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Experimental Stress Analysis

Experimental Measurements of the Forces in the Screws

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Abstract: Cooperation is aimed at tackling the problem of stress in the lid of the driver. The whole issue is being addressed through the finite element method. To calculate described the most realistic status is necessary to enter the most reliable input data into the numerical model. Therefore it was decided to experimental measurements and results obtained are used as input for solving the problem.

Keywords: Stress, Stiffness, Experimental measurements, Casting

1. Introduction

The paper deals with the problem of stress in the lid driver (Fig. 1) using computational and experimental modeling. The computational modeling (FEM) in addition to entering the geometry, material and loads of links, which in this case is defined by a torque screw. Tightening torque is not possible for a given level of computational modeling to consider as an input, but it is necessary to know the power, respectively deformation load screws.

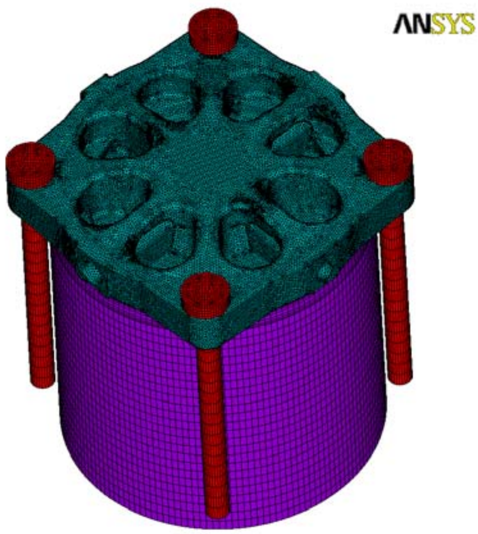

Fig. 1. FEM model of the analysed system (cylinder, lid and 4 screws)

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To calculate the forces in the bolt can be used as described in [2] (it is necessary to know the value of the coefficient of friction between the connected components), but these relationships are derived assuming that no significant deformation of the connected parts, which is not the case. In our case, screw the lid and bend the process of changing the size of force in bolts. For this reason it was decided to survey experimental forces in the screws for the two variants:

- system with old lid,
- system with new (shape modified) lid.

2. Selecting the installation and application of measuring sensors

Places to install the type of strain gauges and strain gauges were selected according to the rules for measuring mechanical quantities using strain gauges. View the location of strain gauges on the screw is shown in Fig. 2.

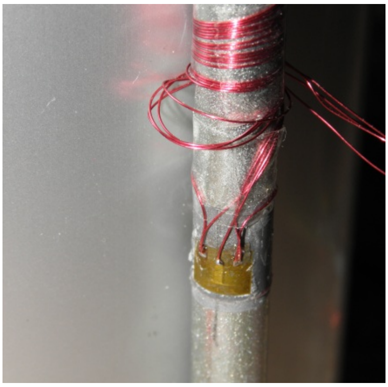
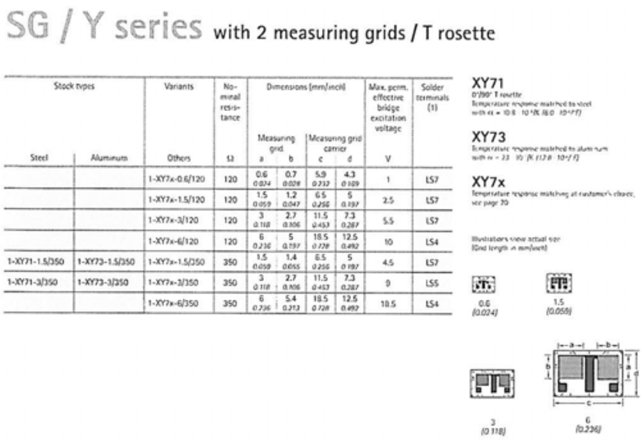


Fig. 2. Strain gauge on the screw

From the pictures it is evident in places where installation of strain gauges was performed (name is circled). This is a place on the bolts at a distance of 70 mm from the bolt head. All biaxial strain gauges are installed. Strain gauges were selected type XY 71 1.5 / 350 from the company HBM. Strain gauges are intended for application on steel surface in places with a standard size for desktop installation. Complete properties of the strain gauges are shown in Fig. 3.



SG / Y series with 2 measuring grids / T rosette

Stock types: Steel	Stock types: Aluminum	Variants: Others	Nominal resistance Ω	Dimensions (mm/inch) Measuring grid a	b	Measuring grid carrier c	d	Max. perm. effective bridge excitation voltage V	Solder terminals (1)
		1-XY7x-0.6/120	120	0.6 (0.024)	0.7 (0.028)	5.9 (0.232)	4.3 (0.169)	1	LS7
		1-XY7x-1.5/120	120	1.5 (0.059)	1.2 (0.047)	6.5 (0.256)	5 (0.197)	2.5	LS7
		1-XY7x-3/120	120	3 (0.118)	2.7 (0.106)	11.5 (0.453)	7.3 (0.287)	5.5	LS7
		1-XY7x-6/120	120	6 (0.236)	5 (0.197)	18.5 (0.728)	12.5 (0.492)	10	LS4
1-XY71-1.5/350	1-XY73-1.5/350	1-XY7x-1.5/350	350	1.5 (0.059)	1.4 (0.055)	6.5 (0.256)	5 (0.197)	4.5	LS7
1-XY71-3/350	1-XY73-3/350	1-XY7x-3/350	350	3 (0.118)	2.7 (0.106)	11.5 (0.453)	7.3 (0.287)	9	LS5
		1-XY7x-6/350	350	6 (0.236)	5.4 (0.213)	18.5 (0.728)	12.5 (0.492)	18.5	LS4

XY71
0°/90° T rosette

XY73

XY7x

Illustrations show actual size
(Grid length in mm/inch)

0.6 (0.024)
1.5 (0.059)
3 (0.118)
6 (0.236)

Fig. 3. Properties of the gauges LY 42 (source: HBM)

All strain gauges were installed according to the procedure HBM company. This procedure determines the first site selected mechanically abraded. The seats were roughened with sandpaper. Subsequently, instead of chemically cleaned and degreased. The purge was used by an RMS resource company HBM. The following points can be adjusted to apply the strain gauge. The bonding adhesive was used quick-Z70, made by HBM.

After application and check functionality of all strain gauges were glued strain gauges coated PU 120, which protects against moisture gauges.

In each of the measurement sites using four strain gauges in full bridge involvement. The way this circuit is shown in Fig. 4 and the full involvement of the central measuring bridge is in Fig. 5. The benefits of this involvement are:

- compensation and remove the effects of changes in temperature measurement,
- increased sensitivity of the circuit (C = 2.6),
- compensate for any bending.

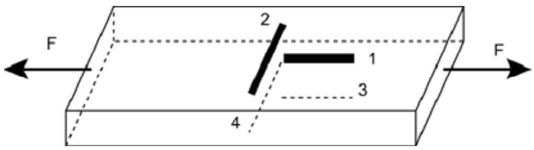


Fig. 4. Diagram of strain gauges in full bridge

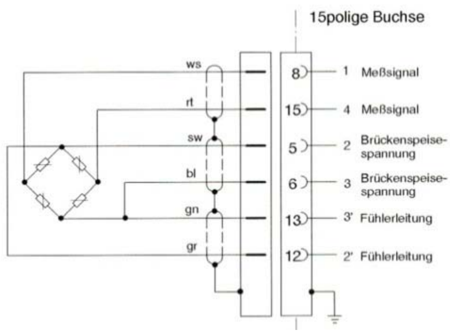


Fig. 5. Electrical connection

3. Measurement and analysis of results

Measurements were made for several operating conditions previously agreed [1]. It involves the measurement of pressure in the empty container with a lid and set up in position 1 and 2, the old lid. Further measurements were done again in position 1 and 2, this time with a new (semi-adjusted) cap. Position 1 and 2 is defined by turning the cap by 90 ° Fig. 6. Furthermore, the measured change in the forces after tightening the bolts to the specified torque. For all of these conditions was carried out measuring the size of forces in the bolts.

The axis forces were evaluated from strain measurements at location 1

$$\sigma_n = \frac{\varepsilon_i \cdot E}{2 \cdot (1+\mu)} \tag{1}$$

$$F = \frac{\varepsilon_i \cdot E}{2 \cdot (1+\mu)} \cdot S \tag{2}$$

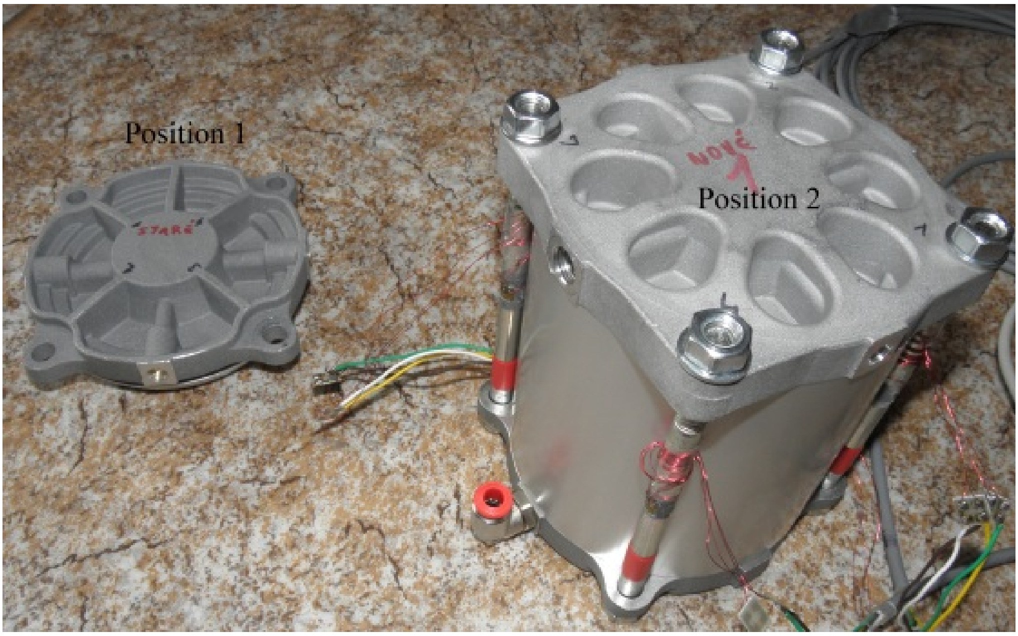


Fig. 6. Schematic connection of the lid's variants (on the left is old lid and new lid is on the right)

Central measuring HBM Spider8 [1] was used for measuring. Strain gauges were brought to the panel Spider8 six of source cable terminated with connector Canon15. The cable was shielded throughout its length. The cable length was set at 2 meters. As the evaluation software was used to measure Easy Catman, the company HBM.

4. Analysis of experiment results

Figs. 7 - 10. shows strength in the course of the process of tightening the screws on the old version (Figs. 7 - 8) and a new lid (Fig. 9 - 10) and lid different positions (turn the lid 90 degrees). The graphs show significant variability forces in the screws, which can cause a local increase in stress in the lid and lid the downstream limit condition (brittle fracture). The analytical calculations [2] for the screw M8 x 1 loaded 16.5 Nm based in the bolt force F = 7378 N, which is substantially higher than the values determined experimentally. This difference can be justified by the analytical calculation does not consider deformation of the connected parts, but if the lid is of considerable strain. Further, the graphs show that the strength of the bolt 3 (green curve) shows almost every measure the lowest value. This phenomenon can be explained by the fact that the screw in the lid 3 is the reduced stiffness of the lid, and it is transmitted in the bolt strength is lower than the other screws. During the experiments also showed that after tightening the screws to gradually reduce the size of the forces in bolts – Fig. 11, which is 60 minutes to stabilize the decline.

5. Computational modelling

The measured forces were input in the FEM model of the analysed system. The results of the computational modelling are shown in the Figs. 12 and 13. Fig. 12 shows the axial displacement (u_y) of the components and Fig. 13 shows the von Mises stress in the system. Due to the different forces in the screws the displacement and stress in the system are significantly influenced by this difference. In addition the bending of the lid near the screws is shown in both figures (Figs. 12 and 13).

Old system with a lid

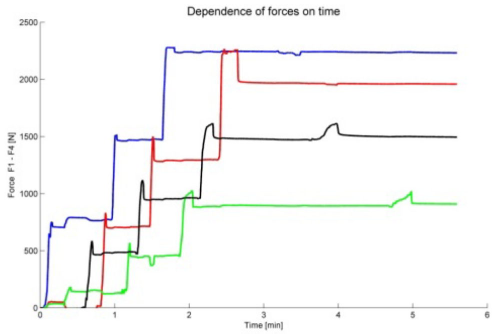


Fig. 7. Forces in the screws - variant 1, position 1 old lid

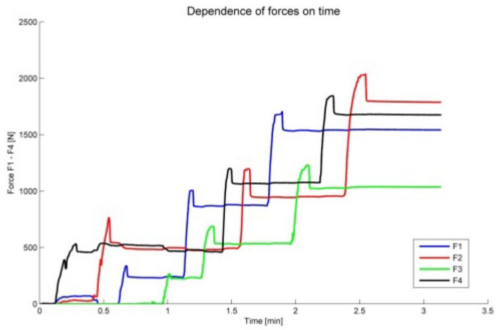


Fig. 8. Forces in the screws - variant 1, position 2 old lid

New system with shape modified lid

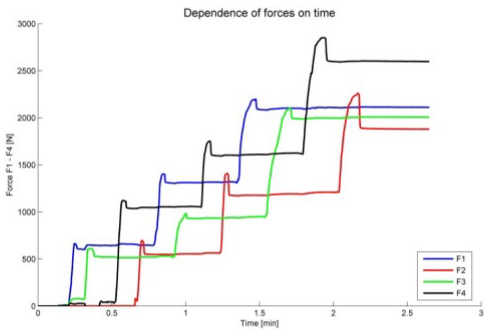


Fig. 9. Forces in the screws - variant 2, position 1 new lid

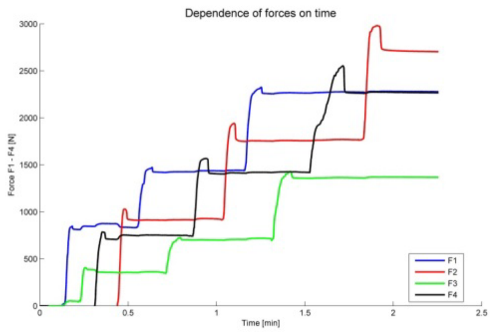


Fig. 10. Forces in the screws - variant 2, position 2 new lid

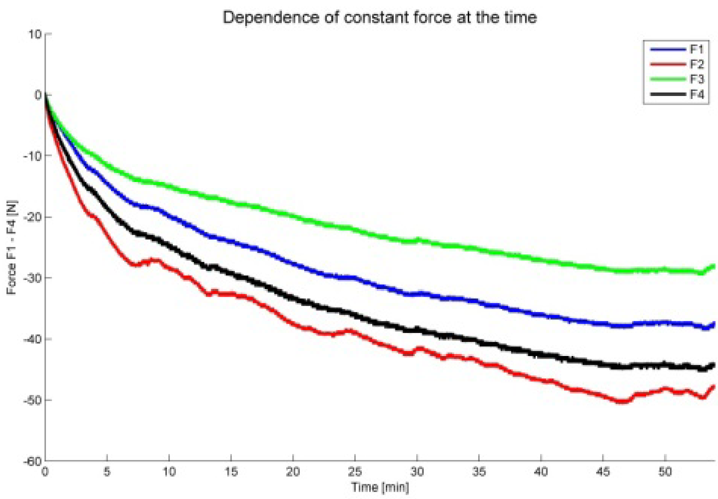


Fig. 11. Time dependence of the measured forces in the screws

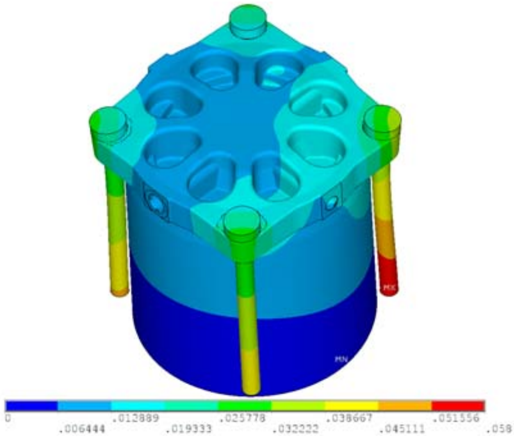


Fig. 12. Axial displacement of the system [mm]

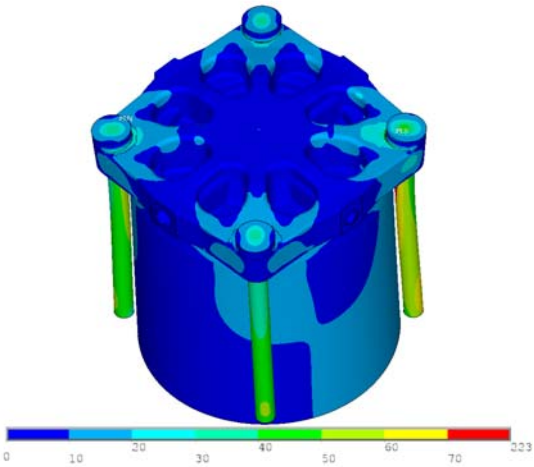


Fig. 13. Von Mises stress in the system [MPa]

6. Conclusion

The paper describes how an experimental model to determine the forces in the numerical calculation. The analysis results clearly show that the observed strength of the bolts are different and that a percentage of the value of 55%, 40%, 26.2% and 52% for both stage 1 and 2 and the status options for the lid and a lid 2 These changes are significant and are due to stiffness paws lid. Another effect is to reduce the size of forces in the bolts. Settling time reduction is about 60 minutes. This influence can be neglected as it is to change the size of forces by 1.5%. Thus the results obtained from experimental measurements are used as input conditions for the numerical solution of the problem.

Acknowledgement

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References

[1] Hoffmann, K. An Introduction to measurements using strain gages, HBM, Darmstadt 1989

[2] Pospisil, F. Threads, bolts, nuts and accessories. SNTL, Prague 1975