NON DESTRUCTIVE FLOW VISUALIZATION OF NATURAL CONVECTION HEAT TRANSFER

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KEYWORDS:

Main subjects: natural convection heat transfer, optical flow visualization
Fluid: buoyancy driven cooling flows
Visualization method: fringe projection
Other keywords: image processing, electronics cooling

ABSTRACT: Optical methods are usually preferred in flow visualization problems: the measure process does not alter the flow field of the fluid under test. Moreover optical methods do not suffer any kind of inertia problems as occurs in other flow visualization techniques which deal with marks particle: it is possible to visualize thermal flow phenomenon characterized by very short characteristic time. Convection, natural or forced, air cooling is still the most utilized method in heat extraction problems in the electronic equipments. Natural convection cooling, in particular, results simple, cheap and reliable.
The aim of this work is to contribute to develop a simple optical technique for the visualization of the natural convection flow generated in an electronic system during its normal operation.
The experimental set-up allows to reveal refractive index changes in the cooling fluid (phase objects) due to the thermal load related to the electronic component normal operation. It's so possible to reveal the shape and the directions of the thermal flow lines for the cooling fluid. In this way we can obtain a better understanding of the optimal convection cooling working volume or information for the optimization of the relative positioning of the different electronic components in a complex electronic system, like a printed circuit board (PCB).
A fringe pattern is acquired through the electronic device under test and recorded by a CCD camera. Two different kinds of images are acquired and processed: the first one with the working fluid at rest without the thermal load, the second one with the fluid under operative cooling condition. By the means of opportune digital filtering and image processing procedure (implemented in MATLAB) it is possible to reveal the phase gradients and the thermal pattern related to the convective flow emerging from the device.
In this paper are presented some experimental results for the onset and development, in air, of the natural convection flow emerging from a single pin heater, a transistor heat sink and a power resistor (both squared and semi spherical section).
All the information for the visualization of the convective flow under test are extracted in white light without coherent sources. The whole process is carried out fully digitally getting the advantage of the recent development of digital acquisition sensors (CCD and CMOS) and image processing techniques.

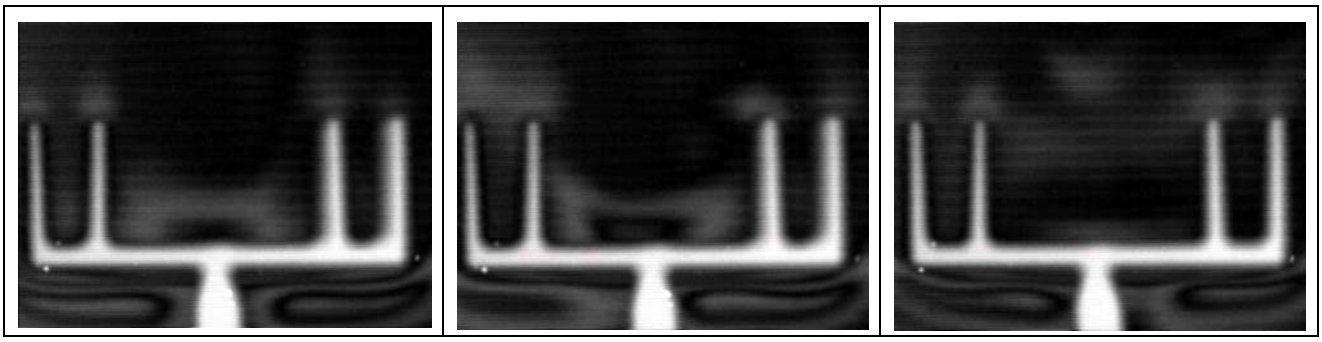

Fig. 1 Flow visualization of the buoyancy induced convective heat transfer for an heat sink: time sequence.

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