ANNALS of Faculty Engineering Hunedoara
– International Journal of Engineering

Tome XII [2014] – Fascicule 4 [November]
ISSN: 1584-2673 [CD-Rom, online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

[1.] Beata HRICOVÁ, [2.] Miriama PIŇOSOVÁ

THERMOGRAPHY AS A TOOL FOR IDENTIFYING OF HEAT LOSSES

[1,2.] Technical University of Košice, Faculty of Mechanical Engineering, Department of Environmentalistic, Park Komenského 5, 042 00 Košice, SLOVAKIA

Abstract: Thermography, among other things, reveals and measures heat generation in machines and installations. It visualises overheated components, detects, and prevents "creeping" breakdowns. It has become a familiar and accepted technique for preventive maintenance. What is less well known, however, is that consistent, large-scale use of thermography can yield impressive savings.
Keywords: Thermovision, Environment, Heat losses

1. INTRODUCTION

The measurement of temperature distribution and its analysis are the main factors involved in infrared thermography. Infrared thermography involves passive and active procedures. In the first case, the test object releases heat consumed at the production stage. By observing and analysing the cooling process, it is possible to reveal defective areas, which are detectable due to the presence of thermal anomalies. For instance, passive thermography procedure is used in industrial applications that incorporate welded metal joints. In active thermography the test object is heated up by an external source. The presence of a significant temperature difference pinpoints subsurface anomalies. In general, active thermography includes:

- ✓ pulsed thermography,
- ✓ step heating thermography,
- ✓ lock-in thermography and
- ✓ vibrothermography.

2. NON-CONTACT HEAT DETECTION OF MEASURED OBJECT

Infrared thermography includes measurement of surface energy levels for prediction and diagnostics. Knowledge of thermal behaviour of materials and understanding of the causes of surface temperature changes are the basis for correct evaluation of thermograms.

The mechanism of heat transmission itself is based on the principle of mutual collision of molecules, resulting in a final process known as heat. When studying professional literature, we encounter many definitions of heat, which essentially agree that the term heat can be defined as a form of energy transmission between the system and its surrounding environment (or two systems – bodies) due to temperature difference. Energy always passes from a body with higher temperature to the cooler body. At the same time, its state is changing – its internal energy is increasing. As soon as both temperatures are equalized, the heat transmission stops. We can speak of heat only then, when there is a temperature difference. It is important to realize that a body contains energy, but it never contains heat. Energy is a property of the body associated with its state, while heat is associated with the process. With infrared thermography, heat transmission is a key aspect. For correct interpretation of a thermogram, it is important to know the three methods of heat transmission (see figure 1).

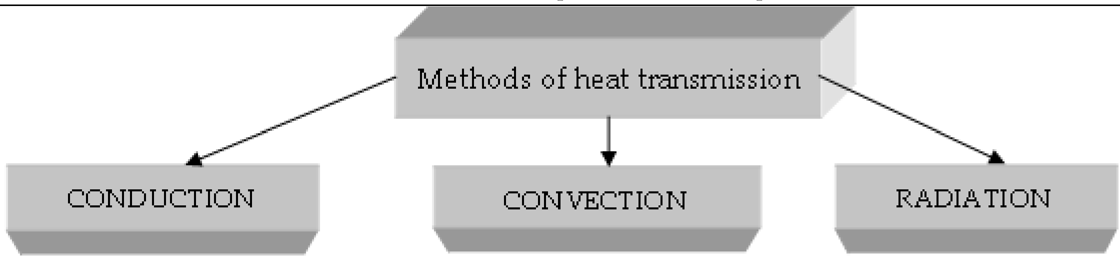


Figure 1. Methods of heat transmission

2.1. Transmission of Heat by Conduction

Heat transmission by conduction is applied primarily in solid bodies, but also in liquids and gases. It occurs as a result of vibrations of atoms in a solid substance and of collisions of molecules in liquid or gaseous state. Basically, it is a movement of energy from warmer molecules towards the colder ones.

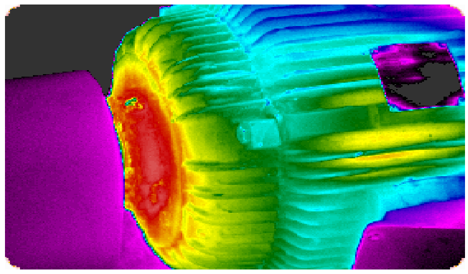


Figure 2 .A thermogram showing an overheated engine [3]

For conductive method of heat transmission Fourier's law is used, where heat transmission depends on the temperature difference, on the size and shape of the material and on the type of the material. Heat transmission by convection is directly proportional to the temperature difference between the two surfaces of the object.

$$q = -k \frac{T_2 - T_1}{L}$$

where: q – quantitative heat flow, k – conductivity of the material, ΔT – temperature difference, L – material thickness.

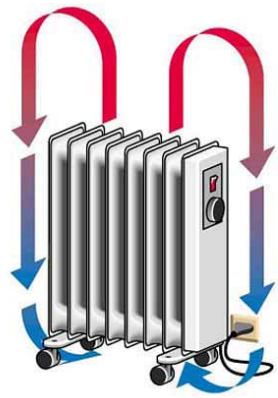


Figure 3. Transmission of heat by convection (heat flow) [4]

2.2. Transmission of Heat by Convection (Heat Flow)

This method of heat transmission is most often applied in moving states of matter, i.e. in gases or liquids. In principle, it is the case of transmission of thermal energy by means of the material – by the movement of a fluid. Under the general term fluid we understand a liquid or a gas. An example of convection is a liquid in a conduit.

The amount of energy transferred by convection depends on the parameter h and the temperature difference between the surface of the object and a spot in the flowing fluid (Newton's law).

$$q = h(T_s - T_\infty)$$

where: q - quantity of transmitted heat per unit of time, h - heat transmission coefficient, Ts - surface temperature, T∞ - fluid temperature.

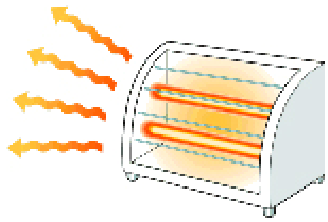


Figure 4. Transmission of heat by radiation [1]

2.3. Transmission of Heat by Radiation

This type of heat transmission takes place through emission of electromagnetic radiation. Radiation does not require solid, liquid or gaseous materials for heat transmission as such. The amount of radiation depends on temperature and on the condition of the surface.

Contactless infrared systems detect electromagnetic radiation. Radiation is characterized by its wavelength and by the frequency of its wavelength.

$$\lambda = \frac{c}{f}$$

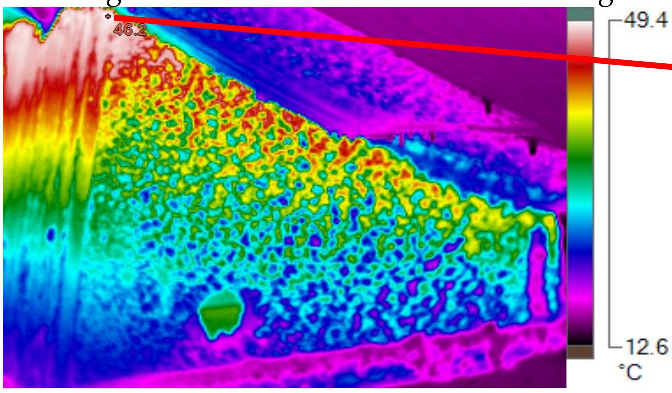
where: c - is the wavelength (the distance between two peaks), f - frequency (the number of previous peaks passing through a given point in one second).

3. IDENTIFICATION OF HEAT LOSSES IN INDUSTRY

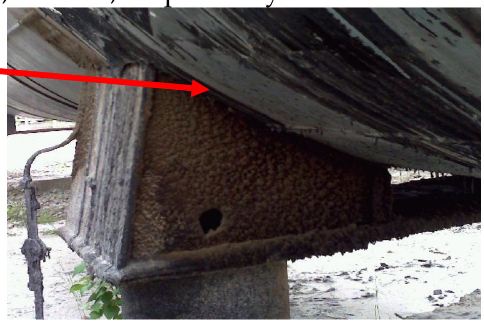
In principle, we distinguish two main techniques of thermographic inspections: a qualitative and a quantitative method. The quantitative method is based on the ability of obtaining a high-quality thermogram and of evaluating thermal information by comparing energy levels. We can say in a simplified way that this is only a creation of images – absolute surface temperatures in the images are not essential. The qualitative method is carried out by means of equipment having the capability of measuring data (actual values), of comparing surface temperatures on the surfaces or in details, in terms of the implemented measurements. The essence of this method is not only creation of images but also data acquisition (temperature).

Diagnostics of thermal losses was carried out on tanks used for bitumen, necessary for the production of bituminous mixtures. It was carried out before the reconstruction of the tanks (before their insulation), specifically for detecting critical spots, where the greatest amounts of heat dissipation occurred.

Thermographic diagnostics was carried out at the background temperature (Background) of 21.5 °C and emissivity of ε = 0,85. After completion of insulation, the measurements are carried out repeatedly at the same spots, in order to determine the extent of improvement at the critical areas. The findings of the heat losses are recorded in Figures 6, 7, 8 and 9, respectively.



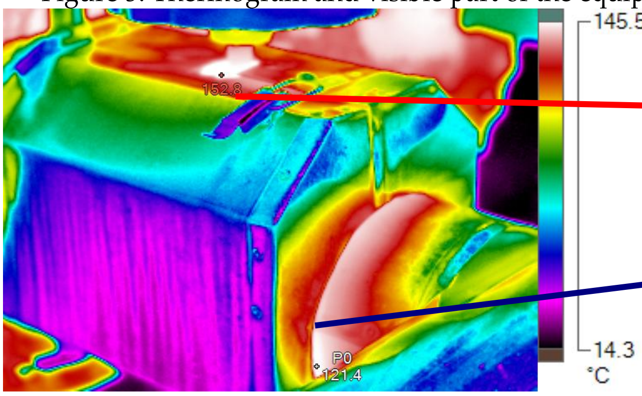
Thermogram



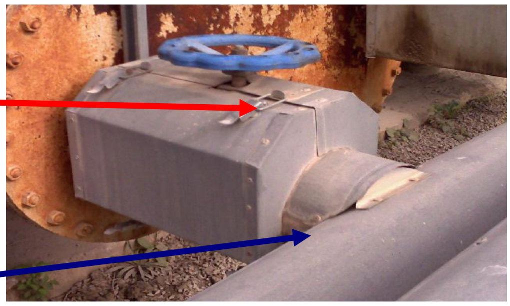
Visible part of the equipment

Name	Temperature	Emissivity
Heat	54.5°C	0.85

Figure 5. Thermogram and visible part of the equipment of the buttress of the bitumen tank No.2



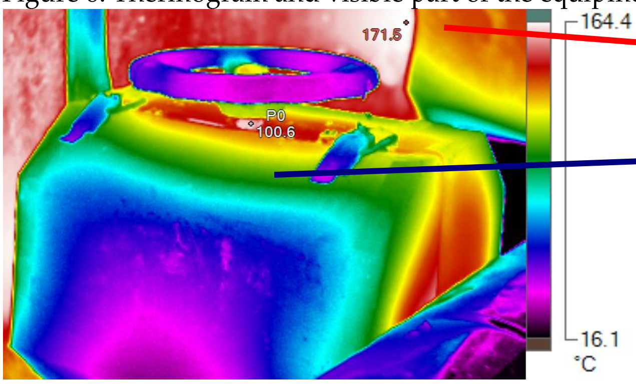
Thermogram



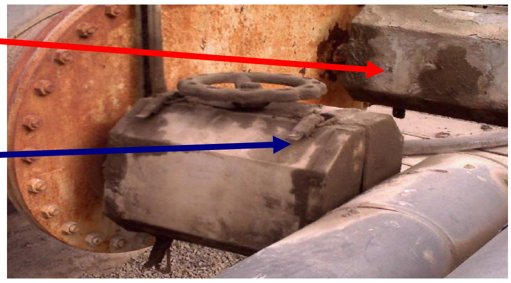
Visible part of the equipment

Name	Temperature	Emissivity
Heat	152.8°C	0.85
After repair	121.4°C	0.85

Figure 6. Thermogram and visible part of the equipment of the diversion tube of the bitumen tank No.2



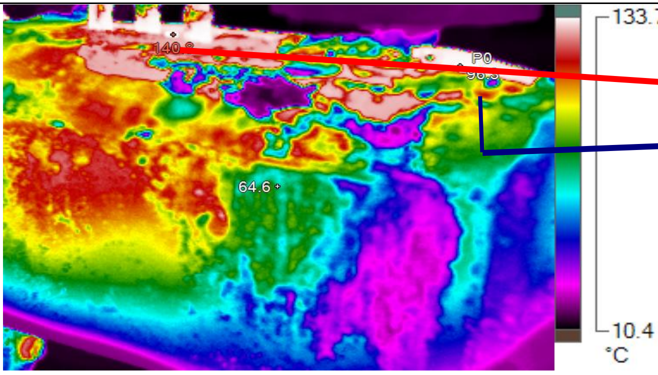
Thermogram



Visible part of the equipment

Name	Temperature	Emissivity
Heat	171.5°C	0.85
After repair	100.6°C	0.85

Figure 7. Thermogram and visible part of the equipment of the diversion tube of the bitumen tank No.3



Thermogram

Visible part of the equipment

Name	Temperature	Emissivity
Heat	140.8°C	0.85
After repair	96.3°C	0.85

Figure 8. Thermogram and visible part of the equipment of the diversion tube of the bitumen tank No.4

The benefits provided by thermography include:

- ✓ contactless measurement without necessity of a shutdown or of a disassembly of equipment,
- ✓ early diagnosis of failures and of accidents,
- ✓ prevention of unplanned shutdowns and of emergency situations,
- ✓ feasibility of recording the real image of the measured spot,
- ✓ high mobility,
- ✓ reduction of losses associated with the shutdown of equipment,
- ✓ reduction of the cost of maintenance of equipment and the cost of any repairs,
- ✓ reduction of the time needed for identification of the failure or for location of the critical area.

CONCLUSION

The increase of the number of thermographic systems that are currently used in the Slovak Republic in various industrial sectors and in different applications, raises a number of specific questions related not only to the technical level of the employed thermographic systems, but also to the level of qualification of the operators of the thermographic systems. Although thermo diagnostics is a relatively young technological discipline, included into the field of technical diagnostics, its benefits have already been proven many times. At the same time, this diagnostics is in many cases irreplaceable or replaceable only with difficulties by other diagnostic methods.

The importance of thermo diagnostics in every area of economy is relatively significant and well-founded. An appropriate assessment of its benefits is essential for the efficiency of its use. The shortcomings identified by the measurement can subsequently be gradually eliminated, depending on the degree of their severity.

From the environmental point of view, the method of thermovision diagnostics is ranked among the methods, which are helpful (among others) also in the process of energy saving, contributing in a considerable extent to saving energy consumption in the whole society.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-0432-12“ and by the VEGA 1/1216/12.

REFERENCES

[1] Daikin Airconditioning Central Europe - Slovakia s.r.o. [cited 2012-02-09]. Available on the Internet: < http://www.daikin.sk/faq/items/heat-transfer.jsp>

[2] KREIDL, M.: Měření teploty: Senzory a měřicí obvody (Temperature measurement: Sensors and measuring circuits). Praha, BEN – technická literatura. 1.vyd., 2005. 239 s. ISBN 8073001454.

[3] Spectrum Infrared Services. Available on the Internet: http://spectruminfraredservices.com/mechanical.php

[4] The Worlds of David Darling. Encyclopaedia of science. [cited 2011-12-29]. Available on the Internet: http://www.daviddarling.info/childrens_encyclopedia/heat_Chapter5.html