Experimentální Analýza Napětí 2010
Experimental Stress Analysis

Experimental Determination of Circumferential and Meridian Stresses of the Blast Furnace Shell

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Abstract: This paper deals with installation of strain gauges on the external surface of the blast furnace shell in two rows, whereas there will be defined 8 measuring points in every row. The final result is evaluation of data obtained during up to 26 days of the operation. In this papers are commentary and discussions to measured time behaviours.

Keywords: Stress, Strain Gauges, Blast Furnace

1. Material of blast furnace shell

The shell is welded shell structure from a normalized boiler steel class 11 483.1 with following mechanical characteristics:

Yield point	Re = 363 MPa
Strength	Rm = 471 – 608 MPa
Ductility	AS = 22 %
Notch toughness	KCU3 = 0,49 J.mm^{-2}

2. Selection of strain gauges interconnection in configuration of „measuring bridge"

According to the torque-less theory of rotating shells there were measured increments of relative deformations in the selected points of the shell, together with related stresses in meridian and circumferential directions.

The most suitable method for such kind of measuring is application of a 'half-bridge' interconnection of the stress gauges with a thermal compensation. The thermal compensation is realized by means of a small piece of unloaded steel plate arranged close to the blast furnace shell.

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3. Application of sensors on the blast furnace shell

The sensors were arranged on 16 measuring points in the area of the blast furnace hearth and dimensional data of their positions are illustrated on the Fig. 1.

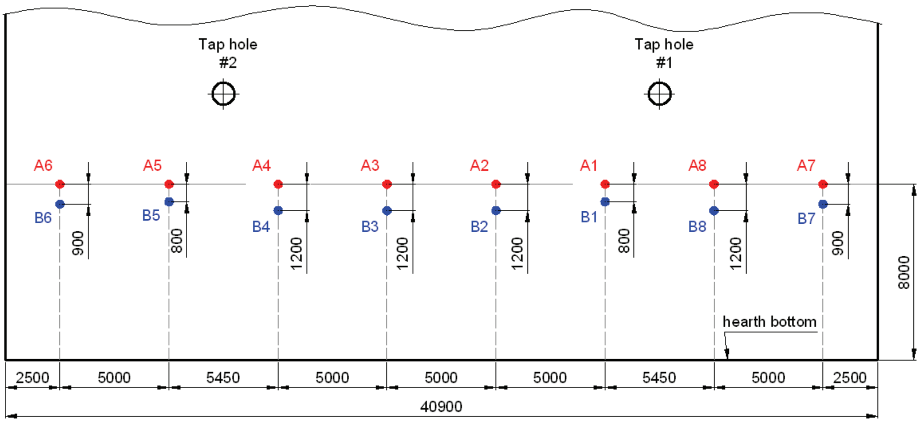

Fig. 1. Disposition of sensors on the extended blast furnace shell.

There were chosen the strain gauges 1-XY11-6/120 and 6/120XY91 produced by the company HBM. The gluing process was performed using the two-part glue X 60 with hardening process at normal temperatures. The strain gauges, installed on the blast furnace shell, were insulated against external influences by means of a silicon insulating paste with aluminium foil ABM 75 and the compensational strain gauges were insulated using the silicon rubber SG 250.

The measuring process and the procedure of measured data evaluation is illustrated on the Fig. 2.

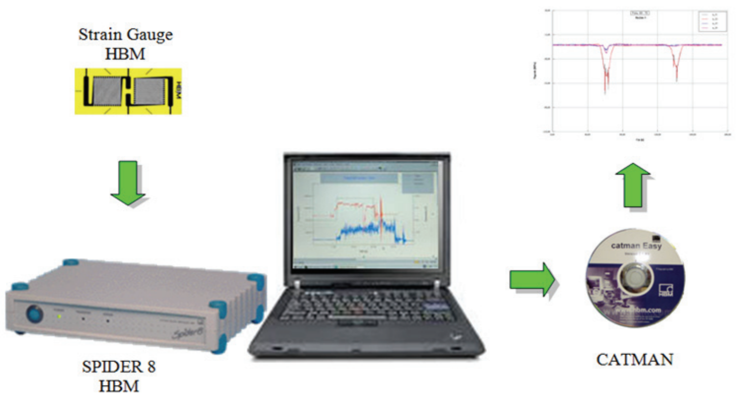

Fig. 2. Measuring chain.

Transmission of signals from the sensors into the measuring apparatus was realized by means of shielded input cables. Measuring equipment consists of 4 modular measuring amplifiers with the A/D converters SPIDER 8. The software CATMAN, which is product of the company HBM, was used for data collection, data processing and their final evaluation.

Photo-documentation of the real connection of sensor on the blast furnace shell, together with compensational strain gauge and its protection, is illustrated on the Fig. 3.

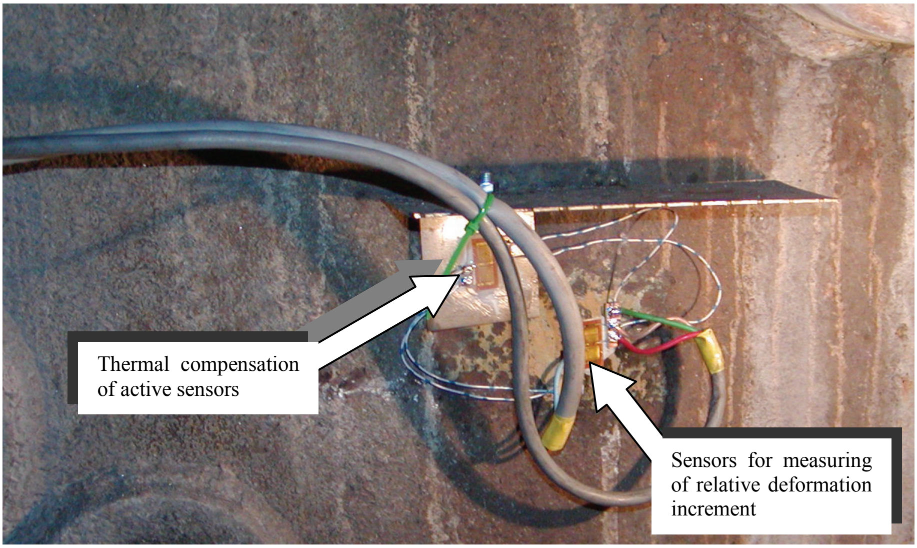

Fig. 3. Application of sensors, protection.

Difficult working conditions during application of strain gauges on the blast furnace shell are documented on the Fig. 4.

Fig. 4. Difficult access conditions on the measuring points with applied sensors.

4. Documenting of measured time behaviours of stress increments on the shell

Measuring of stress increments in 16 sensor application points according to the Fig. 1 was performed during 26 days. There were applied 32 active sensors (for measuring of meridian and circumferential stress increments) and also 32 thermal compensational sensors (for thermal compensation of the meridian and circumferential stress increments). During the above-mentioned time period of measuring the 5 sensors were damaged and therefore it was not possible to measure 5 meridian and circumferential stress increments out of the total number 32 sensors on the blast furnace shell. Taking into consideration reliability of obtained results, it is possible to say that impact of damaged sensors on the global monitored time behaviour and on the circumferential stress increments on the shell, is less important. The surface temperature around measuring points on the blast furnace shell was measured accidentally on selected days by apparatus FLUKE 561 and it did not exceed 50°C. The missing short time periods of records were caused by operation but they do not have any negative influence on total measuring results because of insignificant dynamics.

Time records of the circumferential stress increments in the measuring points A1 – A8 and B1 – B8 (see Fig.1), measured during 26 days, are illustrated on the Fig. 5 and Fig. 6.

Time records of the meridian stress increments in the measuring points A1 – A8 and B1 – B8 (see Fig.1), measured during 26 days, are illustrated on the Fig. 7 and Fig. 8.

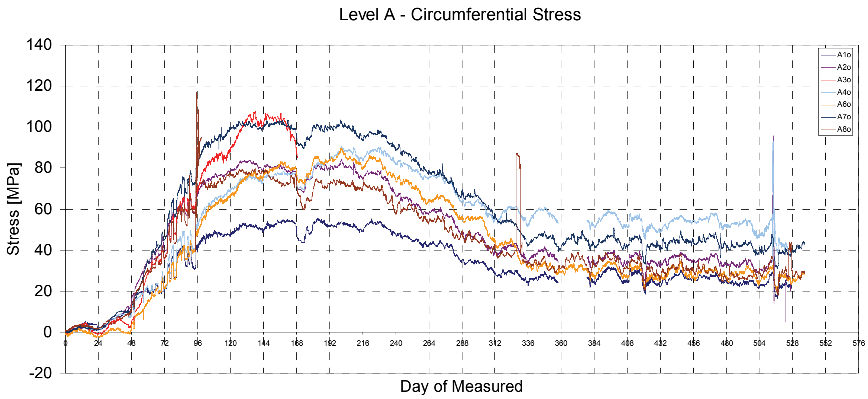

Fig. 5. Circumferential stress increments in the measuring points A1 – A8.

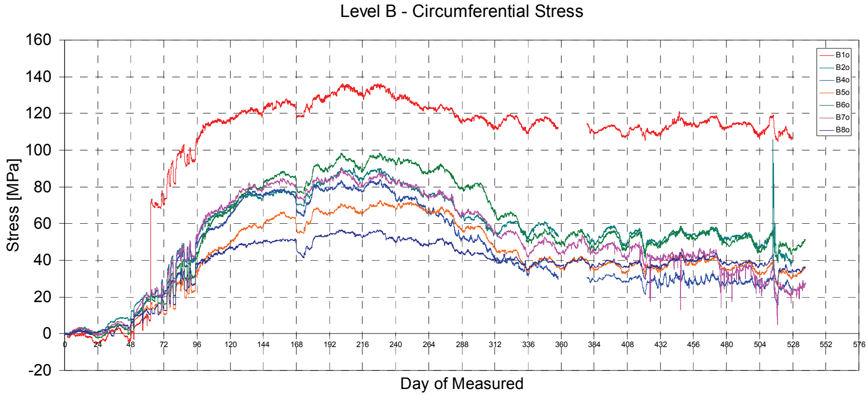

Fig. 6. Circumferential stress increments in the measuring points B1 – B8.

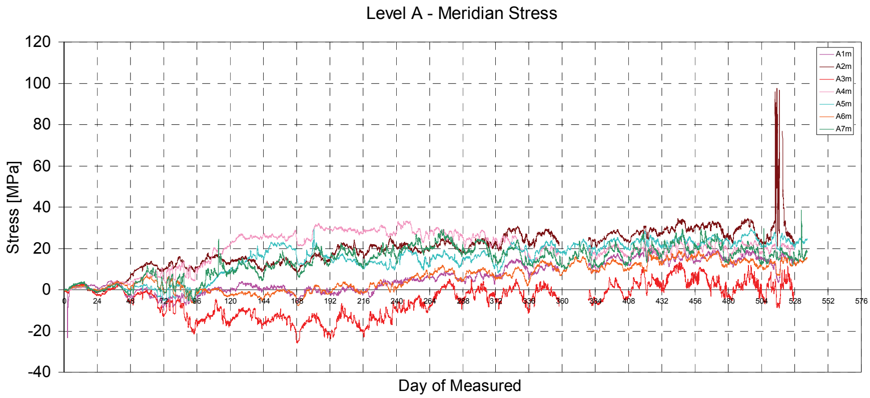

Fig. 7. Meridian stress increments in the measuring points B1 – B8.

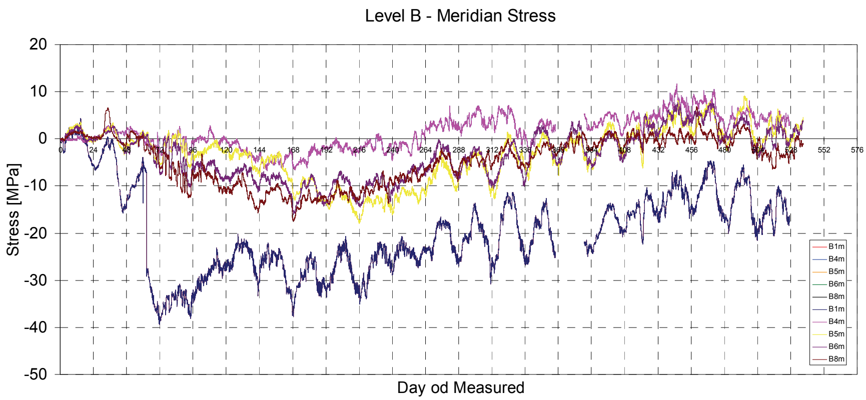

Fig. 8. Meridian stress increments in the measuring points B1 – B8.

5. Commentary and discussion to measured time behaviours of meridian and circumferential stress value increments

The most important, i.e. the determining stress increments are the circumferential increases and therefore they will be commented in the next part more detailed. On the Fig. 9 there are described time behaviours of the circumferential stress increments on the level A and on the Fig. 10 the circumferential stress increments on the level B.

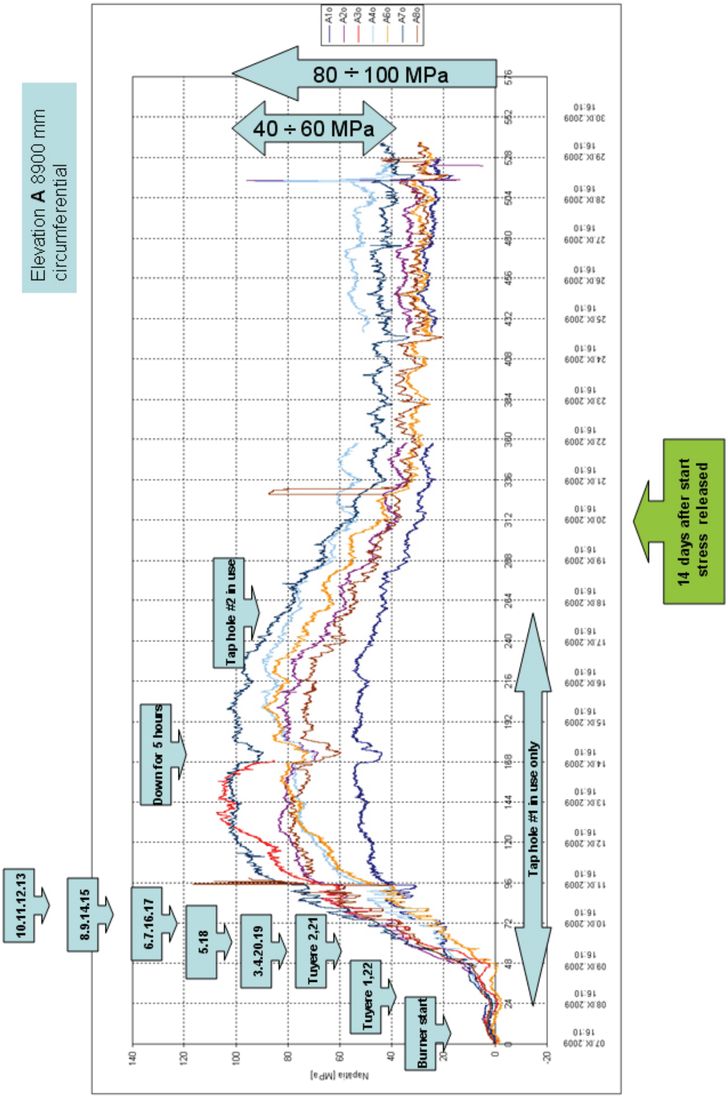

Fig. 9. Described time behaviours of the circumferential stress increments on the level A.

On the left side of the Fig. 9 we can see time of indication of the blast furnace start-up and time progress of opening of tuyeres 1 – 22. Also time decrease in circumferential stress increment during cca 5 hours is documented together with start-up of Tap hole #2 (see Fig. 1). It is possible to see decrease in circumferential stress increment after cca 14 days of operation of the blast furnace on the diagram. On the horizontal axis we can see time of operation of the Tap hole #1 (see Fig. 1). Similarly the same data are shown on the Fig. 10 for level B.

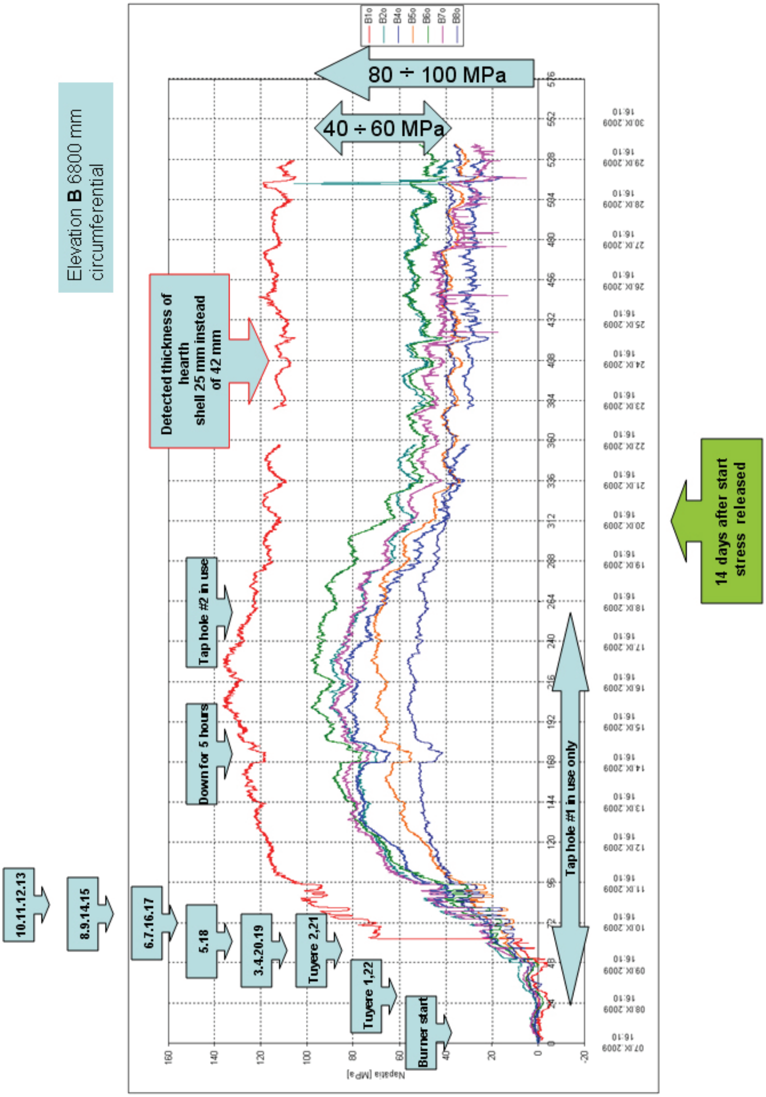

Fig. 10. Described time behaviours of the circumferential stress increments on the level B.

It is visible from the Fig. 9 and 10 that both circumferential stress increments on level A same as level B do not excess 135 MPa. On the basis of other circumferential stress time behaviours in the measuring points we can allege that their values are up to cca 100 MPa. Taking into consideration the value of overpressure in the blast furnace 0,24 MPa together with 1,7 m height of 50% Fe and 50% slag, the total pressure of pre-stress does not exceed 140 MPa. The circumferential stress in the most unfavourable case does not exceed value approx. 300 MPa, where yield point of blast furnace shell material is 363 MPa.

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