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ANALYSIS AND VALIDATION OF STRESS CONCENTRATION ON CUT OUT ORIENTATION PLATES

[1]*S.B.MASUTI,* [2]*K.S. MANGRULAKAR*
[1, 2]**Department of Mechanical Engineering,**

NBN Sinhagad College of Engineering, Solapur, Maharashtra

masutisangam@gmail.com, ksmangrulkar.nbnscoe@gmail.com

ABSTRACT :
Openings/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 an 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.
This hole/opening works as stress raisers and may lead to the failure of the structure/machine component. Hence it is an important aspect of stress analysis to predict stress concentration for regular or irregular holes. The irregularity in the hole shape may be because of chemical degradation. Under the effect of external loading and chemical process some irregular shapes may evolved. It is necessary to know stress distribution around such irregular shaped hole which may be useful to know hole shape evolution.

KEYWORDS:*Stress Concentration, contact stresses*

1. INTRODUCTION

Stress concentration is localization of high stresses mainly due to discontinuities in continuum, abrupt changes in cross section and due to contact stresses. To study the effect of stress concentration and magnitude of localized stresses, a dimensionless factor called Stress Concentration Factor (SCF), denoted as K_t.

$$K_t=\frac{\sigma\ max}{\sigma\ nom}$$

Where, σ max is maximum stressnominal at the discontinuity and σ nom is nominal or background stress. The stress concentration factor can be determined analytically by applying elasticitytheory. For a large thin plate with a small circular hole at the center, that is subjected to uni-axial far-field tension, x-axis,σ,the stressesacting(radial, circumferentialalong andthetangential)around the vicinity of the hole are given in polar coordinates (r, θ) which shown in figure.

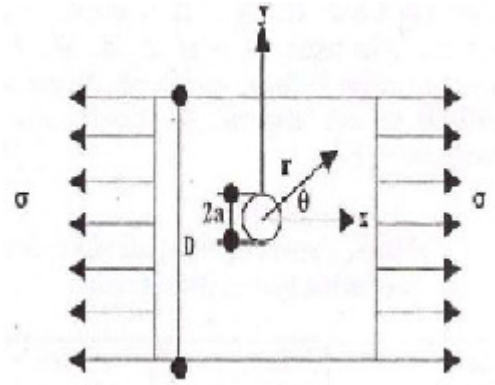

Figure1 Plate subjected to uniaxial tension

Stress analysis of the critical elements under various loading conditions is carried out by the researchers for safe design of the element. Stress is measured by experimental methods or analytical/numerical methods which are as follows.

A. EXPERIMENTAMETHODS

a) Photo Elasticity

b) Brittle Coating

c) Electrical Strain Gauges

B. ANALYTICAL/NUMERICAL METHODS

a) Finite Element Method

b) Boundary Element Method

c) Complex Variable Approach

In this research we are dealing with the experimental Electrical Strain Gauge method for measuring the SCF for different notches of different material and for validation of this research we are dealing with Analytical that is Finite Element Method.

2. IMPORTANCE

Plates and shells of various constructions find wide uses as primary structural elements in aerospace, mechanical and civil engineering structures. In recent years, the increasing need for light weight efficient structures has led to structural shape optimization. Different cut-out shapes in structural elements are needed to reduce the weight of the system and provide access to other parts of the structure. It is well known that the presence of a cut-out or hole in a stressed member creates highly localized stresses at the vicinity of the cut-out. The ratio of the maximum stress at the cut-out edge to the nominal stress is called the stress concentration factor (SCF). The understanding of the effects of cut-out and it orientation on the load bearing capacity and stress concentration of such plates is very important in designing of structures.

3. PRINCIPLE OF WORKING

The setup is welded as shown in the fig. It consist of a base plate, two square tubes for support, a cantilever beam, clips and power screw. The base plate consists of four holes for clamping the setup on the table.

The experiment is to be conducted to study the effect of a circular hole on the stress at the edge of the hole. There are total of 7 strain gauges that are bonded along transverse axis of symmetry starting from close to circular edge to the right end of transverse axis. Since the gauges cannot be bonded exactly at the edge of circular hole at right transverse edge, a polynomial is fitted to the data to extrapolate the strain to an edge as explained in procedure below. Another single gauge is bonded in the middle portion of the specimen (i.e. between hole and load) to measure average strain.

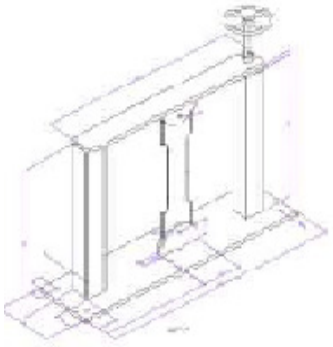

Figure 2 Proposed setup for work

4. PROCESS PARAMETERS

For this project work the input parameters are. :-

1. Different shapes of notches like circular, triangular, rectangular, and square.
2. Different orientation of notches
3. Different radius ratio for bluntness

AND OUTPUT PARAMETERS ARE

1. Stress concentration factor
2. Maximum stress concentration localization area
3. Effect of the radius ratio and orientation of cutout.

5. PROBLEM DEFINITION

Plates and shells of various constructions find wide uses as primary structural elements in aerospace, mechanical and civil engineering structures. In recent years, the increasing need for lightweight efficient structures has led to structural shape optimization. Different cut-out shapes in structural elements are needed to reduce the weight of the system and provide access to other parts of the structure. It is well known that the presence of a cut-out or hole in a stressed member creates highly localized stresses at the vicinity of the cut-out. The ratio of the maximum stress at the cut-out edge to the nominal stress is called the stress concentration factor (SCF). The understanding of the effects of cut-out on the load bearing capacity and stress concentration of such plates is very important in designing of structures.

6. OBJECTIVES

Investigating the effect of stress concentration on different cut outs with different orientation by using ANSYS and validating experimental result with electrical strain gauge method.

8. METHODOLOGY

The methodology of present study include following steps:

A. Introduction and problem formulation.

B Literature Survey.

C Experimental Setup:

The experimental setup is shown in fig below:

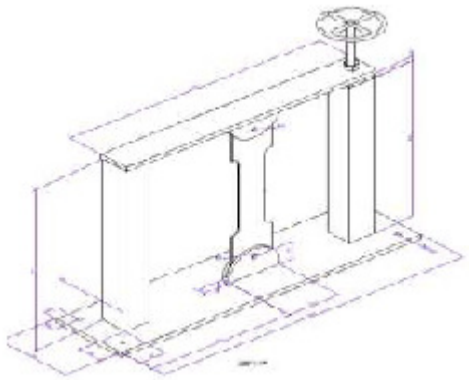

Figure 3Experimental setup for work

9. MEASURING PARAMETERS

1. Different shapes of notches like circular, triangular & square
2. Different orientation of notches
3. Different radius ratio for bluntness

10. EXPERIMENTATION

Experimentation can be done for detection of SCF of different cut-out and orientation fordifferent notches like circular, square, triangular by changing radius ratio etc.

The experimentation can be done in software that is ANSYS and its validation can be done practically by electrical strain gauges.During experimentation the parameter that is radius ratio and orientation of notch can be varied as follows.

1) Radius ratio ($\frac{r}{R}$):- 0.1 to 1.0

2) Orientation of cut-out: - 0° to 90° (Depend upon shape).

3) Cut-out will be in the shape: - Square, Triangle & Circular.

11. SCOPE WORK

After a study of the existing literature, following scope of project have been defined in the investigation of SCF for different notches of different orientation.

1) Selection of different shapes of cut out for experimentation.

2) Evaluate the maximum stress region in different cut-outs with orientation using ANSYS software.

3) Experimentation for SCF of this cutout using electrical strain gauge method and comparing these results.

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