

APPLICATIONS OF SHEAR INTERFEROMETRY IN OPTICAL METROLOGY

by

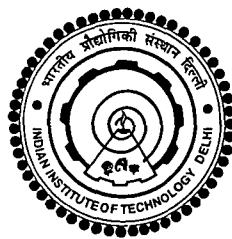
PRITI SINGH

INSTRUMENT DESIGN DEVELOPMENT CENTRE

submitted in fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

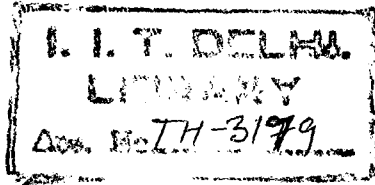
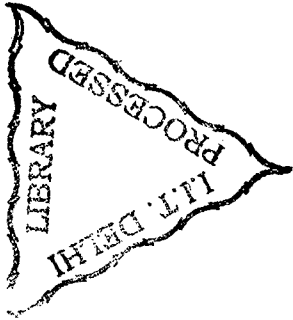
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**DEDICATED TO MY
DEAR FATHER
AND
MY HUSBAND**

CERTIFICATE

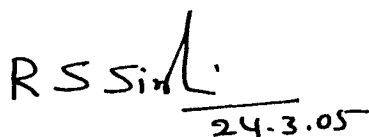
This is to certify that the thesis entitled, “APPLICATIONS OF SHEAR INTERFEROMETRY IN OPTICAL METROLOGY” being submitted by **Ms. Priti Singh**, to the Indian Institute of Technology Delhi, for the award of the degree of “DOCTOR OF PHILOSOPHY” is a record of the bonafide research work carried out by her under our supervision and guidance. She has fulfilled the requirements for 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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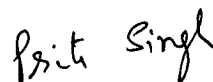
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PRITI SINGH

ABSTRACT

Optical measurement techniques are by far most sensitive, accurate and precise in comparison to other conventional techniques of measurement. These techniques are non-contact type, non-invasive and fast. Optical methods such as classical interferometry, holographic interferometry moiré deflectometry, laser speckle photography, laser speckle shearing interferometry, Talbot interferometry and Lau phase interferometry have been investigated in great details for the measurement of length, strain, deformations, vibrations, refractive index, focal length of optical components and systems and temperature and temperature profile of gaseous flames etc. In this thesis, we are presenting the applications of shear interferometry and digital speckle photography for the measurement of temperature of the gaseous flames and phase shifting Talbot interferometry for the measurement focal lengths of the lenses. Of the many available interferometers, shear interferometers are widely used in scientific/ industrial measurements, as these are common path interferometers and therefore less prone to environmental perturbations. Also shear interferometer does not require a reference beam.

The thesis is organized in five chapters:

Chapter I provides a brief introduction to flame, optics of a flame and most of the optical techniques used for studying a flame. Further, this chapter presents a brief introduction to lateral shear interferometry, Talbot interferometry and digital speckle photography and their applications in Optical Metrology.

Chapter II deals with the applications of shear interferometry for measuring temperatures and temperature profiles of gaseous flames. It presents a detailed experimental investigation and the corresponding theoretical analysis of the measurement of temperatures and temperature profiles of an axisymmetric flame obtained from Bunsen burner and a 2-D flame obtained from a slot burner using shear interferometry and conventional fringe analysis technique. In this analysis the fringe width of the shearing interferogram was used to calculate the temperature of the flames. A program was developed in MATLAB environment to draw the line profile of the shear interferometric fringes and for the measurement of fringe width. Once the relative fringe shift is known, the refractive index and the temperature at different points of the flame are calculated.

Chapter III deals with the applications of shear interferometry combined with Fourier fringe analysis technique to measure temperature and the temperature profile of an axisymmetric flame obtained from Bunsen burner and a 2-dimensional flame obtained from the slot burner used in atomic absorption spectrophotometer. In this analysis the phase of the shear interferograms was the basic measured quantity. A program has been developed in MATLAB to measure the phase of shear interferograms as a result the change in the refractive index can be calculated which allows one to determine the temperature.

Chapter IV presents the measurement of temperature and temperature profile of an axisymmetric flame and a two-dimensional flame obtained from the slot burner by using digital speckle correlation technique. In this analysis, first the cross – correlation

coefficient has to be measured, which is used for the measurement of angle of deflection. After that, this angle of deflection and the Abel integral were used to measure the temperature and the temperature profile of the gaseous flames.

Chapter V presents phase shifting Talbot interferometry with a Fourier fringe analysis technique which is implemented to analyse Talbot interferometric fringes and to evaluate the focal length of the lenses. A four steps algorithm is used to obtain the phase map of the lens. The slope of the phase map was used to measure the focal length.

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