SYSTEM PROPOSAL TO DETECT THE LOCATION OF HOT SPOTS APPEARED INSIDE A SOLID BLOCK BY MONITORING ITS SURFACE

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ABSTRACT: The system proposed in this paper is designed to detect the location of each hot spot appeared inside a solid homogenous block, based on the thermal information received from its surface. The proposes system is composed of hardware part which includes the observed block, the sensorial system, the data acquisition system, and software part which includes the monitoring function and the algorithms which calculate the position of the hot spot located inside the solid block. The authors used the phenomenon of heat conduction from a hot spot towards the surface of the object containing it.

KEY WORDS: hot spot location detection, thermal monitoring, thermovision camera.

1. INTRODUCTION

The idea of this paper came out of the need for the thermal power plants to detect the location of hot spots that appear in the coal deposits in order to cool the place before the coal ignites.

Also, due to chemical reactions inside deposits of coal, garbage or paper, for example, hot spots may appear inside them, without showing or signaling in any way their location. These hot spots lead to ignition and fire in the deposit, phenomenon not desired by the holder of the deposits.

Unfortunately, this phenomenon is difficult to be detected because the deposits of solids are not homogenous, and usually, detection is done too late.

The proposed system is intended to be experimental with the purpose of detecting hot spots appeared in a homogenous solid block.

The results obtained are intended to be used as starting point for simulations of detecting location of hot spots appeared in non homogenous deposits of solids, and after that, for real hot spot location detection in solid deposits.

2. SYSTEM DESCRIPTION

The proposed system is composed of a hardware part and a software part, as shown in figure 1, both detailed below.

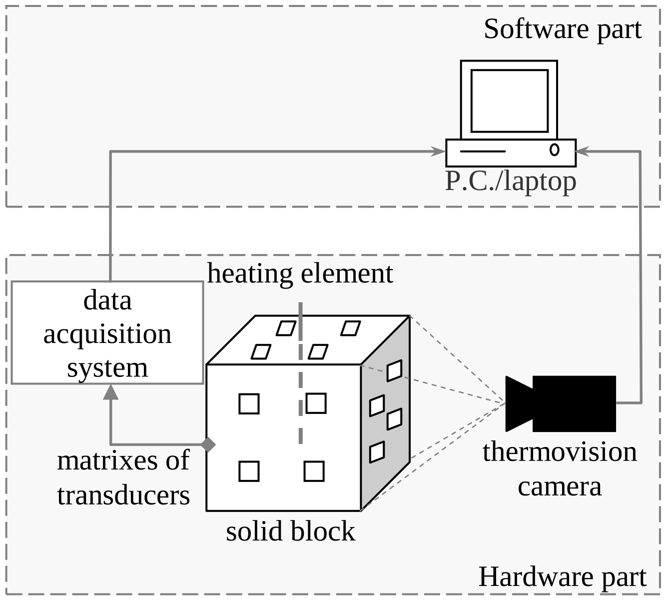

Figure 1 Scheme of the proposed system

2.1 Hardware part

The hardware part, as shown in figure 1 above, and shown again in figure 2 below, consists of the solid block, the sensorial part, the data acquisition system, and a thermovision camera.

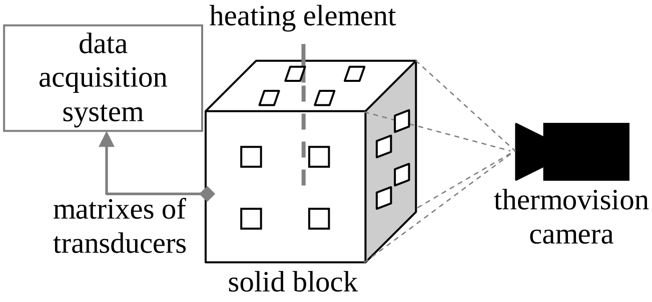

Figure 2 Hardware part

The solid block

The solid block is intended to be a cube of 20cm side, made of cement, with a heating element positioned inside, in centre, and five matrixes of transducers, positioned on the five faces of the cube, excluding the one at the bottom.

The matrix of transducers

The matrix of transducers is used for each of the five visible faces of the cube and uses a number of 20 temperature transducers MCP9701 from manufacturer Microchip Technology, 4 on each of the five sides of the cube, one in the middle of each 100cm^2.

The temperature measuring range is between -40^{0}C and 150^{0}C, with a tolerance of 1^{0}C, at an operating voltage of 2.3-5.5V, and weighing less than 1g (0.22g) [1].

After a carefull search [2, 3], the authors chose this type of transducers especially because of their small dimensions, making them appropriate for the proposed system and experiment.

Figure 3 Temperature transducer MCP9701[1]

The acquisition system

The acquisition system is composed of an analog to digital converter module, connected to a microcontroller from the Atmel family.

For each transducer, a conditioning circuit is used to adapt the signal level from transducers to analog to digital converter. This acquisition system communicates with a P.C. or laptop through serial interface.

The thermovision camera

The thermovision camera used for monitoring in this system is Flir T200, as shown in figure 4. It takes thermographic images from each of the five sides of the cube and sends them to the software part on the P.C. or laptop.

Figure 4 Thermovision camera [4]

The characteristics of the thermovision camera are as follows [5, 6]:

a. Measuring domain: -20… +350^{0}C (+1200^{0}C optional);
b. Detector: microbolometer FPA (Focal Plane Array) no cooling, spectre: 7.5… 13µm;
c. Detector resolution: 200x150 phisical pixels;
d. Thermal sensitivity (NETD –Noise Equivalent Temperature Difference) < 0.1^{0}C (usually 0.08^{0}C);
e. Interchangeable lenses: 25 degrees/Standard;
f. Display LCD: 3.5" color TFT with TouchScreen;
g. Folding optic head with minimum 120^0 from screen;
h. Display: IR+vizibil, Picture in Picture;
i. Measuring: 5 moving spots, 5 max./min. areas, AutoSpot hot/cold, isotherm;
j. Palette: black and white/color;
k. Optic focus: mechanic and manual autofocus;

l. Continuous zoom: 2x;
m. Integrated visible camera: min. 1.3Mpixels (1280x1024);
n. Integrated lamp for visible ilummination: min. 1000cd;
o. Thermal focus: automatic/manual;
p. Memory: min. 1000 JPG images with temperature information;
q. Laser: 1mW/635nm red, II^{nd} class;
r. Autonomy: min. 8 hours of continuous operating, Li-Ion battery;
s. Environmental temperature: -40 … $+70^{0}$C;
t. Protection degree: IP54 (protected against dust and water splashes)
u. Interface: USB, video;
v. Weight with battery and lenses: max. 880g;
w. Single hand operating;
x. Thermal analysis program included.

2.2 Software part

The software part runs on a P.C. or laptop, as shown in figure 1, and receives information from the data acquisition system and from the thermovision camera, comparing them in order to find out if the results are similar.

It is composed of a monitoring part and of a algorithm that uses both data from the camera and from the acquisition system to calculate the hot spot location position.

3. THE WAY THE SYSTEM OPERATES

The proposed system operates as follows:
- the heating element is heated to its maximum value;
- using the heat conduction phenomenon [7], the heat from the heating element, which in our case is the hot spot, advances gradually towards the surface of the cube, like an increasing sphere of heat, as seen in figure 5;
- from the moment of starting the heating element, the acquisition system begins to collect thermal data from the surface of the cube every 10 minutes and send it to the software;
- from the same moment, the camera records images of the five sides and simultaneously sends them to the software part;
- algorithms from the software part receive the data above and calculate the position of the hot spot in the following way: with the received data, the algorithm calculates:
  - the maximum value of temperature for each side of the cube;
  - the maximum two values of the five maximums;
  - the location inside the cube based on the intersection of the lines going through the two maximums and perpendicular on their sides, as in figure 5.

To verify the results, the hot spot (heating element) is positioned in the centre of the cube, though the location is known.

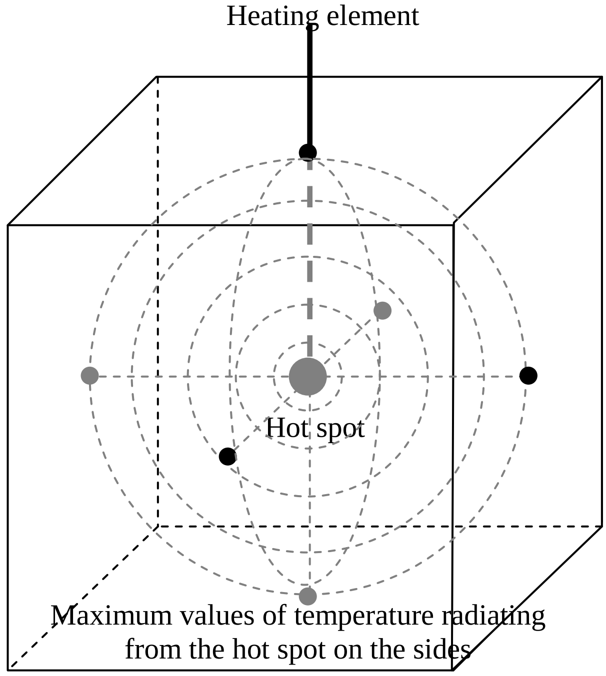

Figure 5 Heat conduction from hot spot towards the surface of the cube

4. CONCLUSION

The results of the paper should be very useful for appliance in real processes, in lignite deposits for example, to discover the location of hot spot appeared spontaneously, before their ignition.

To continue this research, the proposed system must be made functional and experimented on it in various conditions.

Also as a future research, inside the cube will be put a network of temperature transducers which will inform the operator of temperatures values closer to the hot spot and towards the surface, in order for the operator to know the temperature evolution from the hot spot to the surface.

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