bf1systems Push Rod Loadcell

The load that is applied to a pushrod (or any other component) can be measured by mounting a strain gauge to the pushrod.

A strain gauge is a resistor made from foil that is bonded to a dielectric backing (insulator). When the strain gauge is bonded to a material and the material is stretched or compressed it will change in resistance. This change in resistance can be used to measure the amount of force that causes the material to stretch or compress. This is done by converting the resistance change into a voltage and is achieved by connecting four strain gauges into what is known as a wheatstone bridge.

When a number of strain gauges are configured into a wheatstone bridge, they can be used for precise measurement. When a voltage is applied to a wheatstone bridge (typically 5 or 10 volts) it will create an output, usually in milli Volts (mV). If a force is applied to the material that the wheatstone bridge is bonded to (strain gauges), it will compress or stretch. This will produce a change in the wheatstone bridge output expressed as mV/V (mV output from the bridge per unit Voltage input). This mV/V output is then calibrated by applying a known force (kilograms, pounds or Newton's) and the part can then be used as a sensor.

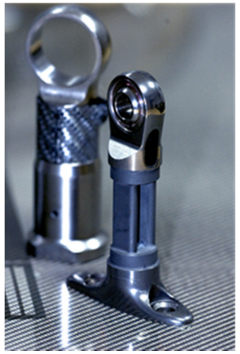
A strain gauge can be mounted onto almost any material sample, the most typical being steel, aluminium, titanium or carbon fibre. This allows the forces within components on cars to be measured, i.e. suspension components. The most accurate data can be achieved if the suspension component is designed with strain gauging in mind.

Push Rod Loadcell Design Considerations

There are many considerations to take into account when designing a push rod loadcell for the modern racing car.

Due to the very nature of high technology motor sport, extreme demands are placed on all components, such as high temperatures, extraneous forces and vibration. These demands are a serious threat to loadcell accuracy, but high accuracy and repeatability is still demanded for consistent racecar set-up.

The effects of these extreme demands can be minimised if they are taken into account when the design process is in its very infancy.



Mechanical design

In recent years, the availability of Finite Element Analysis has enabled improved geometries to be investigated with respect to stress pattern and force filtering of extraneous forces. The key being to concentrate the flow of stress into the area in which the strain gauges are to be bonded and also into the correct direction to maximise the value and accuracy of the signal.

Specification

Comparison of errors before and after compensation

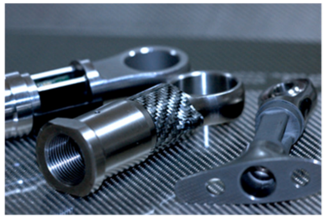
	Before	After
Zero drift per 100°C	10.0%	0.2%
Span drift per 100°C	4.0%	0.5%

Typical accuracy

If all of the above procedures are taken into consideration then the following errors can be expected.

Non-linearity (terminal)	±0.05	% RL
Hysteresis	±0.05	% RL
Repeatability	±0.03	% RL
Temperature effect on rated output per 100°C	±0.5	% RL
Temperature effect on zero load output per 100ºC	±0.2	% RL

Notes:
= Applied load
RL = Rated load
Temperature coefficients apply over the compensated range



www.bf1systems.com

Technical Centre | Owen Road | Diss | Norfolk | England | IP22 4ER
Telephone: +44 (0)1379 646200 | Fax: +44 (0)1379 770029

Environmental Protection

The use of sealants and potting compounds is often used with push rod loadcells, however this is not the most desirable way of offering environmental protection. Anything that does not behave homogenously with the loadcell spring element will introduce mechanical errors i.e. non-linearity and hysteresis. Mechanical covers are far better for protecting the strain gauge circuit. Care must be taken to ensure that the mechanical covers do not restrict free movement of the spring element so a small amount of sealant is still required.

Temperature induced errors

The temperature changes that a push rod loadcell will experience cause large errors in the zero load output and will also change the output span. With compensation techniques these can be minimised.

Zero change with temperature

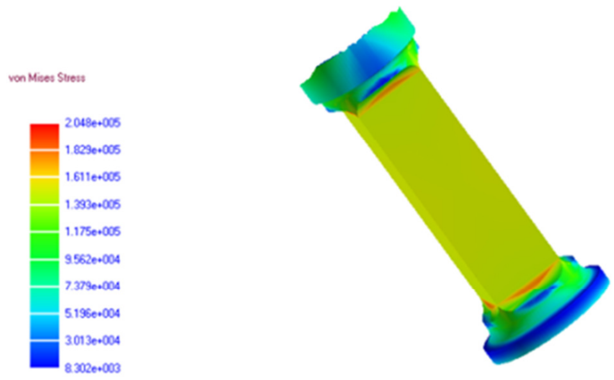
This is compensated for by changing the resistance balance of the loadcell bridge so that the resistance of all arms change by the same degree, thus cancelling out any shift that was previously experienced. The correct amount of resistance change is determined by cyclic testing at various temperatures to record the amount of shift that is experienced. The correct resistance value of compensation wire can then be calculated and added within the circuit.

Span change with temperature

This error occurs because both the gauge factor of the strain gauges and the modulus of elasticity of the spring element change with temperature. Consider a basic loadcell to see a change in temperature of 100°C, the gauge factor rises by say about 1.0%, and the modulus of elasticity of steel decreases by about 3.0%. The result is an increase in transducer span by approximately 4.0%.

Most push rod loadcells do not utilise span drift compensation. The repercussions of this are very serious when it comes to obtaining repeatable track side set up of the car.

The amount of change in the span is determined by load tests at elevated temperatures. Using this data it is possible to calculate a resistance value for a compensation resistor to be added. This compensation resistor is made from a material that has a high thermal coefficient of resistance. The resistance change of this element will compensate for the changes in loadcell span.



Summary

Many push rod loadcells do not implement these ideas within their construction. Without implementing these principles, errors of up to 30 to 40% can be experienced. This is detrimental to the overall accuracy of the measurements obtained and proper race car set up cannot be achieved which costs vital seconds and money.