

**USE OF PHASE SHIFTING TALBOT INTERFEROMETRY  
FOR SURFACE PROFILING AND DSPI FOR  
MONITORING/MEASUREMENT  
OF VIBRATION**

by

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submitted in fulfillment of the requirements of the degree of

**DOCTOR OF PHILOSOPHY**

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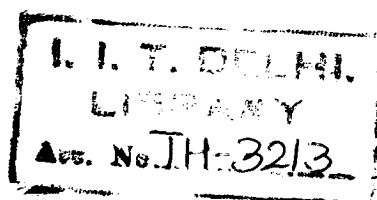


**INDIAN INSTITUTE OF TECHNOLOGY, DELHI**

**MARCH, 2005**

Materials measurement

Surface tests



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MIR-U

DEDICATED TO MY

***PARENTS***

and

***HUSBAND***

# CERTIFICATE

This is to certify that the thesis entitled, “USE OF PHASE SHIFTING TALBOT INTERFEROMETRY FOR SURFACE PROFILING AND DSPI FOR MONITORING / MEASUREMENT OF VIBRATION” being submitted by Mrs. Saba Mirza (nee Akhtar Kazmi), 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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# ACKNOWLEDGEMENTS

I express deep sense of gratitude to my Supervisor, **Prof. Chandra Shakher** for his invaluable guidance, interest, and involvement during all stages of my research. Credit of introducing me to the area of laser based instrumentation and image processing is goes to him.

I am highly grateful to **Dr. A. L. Yvas**, my co-supervisor, **Head IDDC**, for his constant encouragement and inspiration along with valuable suggestions through out my research work.

My special thanks are to Prof. **S. M. Ishtiaque**, **Dean of students**, IITD for his kind help and guidance throughout my tenure at IITD and to remain as guardian to me.

I am very much thankful to **Dr. D. S. Mehta**, **IDDC**, for his encouragement, inspiration and suggestions regarding my research work.

I feel myself fortunate enough to have husband like **Mr. Albab Ahmad Mirza** for his love, constant moral support, patience, encouragement and sacrifice on his behalf to live without family at Canada for the sake of my education. He provided me with this great opportunity, to complete my Ph.D work after my marriage.

I am thankful to my **parents** who have sacrificed a lot for the success of my siblings and me and they always guided us to move in the right direction. The support and cooperation given by my siblings (**Safia, Hina, Seema and Nadeem**) is very much valuable to me.

I am also grateful to my **in-laws** for their support to complete my work comfortably.

I wish to thank **Prof. Qamar Kazmi**, my aunt who has provided me moral support and set an example for me to achieve the success in life. My sincere thanks goes to **Mrs. Shahina Ishtiaque** for sharing and understanding my personal problems during the last stage of my work. Special thanks to **Nadeem**, my brother, for being with me all through my stay at IIT.

I am thankful to my friend, **Mrs. Priti Singh** who has been with me during my stay at IITD and helped me in research work at the laboratory. I am also thankful to **Mr. Shoeb Faridi**, **Mr. Rajesh Kumar** and **Mr. MD. Mosarraf Hossain** , for their help in programming and suggestions.

Help extended by **Mr. Mehdirrta** and the supporting technical staffs of the Workshop and Metrology Lab is very much valuable to me.

Everything would be incomplete without mentioning the name of my beloved daughters **Ariba** and **Adiba**. I always feel sorry for Ariba, for not being able to give due attention and care since their tender age of three months. My particular word of thanks goes to my sister **Dr. Seema**, who performed ungrudgingly a motherly role in upbringing of my daughters. A word fails me to explain her contribution.

Date:

  
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# ***ABSTRACT***

In the present thesis two surface metrology techniques, one for measurement of surface profile using phase shifting Talbot interferometry and other for measurement/ monitoring of behaviour of surface under excitation is presented using digital speckle pattern interferometric (DSPI) and new filtering scheme.

The thesis is organized in four chapters:

Chapter 1 provides a brief description to existing surface profiling techniques and their potential/ shortcomings. Further this chapter discusses phase shifting Talbot interferometry and its application to surface profiling. This chapter also describes the short comings of conventional/ optical techniques and utility of using DSPI for measurement / monitoring of vibration.

Chapter 2 describes theory, experimental details and processing of Talbot interferometric fringes for profiling of step, channel (dip) and continuous objects like surface of gas turbine blade. Talbot interferometry is robust and less sensitive to environmental perturbations. Talbot interferometry increases the range of depth/ height of measurement for continuous objects in comparison to projection moiré topography, scanning moiré technique. This is because in moiré topography, the range of measurement of continuous objects depends on the depth of focus of projection lens. The incorporation of phase shifting with Talbot interferometry enhances the accuracy of measurement. A program is developed in Matlab environment to calculate the phase from four recorded Talbot interferometric fringe patterns which was shifted by  $\pi/2$ . The phase unwrapping is

performed to remove  $2\pi$  ambiguity in the measurement. Finally the height measurements are carried out. The results obtained from this technique show good agreement with those results obtained from the profile projector and manually controlled co-ordinate measuring machine.

Chapter 3 deals with the theory, experimental details and discussions of new filtering schemes to reduce speckle noise from DSPI fringes. The new filtering scheme is based on the proper choice of average filter, sampling, thresholding and averaging followed by either Symlet wavelet filter or Biorthogonal wavelet filters. By using new filtering scheme, the DSPI vibration patterns can be analyzed with better accuracy. To check the potential of filtering scheme a program is also developed to calculate the speckle index and signal to noise ratio (SNR) of filtered and unfiltered interferograms. The results obtained by proposed filtering scheme are compared with the results obtained by earlier studied scheme in terms of SNR. The proposed filtering scheme based on improved pre-processing followed by Biorthogonal wavelet, improves the SNR in DSPI fringes significantly.

In Chapter 4, DSPI and new filtering scheme is applied to study the vibration in square plate under two boundary conditions. Under first boundary condition the plate was fixed at all edges and in the second condition the two adjacent edges of the plate were fixed.

Vibration mode shapes were recorded and filtered by new scheme. The effects of change in excitation frequency and excitation force are also studied. Large numbers of fringe patterns are recorded for both boundary conditions. Experimentally obtained resonance frequencies of the square plate with the boundary condition fixed at all edges are

compared with the classical frequency. The resonance frequencies obtained from DSPI show good agreement with that obtained from classical theory for thin plates. The map of deformation by using the calculated amplitude data, were generated. The amplitude of vibration obtained by DSPI are compared with the measurement done by piezo-electric accelerometer (Model No. 4374 DELTA SHEAR<sup>®</sup> accelerometer of Brüel & Kjær, Denmark). Amplitude measured by two techniques is in good agreement.

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