Infrared thermography measurement of the thermal parameters (effusivity, diffusivity and conductivity) of materials

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Abstract

An accurate knowledge of the parameters of materials employed in e.g. thermal insulation or as building materials is essential. This implies a good knowledge of the thermal properties of these materials. Here, we show that infrared thermography, being non-invasive, is an interesting method to measure the thermal diffusivity, effusivity, or conductivity

1. Introduction

The thermal diffusivity D describes the ability of a given material to transmit a temperature variation, and is linked to the conductivity k by the quantity ρC following Eq. (1) :

$$D = \frac{k}{\rho C}, \qquad (1)$$

where ρ is the density and C the specific heat.

The effusivity *e* describes the ability of a material to absorb or return a thermal power. It is related to D and k by equation (2) :

$$e = \sqrt{k \rho C} \qquad (2)$$

These non independent physical properties are not always easily accessible. Infrared thermography appears as a versatile tool for their measurement. In this paper, we chose to address the surface temperature evolution of several types of samples, e.g. plexiglas or glass, under different thermal excitations (heating, cooling, for different durations). We analyzed the thermal transfer conditions and, using simple mathematical models, we extracted different physical parameters.

2. Experimental procedure

The thermal profiles are visualized using an InSb CEDIP IR camera working around 5 µm, which allows us to record stacks of images with frequencies chosen depending on the type of material to be studied.

Three types of thermal studies have been tested on each of the samples under investigation, using different geometries:

- The temperature variation following a heating step from a halogen lamp (figure 1) allows us to obtain the effusivity of the sample using a conductive description of heat transfer.

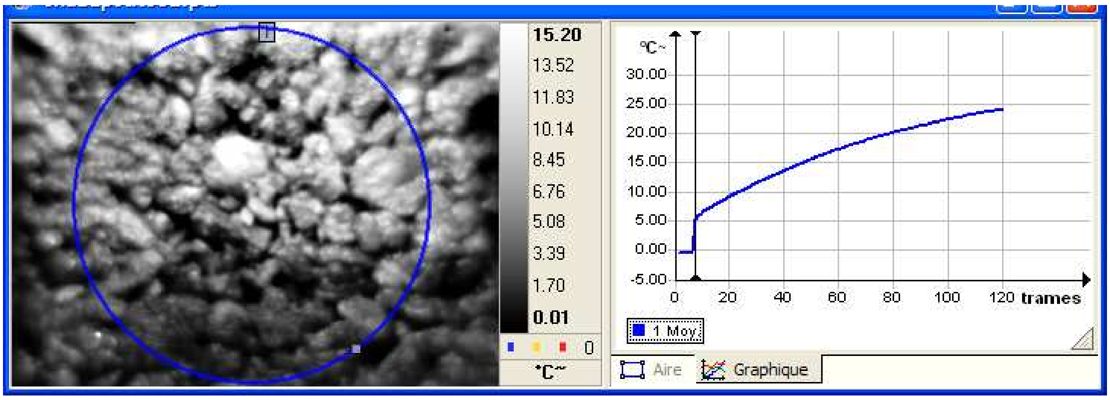

Fig. 1. average temperature evolution on a sample of asphalt (right graph, in ℃). The imaging frame rate is 1 Hz.

- When a heat pulse is absorbed on the surface of a sample, it penetrates along direction x (see figure 2) by thermal conduction.measuring the temperature variations in a plane perpendicular to the heating plane allows one to retrieve the thermal diffusivity.

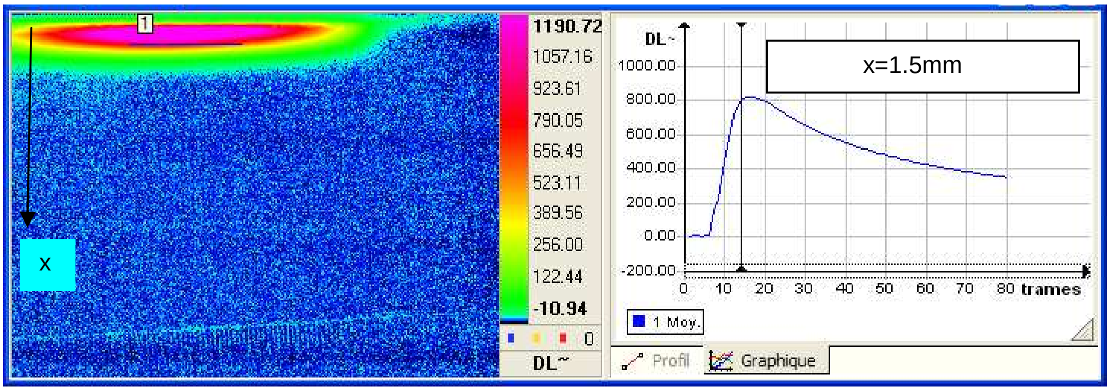

Figure 2:evolution of the temperature with time (right graph, in digital levels), 1.5 mm away from the surface of a Poly Methyl Metacrylate (PMMA) which is heated in a plane perpendicular to that of the image (1 frame=1s ; 1 pixel = 154μm)

- Finally, the whole volume of the sample can be cooled down below room temperature. When the sample is brought back in air at room temperature, the IR camera can follow the evolution of the temperature while the sample is heated through convective heat transfer (figure 3). The specific heat and the thermal conductivity can then be deduced from the evolution of the temperature.

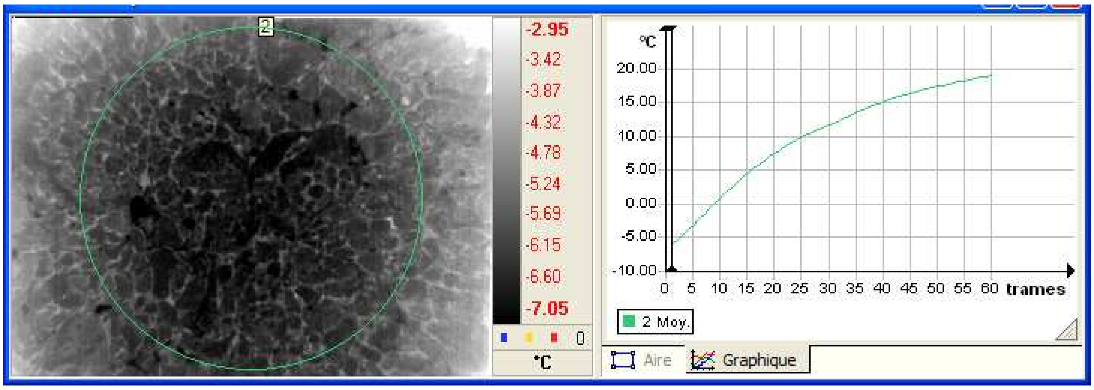

Fig. 3. evolution of the average temperature (in °C) of a sample of asphalt (60 frames = 47mn)

3. Conclusion

In this contribution, we address the mathematical description of thermal responses of materials submitted to several tyupes of solicitations, in order to infer their main thermal parameters : diffusivity, conductivity, and effusivity. These models and their applications will be illustrated by measurements taken with an IR camera on test samples of glass and PMMA.

Thematic section : thermal parameters identification

Poster presentation preffered.