Eccentric Loading Analysis for SuperSC S-Type Miniature Load Cell

A Technical White Paper by Interface

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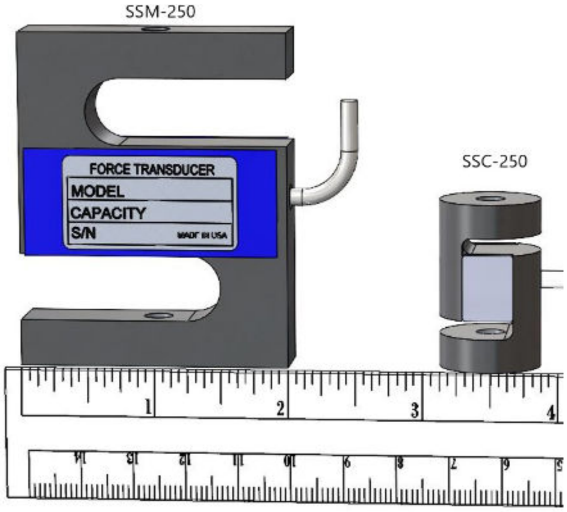
Interface introduced a revolutionary new product in our miniature load cell line in 2022. The product series is our SuperSC S-Type Load Cells, known as models SSC. The SuperSC (SSC) models are part of our family of shear s-cells. Traditionally, the s-cells are produced in a bending configuration; a comparison of eccentric loading performance between the two designs is desired.



FEA Analysis

Analysis was performed on spring elements of equivalent capacity, in this case 250 lbs. Two eccentric load scenarios were considered: a full scale axially applied load with three degrees of misalignment (fig 1) and a full scale load applied to the edge of the element loading surface (fig 2). Loads are commonly applied to spring element edges due to installed fixturing. Data from each scenario was compared against an axially applied load through the mounting threads, representing typical usage. Compression loading is particularly harmful to the spring element due to buckling effects; compression loads were used for the analysis to demonstrate a worst-case scenario. The stress vectors of concern are parallel with the strain gage grid lines, therefore the tension (+) and compression (-) stresses corresponding with their tension and compression gages were used to estimate effects on load cell signal. Mesh control shown in figure 3.

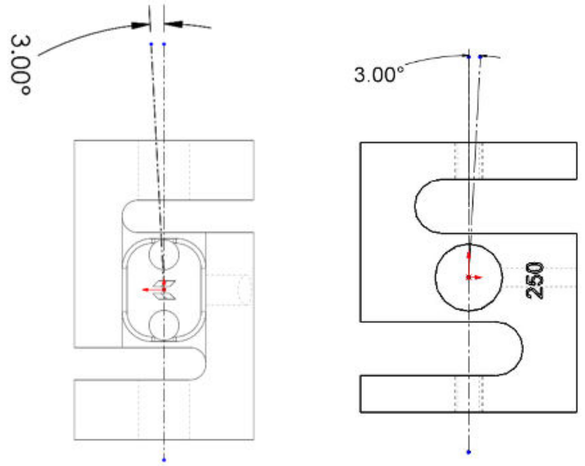


Figure 1 (not to scale)

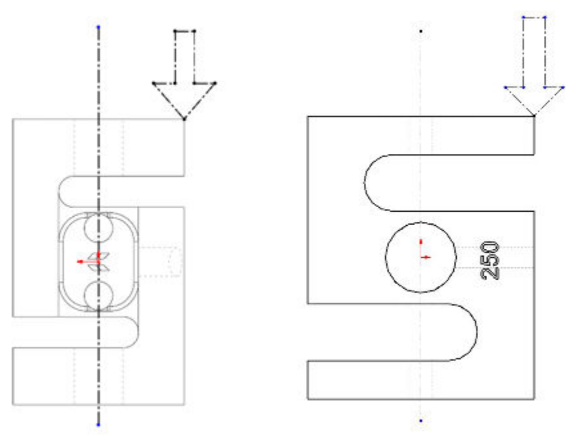


Figure 2 (not to scale)

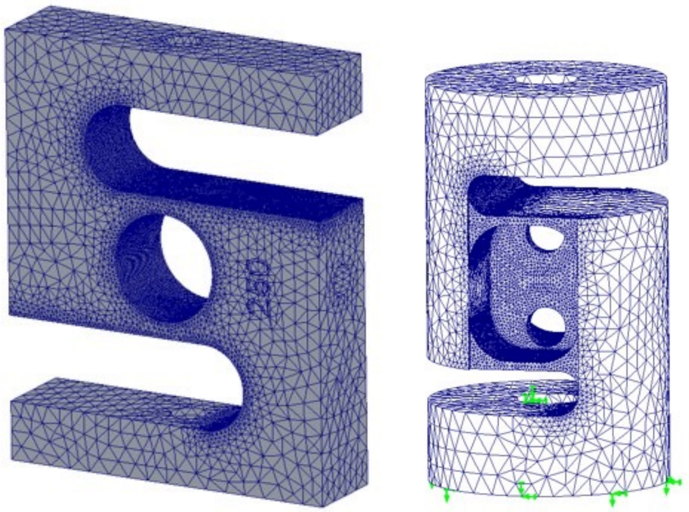


Figure 3

SuperSC Data

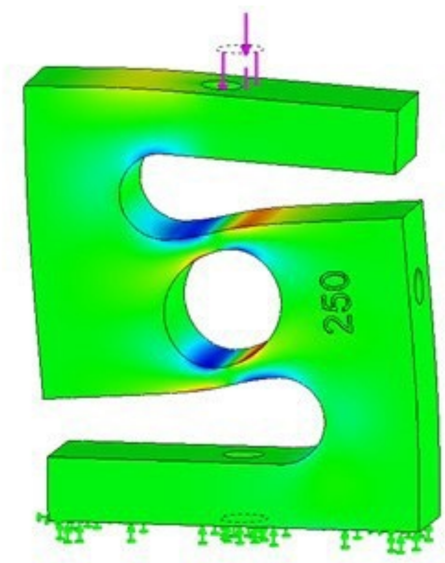
Stress values in pounds per square inch (PSI) were recorded in the location of the strain gages. For output error estimation, only stress in the gridline directions was considered, however maximum stress on the spring element was used to calculate the minimum safety factor of the unit. Due to resultant bending moments, maximum stress could occur on various portions of the spring element, not necessarily the gaging area; this is an important consideration for the user as this stress may not manifest as a noticeable zero shift prior to failure. The data is summarized in the table below.

		SSM-250	SSC-250
Axial Load Stress (PSI)	(+)	13535	17577
	(-)	-12413	-17529
Min. Safety Factor		2.98	2.39
Stress from 3° Misalignment (PSI)	(+)	13653	17689
	(-)	-12259	-17641
Misalignment Error %	(+)	0.87%	0.64%
	(-)	-1.24%	0.6%
Min. Safety Factor		2.89 (-3%)	2.38 (-0.4%)
Edge Loading Stress (PSI)	(+)	13433	19171
	(-)	-12538	-19112
Edge Loading Error %	(+)	-0.75%	9.1%
	(-)	1.01%	9.0%
Min. Safety Factor		0.99 (-200%)	1.77 (-35%)

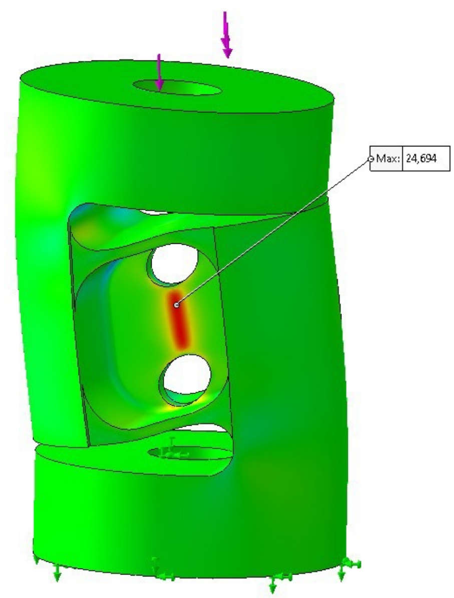
Misalignments

The SuperSC S-Type Load Cell performs particularly well in cases of misaligned loads due to the nature of its I-beam cross sectional design. Tension and compression shifts, as a percentage of axial loading, were lower in the SSC cell. Also, one can consider the ratio of tension and compression stresses as an indication of good linearity performance; closer to 1.0, or equivalence, is desired. The SSC, with a ratio of 0.997 in the misalignment scenario, is relatively well balanced compared to the Interface Sealed S-Type Load Cells, known as model SSM, at 0.917. Shear designs tend to resolve moment loads into the center load bearing portion of the beam (where the strain gages are located), while bending cells tend to shift stress concentrations along the longitudinal portion of the beam. In this case there may or may not be a strain gage in the new stress concentrated region, depending on the magnitude and direction of the applied load.

The safety factor of the load cells also shifted as a result of the eccentric loads: the SuperSC S-Type Load Cells shift, at 0.4%, compares favorably to the Sealed S-Type Load Cells shift at 3%.



SSM Misaligned, magnified 30x

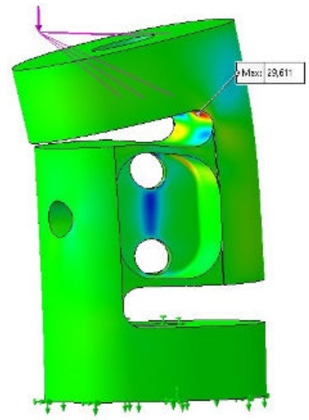


SSC Misaligned, magnified 55x

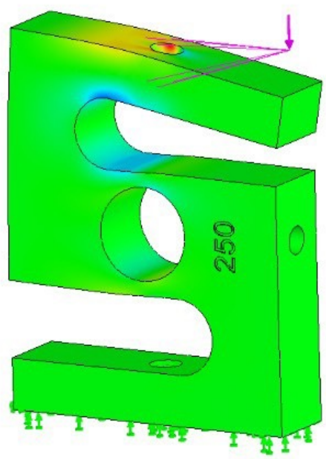
Edge Loading

Upon first inspection the Sealed S-Type Load Cell SSM would appear to be the more desirable choice regarding edge loading. The shift in stress, around 1%, is much better than the SuperSC S-Type Load Cell's shift, which increased by 9%. However, based on the ratios of these new stresses one can expect the SSC cell to perform more linearly despite the increase in signal. The SSC stress ratio is still 0.997 even with the load applied far from the loading thread, while the SSM's stress ratio has shifted to 0.933. If the units are calibrated with the edge loading effects present the SuperSC will perform in a more linear fashion.

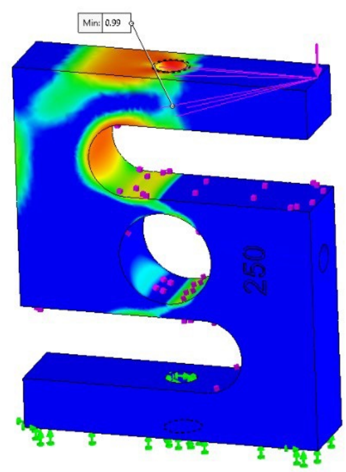
Critically, the SSC safety factor is still above 1.0 in this scenario, meaning that the cell would remain in elastic deformation and survive the loading; service life would be reduced, however. The SSM's safety factor has dropped to 0.99, meaning that while cell may remain in service based on the relatively low error the spring element will begin to plastically deform, rapidly resulting in broken a load cell.



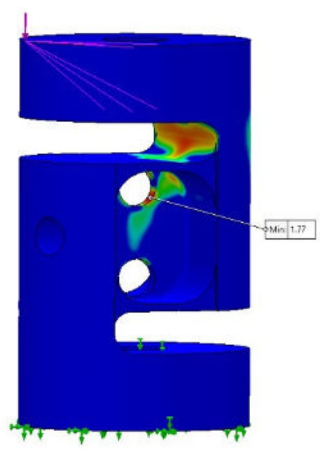
SSC Edge Loading, Magnified 20x Note Shear, web stress despite arm bending



SSM Edge Loading, Magnified 9x



SSM Edge Loading, Magnified 9x



SSM Edge Loading, Magnified 9x

Conclusion

The SuperSC S-Type Load Cell outperforms traditional s-type bending cells in output consistency and safety factor stability when loaded at three degrees of axial misalignment. The SuperSC has a higher output change under edge loading conditions than the s-type design; however linearity is much better and safety factor remains acceptable. S-bending cells are not capable of withstanding this level of edge loading from a mechanical standpoint.

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