

Force Gauge for Measuring Actual Force during Measuring Bucket Calibration

P. Křibala^{1, a}, J. Kamenický¹, V. Dynybyl¹

¹ *Czech Technical University in Prague, Department of Designing and Machine Components, Czech Republic*

^a *petr.kribala@fs.cvut.cz*

Abstract: The article describes design of force gauge for experimental calibration of measuring bucket. The force gauge uses semiconductor strain gauges for measuring actual calibration force loading measuring tooth on the test stand. The force gauge was tested on test stand in laboratory.

Keywords: force gauge, measuring bucket, test stand, semiconductor strain gauge

1 Introduction

Test stand [1] is used for calibration of measuring bucket which measures digging forces. Test stand is shown in Fig. 1. The force gauge is used for measuring loading force on the test stand in laboratory. Each bucket tooth is loaded by hydraulic motor which presses to the arm. The force gauge with contact bolt is between the arm and the measuring tooth, it is shown in Fig. 2. At the first dimensions and shape of force gauge were designed after that shape and dimensions were modified due to FEM analysis. Final force gauge shape was tested by experimental measurement on test stand.

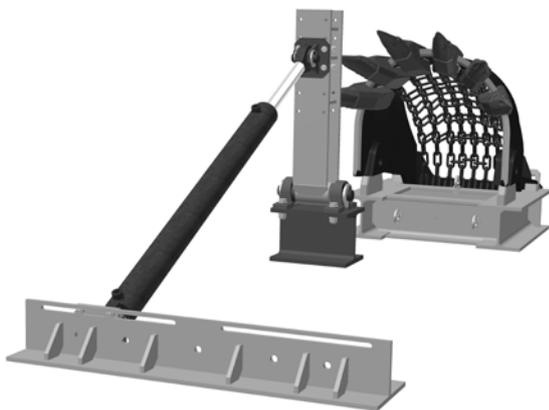


Fig. 1: Test stand for measuring bucket calibration

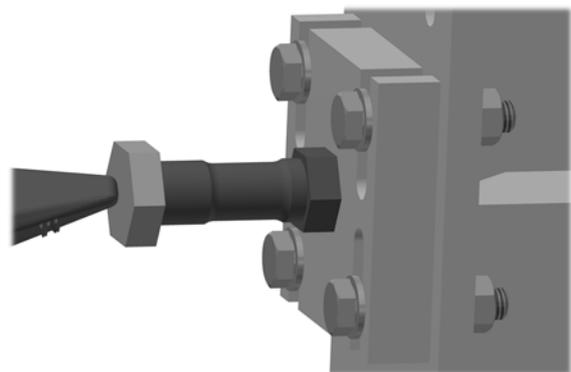


Fig. 2: Force gauge between measuring tooth (on the left) and arm (on the right)

2 Design and Calculation

2.1 Design

Main part of the force gauge is shank (tube) where the strain is measured on outer surface. Force gauge has inner thread on the one side and outer thread with hexagon for attach to the arm on the other side. Loaded force gauge is stressed by pressure. When the force gauge is loaded by eccentric force, the force gauge is stressed by combination of pressure and bending. Force gauge is shown in Fig. 3. Shape and dimensions were modified due to FEM analysis. Normal stress of force gauge loaded by tensional centric force is shown in Fig. 4.

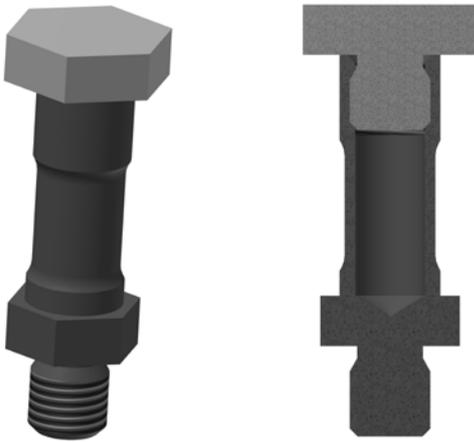


Fig. 3: Force gauge with contact bolt

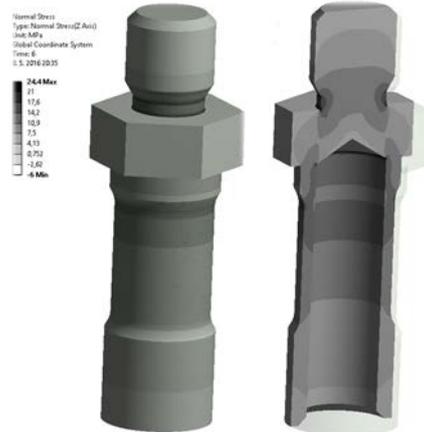


Fig. 4: Normal stress of force gauge loaded by tensional centric force

2.2 Strain gauges

On the force gauge there are four semiconductor strain gauges with support, which are bonded on shank parallel with axis of force gauge. Strain gauges are bonded on shank turned about 90 degrees. Force gauge can compensate bending stress. Semiconductor strain gauge with support is shown in Fig. 5. The force gauge with semiconductor strain gauges and wires is shown in Fig. 6.

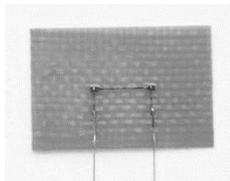


Fig. 5: Semiconductor strain gauge with support [2]



Fig. 6: Force gauge with semiconductor strain gauges and wires

Strain gauges are used for quarter bridges. 60 x higher threshold sensitivity of semiconductor strain gauge (compared with wire strain gauges) makes possible measurement of strain in metals beginning with a value as low as a millionth of one millimeter per meter. [3].

2.3 Experimental measurement

Measurement was carried out in laboratory at CTU in Prague. There were used laptop with measuring PCI Express card National Instruments and measuring device PXIe - 1073 with module PXIe - 4330 (both from National Instruments). Force gauge was attached on the frame of test stand. The rod was screwed into the force gauge. Weights were successively put on the rod and stressed the force gauge. The force gauge was tensioned in this measurement. Test stand for force gauge is shown in Fig. 7 and in Fig. 8.

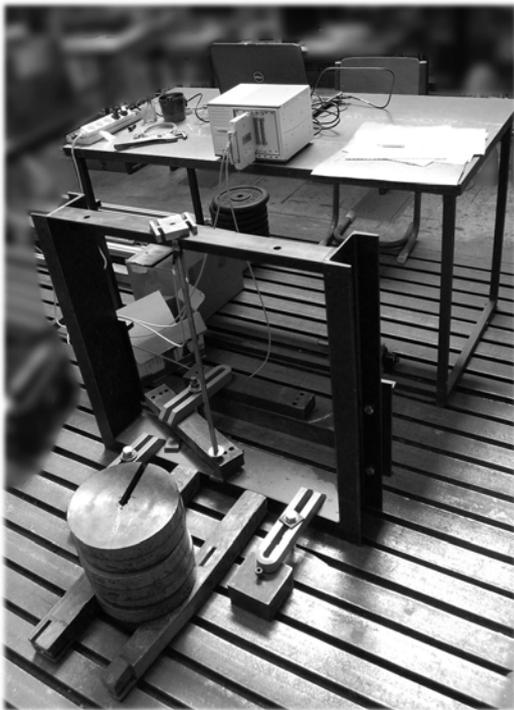


Fig. 7: The test stand for force gauge - unloaded



Fig. 8: The test stand for force gauge – loaded by weights

Force gauge attachment and its weight loading caused stress by combination of tension and bending. It is possible to calculate tension stress and bending stress because of using four strain gauge. Bending stress isn't mentioned in results because it isn't important.

2.4 Results

Results are normal stress calculated in FEM and measured normal stress depending on loading weight which is shown in Fig. 9.

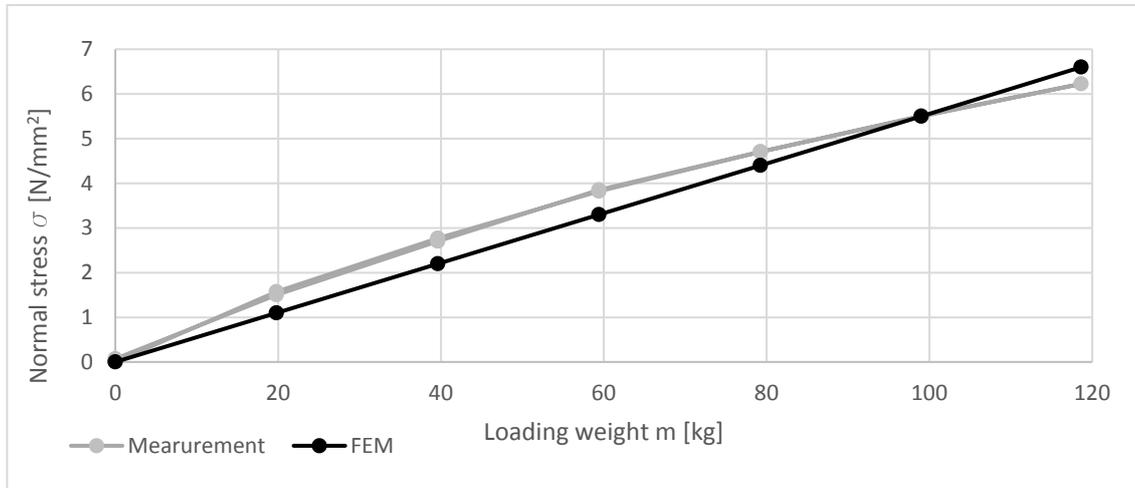


Fig. 9: Normal stress dependency on loading weight

3 Conclusion

The force gauge for calibration of the measuring bucket teeth on the test stand was designed. Dimensions and shape of force gauge was modified according to results of analytical and FEM calculations. The force gauge uses four semiconductor strain gauges for measuring strain during calibration on the test stand. It was discovered by measurement, that the force gauge has moderately nonlinear characteristics. For that reason additional measurement will be done or the force gauge shape will be modified.

Acknowledgement

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References

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