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Prof. Fabio Bozzoli, Ph.D.
University of Parma
Department of Industrial Engineering
Parco Area delle Scienze, 181/A
43124 Parma (Italy)
Tel. +39 0521 905859
Mail: fabio.bozzoli@unipr.it

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"Inverse problem approach: a powerful tool for improving industrial heat exchangers and discovering murderers too"

Abstract
Physical theories allow us to make predictions: given a complete description of a physical system, we can predict the outcome of some measurements. This problem of predicting the result of measurements is called the direct problem. The inverse problem consists of using the actual result of some measurements to infer the values of the parameters that characterize the system. While the direct problem has a unique solution, the inverse problem usually does not.

In our everyday life we are constantly dealing with inverse problems and we are usually quick and effective in solving them. For example, consider our visual perception. It is known that our eyes are able to perceive visual information from only a limited number of points in the world around us at any given moment. On the other hand, we have the impression that we are able to see everything around us because our brain, like a personal computer, completes the perceived image by interpolating and extrapolating the data received from the identified points.

The term "inverse problem" has been steadily gaining popularity in modern science since the middle of the 20th century but, at that time, the solution of inverse problems was considered a mainly theoretical issue. Since the advent of powerful computers, it has also showed its practical value and almost all fields of science have benefited from the application of the theory of inverse problems. Some spectacular examples of inverse problem solutions are also present in crime television series: in almost every episode there are amazing tridimensional reconstructions of the murder starting from pieces of bones, droplets of blood or bullet fragments collected at the crime scene. However, there are great examples of inverse problems in many fields of science.

The first part of this seminar provides an overview of the inverse problem approach: the main principles of formulation, the typical solution techniques and some important applications are presented and discussed. The second part is focused on a remarkable application of the inverse problem approach: the contactless measuring either of the heat transfer coefficient or the heat sources distribution by using infrared temperature maps. The third part of the seminar presents the application of this measuring technique to the investigation of passively enhance convective heat transfer. In particular, a procedure to estimate the local convective heat flux in coiled and/or wall corrugated tubes is presented and tested. The results obtained by the Applied Physics research group of Parma University are particularly useful in the validation of numerical models and in the design of tube heat exchangers aimed at the treatment of highly viscous fluids.

Short Bio

Fabio Bozzoli graduated summa cum laude in Mechanical Engineering from the University of Parma (Italy) in 2001 and he received his PhD in Industrial Engineering in 2005. From 2005 he has been a university researcher in Applied Physics at the Industrial Engineering Department of the University of Parma. His research activity, both theoretical and experimental, is focused mainly on the solution of the inverse heat transfer problems, developing data processing techniques based on infrared imaging for the evaluation of the local heat exchange. He is predominantly interested in the forced convection in heat exchangers, paying particular attention to the problems of the food industry. He has also applied the inverse problem approach to the optimization of ground heat exchangers.

For More Information Contact: Dr. Ian Fischer (973) 596-3354 fischer@njit.edu