XXI ICTAM, 15-21 August 2004, Warsaw, Poland

THE WHOLE FIELD NON-DESTRUCTIVE OPTICAL SLICING METHOD IN THREE-DIMENSIONAL PHOTOELASTICITY

Michael N. Osipov, Vychislav K. Emelin
Samara State University, Department of Mechanics &Mathematics, Ac. Pavlov 1, 443011 Samara, Russia

Summary: The whole field non-destructive optical slicing method in three-dimensional photoelasticity based on the analysis of the scattered light field is presented. This method is based on the combination of the scattered light photoelasticity method, of the speckle photography method and the moiré technique. An analyses of the two-dimensional scattered light field from each plane sheets and theirs interference for the determination of the stress state in the thin optical slice is suggested.

INTRODUCTION

In a photoelastic medium a basic hypothesis consists in assuming that the medium must be slightly anisotropic, and that the secondary principal directions of the refractive indices tensor and of the stress tensor coincide. It follows that for a ray of light propagating along straight - line direction, the wave planes are orthogonal to this direction. In three-dimensional photoelasticity it is usually assumed that the directions of the secondary principal stresses and their values are constant through the thickness of a slice having its parallel faces. This assumption allows to consider this slice as a birefringent plate characterized by the two parameters - the difference of secondary principal stresses and the secondary principal directions.

It is known that optical techniques, such as holographic, speckle and moiré have been used for measurement of small displacements of objects. During the last decade increasing attention to speckle metrology and its applications in experimental mechanics has taken place. Moiré technique is also optical measurement method for strain analysis of materials and structures. These methods have been successfully applied to study of the static and dynamic problems.

The main disadvantage of optical methods in experimental mechanics is that they, in general, determine the displacement field or the difference of principal stresses, while the more important parameter is the strain and stress fields. Therefore the investigator dependents on the critical task of differentiation of the displacement field or he has to integrate the equilibrium equations using the finite difference calculus with known boundary conditions.

The purpose of this paper is to present a new optical technique for studying of the stress state in the three-dimensional photoelasticity. The method is based on the combination of the scattered light photoelasticity method, of the speckle photography method and the moiré technique.

BACKGROUND

The thin isolated optical slice of the photoelastic model is formed by two plane sheets [1] of light emitted from the same laser beam propagated in the direction of the axis **x** (Fig. 1). The polarization of the laser beam is linearly polarized along of the axis **y**. The two-dimensional scattered light field is analyzed in the direction of the axis **z** orthogonal to the plane of the two these illuminated plane sheets. The scattered light (according to Rayleigh's law) which is analyzed in the direction of the axis **z** is linearly polarized too and orthogonal to this axis. The two-dimensional scattered light field from the two plane sheets is analyzed by the analyzer **A**. An analyses of the two-dimensional scattered light field from each plane sheets and theirs interaction for the determination of the stress state in the thin optical slice is suggested.

Using combined method of the speckle photography with a ring aperture and moiré technique, have been received specklegrams for these two planes [2]. The pointwise filtering method is used for the analysis of double-exposure speckle photography. The scheme of the optical arrangement is shown in figure 2. The algorithm for the analysis of Young′s moiré fringe patterns for the optical system with the ring aperture is offered.

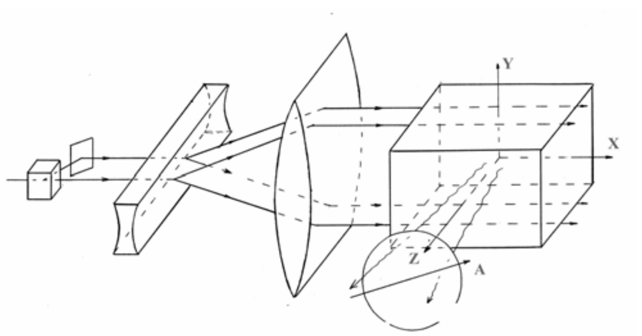


Fig.1. Schematic of optical slicing method.

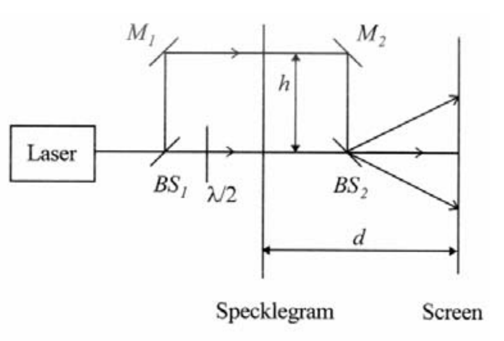
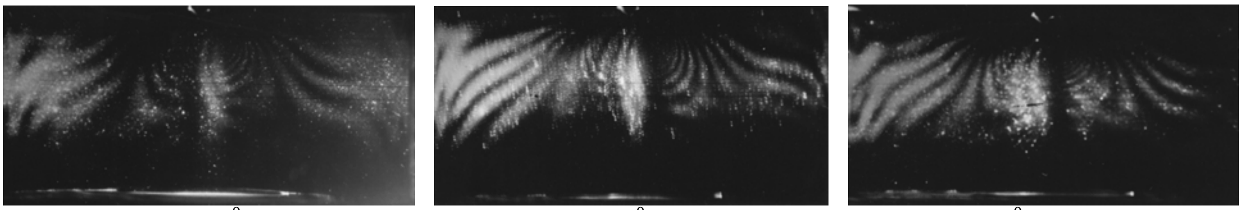


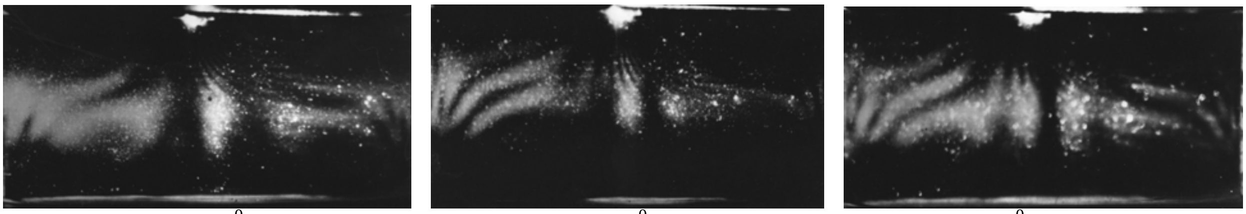
Fig.2. Schematic of the optical pointwise filtering method

This method is known as Young′s method. In the offered method the two narrow laser beams illuminate double-exposure speckle photography simultaneously. The distance between narrow laser beams can be changed. After passing through of the specklegram both laser beams are combined on the screen.
Figures 3, 4 and 5 shows an example of the experimental interference patterns that are observed for various directions of the analyzer **A**. Using Jones's method [1], the equations describing formations of the interference patterns have been received. These equations allow us to define the stress state in the thin optical slice.



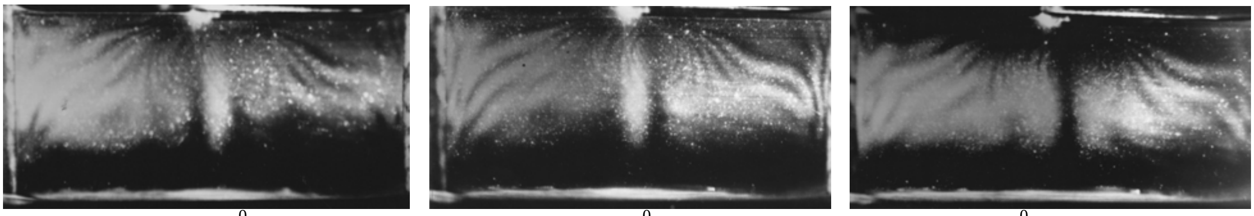
0^0 45^0 90^0

Fig.2. The interference patterns observable from the first plane sheet.



0^0 45^0 90^0

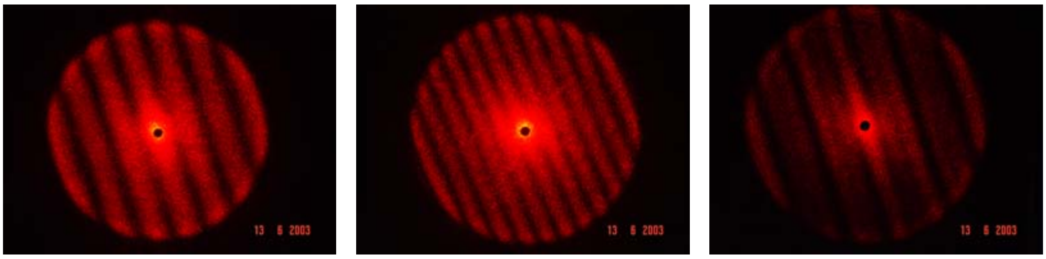
Fig.3. The interference patterns observable from the second plane sheet.



0^0 45^0 90^0

Fig.4. The interference patterns observable from interaction of two plane sheets.

Using combined method of the speckle photography with a ring aperture and moiré technique, have been received specklegrams for these two planes [2]. Photos on a figure 6, show an example of the experimental Young′s fringe patterns (a, b) for these two planes and moiré pattern (c) that is formed from their imposing. The equations for determination of a strain field from the moiré patterns are received.



a b c

Fig.6. Young′s fringe patterns (a, b) and moiré pattern (c).

CONCLUSIONS

The combination of the scattered light photoelasticity method, of the speckle photography method and the moiré technique allows to define the stress-strain state in the thin optical slice. Experimental optical arrangement with a C.C.D. camera is suggested to put this method in to practice. This work is fulfilled at support RFBR 02-01-00211.

References

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[2] Osipov M.N., Shaposhnikov M.Y.: Strain measurements by combining of the speckle photography and moiré method. *Abstracts of the 20th International Congress of Theoretical and Applied Mechanics*, Chicago, USA, 27 Aug. - 2 Sept., 2000.