EXPERIMENTAL METHODS WITH STRAIN GAUGES FOR STUDY PURPOSES

Lukáš JANČAR[1], Václav MOSLER[2], Zdeněk FOLTA[3]

[1]VŠB – Technical University of Ostrava, Czech Republic, e-mail: Lukas.jancar.st@vsb.cz
[2]VŠB – Technical University of Ostrava, Czech Republic, e-mail: vaclav.mosler.st@vsb.cz
[3]VŠB – Technical University of Ostrava, Czech Republic, e-mail: zdenek.folta@vsb.cz

Abstract
Article deals with preparation of technical experiment for study purposes, where students can get to know strain gauges basics. Especially it deals with mechanical and thermal properties, reinforcement and linearity of strain gauges.

Key words: *Strain gauges; Technical experiment; Study.*

INTRODUCTION

During teaching of the lectures Technical experiment (Machine parts and mechanisms department - doc. Ing. Zdeněk Folta, 2015) a request to create practical stand for students was made. The stand should serve as a place to realistically verify the properties of strain gauges in the form of an experiment. There was no already existing stand with sufficient properties found on the market, so it was necessary to design it out of the scratch. The new stand was created with emphasis on easy and smart use, clear to students, and with use of the present standard software and ways of measurement (Mádr, 1991). The aim of the article is to show the concrete technical solution of the stand and how it can be used.

MATERIALS AND METHODS

The goal of the exercise at the proposed workplace is to verify the theoretical knowledge of the properties of strain gauges, namely: linearity, temperature dependence and amplification in various combinations (Škopán & Mynář, 1989). The workspace consists of 7 beams fixed to the structure as shown in Fig. 1. Each beam is provided with one or two strain gauges of different characteristics and a connector for connecting a measuring card, as is shown in Fig. 2. Resistive paper, resistive foil and semiconductor strain gauges are used. The beams have the same shape and are equipped with a set of holes for hanging the weights. Beams are made of various materials, steels 11 373 and 17 421 are used. The output of the measured beam is evaluated using the Mikrotechna M1000 device and LabView software.

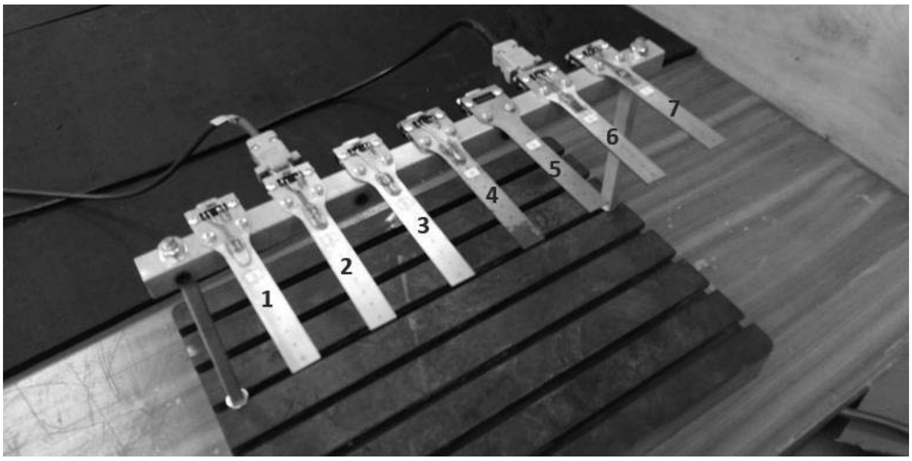

Fig. 1 Created experimental stand

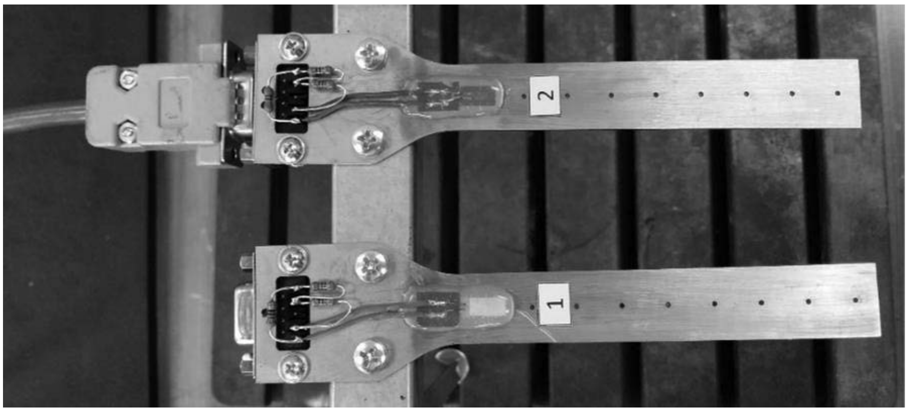

Fig. 2 Location of the strain gauge and its connection

The practice on the stand itself consists of several parts. The first is to determine the bending stress theoretically and practically. One of the holes in one of the beams hangs the metal cylinder of the defined weight and the output voltage U_m is measured, from which the bending stress in the strain gauge location is calculated according to the formula (1). Then the theoretical calculation of the bending stress according to the formula (2) is performed and the two results are compared. The result is to determine what is causing the measurement mismatch and finding unreliable values.

$$\sigma = \frac{4 \cdot U_m \cdot C \cdot E}{k \cdot n \cdot A \cdot p \cdot 1000} \; [MPa] \tag{1}$$

$$\sigma_o = \frac{M_o}{W_o} \;\; [MPa] \tag{2}$$

The second part of the measurement is the determination of the strain gauge linearity. Three beams are compared, one of which is fitted with a paper resistive strain gauge, a second with foil resistive gauge and a third with semiconductor strain gauge. The weight is gradually suspended in the holes in the beams and the signal strength and the bending moment are determined. The result is evaluation of dependence between bending moment and signal and its linearity. In Fig. 3 is a graphical representation of the signal running by gradually suspending the weight into all the holes of the beam fitted with a semiconductor strain gauge.

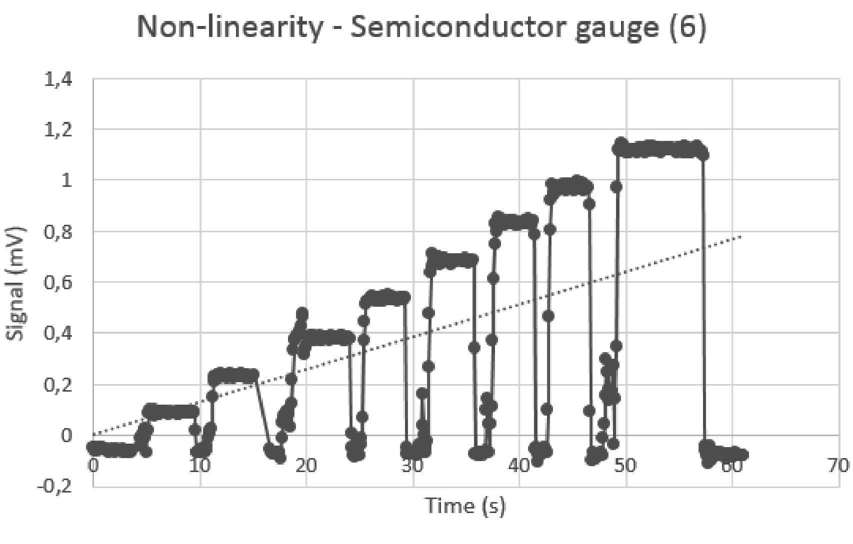

Fig. 3 Signal running - semiconductor gauge

In the third part, students have the opportunity to try amplifying the signal with a strain gauge bridge. The values measured on the beam with one active strain gauge added to the bridge by three resistors and a beam with two active strain gauges are compared. The fourth part deals with the determination of the modulus of elasticity of beam materials. It is measured on two beams fitted with the same strain gauges, one of which is made of structural steel, the other is of stainless steel. From the measured value of the signal, the modulus of elasticity of both beams is calculated from the formula (1) and the magnitudes of the signals can be compared for identical strain gauge connection, but other beam material. The last part of the measurement demonstrates the temperature dependence of different types of strain gauges with and without thermal compensation, it means when using only one or a two strain gauges in the bridge. Measurement is carried out similarly as in the previous steps, only artificially increasing the temperature of the strain gauge by heating to about 40 ° C. This is achieved by warming the strain gauge with warm air. The resulting values are tentative, but they can illustrate the temperature dependence of both types of strain gauges connection. The resulting signal waveform during warming and start of back cooling is shown in Fig. 1 (paper resistive strain gauge), Fig. 2 (foil resistive strain gauge) and Fig. 3 (two foil resistive strain gauges in the bridge).

RESULTS AND DISCUSSION

The stand described above allows to students get to know with strain gauges properties in a practical way, to understand connection options and calculation of physical values, like strain, force or deformation.

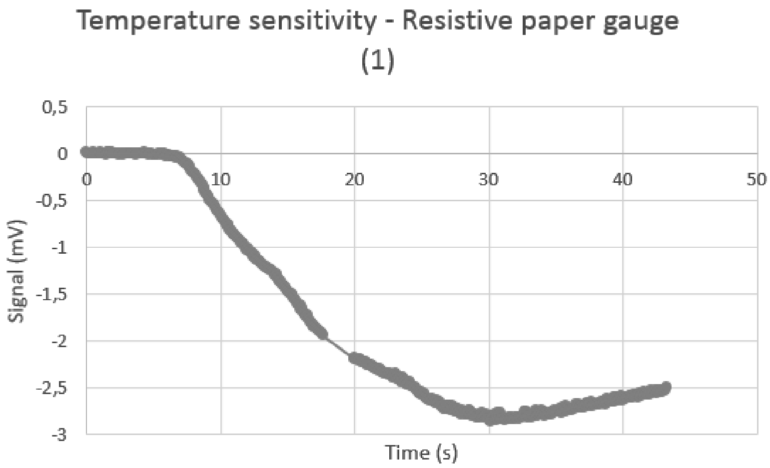

Fig. 4 Temperature sensitivity for resistive paper gauge

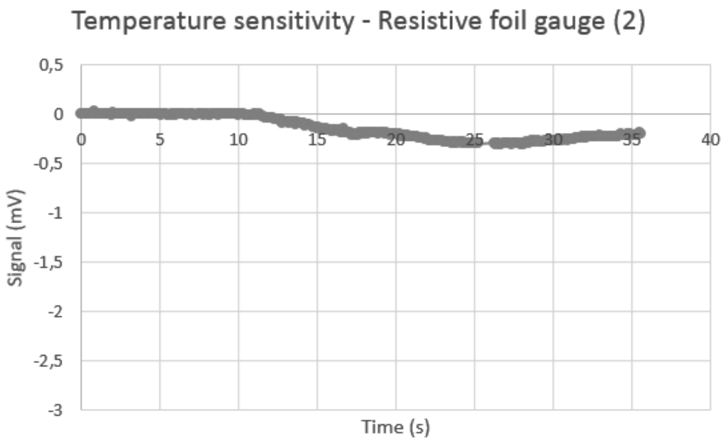

Fig. 5 Temperature sensitivity for resistive foil gauge

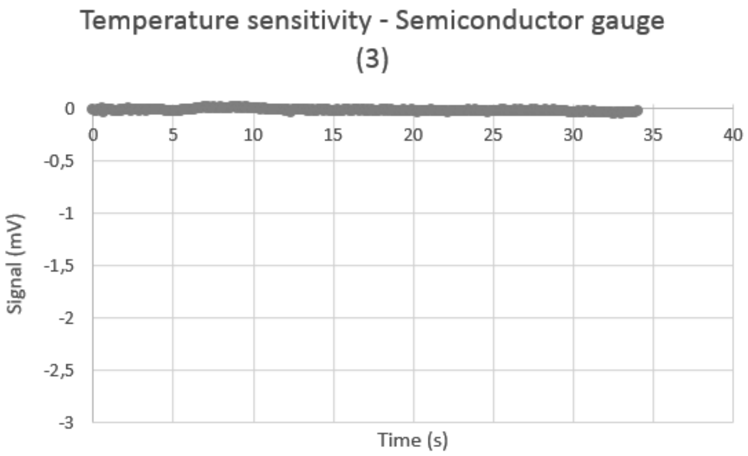

Fig. 6 Temperature sensitivity for semiconductor gauge

CONCLUSIONS

The benefits of creating the stand are mainly better understanding of the subject being taught, the ability to get in touch with individual elements used in the measurement, and to see a particular engagement with one's own eyes. It is also a great benefit for students to try working with measuring devices and applying acquired knowledge on a particular real experiment. The stand itself is not a discovery, but the application of the measuring methods used today (Olmi, 2015) to a compact test stand. Experiment uses current measurement sensors and evaluation techniques (Janíček, 1989).

REFERENCES

1. Janíček, P. (1989). *Technical experiment.* Brno: VUT.
2. Mádr, V. et al. (1991). *Physical measurement.* Prague: SNTL.
3. Machine parts and mechanisms department - doc. Ing. Zdeněk Folta, P. (2015). *Experimental methods in field: Lectures.* Ostrava: VŠB - TU Ostrava.
4. Olmi, G. (2015). *Load Cell Training for the Students of Experimental Stress Analysis.* Exp Techniques. doi:10.1111/ext.12175.
5. Škopán, M., & Mynář, B. (1989). *Experimental methods and machine testing.* Brno: VUT.

Corresponding author:
Ing. Lukáš Jančar, Department of Machine Parts and Mechanisms, Faculty of Mechanical Engineering, VŠB – Technical University of Ostrava, 17. listopadu 15/2172, Ostrava - Poruba, 70833, Czech Republic, phone: +420 597 324 313, e-mail: lukas.jancar.st@vsb.cz