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

by

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Materials measurement

Surface tests

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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Date: **SABA MIRZA**

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 2π ambiguity in the measurement. Finally the height measurements are carried out. The results obtained form 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 studed. 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® accelerometer of Brüel & Kjær, Denmark). Amplitude measured by two techniques is in good agreement.

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