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Photo Elastic and Finite Element Analysis of Circular Ring Subjected to Diametral Compression

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***Abstract*— A circular ring is a plane figure bounded by the circumference of two concentric circles of two different radii. Different types of materials are used to manufacture circular ring based on components, such as Polyurethane, Araldite (Epoxy resin), Mild steel, Cast iron, Rubber. These components find wide applications in engineering. There are typically subjected to compressive or tensile loads. Using photo elasticity technique the stress and strain under various diametric loadings can be obtained. As of now analytical solutions for ring subjected to diametral compression is not available in the literature. In the present study a ring made of photo elastic material is subjected to diametral compression and the principal stresses are determined by the photoelastic technique and the results have been compared with that of FEM simulation. The results obtained are in good agreement.**

Keywords: Photo elasticity, Isochromatics, FEA Tool, Diametral, principal stress

I. INTRODUCTION

Strain distribution in bodies subjected to large deformation has been determined in very few cases. The theoretical solution for this kind of problem presents great difficulties and with recent developments in experimental methods the solution of the two dimensional problems such as analysis of strain in circular ring subjected to large diametral compression is obtained with ease.

Regular geometries of structural components such as circular, semicircular, rectangular are used in Aerospace, Marine, Ordinance, Naval, Automotive and the vital sector of power generation. Various loading configurations may be assumed by the component depending on its position in the whole assembly, orientation with respect to surrounding parts and its function. For example, wheels of locomotives and automobiles are loaded at the center by axle and at the bottom most point of periphery by reaction by the ground. In the lathe machine, job is held in position either by three-jaw chuck, in which case, the job is loaded by three compressive forces 120 degree apart on the periphery or by four-jaw chuck, where, it is loaded by four compressive forces 90 degree apart or by six-jaw chuck for firm grip, where, loading is by six uniformly spaced forces on the periphery.

In simple gear trains, pinion is compressed by a shaft at the middle and by a wheel at a point on its periphery. In more complex gear trains, the gear wheel may be connected to two or more pinions, in which case, the wheel is loaded at two or more points on the boundary along with the central load and torque. In ball bearings, cylindrical rollers are diametrically compressed. In a simple rolling mill, rollers are compressed by two forces, one at center and the other at periphery. In a complex rolling mill, where backup rollers are provided to avoid bending, rollers are loaded at more than one point on periphery. Ship-Anchor is another example. In all such situations, detailed stress analysis is required for optimal design. Sometimes, overdesigning the parts can be avoided. All the times, critical locations of the part can be found according to any of theories of failure, once the state of stress of the component under given loading conditions is determined

II. PHOTOELASTIC EXPERIMENTAL DETAILS

The experiments were conducted using circular polariscope. The two types of materials used for the specimens were araldite and polyurethane elastomer. The araldite specimen is an annular ring of 100 mm outer diameter and 50mm inner diameter and 6mm thick. For polyurethane elastomer specimen was of 100mm outer diameter, 50mm inner diameter and 12mm thick as shown in figure.1.The experiments were carried out by subjecting the specimens to varying loads ranging from 100 N- 200 N.

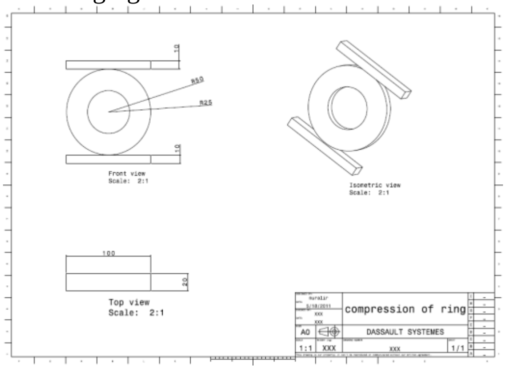

Fig.1 Geometry of circular ring

III. FINITE ELEMENT ANALYSIS

The finite element method has become a powerful tool for the numerical solution of a wide range of engineering problems. Applications ranges from deformation and stress analysis of automotive, aircraft, building, and bridge structures to field analysis of heat flux, fluid flow, magnetic flux and

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other flow problems. With the advances in computer technologies and CAD systems, complex problems can be modeled with relative ease.

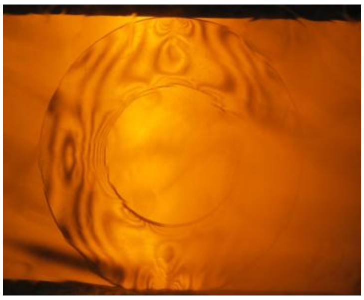
Finite element analysis (FEA) is a way to simulate loading conditions on a design and to determine the design response to those conditions. The FEM represents one of the most significant developments in the history of computational methods. The use of modern FEM has transformed most of the theoretical mechanics and abstract science into practical and essential tools for a magnitude of technological developments, which affect many aspects of our life.

The type of element used for modeling is solid 45, Araldite and polyurethane elastomer materials are analyzed at different loading conditions, by varying the material thickness. FEA results for Araldite and polyurethane materials at various loads are as shown in the Fig 3-6 &11-12.

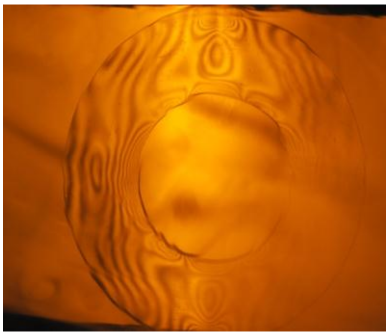
IV. RESULTS AND DISCUSSION

A. Araldite specimen subjected to diametral compression

Fig 2 shows the fringe pattern obtained in the specimen due to different loading conditions



a) Load of 147.15 N



b) Load of 196.2 N

Fig.2 (a) & (b). Pattern of fringes of Araldite specimen at different loads

B. FEA of Araldite material

Figures 3 to 6 shows displacement and stress contours of araldite material when subjected to different loading conditions.

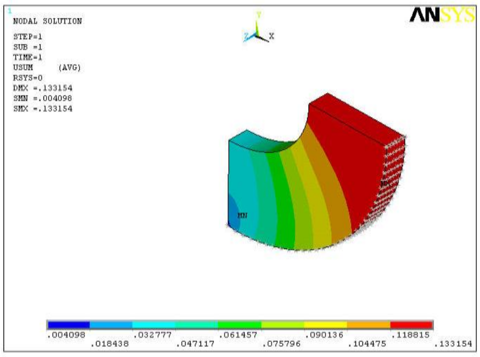


Figure.3.Displacement contours at 147.15N

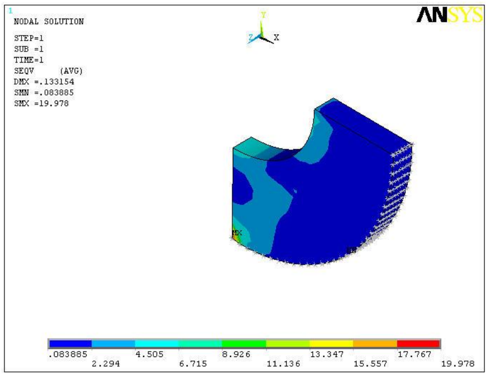


Figure.4.Von-mises stress contours at 147.15N

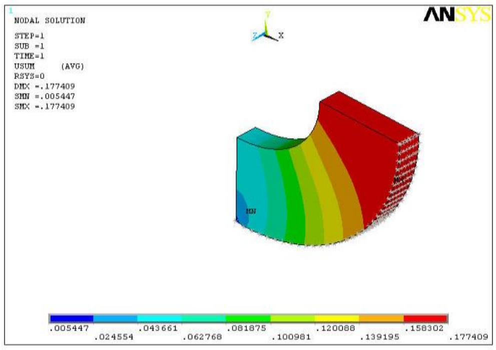


Figure.5.Displacement contours at 196.2N

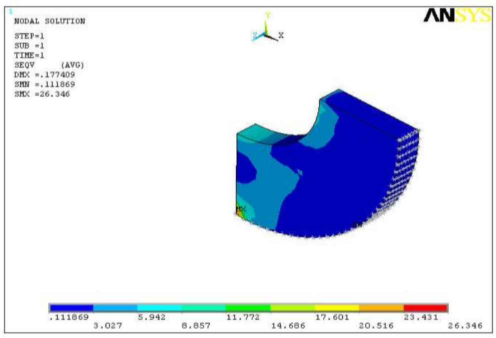


Figure.6.Von-mises stress contours at 196.2N

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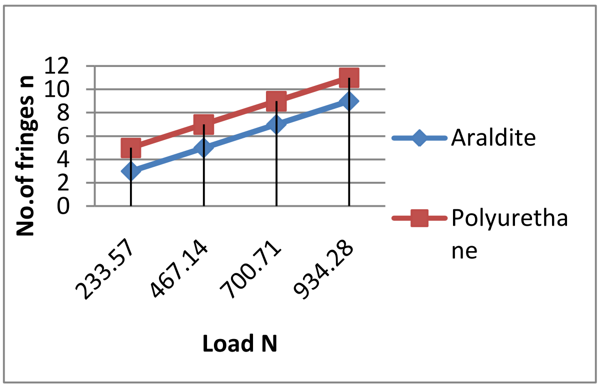

Figure.7 Load v/s fringes for araldite and polyurethane material

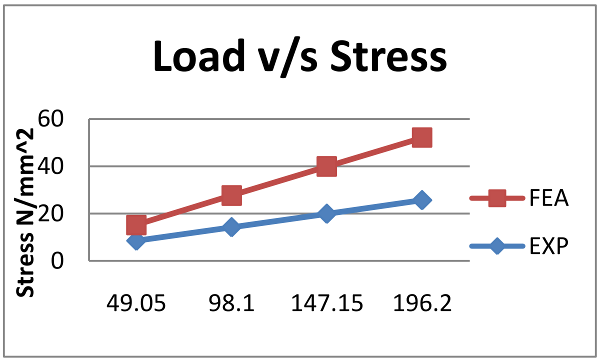

Figure.8 Load v/s Stress for araldite material

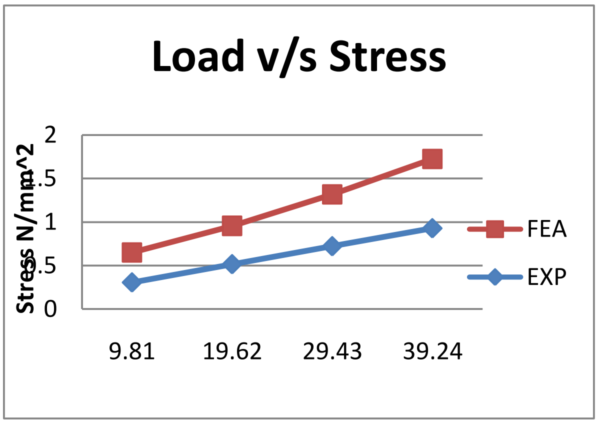

Figure.9 Load v/s Stress plot for polyurethane material

Fig.8 and fig.9 shows load versus stress plots at different loading conditions, as the load increases stress also increases both in araldite and polyurethane materials. And also experimental results are less than analytical results.

V. CONCLUSION

When a circular ring is subjected to diametral compression between the two flat platens,the following conclusions are made based on the experimental and FEA results.

- As the load increases number of fringes also increases both in araldite and polyurehenematerials.
- As the load increase stresses and strains also increases.
- Expeimental results are in good agreement with the FEM results

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