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Experimental Stress Analysis of Metallic Plate with Different Cut outs

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ABSTRACT

The metallic plates with different cutout are widely used in aerospace, mechanical and civil engineering structures. The different cutout shapes in structural element are needed to reduce the weight of the structure. The various cutouts of metallic plates create stress concentration in plate. The rise in stress concentration leads to failure of the structure. Therefore the stress concentration measurement is necessary. The plate is considered with different cutouts and subjected to a uniaxial tension load. The main objective of this study is to find out the stress concentration analysis of plate with various cutout and different cutout orientations. The stress concentration of metallic plate will be analyzed by using finite element program ANSYS. Results will be compared with experimental testing results.

Keywords— **Cutouts,Finite element analysis**, **Metallic plate, Stress concentration, Tension.**

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I. INTRODUCTION

The different types of cutout are used for different applications such as aerospace, fabrication of structural members, mechanical structure. Making cutout is not only for connecting but also reducing the weight of structural member. A stress concentration is a location in an object where the stress is concentrated. The existence of irregularities or discontinuities, such as holes, grooves, in a part increase the magnitude of stresses near the discontinuity. The plate with cutout or holes is called as perforated plate. The plates with hole are also used in coal washer, heat exchanger, washing machine, thresher machine, shadow masks and many more. The holes in a plate are arranged in various shapes such as circular, square, triangular, pentagonal, hexagonal and elliptical. Cut-outs are made into structures in order to satisfy some service requirements, results in strength degradation. In practice different shape of holes are used for different applications for example manhole of any pressure vessel is either circular or elliptical while the window or door of an airplane is rectangular hole having chamfer of some radius at corners.

The structural elements are failed that cause sudden changes in geometry, these changes in geometry increase the local stress fields of the parts. Hence it is an important aspect of stress analysis to predict stress concentration for regular or irregular holes. In some applications, the plate with cutout causes the stress concentration near the cutout. An object is strongest when force is evenly distributed over its area, so a reduction in area, e.g., caused by a crack, results in a localized increase in stress.To study the effect of stress concentration and magnitude of localized stresses, a dimensionless factor called Stress Concentration Factor (SCF), is used. In this study three parameters are used as the shapes of cutout, the bluntness and the rotation of cutout**.**

In this project different conditions and shapes of cutouts will be considered for evaluation of stress concentration. There are different experimental methods for measuring stress concentration factors including Photo elastic stress analysis, Brittle coatings or Strain gauges, Finite element method, Boundary element method and Complex variable approach. This evaluation will be done by computer aided simulation and validation will be done with the help of experimental tests.

II. LITERATURE REVIEW

SalehYazdaniet. al. [1], developed experimental and finite element analysis (FEA) of fiber metal laminates (FML) plates with cutouts. This paper investigates the experimental and numerical stress analysis of Fiber Metal Laminates (FML) with different types of cutouts. They shows that using global mechanical properties instead of the ply by ply mechanical properties in modelling are quite accurate.

Sartaj Patel, et. al. [2], presented aircraft is symbol of a high performance mechanical structure with a very high structural safety record. In this paper an attempt had made to find the maximum tensile stress location in the bottom skin of transport aircraft. The component wing box with the access cut out in the bottom skin is considered for the analysis. The maximum tensile stress location is identified. This location is the stress concentrated areas. In this location should be identified and the crack can be avoided.

D. B. Kawadkaret. al. [3], presented the analysis of stress concentration in plate with various cutouts and bluntness with different cutout orientation. They observed that the maximum stress in the perforated plate with the circular cutout is about three times the applied load. They show that, as bluntness increases the stress concentration is increases. They also finding is that as the stress concentration increases as the cutout become more oriented from baseline. They also conduct the experimental photo elastic test on Araldite model loaded in one direction for different cutouts.

Patel Dharminet. al. [4], presented the study of stress analysis of an infinite plate with cut-outs. In this paper an effort is made to review the investigations that have been made on the stress analysis of infinite plate with cut-out. An attempt has been made in the article to present an overview of various techniques developed for stress analysis of infinite plate.

Adis J. Muminovicet. al. [5], presented computer based software for analysis of stress concentration factors with a good knowledge of programming languages, small software applications can be developed for specific engineering problems, in order to avoid purchasing expensive software packages.

LotfiToubalet. al. [6], presented a non-contact measurement method, namely electronic speckle pattern interferometer (ESPI), was used to investigate the tensile strain field of a composites plate in the presence of stress concentrations caused by a geometrical defect consisting of circular hole. In this stress concentration characterization study of a laminate carbon/epoxy has been carried out. They show the strain concentration in woven fabric composites with holes is influenced by the loading direction,there is a high agreement between those stresses for woven fabric composite with a non-axis (weft direction 0 degree) tensile load. And the off-axis direction (90 degree, 45degree), the comparison does not show a good agreement.

Tawakol A. Enab [7], presented the stress concentration factors (SCFs) at the root of an elliptic hole in unidirectional functionally graded material (UDFGM) plates under uniaxial and biaxial loads are predicted. They used ANSYS Parametric Design Language (APDL) to build the finite element models for the plates and to run the analysis. A parametric study is performed for several geometric and material parameters such as the elliptic hole major axis to plate width ratio, the elliptical shape factor, the gradation direction of UDFGM. They show that, SCF in the finite plate can be significantly reduced by choosing the proper distribution of the functionally graded materials. They show for both isotropic and UDFGM plates, the stress concentration factors depends on the normalized major radius of the elliptical hole.

ArzYahyaRzayyig [8], presented the plates with interior openings are often used in both modern and classical aerospace, mechanical and civil engineering. The understanding of the effects of two cutouts on the stress concentration factor, maximum stress and deflections in perforated clamped rectangular plates, were considered. Parameters such as location, size of cutout and the aspect ratio of plates are very important in designing of structures. These factors were presently studied and solved by finite element method (ANSYS) program. The results based on numerical solution were compared with the results obtained from different analytical solution methods. The main objective of this study is to demonstrate the accuracy of the analytical solution for clamped square plate. They presented the result indicated that the maximum stress, deflection of perforated plates can be significantly changed by using proper cutouts locations and size. The results show that the rectangular plate containing two cutouts arranged along the width is stronger and stiffer than when arranged along the length at a given spacing, and the square plate is always stronger and stiffer than an equivalent rectangular plate for the same loading condition.

M Mohan kumaret. al. [9], presented the design of structures needs to key requirements of safety and weight. To achieve these requirements, smooth flow of stresses and optimum factor of safety at all points in the structure are necessary. The presence of cut outs becomes a necessary feature in the structures which obstruct the flow of stresses and there will be local concentration of stresses near the cut outs which needs to be estimated so that a safe and weight efficient design may be worked out. In this work, stress concentration factors (both elastic and plastic) near the elliptical cut outs of various standard geometries and for different material are computed using FEA and a comparison is made with analytical and semi-empirical methods available which demonstrates the behaviour of the structures with cut outs in the plastic regime. The ratio of nominal stress at failure to the ultimate strength of the material is calculated for the different plastic stress concentration factors for all the elliptical cut out configurations and a comparison is made between the theoretical and FEM results.

Louhghalamet. al. [10], presented the rectangular openings plates develop stress concentrations under bending. While these stresses can be determined using finite element method, in many problems this would be difficult because a high density mesh would be needed in the neighborhood of every opening corner. In this paper, it is shown how a complex-variable conformal mapping approach can be numerically coupled with the finite element method to analyze these corner stresses. In essence, the method relies on finite element analysis to obtain information on the stress field in a region surrounding the plate opening; this information is subsequently used to set up the parameters of the conformal mapping approach to obtain the near field stresses at the opening corners. This approach can be used even with relatively coarse meshes where the finite element results, by themselves, do not resolve the stress concentrations.

Jain N.K. [11], present the comprehensive plane stress finite element study is made for reduction of stress concentration factor (SCF) in a uni-axially loaded infinite width rectangular isotropic and orthotropic plate with central circular hole. The finite element formulation is carried out by the ANSYS package. They shows, the stress concentration can be reduced up to 24.4 % in an isotropic and 31 % in an orthotropic plate by introducing four coaxial auxiliary holes on either side of main hole. This study conveys that the introduction of these holes helps to smooth flow of the tensile stresses passes through the main hole and results, a reduction in stress concentration factor. They show that, reduction in maximum stress levels, the improvement in fatigue life of a component

III. DESIGN CALCULATION

Stress concentration is localization of high stresses mainly due to discontinuities in continuum, abrupt changes in cross section and due to contact stresses. In the tension test of an isotropic bar of constant cross-sectional area, the stress is assumed to be uniformly distributed over the cross section, provided the section is sufficiently far removed from the ends of the bar, where the load may be applied in a non-uniform manner**.** At the end sections, ordinarily the stress distribution is not uniform. Non-uniformity of stress may also occur because of geometric changes (holes or notches) in the cross section of a specimen. This is non-uniformity in stress distribution may result in a maximum stress $\sigma_{\max}$ ata section that is considerably larger than the average stress (σ_{nom} = P/A where P is the total tension load).To study the effect of stress concentration and magnitude of localized stresses, a dimensionless factor called Stress Concentration Factor (SCF) Kt.

$$K_t = \frac{\sigma_{\max}}{\sigma_{nom}}$$ Eq. (1)Where the $\sigma_{\max}$ is maximum stress at the discontinuity and σ_{nom} is the nominal stress.

A. Plate with different cutouts

The rectangular plate having the dimensions 300 mm × 100 mm and 6 mm in thickness. The location of cutout is at the center of the plate. The circular cutout having 20 mm diameter. The plate is fixed at the one end and loading condition is at the other end.

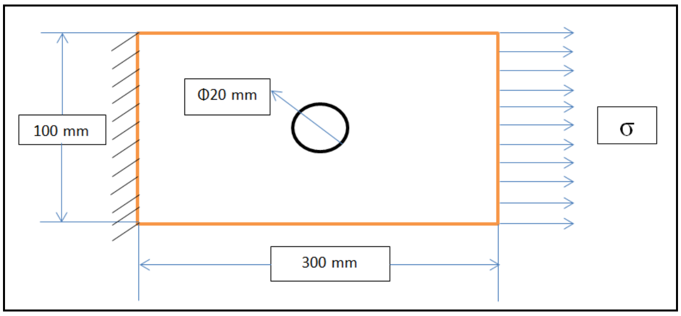

Fig1. Plate with circular cutout

B. Finite Element Model

Finite element analyses are conducted for the stress concentration analyses of perforated plates. The aluminium plates having dimensions 300 mm (x-direction), 100 mm (y-direction), and 6 mm (z-direction). Material properties are Young's modulus of 70 GPa and poisons ratio of 0.3. The location of the cutout is at the centre of the plates. An eight-node solid element is used for modelling. To investigate stress concentration in an elastic range, the plates are modelled as a linear elastic material. The loading condition is a uni-axial tensile force at the right sides and plate is fixed to the other side.

IV. CONCLUSION

The plates with cutout are widely used in structural members, these cutouts induces stress concentration in plate.The existence of stress concentration due to irregularities or discontinuities, such as holes and grooves.The aim of this project is to find out the stress concentration of plate with the different cutouts and bluntness with different cutout orientation.From the analysis it is observed that the maximum stress in the perforated plate with the circular cutout is about three times the applied load.

REFRENCES

[1] SalehYazdani, G. H. Rahimi, Mehdi Ghanbari, Experimental and numerical stress analysis of FML plates with cutouts under in-plane loading, MECHANIKA, 2013, 19(2), pp.128-134.

[2] Sartaj Patel, Mahesha. K, Harish E.R.M, Stress Analysis of Fuel Access Cutout of the Bottom Skin of a Transport Aircraft, International Journal of Innovative Research in Science, Engineering and Technology, 2013, 2(7), pp.3289-3235.

[3] D. B. Kawadkar, Dr. D. V. Bhope, S. D. Khamankar, Evaluation of stress concentration in plate with cutout and its experimental verification, International Journal of Engineering Research and Applications, 2012, 2(5), pp.566-571.

[4] Patel Dharmin, PanchalKhushbu, JadhavChetan, A review on stress analysis of an infinite plate with cut-outs, International Journal of Scientific and Research Publications, 2012, 2(11), pp.1-7.

[5] J. Rezaeepazhand, M. Jafari, Stress concentration in metallic plates with special shaped cutout, International Journal of Mechanical Sciences, 2010, 52, pp. 96–102.

[6] LotfiToubal, MoussaKarama, Bernard Lorrain, Stress concentration in a circular hole in composite plate, Composite Structures, 2005, 68, pp. 31–36.

[7] Takwakol A. Enab, Stress concentration analysis in functionally graded plates with elliptic holes under biaxial loadings, Ain Shams Engineering Journal, 2014, 5, pp. 839–850.

