Preface

The Earth's natural energy resources (i.e. essentially the sun and the fossil fuel reserves: oil, coal and natural gas) are limited, which is of concern especially for future generations, as the demand for energy is continuously increasing. Most probably, even if much cheaper and/or safer energy forms (such as for example, nuclear fusion or a significant increase in the use of renewable energy) will become available in the near future, a significant rationalization of the production and use of energy will be unavoidable. This process has—or should have—already started with the Kyoto protocol, which came into force on February 16 2005, with the ambition of not overloading our planet with chemical and thermal pollution.

Energy conversion as well as energy use and energy saving are focussing more and more attention on heat transfer questions and, since heat transfer often involves fluids, thermo-fluid-dynamics represents a fundamental engineering issue to be faced. How can energy be efficiently transferred, in the form of heat, between a body and a fluid?

Computational Thermo-Fluid-Dynamics is of course helpful in answering such a question, even if the acronym CTFD is not frequently seen in the literature. However, in spite of recent advances in numerical techniques, partly due to the enormous increase in the efficiency of computers, the need to perform experiments, especially in complex fluid flows, still exists. In addition, although computer models have been increasingly successful in simulating and solving a wide range of rather intricate thermo-fluid-dynamic problems, it is nevertheless indispensable that their results are experimentally validated.

Naturally, experimental techniques have also undergone enormous development and, amongst these techniques, InfraRed Thermography (IRT) has proved to be a very effective investigative tool for thermo-fluid-dynamic experimental research. One major drawback experienced by the authors over the last two decades, while using this technique (this is particularly true for Astarita but Carlomagno has been working in this field for longer than he cares to admit), was the fact that they had to continuously update their research instrumentation because of the uninterrupted development of infrared cameras. Fortunately, the involved costs decreased almost accordingly.

Infrared thermography is a methodology that allows remote detection of thermal energy that is radiated from objects in one of the InfraRed (IR) bands of the electromagnetic spectrum, conversion of such energy into a video signal, and representation of the surface temperature map (distribution) of an object. In simpler terms, IRT allows one to obtain a temperature map over a body surface.

The method has great potential to be exploited in many application fields and for many different purposes, as long as temperature variations are involved. For example, IRT may be used in various types of diagnosis (in medicine, architecture, maintenance), or for material characterization and assessment of procedures, which can help in improving the design and manufacture of products, as well certain modes of their testing. As technology evolves, infrared systems offer new opportunities for innovative applications. Undoubtedly, any process which is temperature dependent may benefit from the use of an infrared device.

The aim of this monograph is to present an analysis of how to exploit thermographic measurements in complex fluid flows, either to evaluate wall convective heat fluxes, or to investigate flow field behaviour over complicated body shapes in order to better comprehend some peculiar fluid dynamics phenomena, such as flow instability, flow separation and reattachment.

The monograph covers the following important points, which may be of benefit both to newcomers and those already using infrared thermography in convective heat transfer:

1. What is infrared thermography and how did it develop in thermo-fluid-dynamics?
2. What are the very basic principles of radiation heat transfer that make the IR scanner (camera) a temperature transducer?
3. What is the current technology of modern IR cameras?
4. Once a camera has to be acquired, how can one evaluate its performance?
5. How is the calibration of this temperature transducer performed?
6. Since an IR camera is nothing more than a temperature transducer, we provide detail on the heat flux sensors that must accompany it, including their limits in space and time and paying particular attention to their use in infrared thermography.
7. The degradation (modulation) of the thermal image (introduced by the IR imaging system, the heat flux sensor and the environment) is considered and we provide a general analysis of its restoration.
8. We discuss a number of selected applications in several different areas with the principal aim of indicating either how this experimental method progressed or how to apply it correctly.

Of course, some of the points tackled herein are of little use to those who are already involved with infrared thermography. However, these elementary points are included to provide researchers with little experience of IRT enough knowledge to begin using it, and also for the sake of completeness.

The development of ideas and the final achievement of the volume and the thoughts contained therein are due not only to the authors' knowledge but also to helpful insights provided by many others. The observations, criticisms and findings of our Master and PhD students over the past several years contributed to broadening and refining this work; further, they carried out the majority of the experimental work. In addition, the authors are truly grateful to several colleagues for offering data, their valuable comments and intense support. Amongst others, we would especially like to mention Gennaro Cardone, Luigi de Luca and Carosena Meola, whose information, contributions and resources were essential to accomplish the final goal of writing this monograph and to George Powell for copy editing the final version. Finally, the authors are grateful to Wolfgang Merzkirch for the suggestions he made after reading the initial manuscript.

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