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POSSIBILITIES OF USING THE THERMOCAMERA IN THE THERMODYNAMIC PROCESSES

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Abstract: *Paper discusses the possibility of the thermocamera on some different examples. Presented examples are from different scientific and commercial ranges and in each from them are used other important prerequisites form measuring. Typical examples of usability of the thermocamera are the measuring the temperature load in the case of the electronic components in the PC, measuring the big electric devices and measuring the thermal stability of the building walls. End of the paper describes the using of the thermocamera in the fuel cell technology – direct methanol DMFC and hydrogen PEM cells.*

Key words: *Thermocamera, thermodynamic processes, measurement*

1 INTRODUCTION

The temperature measuring is very significant part of the scientific research from the thermodynamic processes.

The contact less temperature measurement method is very useful complement to the classic contact method. The thermocamera measurement method begins the very often method aside the classic IR thermometers presently used.

The result of the thermocamera measuring is the temperature scale converted into artificial colors in praxis. The demand temperature areas are accents.

This contact less measuring has to attach to the calibration contact method for increasing the accuracy. This kind of contact less measuring method is usable as the complementary form of the dynamic temperature changes besides the larger objects.

The price of the thermocamera presently hangs down and it is possible to include this device into standard research laboratory equipment oriented for the thermodynamic processes.

The complex measurement system for the IR measurements is the price acceptable. Vary of these devices are standard equipped with the classic digital camera, includes the powerful laser sight, the full color LCD display, slot for memory cards and many more.

2 THERMOCAMERA SYSTEM DESCRIPTION

The thermocamera employed in our experimental laboratory is Fluke Ti55FT model and has following technical specification [2]:

- Temperature range from –20^{o}C to 600^{o}C
- Accuracy of measuring +/– 2% from data
- Micro bolometric sensor with vanadium oxide
- Basic lens 23^{o}(H) x 17^{o} (V)
- Spectral sensitivity from 8 μm to 14 μm
- Temperature resolution <= 0,05 ^{o}C
- Display resolution 0,1 ^{o}C
- Memory storage – CF memory card
- LCD display 320 x 240 full of colors
- Output for external PAL monitor (cinch)
- Build-in digital camera with 2Mpixel chip
- Laser sight
- Weight cca 2,5 kg

The optional accessories part of thermocamera is created by the complete cableway, reserve battery, battery

charger, special transport box and software SmartView 2.1 for analysis and data evaluation on enclosed CD.

Software SmartView enables acquired data evaluation from memory card present in the certify format and the data transposition onto other types including the color scheme changing.

Fig.1.: Thermocamera Fluke Ti-55FT

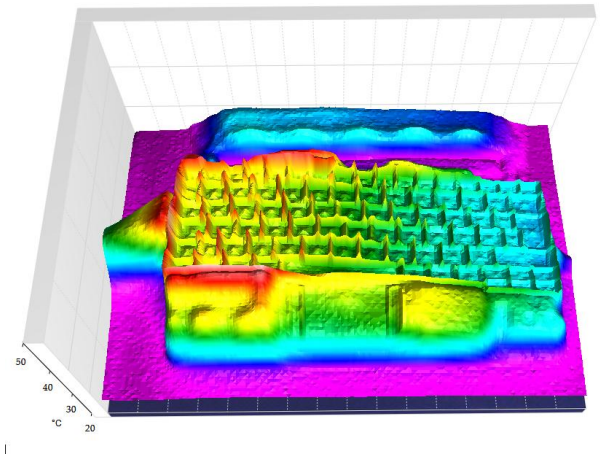

Fig.2.: Examples of usability of thermocamera in laboratory praxis and learning

This thermocamera is not suitable for measurements with the high accuracy. For the majority of high accuracy measurement is necessary the thermocamera calibrate with the classic temperature contact device. Set up the suitable level of emissive factor for the each objects is necessary.

The thermocamera is the valuable tool for tracing the physical phenomena with thermal background or the temperature changes attendance by the dynamic process [1].

Ideal using of this device is the sequential scanning of the process data for example from measurement of the fuel cells, thermal load of the electro technical components in the PC and many more processes with thermal exposure.

Measuring of the temperature load on the PC compounds

The temperature instability and unhomogenity cause directly or indirectly the most part of the faults and errors in the computer praxis.

The unsatisfactory cooling level of the processors and chipset causes the majority of the fault states in the modern powerful computer devices.

In these expose examples is optimal situation for the thermocamera appointment.

For this situation is not necessary the high precisions by the camera sensor calibration. The most of these describe processes does not require special setting of the camera, satisfactory setting of the emissive factor is enough in the standard limits between the 0,8 and 0,95. Among these standard limits be found the majority of the measured materials.

The dynamic character of these measurements doesn't require the exact fixed value. More usable results from this measuring is the scanning of the dynamic temperature changes in the time depending scale.

The next important parameter is the resolution of the difference between the temperatures of varies computer chips on the motherboard or in the notebook.

For the ideal utilization of the thermocamera is necessary adjusting the condition of measurement the PC component – remove them from the PC case and replace the conductor bundle. In the closed PC case is very high amount of disturbing thermal sources with the radiation potential and there are decrease the measurement accuracy.

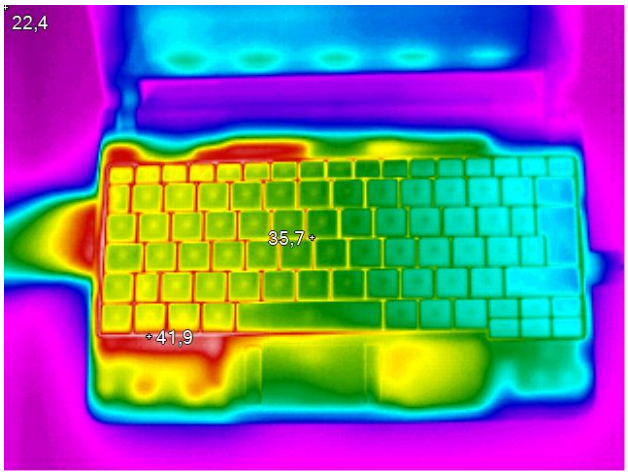

Fig.3.: The temperature profile measurement on the notebook.

The temperature measurement by the big converter

In this case it is diagnostic kind of the measurement. The basic goal of this measurement is temperature scanning of the separate windings on the big converters in the electrical machines laboratory. After these measurements follows the off-line data analysis in the SmartView software. The fundamental part of this measurement was in the temperature time dependency on the windings.

This measurement verifies the main idea about the uneven temperature development on the using windings.

The main problem in this example was in the simultaneous calibration by the classic contact thermometer. This kind of the electrical machine is under

permanent high voltage and current and on the first position come in on the safety question. For this type of unsafe measurement is thermocamera ideal solution.

Fig.4.: The example of the big converter windings measurement

The measurement of the parameters of the electrical heating

In the laboratory of the electrical heating was measured the heating system parameters. In this case is the measuring problematic more complicated because the heating body was constructed from the glazy stone surface and for tis surface is problematic to set the right value of the emissivity factor. If we use the general setting of this factor, it is possible to make the high difference between the contact and contactless obtained data. In this case is necessary to do both methodic – classic IR thermometer with the calibrate value of the emissivity and the surface scanning of the radiator body by the thermocamera.

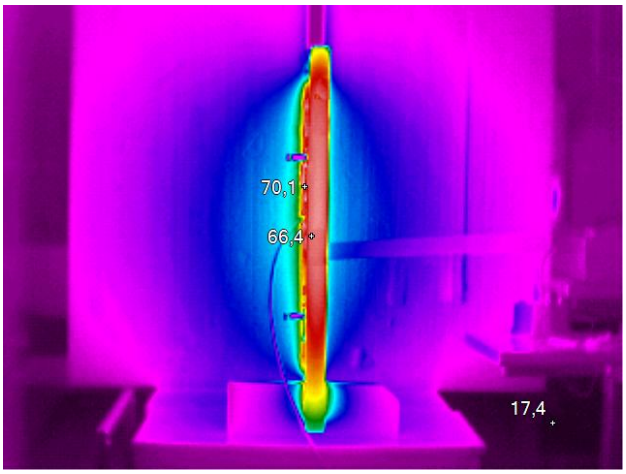

Fig.5.: The measuring the thermal radiation field around the electrical heating body.

The temperature measuring of the distilling apparatus

In the electrochemistry lab we have distiller device for production of pure water for fuel cells technology – production of the hydrogen.

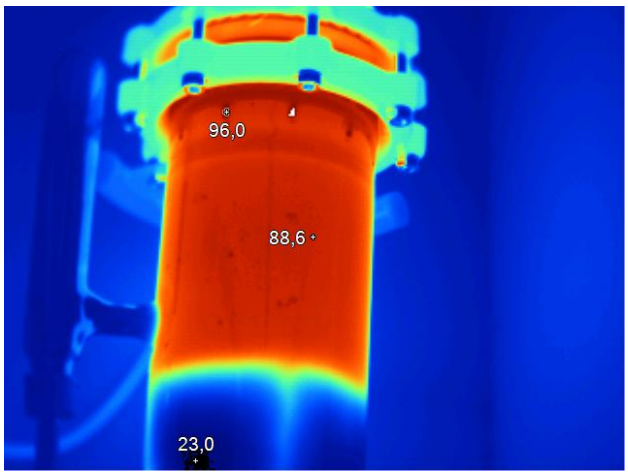

Fig.6.: The measurement of the temperature profile by the distiller vessel.

This device has high amount of the electrical energy and the cooling water consumption is inconsiderable too. For the optimal setting of the temperature and the cooling water flow is necessary to find out the right temperature distribution in the distiller body. For the optimal functioning is necessary to set the optimal temperature of the vessel – very high temperature and very low temperature are undesirable and cause the heat and water looses.

For the finding the optimal temperature distribution we use the thermocamera.

The measuring the thermal profile of the facade of the households

This kind of measurements are the most typical using the thermocamera.

The thermal profile of the facade has the big influence for the economy of the household via the possible faults in the facade construction, isolation and the consequential fossil fuel consumption.

The first application section is oriented for the measuring the heat penetration through the wall and the second important section is oriented for the measuring the differences of the thermal conductivity of the construction materials.

This kind of measurements enables the construction errors detect and repair them.

These construction errors are called thermal bridge and they are the causality for the next construction problems like are for example high humidity places. The biggest problem in this case is the dependency of thermal profile measurement on the outdoor season.

The most ideal situation for this measurement is the largest temperature differences between the indoor temperature and outdoor temperature.

From this point of view it is suitable time for this in the winter season. All errors and all problems are very good visible in this cold weather.

The calibration process of the thermocamera is in this case very easy, the basic set-up of the internal emissivity parameters for the standard values are sufficiently for wide range of measured materials and situation.

Fig.7.: The measurement of the facade temperature profile.

3 DYNAMIC MEASUREMENT OF METHANOL FUEL CELLS

Thermocamera is very useful devices in analyze of dynamic temperature changes on the cell surface. Initial section of methanol cell part starts with the slowly increasing of temperature of fuel, in this case methanol solution. Acquiring of thermal picture allows make prediction of quality of the catalytic process.

The measurement of the DMFC with temperature scanning.

The next important rule of thermocamera in this case is in checking the correct connection of tubes for methanol solution transport. In this case is used fact of increasing the temperature of place when occurred methanol solution leakage. It was very useful in the learning courses, because methanol including their solution is defined like the neural poison and checking the safety in the lab is foremost.

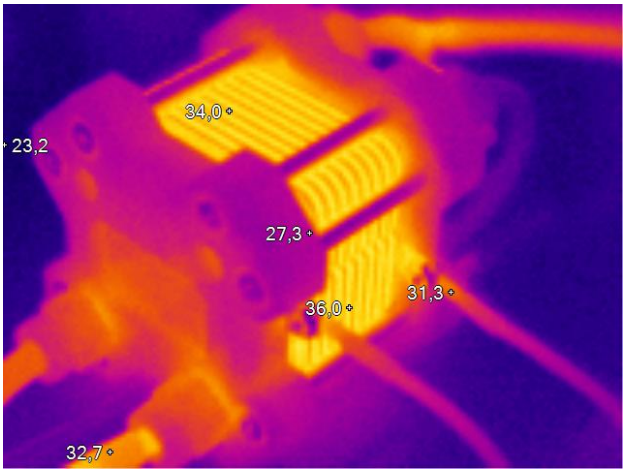

Fig.8.: The measurement of the temperature profile of the DMFC cell

The using of the thermocamera is eligible in the low-temperature PEM cell technology too. The temperature differences are very high. Some parts of the electrolyzer come up to 70°C. The temperatures of the main cell are lower and cost with the operative conditions. The higher temperature has the leaky electrodes and after the certain time begins grow the temperature by the inside metal grid. The temperature differences are measurable between the input and output pipes valves for the gas and liquid fuel.

The analysis of temperature profile is the subject of the next research in present. This research studies predict the existence of the next problem – the reflexivity of the IR images in the metal fixation material from the fuel cell construction. This problem rapidly increases by using the minimal distance between the camera objective and the metal parts of fixed system of the fuel cell. In this case is possible to see in the metal mirror the body of the main camera in the IR spectrum. This kind of experimental measurement is very ambitious for the preparing.

The last part of presented paper described the measurement of the temperature profile of the PEM fuel cell. This measurement was focused on the small plate of the basic fuel cell construction and we use thermocamera with the tripod for the long lasting measurement.

The basic measurement was oriented for the temperature expression of the dynamic parameter of the cell – build up and the normal working stay.

Acquired pictures will be used for the next part of research work on the PEM fuel cell. Analyzed pictures will be used with the classical contact method provided by the NTC to the building the model of the temperature profile of the PEM membrane. The using all of these contact and contact less method help us to create the most functional theoretical model of the physical processes on the PEM fuel cell membrane [3].

4 REFERENCES

[1] LIDE, D.R., CRC Handbook of Chemistry and Physics, 88th Edition, CRC; 2007, ISBN-13: 978-0849304880.

[2] Fluke Electronic; http://www.fluke.com/

[3] DEJMEK, JIŘÍ; ŠTEKL, PAVEL. Measurement of the PEM fuel cell katex membrane thermal profile. In Dejmek, Jiří; Štekl, Pavel. Elektroenergetika 2007. Košice : Technical University, 2007, s. 323-327.

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