2011 International Conference on Environment Science and Engineering
IPCBEE vol.8 (2011) © (2011) IACSIT Press, Singapore

Analysis of Speckle Pattern Interferometry System

A A M Shamsir
School of Physics
Universiti Sains Malaysia
Penang, Malaysia
aams09_phy026@student.usm.my

M Z M Jafri
School of Physics
Universiti Sains Malaysia
Penang, Malaysia
mjafri@usm.my

***Abstract* — The ESPI measurement on an object is dependent on the direction in which the object is deformed. When the object is displaced or deformed in the direction normal to viewing direction, the phase of one beam increase, so that the relative phase of the two beams changes. When this change is a multiple of 2π, the speckle pattern remains the same, while elsewhere it changes. In this research field, this method is widely used to develop a new laboratory setup for implementing the speckle pattern interferometry. In speckle interferometry, an optically rough test surface is illuminated with an expanded laser beam creating a laser speckle pattern in the space surrounding the illuminated region. The speckle pattern is optically mixed with a second coherent light field that is either another speckle pattern or a smooth light field. This produces an interferometric speckle pattern that will be detected by sensor to count the change of the speckle pattern due to force given. In this project, an experimental setup of ESPI is proposed to analyze a stainless steel plate using 632.8nm (red) wavelength of lights.**

Keywords- ESPI, interferometry, speckle pattern.

I. INTRODUCTION

Conventional methods of measuring physical parameters such surface strain, displacement and profile utilize strain gauges and other mechanical or electrical sensing devices [1]. Although these methods can potentially produce high-precision measurements, their main drawback is the requirement for contact with the surface under test and the localized measurement area [2]. In general, large number of separate measurements is required to build up an overall picture of the physical parameter.

Optical metrology methods are developed to overcome these drawbacks and provide a whole-field (or full-field) non-contact metrology techniques that are able to provide measurements over large areas of the object surface at any time that is less laborious and of comparable accuracy [3]. Measurements can be made for smooth or rough surfaces that can be either opaque or transparent at different choices of sensitive and dynamic ranges [4]. Optical metrology methods such as interferometry methods and optical profilometry have been used in many applications to provide whole-field information of test objects [5].

Interferometric methods are used to measure displacements in the range of the wavelength of light [6]. They are of interest due to their height sensitivity and relatively low cost components. They are however susceptible to environmental disturbances like vibrations because of their height sensitivity. The nature of measurement can be the displacement, strain or temperature [7]. Holographic interferometry, moiré interferometry and speckle interferometry are among the main interferometry methods which have been developed for displacement measurement [8].

II. METHODOLOGY

In speckle interferometry, an optically rough test surface is illuminated with an expanded laser beam creating a laser speckle pattern in the space surrounding the illuminated region. The speckle pattern is optically mixed with a second coherent light field that is either another speckle pattern or a smooth light field. This produces an interferometric speckle pattern that will be detected by sensor to count the change of the speckle pattern due to force given [9]. In this project, an experimental setup of ESPI is proposed to analyze a stainless steel plate using 632.8nm (red) wavelength of light. From the setup, the intensity of the speckle patterns obtained will be analyzed.

The schematic diagram of the experimental setup is shown in Figure 1. In this experiment the Spectra-Physics model 117A He-Ne laser of wavelength λ = 633 nm is used as the coherent light source. The light beam from the He-Ne laser (4 mW output power) is passed through a 2.54 cm edge cubic beam splitter, to split the laser beam into two coherent beam of equal intensity. One of the beams is directed to a half-silvered mirror. The other beam is directed to the test surface. The reflected beams from the test surface will interfere with the expended beam through convex lens to form the speckle image and will be detected by a light-to-voltage converter optical sensor. The light-to-voltage converter optical sensor is a combination of photodiode and a transimpedance amplifier on a single monolithic integrated circuit. The photodiode active area is 0.5mm x 0.5mm and the sensors respond to light in the range of 320nm to 1050nm. Output voltage is linear with light intensity (irradiance) incident on the sensor over a wide dynamic range.

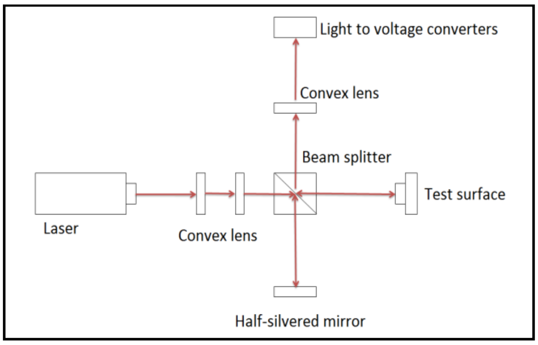


Figure 1. Schematic diagram for the setup of the ESPI system.

A. Generation of Fringe Changes of Speckle Pattern

The change of speckle pattern fringe is generated by using the software BASIC Stamp Editor v2.5. Figure 2 shows the layout of the BASIC Stamp software. A short program is written to obtain a count of fringe due to light that have been converted to voltage from the speckle pattern image. The BASIC Stamp program used to show the count of fringe is

```
result          VAR   Word
resultMax       VAR   Word
idx             VAR   Word
PAUSE 10
start:
resultMax = 0
FOR idx=1 TO 250
LOW 0
SHIFTOUT 3, 1, MSBFIRST, [%1101\4]
SHIFTIN 2, 1, MSBPOST, [result\12]
HIGH 0
resultMax = result MIN resultMax
NEXT
DEBUG DEC resultMax
RETURN
```

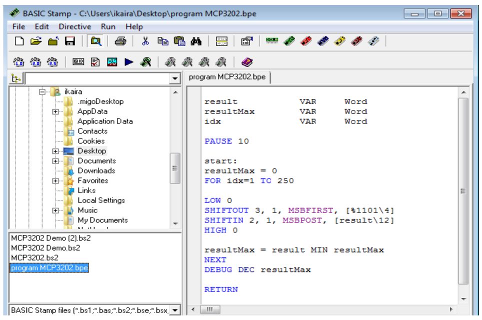


Figure 2. Layout of the BASIC Stamp Editor v2.5

B. Measurement of Deformation Caused by Static Load

Deformation on the test surface is applied in the form of displacement of the targeted area of the surface. Figure 3 shows the setup of the test surface and how the force is applied to it. The test surface is a stainless steel of dimension 19cm x 2cm x 0.05cm. It is fitted to the sample holder by fastening one of its ends to the sampler holder using screws. A 3mm hole is drilled to the other end of the test surface.

The force to displace the surface is loaded by attaching a series of weights to the end of inelastic cord. The cord are attached to the test surface through the hole and then through the pulley at which the weight are then attached.

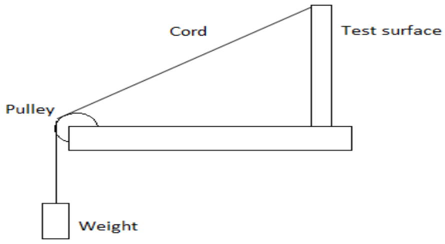
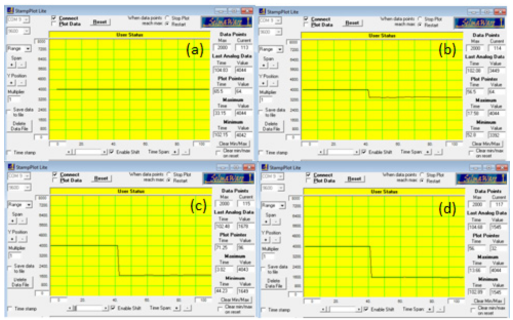


Figure 3. The setup of the test surface and weight to the sample

III. RESULTS AND ANALYSIS

The speckle images on the test surface are taken before and after the test surface are subjected to the deformation. Weights of 10g until 100g are tied to the ends of the inelastic cords to subject the test surface to an out-of-plane deformation. Figure 4(a) shows the stainless steel states before it deform. The optical sensor detects the high voltage of the beam which means the fringe is in the bright fringe. Figure 4(b) until Figure 4(j) shows the state of the stainless steel after deforms with different load from 10g until 100g. The graphs indicate increment of change between bright and dark fringe due to the increment of load given. It shows the bright fringe turn into darkest fringe and the different between bright and dark fringe shows in Table 1.The count different between before and after deform is shown in Figure 5. It shows increment of count different when the stainless steel attached with 10g until 40g load and become constant from 40g until 100g load attached. When deformation increment is too large, the microstructure of the surface will be altered and the current speckle pattern will lose correlation with the reference speckle pattern, and consequently no fringe can be observed [10].



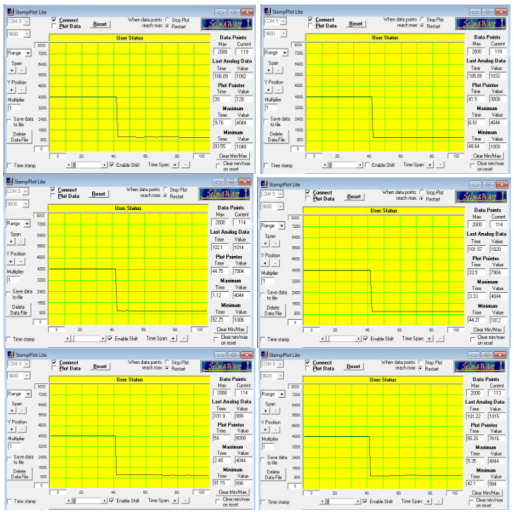


Figure 4. Count of fringe before and after deform with different load; (a) before deform, (b) until (j) after deform with 10g until 100g.

TABLE1: DIFFERENT OF FRINGE DUE TO LOAD GIVEN

Load (g)	Before Deform (count)	After Deform (count)	Different
10	4044	3392	652
20	4044	1649	2395
30	4044	1545	2499
40	4044	1048	2996
50	4044	1009	3035
60	4044	1006	3038
70	4044	1012	3032
80	4044	996	3048
90	4044	994	3050
100	4044	987	3057

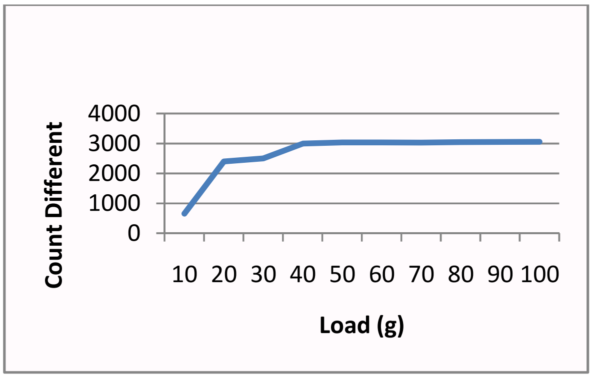


Figure 5. Count different of speckle pattern intensity due to load given

IV. CONCLUSION

In a summary we have successfully analysed the speckle pattern change in intensity after the deformation of metal using this method. We have developed an interferometry system that highly sensitive and relatively low cost to observe the speckle pattern of metal deformation by using a BASICS Stamp and StamPlot Lite software.

ACKNOWLEDGMENT

This research was supported by USM-RU-PRGS 1001/PFIZIK/833017. Appreciations are extended to USM and all who involved in this research project.

REFERENCES

[1] G. Schirripa Spagnolo, G. Guattari, E. Grinzato, P.G. Bison, D. Paoletti, D. Ambrosini, "Frescoes Diagnostics by Electro-Optic Holography and Infrared Thermography," 6thWorld Conference on NDT, 1999.

[2] Osuk Kwon, J. C. Wyant, and C. R. Hayslett, "Rough Surface Interferometry at 10.6 µm," Applied Optics, Vol. 19, pp 1862, 1980.

[3] J. Kornis, P. Pacher, "Simulation and Visualization in the Education of Coherent optics," Proceedings of the Second European Conference on Physics Teaching in Engineering Education, 2000.

[4] C.R. Coggrave, "Wholefield Optical metrology: Surface Displacement Measurement," phase vision Ltd 2002-2004.

[5] Peter J. De Groot et al, "Interferometric Optical Systems Having Simultaneously Scanned Optical Path Length and Focus", U.S Patent 2004/0027576 A1.

[6] L. Montgomery Smith and Chris C. Dobson, "Absolute displacement measurements using modulation of the spectrum of white light in a Michelson interferometer," Applied Optics, Vol. 28, Issue 16, pp. 3339-3342, 1989

[7] H.J. Tiziani, "Shape, Surface and Deformation Measurement: Scope and Trends", Solid Mechanical and Its Application, Vol 82, 2002.

[8] Michel Gre´diac," The use of Full-field Measurement Methods in Composite Material Characterization: Interest and Limitations," Composites: Part A 35, pp 751–761, 2004.

[9] L.C. DE BACKER, "In-plane Displacement Measurement by Speckle Interferometry", Non-destructive Testing, Vol 8, 1975.

[10] X.L. Gong and S. Toyooka, "Investigation on Mechanism of Plastic by Digital Speckle Pattern Interferometry," Experimental Mechanics, Vol 39, 1999.