sent with an Arduino-based microcontroller. The data collection was possible with the use of an integrated circuit (IC) that contained a precision 24-bit analog-to-digital converter with a programable built-in gain amplifier.

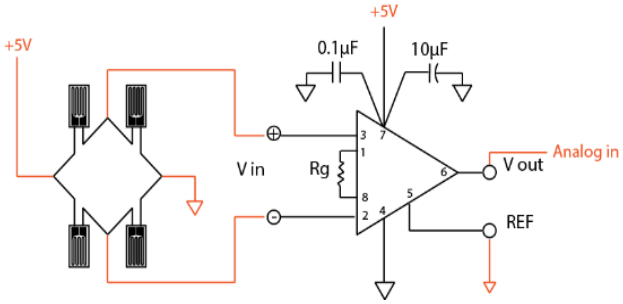

Fig 3: Electronic schematic

Information was postprocessed with a dynamic software to monitor measurement data with graphs and in numerical format. The results provided a validation of theoretical models and computer simulations.

The User Explains

The proposed Wheastone bridge configuration, the strain gauges used and the designed electronic amplifier system were tested and validated in the laboratories of the School of Engineering at the University of Seville. A tensile test was carried out with a test piece carrying this strain gauge layout. With these tests, the parameters of the amplifier circuit were adjusted, achieving levels of accuracy comparable to those obtained with a commercial equipment.

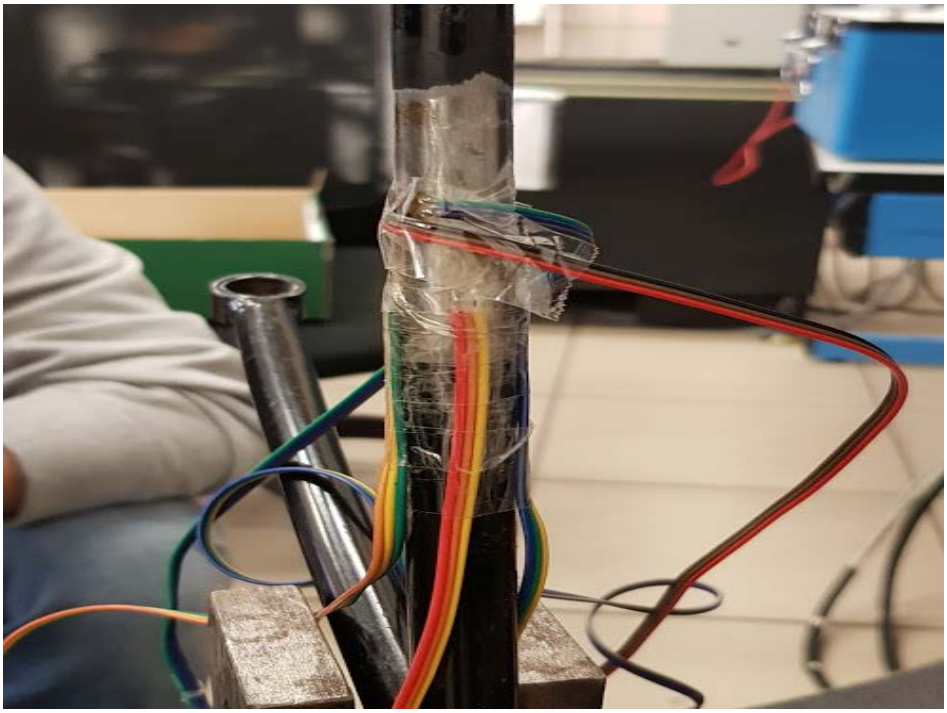

Fig 4: Specimen

Fig 5: Laboratory test

Thanks to the material provided by Micro-Measurements®, we could implement the configuration proposed in our car.

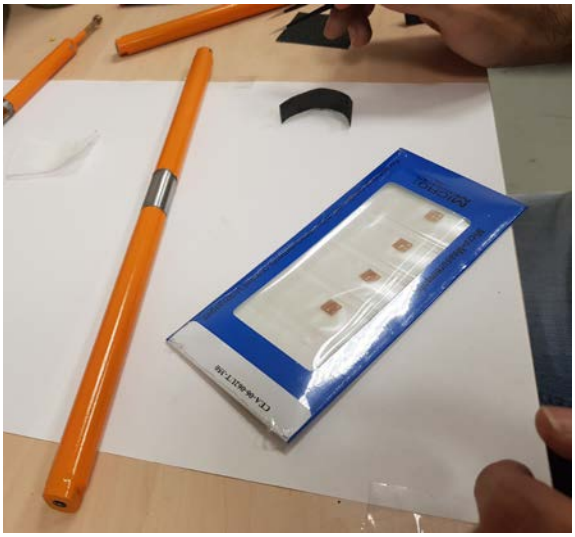

Fig 6: Micro-Measurements® strain gauges

Fig 7: Bonding the strain gauges

Fig 8: Strain gauges in the car

Acknowledgement:

ARUS team was founded in 2012, when a group of friends discovered the Formula Student competition. In 2014, with a really low budget, they qualified to compete in the German Formula Student competition and managed to finish the Endurance, the hardest event in the competition. Today, thanks to our sponsors and more than 150 people that have been part of the team, we strive to achieve being the only Spanish team that competes in both combustion and electric categories. Our engine: hard work, passion, strong fellowship and a lot of hearts that all beat for the same dream.

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