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THERMAL MEASUREMENT OF CONVEYOR TRUCKS AND OTHER STRUCTURAL POINTS ON BUCKET WHEEL EXCAVATOR SchRs 1320

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Key words: thermal measurement, bucket wheel, excavator, SchRs 1320, belt conveyor

Abstract:

At the beginning of December 2009, staff members of the division of technical diagnostics laboratory of the Brown Coal Research Institute, JSC (henceforth referred to as VÚHU) carried out the thermal measurement and its subsequent evaluation concerning surface temperatures of teeth of buckets, driving motors and gearboxes, rotating drums, pulleys and belt conveyors, current joints and contacts of electrical equipment of substations and transformers of an excavator SchRs1320.

At VÚHU, JSC at Most, equipment Therma CAM^{TM} PM 545 from the company FLIR Systems, together with extensive software both obtained from the manufacturer (Therma CAM Reporter 2000 Professional) and created at VÚHU, JSC at Most is used for this purpose.

1. Principle of The Measuring

The thermovision apparatus is composed of a camera and accessories. The camera has a 3rd generation matrix uncooled mosaic (FPA) detector with 320 x 240 pixels (microbolometres). The 7.5 – 13 μm spectral band with a possibility of measurement of temperatures from -40 °C to +500 °C with an accuracy of ± 2 % of the range or ± 2 °C; temperature sensitivity at 30 °C is 0.08 °C.

This measuring apparatus works on the principle of detection of infrared radiation. In measurement, thermal properties of bodies described by the Stefan-Boltzmann law is used; the law says that for an absolutely black body the intensity of infrared radiant flux depends on the temperature of the body. For real bodies, i.e. non-black body radiators, emissivity of the surface of radiator being measured is included as well. The emissivity of surface of the body is thus a parameter that is defined as a ratio of intensity of radiation emitted by the body to the intensity of radiation emitted by an absolutely black body at the same temperature.

This emissivity can, depending upon the properties of the body surface, move in the range from 0 to 1, and for some materials it varies depending upon the temperature or wavelength of infrared radiation.

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The thermovision apparatus Therma CAM^{TM} PM 545 is able, by means of a built-in imaging system, to create a temperature image describing the temperature properties of field of the object being measured. Individual isothermal areas are differentiated by colour; for this purpose, a set range of colours that can be arbitrarily changed is used. The image of the object being recorded can be created by an attached special video recorder or stored as image (thermogram) in a 14-bit dynamic range on a 175 MB PCMCIA CARD ATA. In the course of measurement, all data on measurement conditions that are necessary for the evaluation of thermograms are recorded. Nevertheless, it is necessary to set other parameters of the object in the camera, such as already mentioned emissivity, ambient temperature and distance between the object and the camera.

On the left margin of thermograms there is a scale that divides the set range of measured temperatures into individual isothermal intervals of energy levels given in "isothermal units". To each thermogram, an accompanying photograph can be created by means of a special digital camera. For the further processing of pseudo-colour thermograms (images of the recorded object, where each colour of the scale corresponds to the defined range of temperatures) transmitted together with the photographs to a PC, an extensive computer program ThermaCAM^{TM} Reporter 2000 Professional is used.

Pseudo-colour thermograms serve as basic element for the evaluation of thermal condition of the object of measurement.

2. Course of Measuring and Evaluation

For thermogram evaluation, lucid forms filled in with all data required for correct evaluation were used. To each thermogram one form belongs. These forms are given below. Owing to the large number of them, all thermograms could not be taken; merely those are taken that describe best the thermal anomaly of measured part of bucket teeth or other thermal properties.

- The thermovision measurement of all current joints, contacts and terminals of MV and LV substations of excavator SchRs1320 in an open-cast mine of Severočeské doly, JSC – DNT was carried out on the 8th December 2009._Furthermore, on the excavator SchRs1320, the surface temperature of bucket teeth, driving motors and gearboxes, all rotating drums, pulleys and belt conveyor was measured.
- To each thermogram, a digital photograph was always taken for the better identification of measured part of equipment.
- For the correct evaluation of obtained thermograms, the ambient temperature was simultaneously measured in all rooms of the substation and also outside it using a calibrated digital thermometer.
- For the determination of correct value of emissivity of the surface of measured part of equipment of excavator SchRs1320, a representative test specimen was always selected, the temperature of which was measured with the calibrated contact digital thermometer, and after inserting the values of ambient temperature and of distance between the point of measurement and the camera. By adjusting the values of emissivity, the camera was calibrated to the correct temperature measured by the contact thermometer.
- Altogether, 68 thermograms were recorded and evaluated.
- The thermovision measurement was carried out during the operation of excavator SchRs1320, which had been fully loaded for one hour as a minimum. This ensures the warming of all measured parts to proper operating temperatures when possible anomalies would manifest themselves fully.

3. Conclusion

From the evaluated thermograms attached to the technical report and from the above-mentioned results of measurement, it follows unambiguously that:

- In MV/LV and LV substations, any thermal anomaly showing an increased transition resistance of joints or decreased insulating ability has not been found in the course of measurement of current joints of electrical equipment of the substations. Only in a MV/LV substation R3 an increased temperature was measured on the left phase line of current joint of the cable (see thermogram No. J1208-56). The operating temperature of selected electrical components reached the maximum measured temperature of 91.7 °C.
- The temperature of some rollers of support stand of the belt conveyor of excavator SchRs1320 was increased in the area of upper or lower mount, which meant a beginning fault (see thermogram No. J1208-32). The rollers were marked in situ.

- Ø On the drive and idler pulleys of belt conveyor of the excavator SchRs1320, neither temperature difference nor increased surface temperature was measured.
- Ø On the belt of conveyor track on the bucket-wheel boom of excavator SchRs1320, an increased temperature was measured on the left side of the belt in the direction of flow of excavated material (see thermograms Nos. J1208-36 to 45)
- Ø The operating surface temperature of driving motors moved in the range from 46 to 58 °C without anomalies found.
- Ø The measured operating surface temperature of installed gearboxes of drives moved in the range from 55 to 59 °C without anomalies found.
- Ø The surface warming of bucket teeth was in comparison with another excavator considerably low (see thermograms Nos. J1208-26 and J0804-51).
- Ø The measured values of temperatures relate to the boundary conditions and air temperature in the time of measurement.

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In reports, the following data are stated: *point of measurement* – specification of part being measured; IR information (*Date of creation* - date of measurement; *Time of creation* – exact time of measurement; *File name* – name of thermogram – consists of month, date of measurement and sequence number of thermogram). Label - *IR: max*- maximal temperature of all thermogram area. Object parameter (*object distance* **–** distance between the object being measured and the objective; *ambient temperature* **–** temperature of the surroundings in the time of measurement; *emissivity*). Label (*Fault - SPO 1* – fault temperature; *SPO 2* – comparison temperature). Temperature profile in the given plane – Graph illustrating the temperature curve intersecting the lines of thermogram (Maximal temperature - LIO 1: max and Minimal temperature - LIO 1: min.).

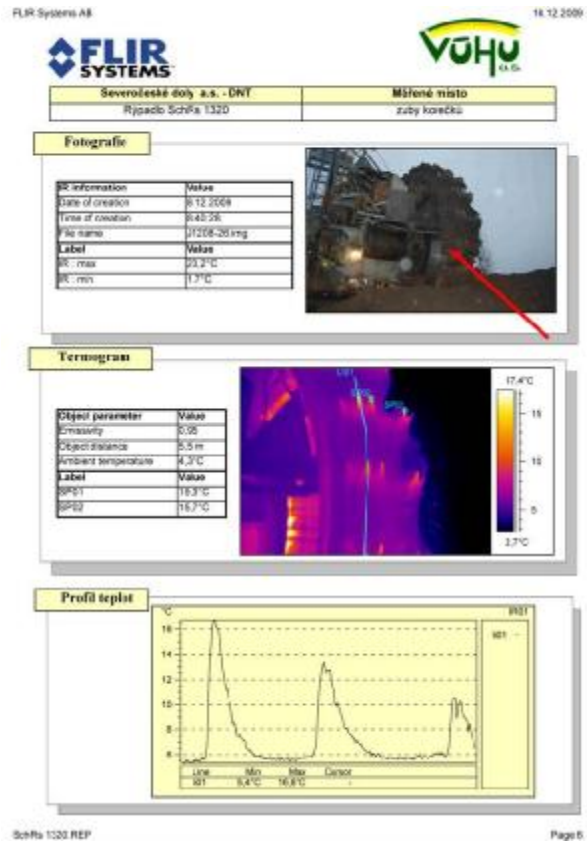

Fig. 1 – Bits of bucket

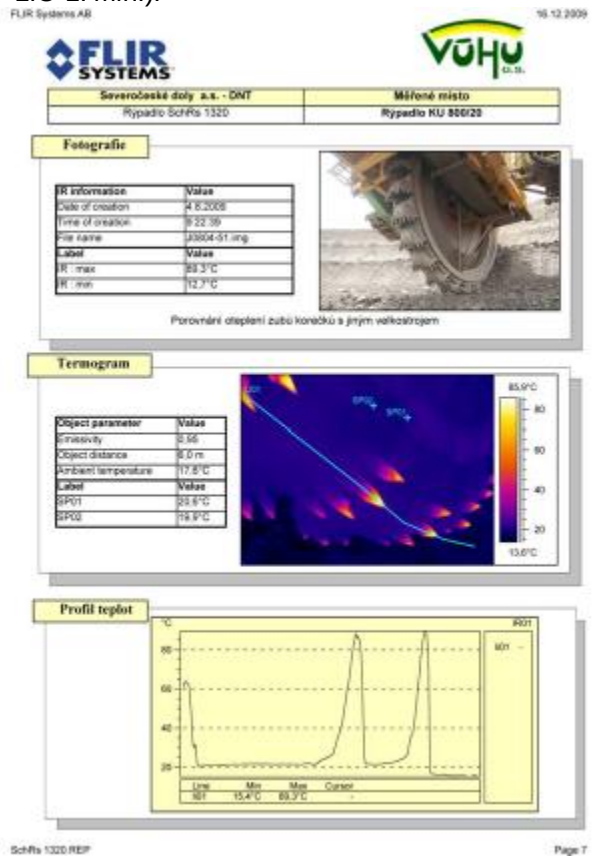

Fig. 2 – Bits warming comparison

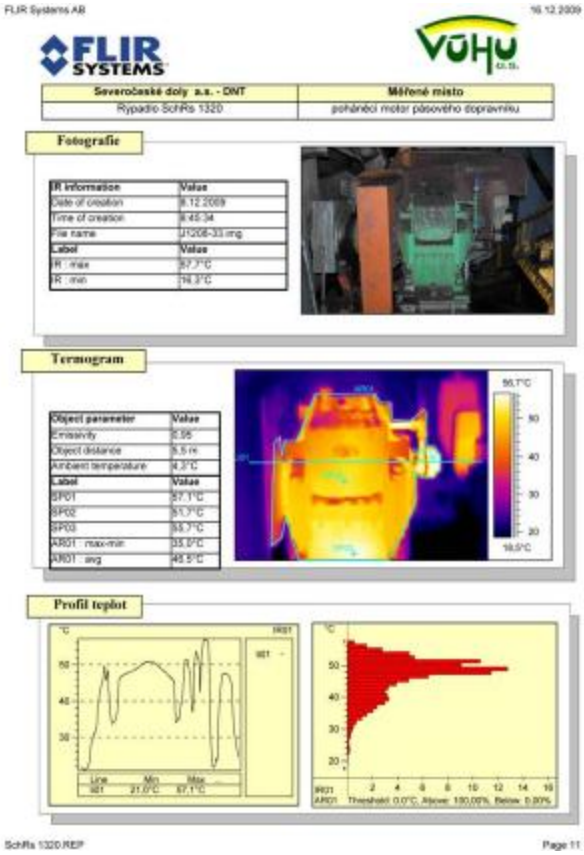

Fig. 3 – Drive of belt conveyor

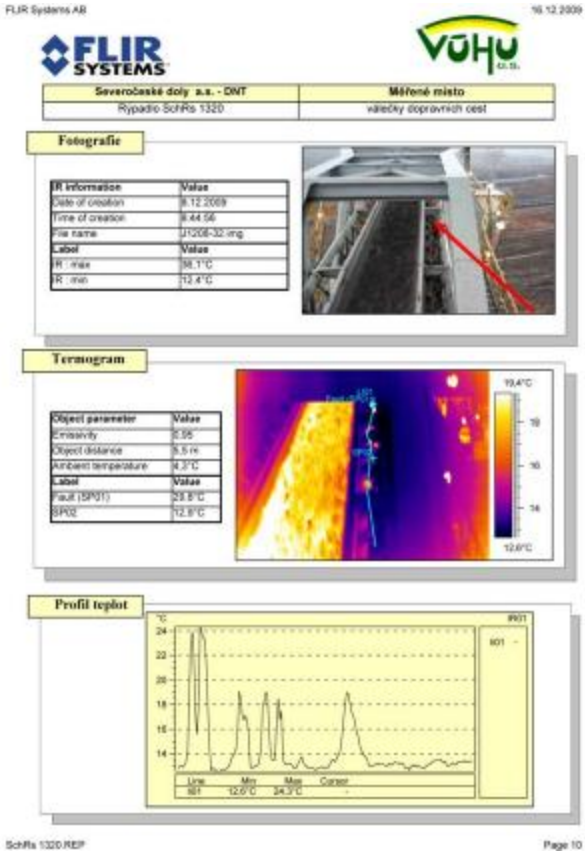

Fig. 4 – Rollers of conveyor

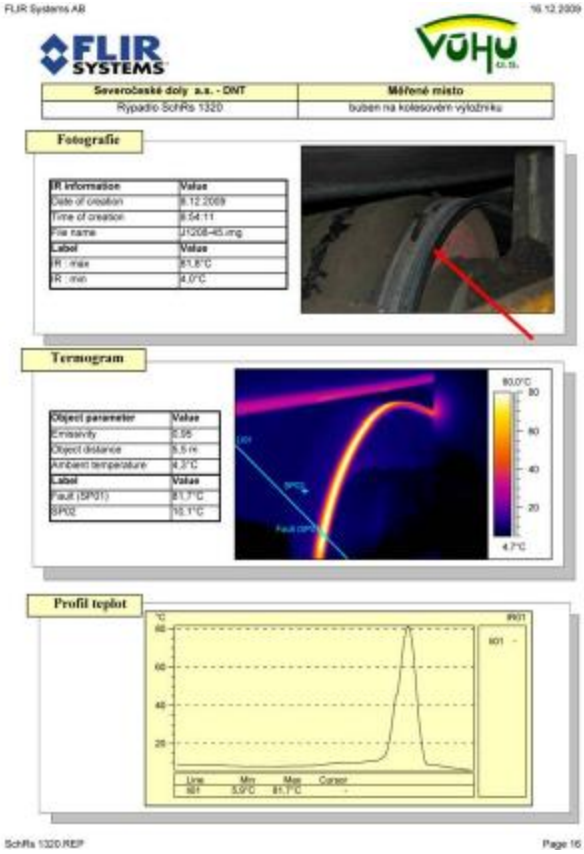

Fig. 5 – Drum of conveyor

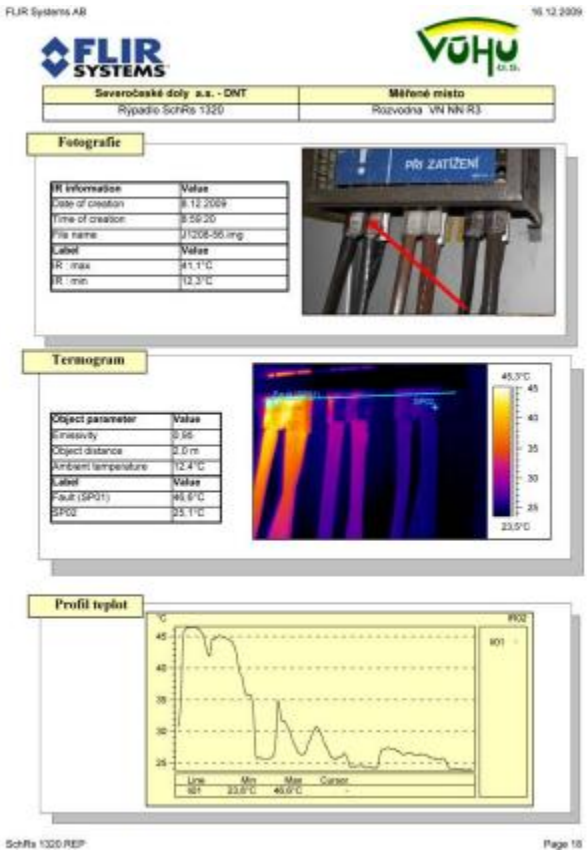

Fig. 6 – Distribution point VN NN R3

References:

Recenzia/Review: *doc. Ing. Jozef Krešák, PhD.*