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COMPLEX LONG TIME MEASUREMENTS CARRIED OUT ON LIGNITE HEAP ON SOKOLOVSKÉ UHELNÉ A.S.

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Abstract:
Long time in situ measurements carried out on selected lignite (brown coal) heaps in the summer and winter season of 2012 and 2013 are described in this paper. The study was prepared in the frame of the research project TAČR No. TA01020351 "Research of prediction possibilities of infusion occurrence and following brown coal fuel self-ignition" supported in the programme ALFA. The main goal is to inform about the progress in the project focused on the research, development, and verifying of the complex methodology for an early identification of the start of an irreversible infusion state of lignite (brown coal) mass tending to its ignition (fire).

Key words: *lignite, brown coal, deposit, heap, coal self-ignition, monitoring, critical temperature prediction, gas emissions, economic loss decrease, environment improvement*

INTRODUCTION

Solution of the project is based on long term experience of solver team members with the issue of spontaneous oxidation and thermal accumulation of coal mass, thermal imaging measurements applications, coal petrology and adapted methodology of applied geophysics incl. logging measurements. It presumes field large area measurements of surface and internal temperature and derived symptoms of self-ignition of coal mass on real bodies of lignite heaps (deposits, fillings of out mined spaces) or rest pillars and use of laboratory methodology of oxidation (incl. self-ignition) process simulation and analysis of characteristic parameters of parallel taken coal samples. Relevant data are to be gained analysis of which determines deciding influences on the lignite self ignitron process and verify the relation of distribution of temperature anomalies to surface temperature changes without using rods penetrating the heap. Long period measurements were carried out in shed coal stacks in deposits where inner and outer temperature development can be observed from the start of shedding till its self-ignition. Modified version of geophysical logging of thermometry for comparing of inner temperature of a test body in injected probes and outer temperatures. Gaseous responses of inner image changes and changes of external gas aura in time are observed as well as humidity and porosity changes. Basic parameters of quality of coal composition in the whole heap are observed and analysed. Laboratory simulation of adiabatic thermal and oxidation methodology are very important, too. Atmospheric influences take a significant part in the influence on a degree to inclination to self-ignition besides geochemical processes lignite mass carbonization.

Particular comparison and complex interpretation of results will be synthesised into optimum methodology basic of which a thermal imaging will be the basis.

IN SITU OPERATION MEASUREMENT

Analysed samples, processing

Long time operational measurement of inner and outer coal body temperatures in winter and summer (on various climate and atmospheric conditions), sample takes of fresh and infused coal, meteorological data on air temperature, precipitations, wind, UV radiation, and measurement of lignite self-ignition indicating gases were carried out by the solving team during 2012 and 2013. The measurement took place on four experimental lignite deposits at Hrabak stack in Vrsanska uhelna mining company and on five deposit at TUM stack in Sokolovka uhelna mining company (fig. 1). Average time for one complex measurement was about two months. Hundred thousands data were measured by up to date technology and our own measurement technology on measured key parameters which have a decisive influence on the self-ignition process. Modified geophysical logging methodology of thrusted steel 5 and 4 m were used.

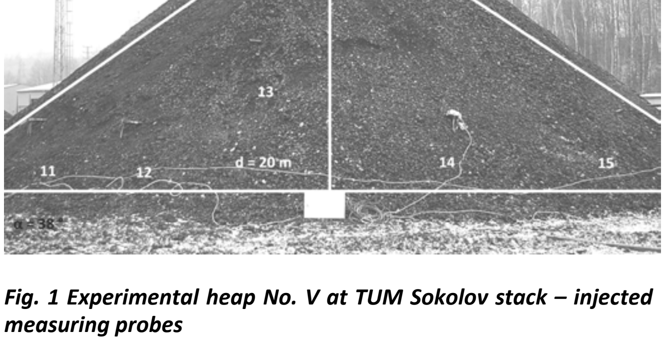


Fig. 1 Experimental heap No. V at TUM Sokolov stack – injected measuring probes

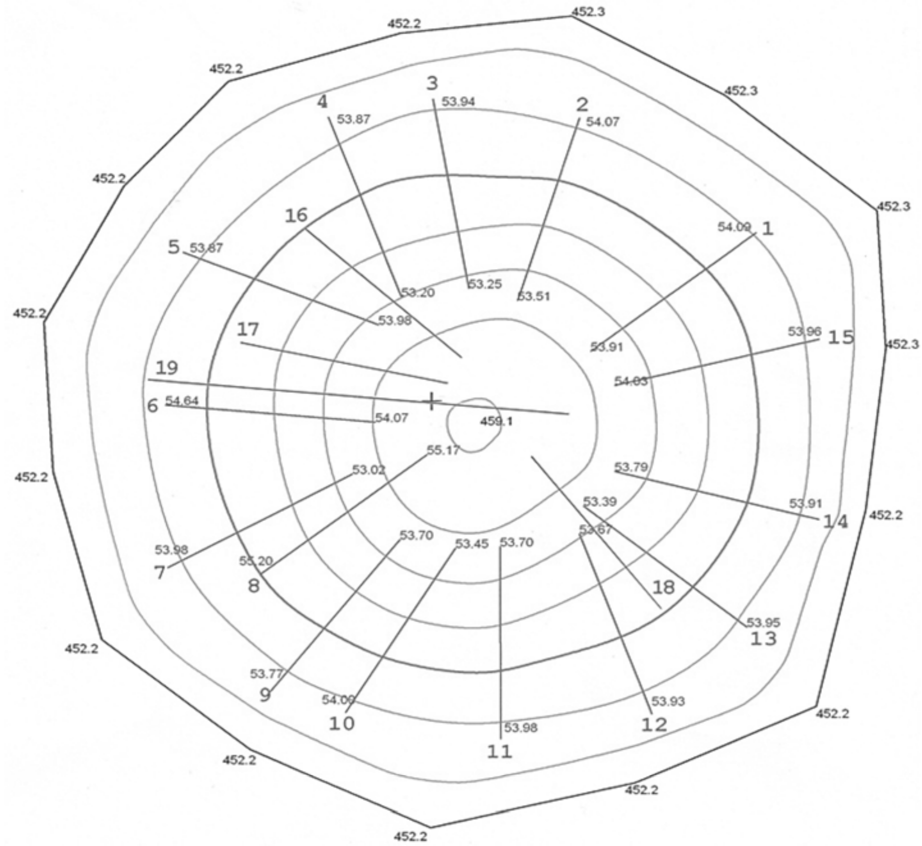


Fig. 2 Experimental heap No. V – schematic dislocation of probes

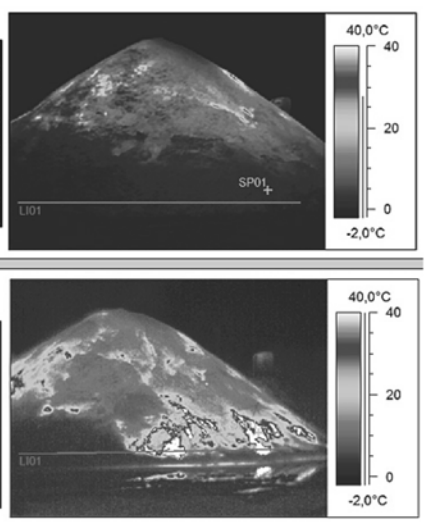
Measurement of surface temperature

„Methodology of temperature measurement of lignite heap" was created and published for surface temperature measurement [1, 2]. The methodology describes fundamental procedure and measurements conditions of actual temperature on lignite heap coat surface by means of thermal imaging set (fig. 2). Measurement procedure, evaluation of taken thermogrammes and proposal of recording measured results is in the methodology.

Thermal imaging measurements were carried out of lignite heap coat surface during each observation period of four complex measurements, i.e. since the time of start shedding the heap until demounting measuring technology and was liquidated by stack operator. Gas sample measuring corresponds fully with the measurements. Thermal imaging measurement records were processed to prepared protocols. A graph of surface temperatures, see fig. 3 was created from evaluated thermogrammes taken at each one measurement set.

Inner point temperature measured by means of measuring probes

Prototypes of steel probes with 50 mm diameter, ca 5 m length with specially covered sample taking places equipped with gum hose for gaseous samples and thermocouples for exact temperature measurement. The pitch between measuring points alongside the probe is 1 m. Modern K type thermocouples connected to measuring centre with a wireless data transmission are used to continuous measurement of inner temperature of the stack heap body and its dynamic changes. Sample taking probe is equipped with a hook for easy inserting and removing to and from the coal (fig. 4).



Object parameter	Value
Emissivity	0,95
Object distance	20,4 m
Ambient temperature	-0,8°C
Relative humidity	0,50
Label	**Value**
IR : max	30,6°C

Object parameter	Value
Emissivity	0,95
Object distance	21,8 m
Ambient temperature	4,3°C
Relative humidity	0,50
Label	**Value**
IR : max	324,3°C

Fig. 3 Example of an output of surface temperature measurement – temperature graph at TUM Sokolov stack

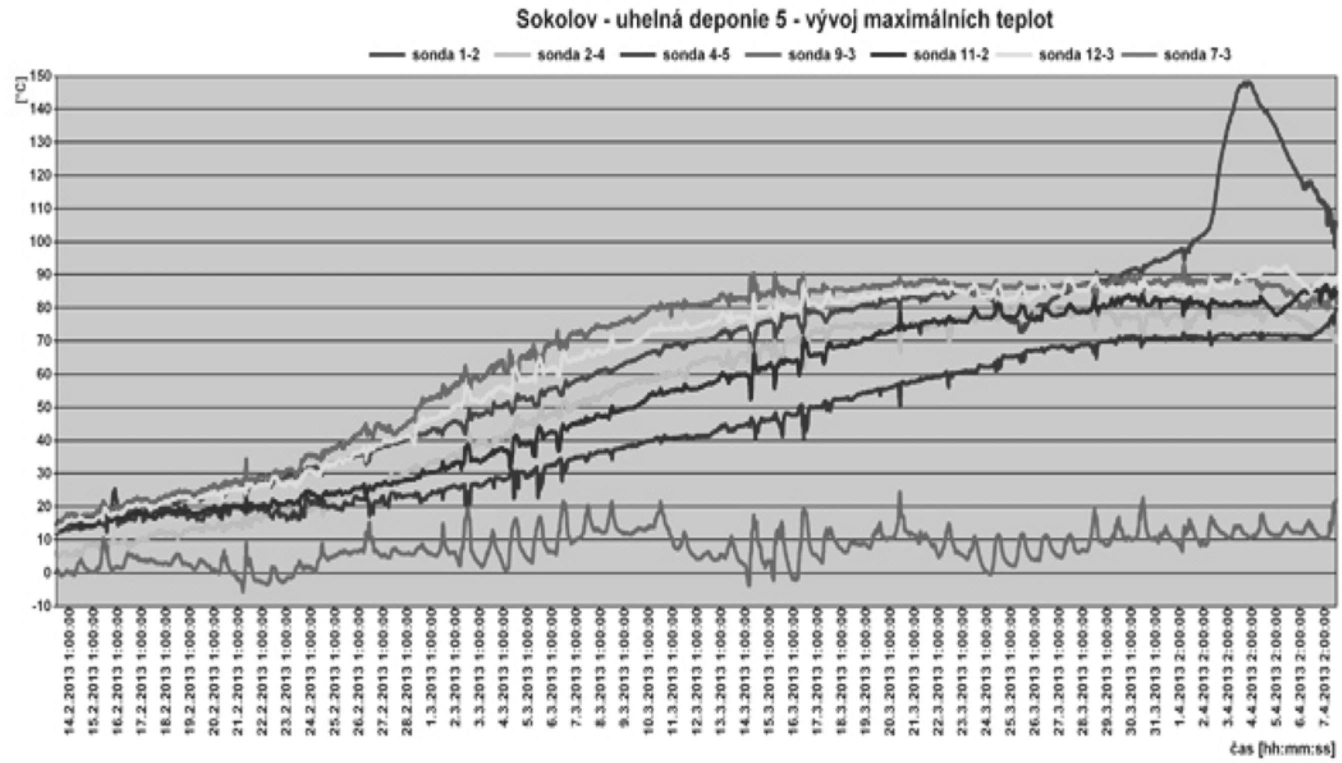


Fig. 4 Example of output of inner temperature measurement at TUM Sokolov stack

Probes were inserted to lignite mass in two stage chess-board like horizons so as the largest possible area of observed deposit was covered. Evaluation centres with wireless data transmission were programmed to acquire information of inner temperature of coal mass in sample frequency once in a second. (it can be changed if needed). Actual temperature values were possible to obtain through a wifi modem to a mobile phone or notebook everywhere and thus enabling an operative action at a significant temperature change. The data can be read later via a cable connection or through Blue tooth.

Measuring inner line temperature by means of auxiliary probes

A modified geophysical method of geothermal drilling variant – logging was applied to verify the level and dynamics of the development of temperatures in the space of observed body. Basic and proven in operational conditions way of measuring inner temperature in a shed body of lignite uses inserted steel rods with conical end. The inner help probe – steel round rod 4 m long is inserted to an outer probe – pipe. It was proven in the VUHU laboratories that inner temperature of the lignite mass warms a steel pipe durably laid in the heap which transfers the temperature to auxiliary probe. During the observation the probed is pulled out and its temperature is immediately measured in metre intervals by means of a thermal imaging camera. An example of a record of 3rd and 4th metre of the auxiliary probe No. 13 and evaluated in a prepared form can be seen in figure 5. Maximum measured temperature of 62.9° C in a metre interval of a steel kernel can be seen in the example.

Supplementary probes thus represent a simple and cheap variant of obtaining basic information of the temperature development in the experimental lignite heap. The length of the supplementary probes can be changed according to the size of lignite mass coal in one or two metres using longer pipe and rod.

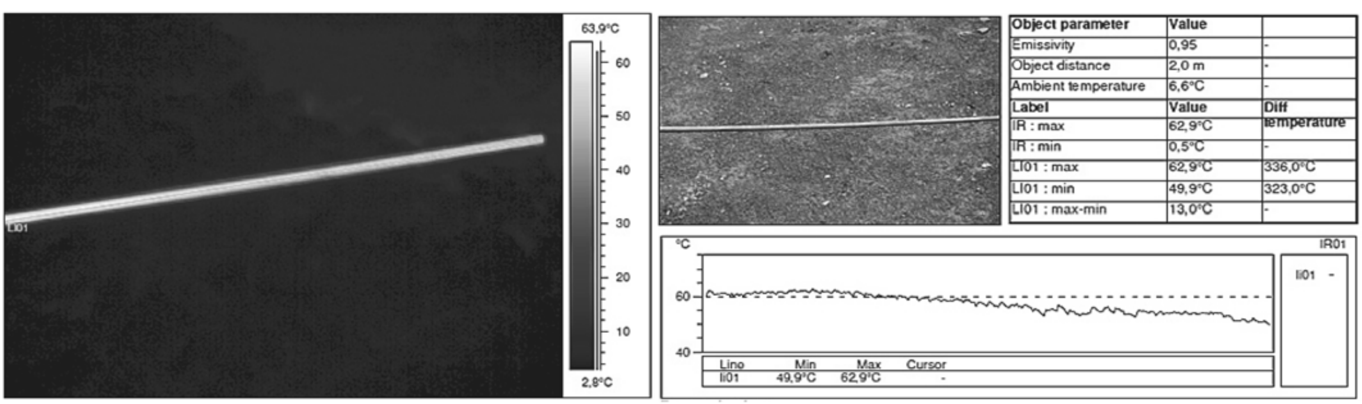


Fig. 5 Output of probe No. 13 - 3 to 4 below surface

Fig. 6 Professional meteorological station OREGON WMR200

Measuring meteorological influences

The influence of atmospheric conditions (sun shine time length, aeration, precipitation, barometric pressure, temperature) on processes leading to self-ignition of lignite, degradation of coal mass due to value changes of physical chemical factors and weighing of further fault factor for the self-ignition evaluation was carried out by means of a professional meteorological station Oregon WMR200 see figure 6. Local barometric pressure, temperature and humidity were so measured with own measuring station (fig. 7).

Gas monitoring in situ

Operation measurement of gas indicating lignite self-ignition on experimental stacks was realised by the VŠB-TU Ostrava co-acceptor who carried out laboratory analyses the gas with Tepox methodology (fig. 8).

Operation in situ measurement was done with mobile infraanalyser BRAGER X-am 5600 and by means of gas sample taking into tedlar sacks for chromatographic analyses. Mobile infraanalyser Geotech G110 was used at high CO2 concentration. Laboratory of Material Self-Ignition of HGF VŠB-TU Ostrava carried out the analyses of gaseous images of indicating gas. Gas Laboratory of the VŠB-TU Ostrava Nanotechnology Centre did chromatographic analyses.

Laboratory investigations

Some samples of deposited coal were taken from heap surface and from below in the frame of complex long time measurement of lignite heap in order to:

1) to carry out a chemical analysis of the deposited fuel. Laboratory investigation of the coal samples should find changes of selected parameters as temperature fields develops and structure of coal mass changes. The samples were taken :
   - after shedding,
   - during long time observation,
   - after long rain to determine humidity ,
   - after ending long time observation, before heap removal.
2) for laboratory investigation [4, 5] with calorimetric tests when following was measured:
   - tendency to self-ignition (oxireactivity), 4 samples
   - influence of granularity on oxireactivity, 3 samples, two granularities each
   - influence of humidity on oxireactivity, 2 samples, minimum four humidity levels each;
   - influence of temperature on oxireactivity, 2 samples, 30 to 150°C. Each.

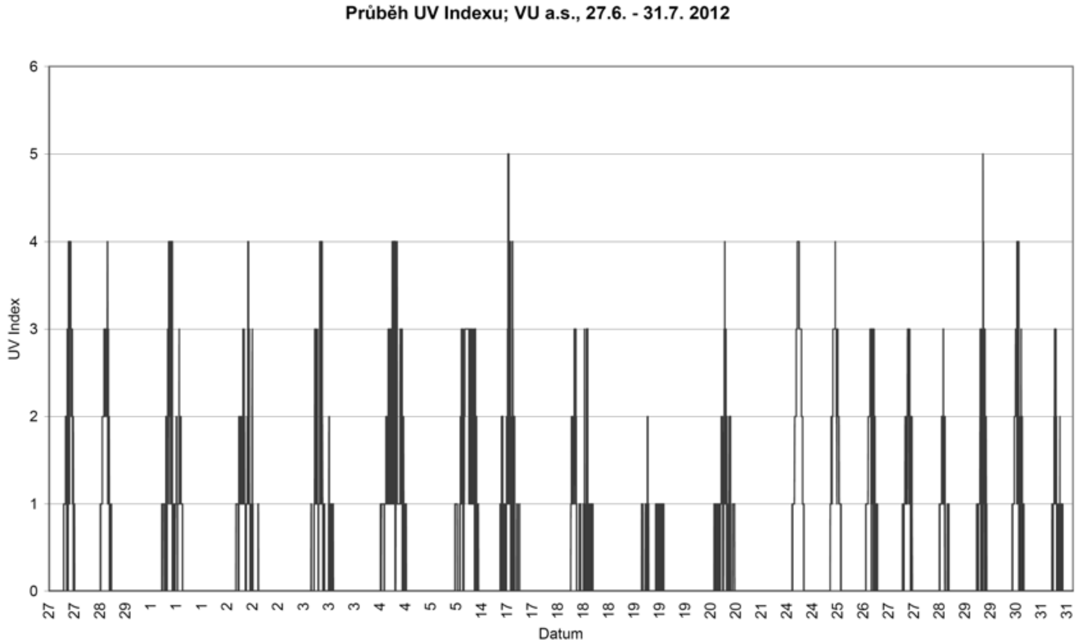


Fig. 7 Output example of weather influence measurement

Fig. 8 Accompanying features of large infusions at TUM Sokolov stack

CONCLUSION

Large database of information was created in 2012 and key data were so gained which will be analysed by numerical methods during 3rd stage of project in 2013.

Further long time period measurement will take place in 2013 to secure a total complexity of information necessary to successful management of given goals in the frame of the solution of the research project. This will be done on the base of agreement with lignite stack operators and dealings and conclusions made during preceding stages Experimental lignite heap will be used at Severoceske doly, a. s. mining company. The solving team expects that they will gain rare data mainly in the final stage of self-ignition development.

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