IMPLEMENTATION OF *"The Invariant h"* METHOD IN LIQUID CRYSTAL THERMOMETRY BASED HEAT TRANSFER RESEARCH INCLUDING FILM COOLING

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Abstract

This paper deals with the implementation of the recently developed "***invariant h method***" for the measurement of heat transfer coefficient h and its associated free stream reference temperature To_∞ in liquid crystal based convective heat transfer studies. The original "***invariant h method*** " previously described in a separate publication by Camci (2000.a) requires the acquisition of a complete wall temperature history during a transient heat transfer experiment. However, many transient heat transfer facilities used today prefer a simpler approach in which only one (or a few points) temperature point at a selected time is captured on the heat transfer surface. The popularity of this approach is mainly due to the unique property of liquid crystal coatings that display color only in a pre-selected temperature bandwidth. Color interpretation for thermographic purposes is available only in a user selected temperature band in a transient experiment using liquid crystals. Another reason for the popularity of this approach is the simplicity of the specific inverse solution of one dimensional transient heat conduction equation that is based on constant To_∞ in time. Many times, this condition is the result of stationary free stream flow conditions (constant Re number) in a transient experiment. In this approach, if one can deduce wall temperature from a liquid crystal coating at a known time, the heat transfer coefficient h can be obtained in a very time efficient procedure. The time consuming convolution integral type solution or a series summation based solution is reduced into a simple algebraic procedure using an exponential function and complimentary error function in non-dimensional time β. The current study explains the implementation of the "***the invariant h***" principle into liquid crystal based convective heat transfer research. The paper shows that the method is accurate and time efficient in performing h and To_∞ measurements in a simultaneous mode. The capability of obtaining an accurate To_∞ from the same experiment performed for obtaining h is extremely attractive in transient experiments. The new approach eliminates cumbersome and error prone temperature measurements at many streamwise locations in the free stream. The method is also applicable to film cooling research in which accurate measurements of adiabatic wall effectiveness η and film cooling heat transfer coefficient hf is of interest. The method presented is capable of simultaneously determining (η and $\mathbf{h_f}$) pair by using only one film cooling experiment in contrary to the conventional multi-experiment approach.