Strain Distribution in Circular Disk of PMMA by Using Reflection Polariscope

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Abstract. The experiment was conducted to study strain distribution in circular disk of PMMA by photoelasticity in reflection polariscope. The strain in circular disk was induced by two point load created by hydraulic system (535.37-994.63 N) with the step increase of 153.21 N. We added the Babinet compensater in basic reflection polariscope to observe the fractional isochromatic fringe order in the first quadrant of disk and we calculated strain by using stress-strain optic laws. The result showed the relation between absolute of different strain in first quadrant of circular disk and the relation of force with absolute of different strain. It was found that maximum different strain produced at contact area of disk decreased along horizontal and vertical direction. The relation of force with different strain was linear.

1. Introduction

Photoelasticity [1-3] is an experimental method to determine the stress-strain distribution in materials and structures [4-6]. The degree of strain is variable relating to deformation of material. That can be seen by isochromatic fringe order. The different strain of circular disk increases when fringe order increases. The application of different strain of circular disk is important to design the size and shape of mechanical parts of machine, instrument and engine. In this research, we will investigate the different strain distribution of PMMA and the relation between different strain and magnitude of forces by analyzing the isochromatic fringe pattern circular disk shape**.** Then the results are used to calculate the strain distribution by using stress-strain optic law [7] in equation 1.

$$\varepsilon_1 - \varepsilon_2 = \left(\frac{1+\upsilon}{E}\right)\left(\frac{Nf_\sigma}{h}\right) \tag{1}$$

where υ and E are Poisson's ratio and the modulus of elasticity respectively.

f_σ , h and N are fringe value, fringe order and thickness of circular disk

The fringe order in equation 1 is the relative retardation in terms of a complete cycle comprising of integer/fractional number. This can be observed by adjusting compensator in photoelasticity. And fringe value is property of material relating to proportional of force and fringe order which depend on shape of sample. The benefit of the research is to understand the strain behaviour in circular disk, which can be developed further to the other shapes and also can be used to predict deformation behaviour in more complicated shapes.

2. Experimental procedure

In this research, the diameter and thickness of circular disk are 2.5 and 0.6 cm, respectively. Two-point loading pressed at the top and bottom of sample by hydraulic press system was applied. The magnitude of force was 535.37, 688.58, 841.61 and 994.63 N. The constant values of circular disk are fringe value of 57.9 kN/(order fringe), Poisson's ratio 0.38 [7] and the modulus of elasticity 2,800 MPa. We observed the number of fringe order in every point of grid in circular disk by using plane reflection polariscope [8]. These parameters were used to calculate different strain in equation 1.

Figure 1 is the grid on isochromatic pattern of disk. Step point to point of grid X/R and Y/R are 0.1 from center to edge of disk in horizontal and vertical direction.

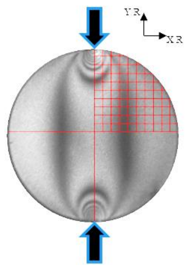
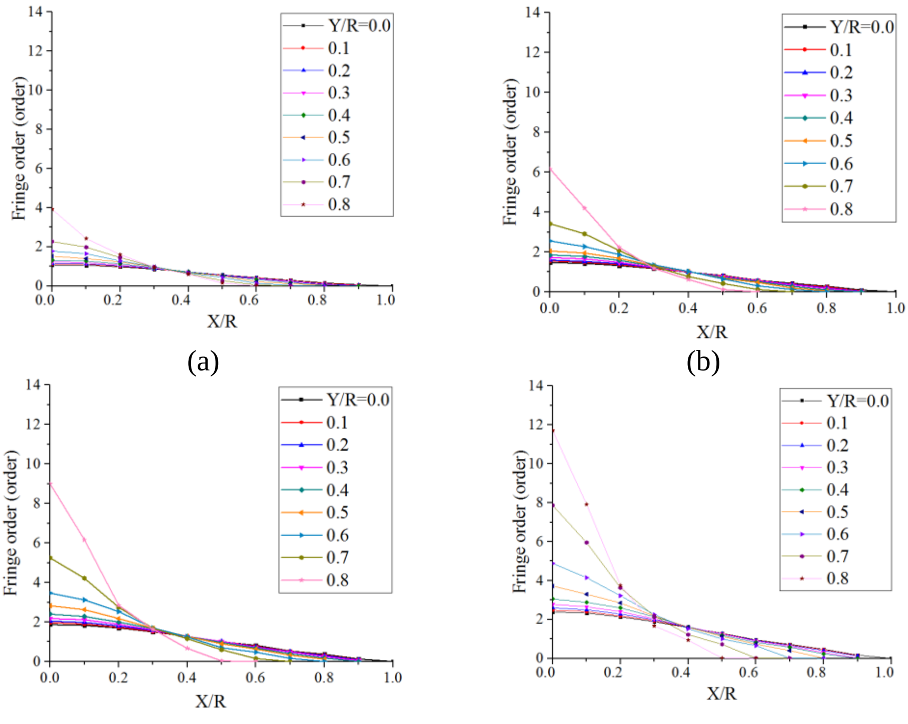


Figure 1. Grid on disk

3. Result and discussion

3.1. *Number of isochromatic fringe order*



(a) (b) (c) (d)

Figure 2. Fringe order in x-y plane of circular disk and magnitude of force are (a) 535.37 N (b) 688.58 N (c) 841.61 N (d) 994.63 N

According to the experiment, we observed the isochromatic fringe order of circular disk and we plotted the relations between fringe order distribution with horizontal (X/R) and vertical direction (Y/R) as shown in Figure 2. It was found that fringe order of circular disk decreased in horizontal direction from center of disk X/R=0 to the edge of disk. The maximum fringe order was produced around contact region zone of circular disk. The fringe order at position (0,0.8) of disk is 3.92, 6.17, 9.00 and 11.71 order for the magnitude of force 535.37, 688.58, 841.61 and 994.63 N. Fringe order at all magnitude of force is constant at the range of x-y plane at (0.3-0.4,1.0-2.0) on circular disk.

3.2. Determination of different strain

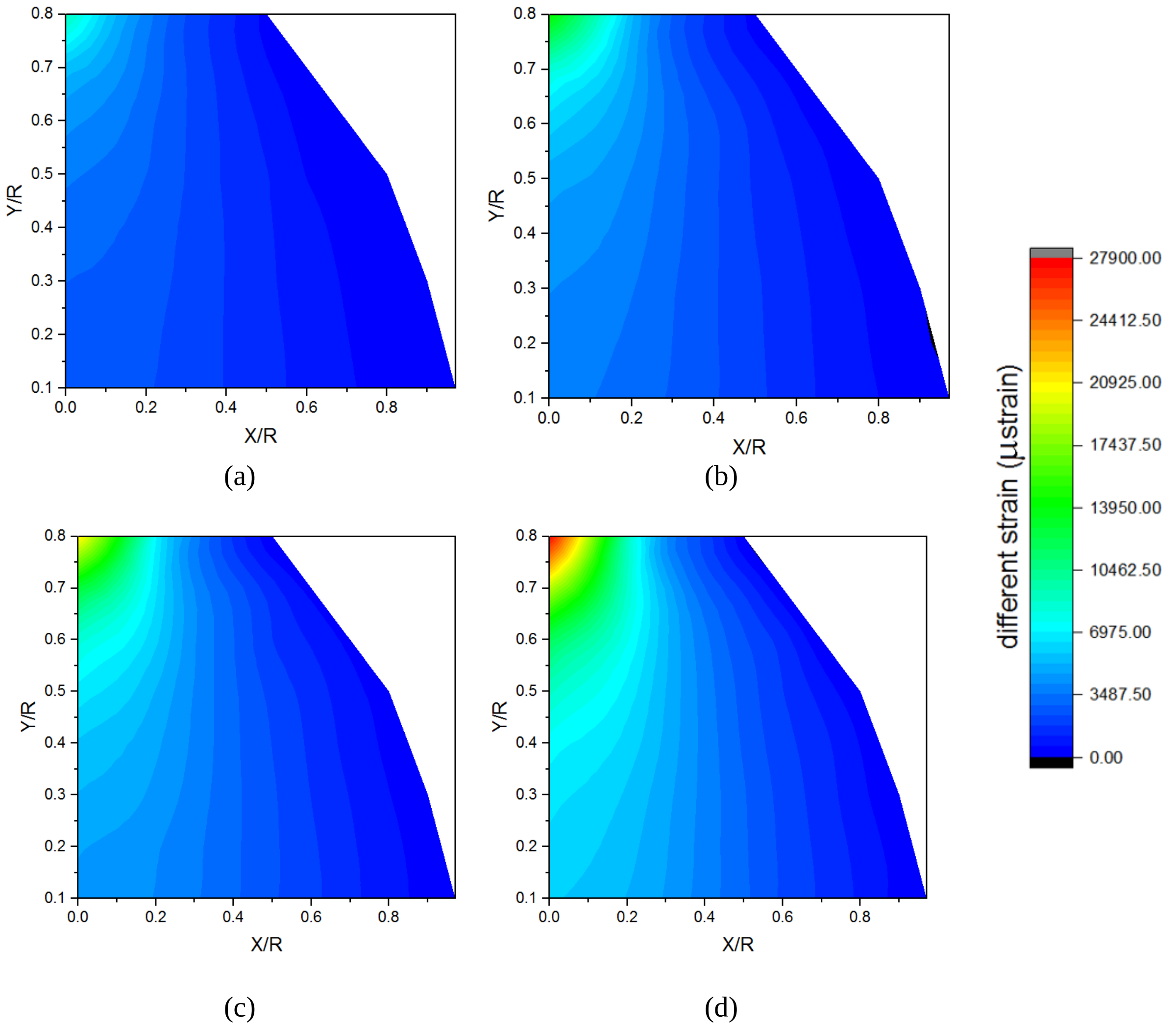
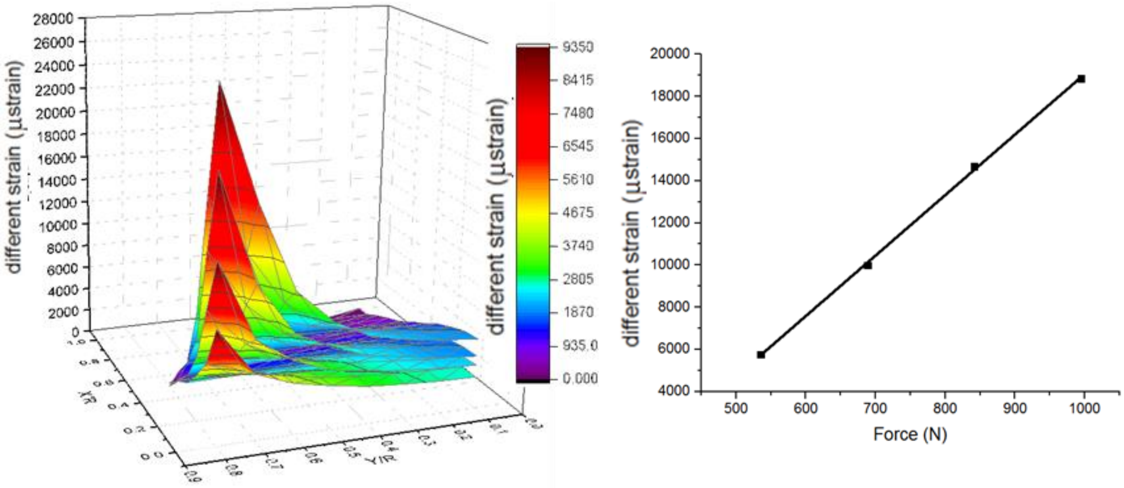


Figure 3. Different strain in x-y plane of circular disk and magnitude of force are (a) 535.37 N (b) 688.58 N (c) 841.61 N (d) 994.63 N

Different strain distribution of disk is shown in Figure 3. It was found that high value of different strain at contact area at the top of disk and different strain decreased from top to center and edge of disk in vertical and horizontal direction. The small different strain at the edge of disk is zero of μstrain. The different strain in circular disk increased as magnitude increased. The maximum different strain was produced around green and red region in Figure 3. They are 9326, 14679, 21413 and 27860 μstrain of force 535.37, 688.58, 841.61 and 994.63 N.

3.3. Relation of maximum different of strain with force

Figure 4 (a) shows the comparison of relation of different strain with force. We plotted the relation of the high value of different strain at position of (0,0.8) on circular disk with the different strain with magnitude of force consisting of 535.37, 688.58, 841.61 and 994.63 N. This relation is linear as shown in Figure 4 (b). It is because the maximum of force in this experiment was in the limit of elastic property of PMMA.



(a) (b)

Figure 4. Relation of force with different strain (a) relation of different strain with magnitude of force (b) relation of different strain at (0,0.8) with magnitude

4. Conclusion

When we induced stress strain on circular disk, it was found that the high of strain value produced at contact region and different stain decreased along vertical and horizontal direction disk. The difference of strain depended on isochromatic of fringe order. When we increased magnitude of force from 535.37 to 994.63 N, the relation of stress-strain of circular disk with magnitude of force was linear.

5. Acknowledgements

This work was supported by Laser and Applied Optics Research Laboratory, Department of Physics and Materials Science, Faculty of Science, Chiang Mai University. The authors are thankful to Faculty of Science, Graduate School and Chiang Mai University for financial support.

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