LASER SPECKLE TECHNIQUES FOR TEMPERATURE PROFILE MEASUREMENT

By

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DEDICATED TO

MY

DEAR FATHER AND

MEMORY OF MY MOTHER.

CERTIFICATE

This is to certify that the thesis entitled ,**"LASER SPECKLE TECHNIQUES FOR TEMPERATURE PROFILE MEASUREMENT"**, being submitted by **Mr. Anil Kumar Nirala**, to the Indian Institute of Technology, Delhi, for the award of the degree of **"DOCTOR OF PHILOSOPHY"**, is a record of the bonafide research work carried out by him under our guidance and supervision. He has fulfilled the requirements of submission of this thesis, which to the best of our knowledge, has reached the required standard.

The material contained in this thesis has not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Measurement of temperature profile is crucial to study a combustion process in detail. It helps in optimizing shape and size of a burner. It often indicates the problems associated with design and suggests new combustion strategies. Since local temperature strongly influences the species reaction rates and equilibrium concentrations, the accurate knowledge of flame temperature is necessary to precisely evaluate and analyze the combustion process. Many methods are available to measure temperature distribution in gaseous flames. These are thermocouple, pyrometry, line reversal method, Raman scattering, Rayleigh scattering, coherent anti-Stokes Raman spectroscopy (CARS), laser-induced fluorescence spectroscopy (LIFS), imaging, tomography, schlieren photography, deflection mapping, moire deflectometry, interferometry , speckle photography and Talbot interferometry.

Thermocouple can affect the combustion process due to physical intrusion of its measuring junction into the flame. Spectroscopic methods like Raman and Rayleigh scattering, CARS, LIFS etc. provide point by point data of the temperature field of the flame. To get full field temperature profile, holographic interferometry is the best available method. But it has extremely high sensitivity to vibrations. Moire deflectometry is less sensitive to vibrations but requires prior specification of temperature profile directions. Laser speckle photography gives full-field temperature data and is less sensitive to vibrations and does not require any prior specifications of temperature profile directions. But to get full field temperature map using speckle photography, point by point analysis has to be done and correction of fringe width due to halo effect is required which requires additional efforts and is time consuming. To

circumvent these problems, laser speckle shearing interferometry has been investigated to obtain temperature profile of flames.

Chapter-I provides a brief introduction of flames, speckles, method of making measurements using laser speckle techniques, optics of flames, Talbot and moire effect.

Chapter -II deals with the determination of temperature profile of an axisymmetric flame using speckle photography and optimization of the experimental parameters to get temperature over the entire volume of the flame.

Chapter-III presents the determination of temperature profile of a two dimensional slot burner flame used in Atomic absorption spectrophotometer using speckle photography.

Chapter-IV gives the details of the experimental and mathematical modelling to determine temperature profile of the axisymmetric flame using laser speckle shearing interferometry.

Chapter-V deals with the investigation of temperature profile of the two dimensional slot burner flame using speckle shearing interferometry.

Chapter-VI presents a critical assessment of temperature profiles of the axisymmetric flames and the two-dimensional slot burner flames, measured using speckle photography, speckle shearing interferometry and Talbot interferometry.

THE WORK HAS RESULTED IN THE FOLLOWING PUBLICATIONS

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1. Chandra Shakher, **Anil Kumar Nirala** , J. Pramila & S. K. Verma," Use of speckle technique for temperature measurement in gaseous flame", J. Optics (Paris), Vol.23, no.2, 35-39 (1992).
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