Thermography – new trends in heating installation inspection

Termografia – noi tendinţe în inspecţia instalaţiilor de încălzire

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DOI: 10.37789/rjce.2023.14.4.9

Abstract. *Technology is always evolving at a quick rate and specialists try to integrate it in their works, either if we are discussing engineering, or any other domain. Furthermore, the most important accomplishments, in a research domain, are achieved when using the latest technology and research interdisciplinary.*
So, starting from all the above, in this paper we are trying to create a connection between monitoring methods and technologies, used in Thermography, and the installation inspection which is a part of Building Services. Data was acquired from thermal images and processed to establish the integrity of a heating installation.

Key words: *thermography, thermal images, heating installations, thermal inspection, clogged pipes*

1. Introduction

A picture says a thousand words; infrared thermography is the only diagnostic technology that lets you instantly visualize and verify thermal performance. Infrared cameras show you thermal problems, quantify them with precise non-contact temperature measurement, and document them [1].

Recent innovations in the development of thermal cameras have made them available to specialists in many industries, making them a common presence in industries such as building inspection, electrical, plumbing, fire, law enforcement and more [2].

Infrared thermography (IRT), thermal video and/or thermal imaging, is a process by which a thermal camera captures and creates an image of an object using the infrared radiation emitted by that object in a process, which are examples of the science of infrared imaging [3].

Thermographic cameras typically detect radiation in the long infrared range of the electromagnetic spectrum (approximate 9,000-14,000 nanometres' or 9-14 µm) and produce images of this radiation, called thermograms [4, 5]. Because infrared radiation is emitted by all objects with a temperature above absolute zero, according to the law of blackbody radiation, thermography makes it possible to observe the environment with or without visible illumination [6]. The amount of radiation emitted by an object increases with temperature, so thermography makes it possible to observe temperature variations [7,8].

Today, infrared thermography is one of the most effective technology available to locate problems quickly, accurately, and safely prior to failure [1].

2. Materials and methods

Everything in life gives off electromagnetic radiation, most of which goes unnoticed and is completely invisible to our eyes. The human eye perceives a very small window known as the visible light spectrum that makes up the colours that we can see [9].

Like the principle of ordinary camera, thermal radiation is equivalent to visible light, first through the lens to the detector, in the processing of images, and finally output stream, forming a video image for human observation [10].

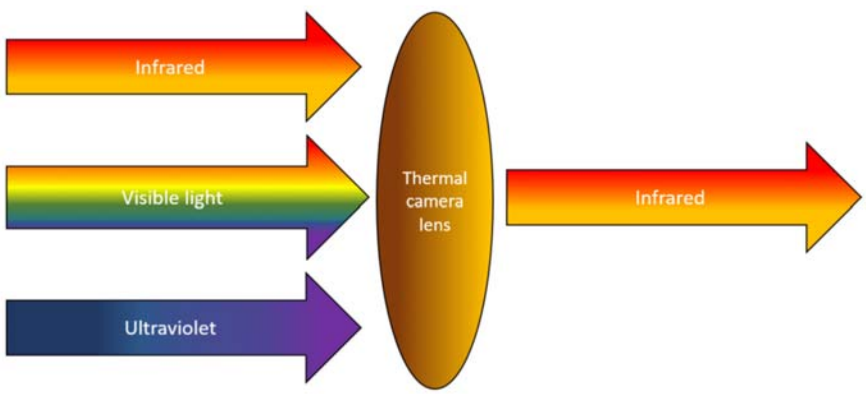

Fig. 1. Thermal radiation output for human observation [starting from [10]

An object emits more IR radiation the hotter its temperature rises. Infrared thermography cameras allow us to use our eyes to measure the temperature of an object instead of having to risk contact with something potentially dangerous. With the use of thermal imaging, we can "see" and "measure" thermal energy that was previously invisible to us. This type of heat radiation is known as infrared radiation [10].

A FLIR Vue Pro R 640 thermal camera (with radiometric recordings and a resolution of 640 x 512 pixels) was used for acquiring the thermal images and FLIR Tools software was the image analysing software.

The first steps before the image acquiring phase were to set up the technical parameters for the thermal camera. For that we used FLIR UAS software where we set the following:

- the measurement type (indoor);
- the capture mode (single);
- thermal IR zoom (100%);
- the photo format (radiometric JPEG)
- the thermal colour palette (Lava)
- the emissivity of the material (0,95);
- the atmospheric temperature (23℃) and humidity (30%);
- the weather type (sunny);
- the distance between the camera and the studied object (2,5m).

Our data interpretation and processing are based on the fundamentals of the physical principles of thermal energy exchange between two different environments (in our case: hot water inside the heating pipe and air inside the office), thus resulting in an energy exchange.

The data processing software that we used in our case study was FLIR TOOLS. Using this software, we analysed each thermal image and after that we selected the most clear and suggestive ones. After that, on those images we established the "critical areas" (surfaces on the interest areas where significative emissions of thermal energy appeared) and on those areas specifical measurements were made using tools available from the software.

3. Discussions

For the experimental part we chose to acquire thermal images of a heating installation from inside an office from the Faculty of Civil Engineering of Politehnica University Timişoara.

From this heating installation we studied the radiator (Fig. 2) and the pipes, especially the connection point between two pipes (Fig. 4) and the pipe entering point from the celling of the office (Fig. 3).

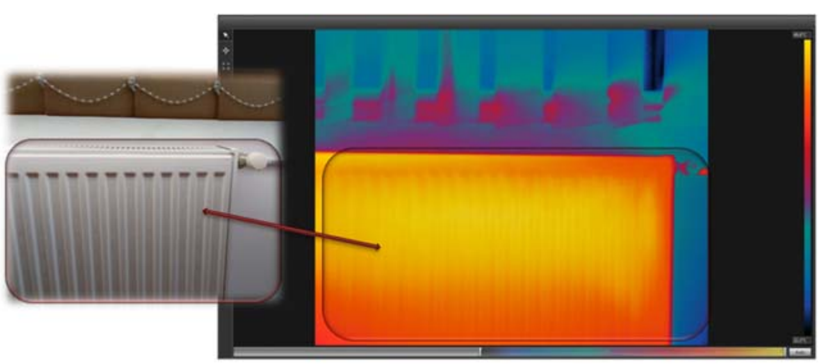

Fig. 2. The interest area from the radiator (left side - real image; right side: thermal image)

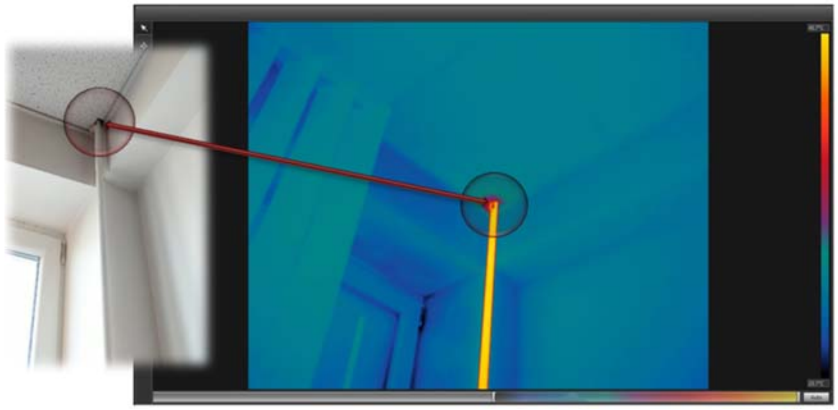

Fig. 3. The pipe entering point from the office' celling (left side - real image; right side: thermal image)

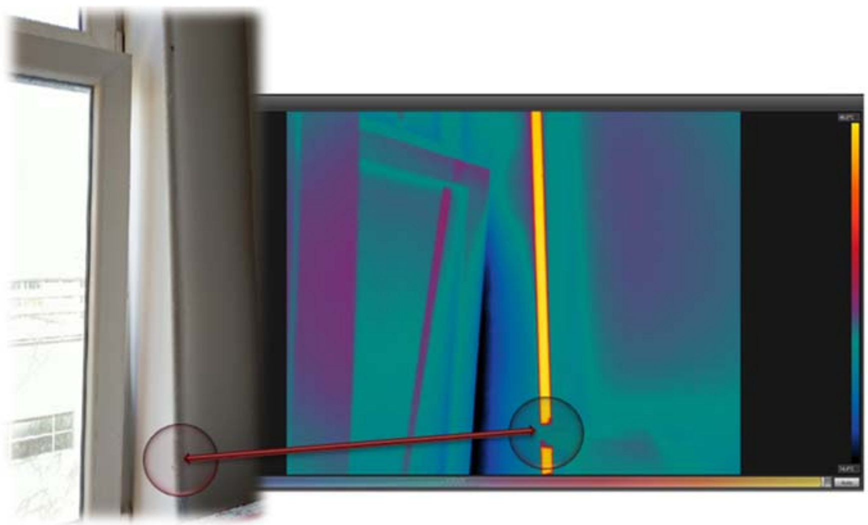

Fig. 4. The connection point between two pipes (left side - real image; right side: thermal image)

Because we desired an accurate interpretation of the thermal images, the first step that we took in this direction was to select the best images from the batch that was made during the photo session. The selection was made visually, in the processing software, by comparing multiple images of the same area and selecting the one with the higher clarity and an increased detail density.

After selecting the images for each of the three cases we selected the interest areas:

- on the radiator, the interest area contained both its upper and lower part, and the area around the radiator valve;
- on the heating pipe we chose two interest areas: first - around the pipe connector, and second – on the pipe entering point from the office' celling.

Further, for better measurements and image interpretation the images were adjusted using predefined filters from the processing software.

4. Results

On the radiator image, firstly we made a visual analysis in which we concluded the lack of uniformity of the temperature both on its lower and upper parts, even if the radiator surface is made from the same material, which reflects the heating uniformly on its surface.

Furthermore, we analysed the image by making punctual temperature measurements, in order to determine the temperature difference between different areas on the radiator. For this, we used the thermos-spots Sp2, Sp3 and Sp4 on the radiator area and, for comparison we used thermo-spots Sp1 and Sp5 around the radiator valve.

Analysing the thermos-spots around the radiator valve (Fig. 5) we observed a temperature difference about 2,4℃ (Sp1 has 42,4℃ – the temperature before the valve; and Sp5 has 40,0℃ –the temperature after the valve).

Meanwhile, the thermos-spots on the radiator surface (Fig. 5) have larger temperature differences, depending on where they were measured:

- on the bottom of the radiator surface Sp2 has 42,6℃ – like Sp1;
- on the upper part of the radiator surface Sp3 has 45,8℃ – a higher temperature than the previous spots;
- on the middle of the radiator surface Sp4 has the highest temperature 49,3℃.

It can be concluded, that in its inside are air gaps and residual deposits, which must be eliminated in order that the radiator to be warmed up the same on all its surface and to emit the optimum heat quantity.

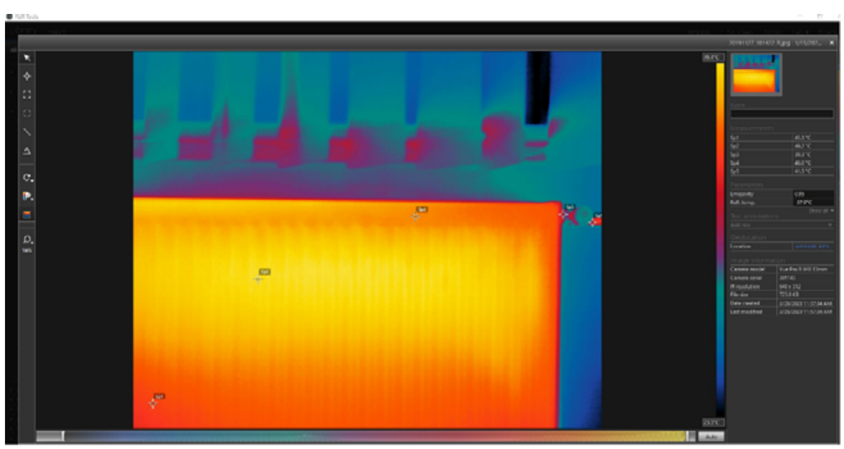

Fig. 5. The interest area from the radiator

In the second part of our study case, when visually analysing the image with the connection point between two heating pipes (Fig. 6), we conclude that: the uniformity of the thermal reflection that appears on the pipe connector indicates that the connection is not fully isolated.

Also, when analysing the image using thermo-spots, we observe a temperature difference between Sp4 (taken on the pipe connector) and Sp5 (taken on the lower part of the pipe connector, where a temperature inconsistency appears) of 4,2℃. This can be caused either by a very thin crack (not visible with the human eye) in the material from which the connector is made.

Furthermore, when comparing the thermo-spots Sp1 with Sp7, thermal spots taken on the two pipes (above and under the connector – Fig. 6), we observe that the emitted radiation is almost the same (Sp1 – 46,0℃ and Sp7 – 45,3℃ resulting only a 0,7℃ difference which can appear due to the interaction between two different environments - the air inside the office, which has a lower temperature, and the heating pipe, which has a higher temperature because of the hot water circulating through it).

Moreover, when analysing the area around the pipe connector (Sp2 - 36,6℃, Sp3 - 37,8℃ and Sp6 - 34,7℃) we observe that the radiation values are all around 36,37℃, a lower value comparing to the emitted radiation from the pipes (Sp1 and Sp7 – a medium value of 45,65℃), that can be caused to the residual deposits on the area where the two pipes are connected.

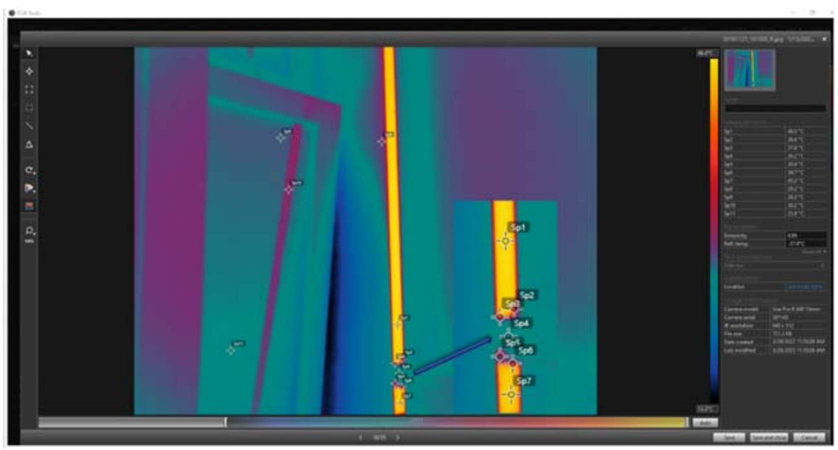

Fig. 6. The connection point between two pipes

In the third part of our study case, on the pipe entering point from the office' celling, when visually analysing the image, inconsistencies of the emitted radiation can be observed (around the entering point on the celling and also on the pipe – Fig. 7).

These inconsistencies are also confirmed when analysing the image using the thermos-spots function from the processing software:

- thermo-spot Sp1 was taken on the pipe, where the first inconsistency appears. It can be observed that is an isolated area which reflects a lower quantity of radiation, so we can conclude that in that area, a residual deposit is inside the pipe;
- comparing the radiation vales of thermo-spots Sp2 and Sp4 (points selected on the celling, on both sides of the pipe) it can be observed that Sp4 has a lower radiation value than Sp2, indicating that on the celling may be a leakage around the entering point.

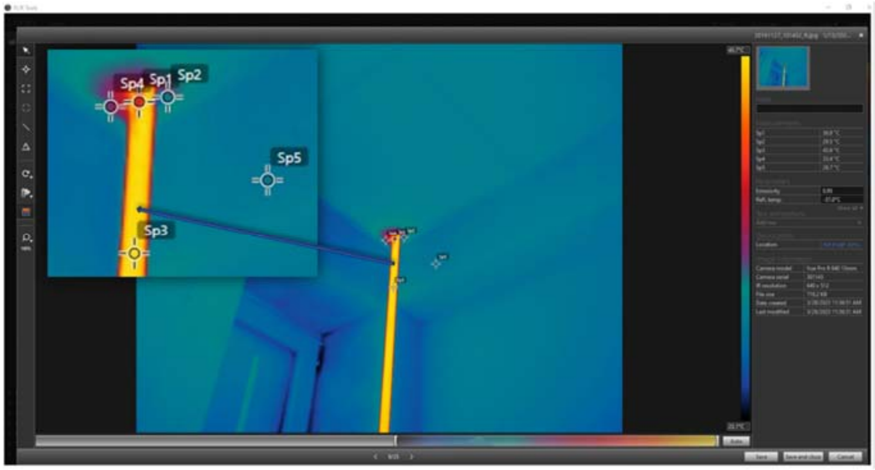

Fig. 7. The pipe entering point from the office' celling

4. Conclusions

So, we can conclude that Thermography is a useful method for heating installation monitoring because:

- it is contactless – the thermal scanning is made from a distance, where both the operator and the target are safe;
- it is bi-dimensional – the thermal footprint can be visualized/analysed, the obtained information regarding the analysed object are complete and different areas of the studied object can be compared;
- it is obtained in real time – it permits both moving and standing object thermal scanning.

Furthermore, when analysing the data both a qualitative and quantitative analyse can be done (Fig. 8).

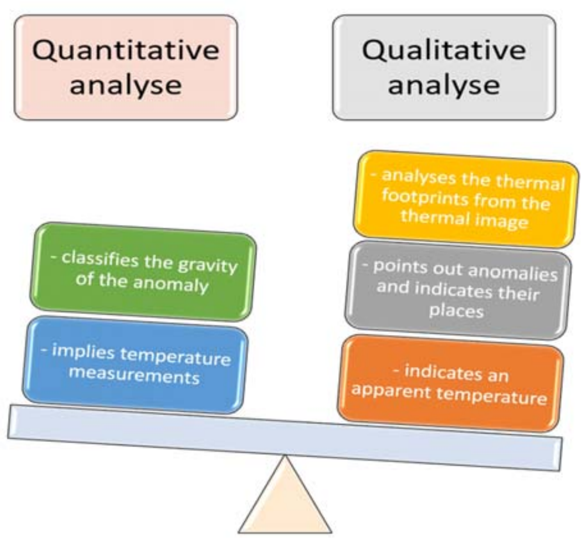

Fig. 8. The quantitative and qualitative analyse of a thermal scanning

But always must be taken into account that the material type, the surface structure and geometry are key factors that can influence the emissivity and of course the quality of data interpretation and processing.

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