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Analysis of load cell

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Abstract
Weight measuring machines are widely used in our day to day life. Whether it is any grocery store, vegetable shop or even a jewellery shop, weight measurement systems are used everywhere. Weight of the chemicals is also measured in laboratory and these items are weighed using electronic weighing machines to have exact predefined proportionate.
Electronic weighing techniques present the management with rapid, timely and accurate information that provides quick response times for customers. The popularity of such type of systems can be seen in all sectors of industry. In fact, its spectrum of use spans from the traditional retail industry, to manufacturing and warehousing, to postal, health and transport industry.
This paper includes mechanical design of a load cell which can satisfy the performance at full load and modeling and FEM of metallic element is done to focus on those conditions of load cell use that either compromise, or enhance the actual scale performance.

Keywords: Load cell, Measurement, Strain Gauge, Simulation.

Introduction

A load cell is being used to sense the weight of an object, so here load cell works as a sensor. When a load is applied to the load column it gets compressed and its length changes. This load column acts as a primary transducer because it converts applied force into change in length. This change in length cannot be measured directly. At the same time a strain gauge is connected to load column. This attached strain gauge acts as a secondary transducer since it measures the actual displacement of the load column. When this strain gauge is compressed, its length gets changed, which depends on the magnitude of the applied force on the top of the load cell. The resistance of the attached strain gauge changes when its length varies. This change in resistance is measured in terms of change in the output voltage and amplifies using a differential amplifier. If the voltage comes as negative, the inverter makes it positive. Thus, the load cell gives a voltage level, which is equivalent to the weight applied.

A load cell is a transducer, which is used to generate an electrical signal whose magnitude is directly proportional to the force which is being applied on it. The conversion of the load into voltage occurs in two stages. Strain gauges are mostly being used as the sensing element. Foil gauge offers the largest choice of different types and in consequence it found to be the most used in load cell designs now days. When a load is applied on the load cell through some mechanical arrangements the strain gauge deforms. The strain gauge which is connected to the load cell converts the deformation i.e. strain into electrical signals i.e. Voltage. The deformation is converted into an electrical signal as shown in Fig.1. The systematic representation of the digital load cell is shown in Fig.2.
A load cell is a mechanical device which is normally used in weighing industry. One of the most popular types of load cell is an S-type load cell[1]. It is normally used in both tension as well as compression applications. It has shown an excellent performance in a compact package. The reliability of the results attained by the load cell is dependent on various factors such as shape and size of load cell and electrical components and their associations [2]. In order to achieve better accuracy in the results, the selection of gauge area is very important. In this paper, the load cell is considered for compression loading with two different gauges. The finite element analysis is done to find the exact location for mounting the strain gauge. The objective of this paper is to design and to test the load cell with different gauge areas for the better accuracy under compressive load within the defined ranges.

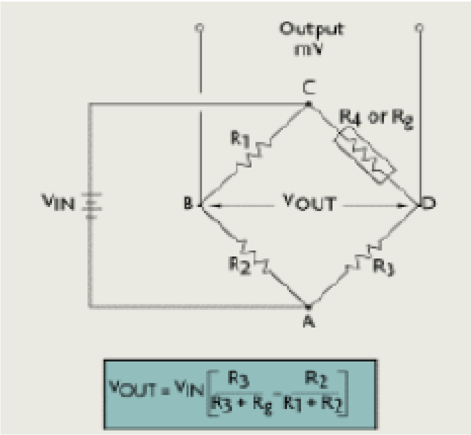

Fig. 1 Wheatstone bridge

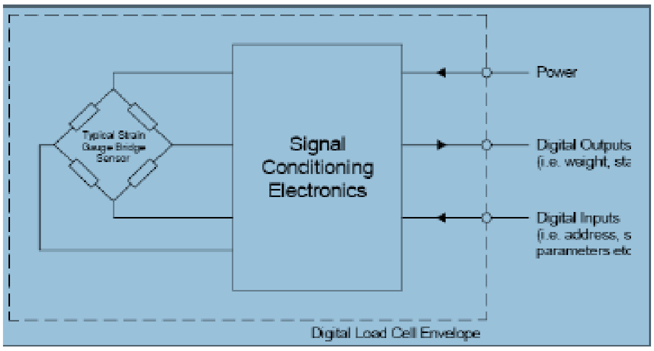

Fig. 2 Systematic representation of load cell [4]

Finite Element Analysis

The electric signal generated by the strain gauge is due to change in resistance which is proportional to the applied load on the load cell. So the exact location for installation of strain gauge where the strain is maximum under the rated loading condition is the main area of interest. At the same time, the gauge area plays the most important role on the behavior of load cell. To analyze this, two S-type load cells are designed in CATIA V5 software with rectangular and elliptical gauge areas for maximum load carrying capacity of 200Kg. Fig.3 shows basic dimensions of S-type load cell for rectangular gauge area. The most commonly used and standard gauge area cross-section for S-type load is circular cross section. The analysis is made to suggest different gauge area cross-sections in order to satisfy the design criteria and to achieve better force measurement with improved accuracy.

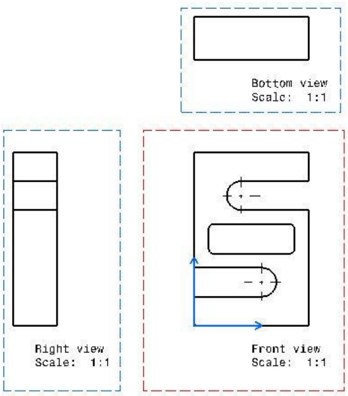

Fig. 3 S-type load Cell

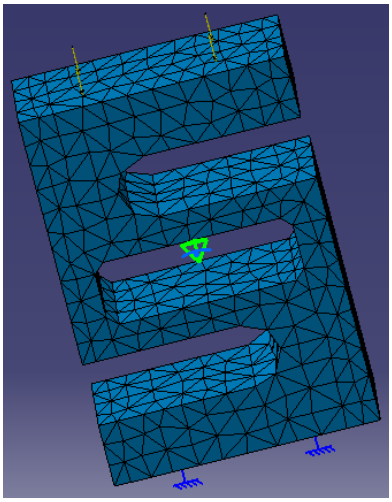

Fig. 4 Meshing of S-type load Cell with rectangular channel

Meshing of the load cell was done as shown in fig.4 with the help of analysis tool of CATIA. The number of nodes and elements generated was as follows:

Entity	Size
Nodes	1012
Elements	3323

Quality of the meshing is shown in the Table No. 1. Generally, there are four main criteria to evaluate the qualities of the solid mesh, which are known as aspect ratio, skewness, orthogonality, and smoothness. Aspect ratio is the most important criteria to evaluate the qualities of each individual element. On the other hand, skewness, orthogonality and smoothness, show the quality prediction for two adjacent elements sharing the same inner face of the grid. The type of the grid chosen is as octahedral.

Table No. 1 Quality of Meshing for rectangular channel load cell

Criterion	Good	Poor	Bad	Worst	Average
Skewness	3315 (99.76%)	8 (0.24%)	0 (0.0%)	0.739	0.422
Stretch	3323 (100.0%)	0 (0.00%)	0 (0.0%)	0.463	0.654
Min. Length	3323 (100.0%)	0 (0.00%)	0 (0.0%)	2.306	3.852
Max. Length	3323 (100.0%)	0 (0.00%)	0 (0.0%)	8.780	6.847
Shape Factor	3323 (100.0%)	0 (0.00%)	0 (0.0%)	0.500	0.720
Length Ratio	3323 (100.0%)	0 (0.00%)	0 (0.0%)	2.864	1.824

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Table No. 2 Quality range

Mesh Quality	Poor Quality Range	Good Quality Range
Aspect Ratio	(0.0, 0.3)	(0.01, 1.0)
Skewness	(-∞,0.4)	(0.01, 1.0)
Orthogonality	(60, 180)	(0, 89)
Smoothness	(0.0, 0.08)	(0.008, 1.0)

Generative structural analysis in Fig. 5 shows the maximum Von Mises Stress at mid of the rectangular gauge area.

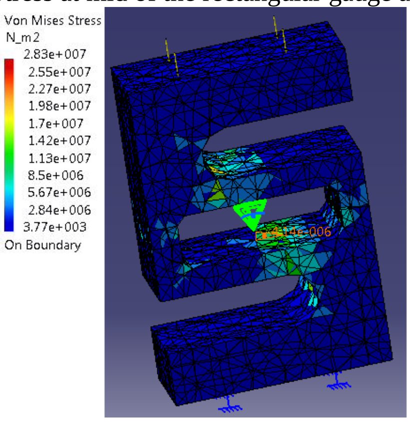

Fig. 5 Structural Analysis of S-type cell with rectangular channel

In second case the S-type load cell with elliptical gauge area as shown in Fig. 6 is selected for the analysis. By keeping all other parameters same as previous case the analysis is done.

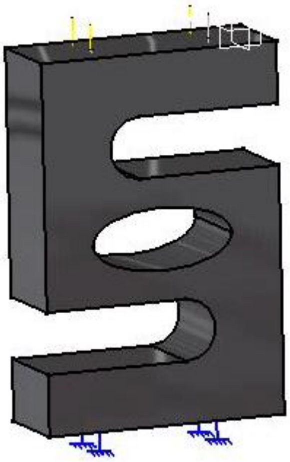

Fig. 6 S-type load cell with elliptical channel

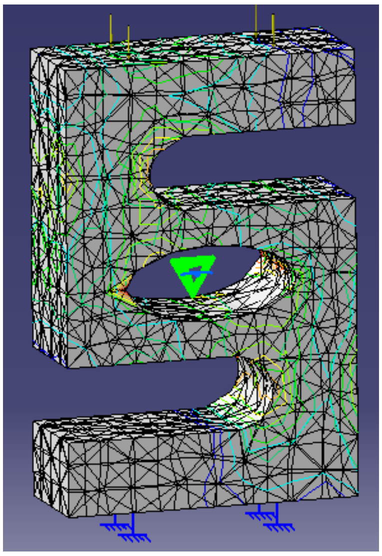

Fig. 7 Meshing of S-type load Cell with elliptical channel

Meshing of the load cell with elliptical channel was done as shown in fig.7 with the help of analysis tool of CATIA by keeping the other factor same as in previous case.

The type of the grid chosen is as octahedral as in previous case.

The quality of the mesh is again found satisfactory as shown in Table No.2.

Table No. 3 Quality of Meshing for elliptical channel load cell

Criterion	Good	Poor	Bad	Worst	Average
Skewness	5974 (99.33%)	40 (0.67%)	0 (0.00%)	0.828	0.407
Stretch	6014 (100.00%)	0 (0.00%)	0 (0.00%)	0.444	0.662
Min. Length	6014 (100.00%)	0 (0.00%)	0 (0.00%)	2.103	4.012
Max. Length	6014 (100.00%)	0 (0.00%)	0 (0.00%)	14.566	7.074
Shape Factor	6014 (100.00%)	0 (0.00%)	0 (0.00%)	0.410	0.728
Length Ratio	6014 (100.00%)	0 (0.00%)	0 (0.00%)	3.260	1.799

After examining the qualities of the meshing as per Table No.2 the meshing is found to be satisfactory for this geometry. The concentration of stress in this case is not very satisfactory as the previous case which can be found in Fig.8. So the location of installation of strain gauge in the second case cannot be determined accurately.

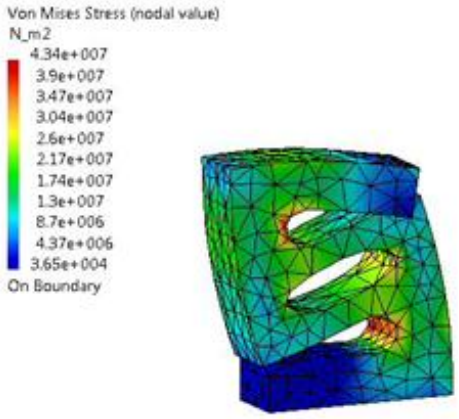

Fig. 8 Structural Analysis of S-type cell with elliptical channel

Conclusion

From the results of FEM analysis, it has been concluded that the S-type load cell with rectangular gauge area is having more concentrated area as compared to S-type load cell with elliptical gauge area. In this manner, it can be inferred that the S- type load cell with rectangular region gives better precision. In this study focuses was on the effect of gauge area shape on the accuracy of the load cell with load cell material as steel. Additionally a further study can be done to break down the impact of various materials on the precision of load cell with different working conditions.

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