Infra-red Measurement of Temperature and Spectral Filters Application.

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Abstract. *We are engaged in temperature and heat measuring problems as well as infra-red radiation in our contribution. It is inevitable to be familiar with these problems at the contemporary usage of thermovision system*

1. Introduction

Temperature is the measure of thermal energy included in any object. There are many methods and facilities for temperature measuring of any object while it is defined by the temperature scale. Temperature measurement by contact methods is very difficult in some cases and not possible for reasons of working because these methods solicit a direct and relatively long contact with the measured object. Therefore it is necessary to aim also to such temperature measuring ways which do not require a contact with the measuring equipment. Equipments which meet such requirements are based on the sensing of radiated infrared energy. This particular thermal fields displaying method is an up to date one and is used in the dismantling diagnostic, research and development, following and proceeding control and things like that. [2]

2. Theoretical Analysis and Experimental Measurement

Temperature and heat measuring and radiation Temperature is a state quantity describing the temperature state of a body. The body temperature is characterized by the kinetic energy of it particles. Temperature changes never became of their own.

Heat is one form of energy. It originates from transformation of other kinds of energy (mechanical, electrical, magnetic, chemical, nuclear) changing in various forms and is transmitted to other bodies or systems what causes changes of their temperature state.

Temperature says substantially in which direction the thermal flow will run between two objects. There are three fundamental types of transfer of heat: (see Fig.1). [1]

- conductivity
- convection
- radiation
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All heat is transmitted by one form of these three types of transfer, but usually by combination of two or all three types. Infrared thermography is naturally nearest to the radiation transfer of heat, but it is important for us to understand all three types to be able to understand better the importance of infrared thermograms (thermal patterns).

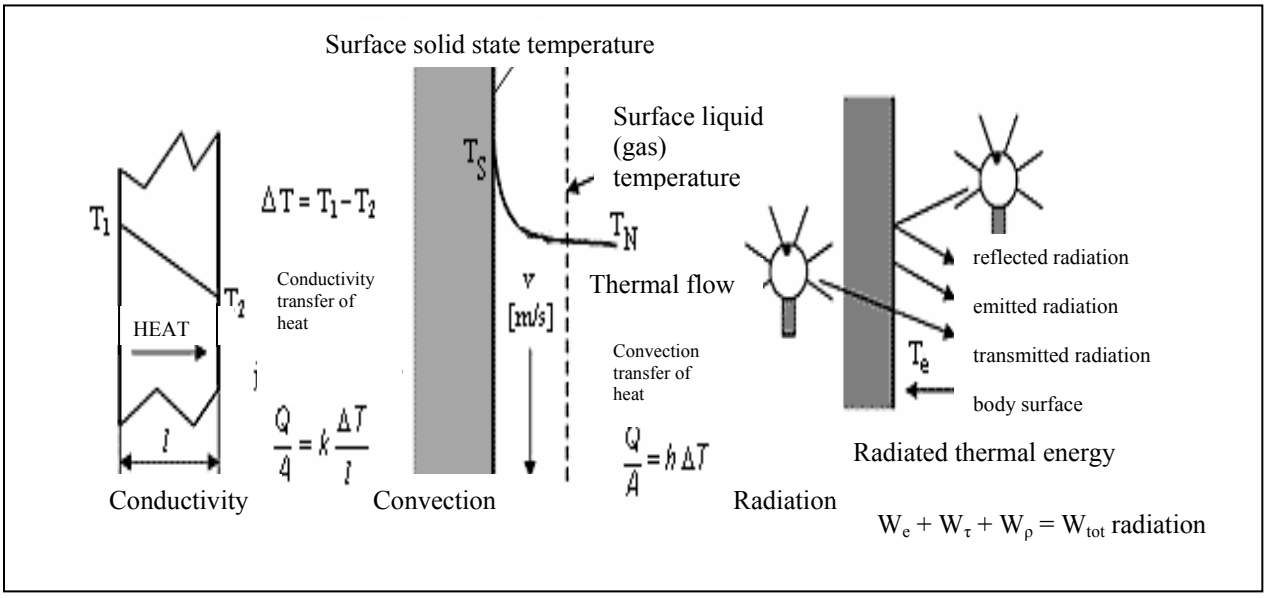

Fig.1. Three types of transfer of heat

The transfer of heat by conduction is applied mainly at solid state bodies, but also at liquids and gasses. The question is about the transfer by atom vibrations of solid state bodies or molecule collisions in gases and so it comes to the motion of energy from the warmer molecule to colder ones. The illustration in the picture says that the heat transfer velocity rises with the increasing of thermal conductivity and decreases with the increasing of the board thickness. The Fourier's law for heat conduction has the mathematic expression

$$\frac{Q}{A} = k\frac{\Delta T}{I} \qquad (1)$$

Where

Q	thermal flow
A	unit area
l	thickness the solid state board
ΔT	thermal gradient
k	thermal conduct

The thermal flow corresponding to a unit area is proportionally with the thermal gradient and it is not proportionally the solid state board thickness with the thermal conductivity k.

The thermal conductivity is in general is higher for metals and fewer for non – metal and porous materials.

The transfer of heat by conduction becomes effective in moving states and always occurs at the transfer of heat between solid and liquid (gaseous) state. The free flow becomes effective as for as the transfer of heat is caused the liquid density and the warmer part increases up as a result of the increasing pressure.

The forced flow becomes effective in that case when the other source like for instance cooling ventilator which gets the liquid (gas) moving. The graph illustration describes the situation of the heat transfer from the solid board the situation of the heat transfer from the solid board into the moving liquid (gas). At the transfer of heat by conduction the transfer is realized in two ways: by liquid (gas) direct conduction and by the motion of liquid (gas) itself.

The Newton's rule for cooling defines the coefficient of transfer of heat by convection h which combines both mechanisms:

$$h = \frac{\frac{Q}{A}}{T_S - T_N} \qquad (2)$$

Where

h	coefficient of transfer of heat by convection
Q	thermal flow
A	unit area
T_S	solid state temperature
T_N	liquid (gas) temperature

The transfer of heat by convection corresponding to a unit area can be expressed by the adapted Newton's rule

$$\frac{Q}{A} = h\,\Delta T \qquad (3)$$

Where

Q	thermal flow
A	unit area
h	coefficient of transfer of heat by convection
ΔT	thermal gradient

The natural explanation of this relation says that the thermal flow velocity rises with the rising difference of temperatures and with the rising heat transfer coefficient. The increasing liquid (gas) velocity results in increasing heat transfer coefficient.

The transfer of heat by radiation differs from the previous ones in some aspects:
It can pass trough vacuum, i tis realized by electromagnetic emission and absorption, goes on with the speed of light and behaves as the light, energy emited from the surface is proportional to the fourth power its absolute temperature.

The thermal infrared radiation leaving the body surface can be emited by the surface, reflected from the surface or it can pass trough the surface (see Fig.1). But the surface temperature depends only on component namely on the part of emited energy.

The infrared radiation from the investigated body passes to the infrared device by means of various methods. While this medium is vacuum, then it does not lose any energy. But in practice at most measurements this medium is the air. For short distances e.g. some meters, the influence o fair can be omited. But if this distance rises, then naturally i tis the source of errors. Also some materials are for infrared camera nontransparent e.g. glass, plastics, gases and the like. In case we need to measure trough these materials i tis necessary to know the spectral characteristic of these materials, while we determine the correct measurement result by a suitable choice of the filter.[3]

3. Results

The measurement of the thermal infrared radiation forms the basis of the contact less temperature measurement (Fig.1, Fig.2, Fig.3).

Fig.1. Transfer of heat by conduction

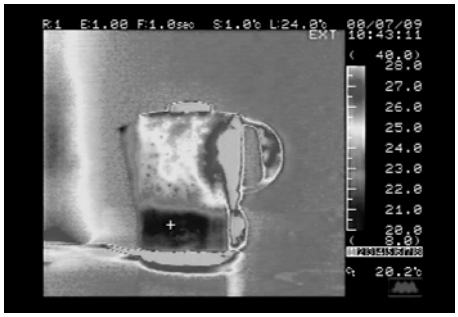

Fig.2. Transfer of heat by convection

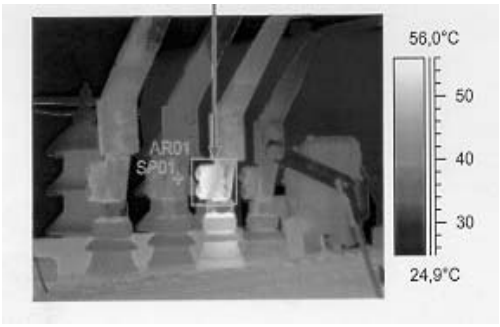

Fig.3. Transfer of heat by radiation

3. Conclusion

We deal in our contribution with the temperature, heat and infra radiation problems. The measurement of infrared radiation is close connected with the problems of medium in which the system measures. Because of present many people use the infrared camera, it is necessary to call attention to the fact that it is possible only by means of knowledge of material spectral characteristic to obtain the correct result. The experimental measurements were realised at the biggest transmitting centre SRV - Rimavska Sobota, on the basis of which the method of measurement of antenna system of radio transmitters with the help of thermovision was elaborated. The factors that can affect the measurement accuracy (e.g. fog, rain, wind velocity etc.) were taken into account.

4. References

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[3] Chupáč, M.: Diagnostics of antenna systems of radio transmitters with the use of thermovision PhD - thesis, Department TAE, University of Zilina, 2002.
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