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Stress Concentration of Rectangular Plate with Central/Off-Central Circular Hole under Uni-Axial Loading

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Abstract: ***In this project Sic/AA7075 unhybrid metal matrix (UHMMC) plates are prepared under sand casting method. Sic was reinforced with AA7075 at the wait varying percentage of 5%,7.5%,10% and 12.5%,53µm grain size was prepared. The circular centre cut-out holes/off centre circular cut-out holes are prepared on the plates in the machining process, the circular centre /off centre cut-out holes are varying from 2.5mm, 5mm, 7.5mm,10mm and 12.5mm radius. The objective of this project work is to finding the stress concentration on the plates by increasing the reinforcement of the Sic to the AA7075 UHMMC, by varying the circular radius in the plates.***

An experimental study completed on the Universal Testing Machine on the plates with constant circular centre/off centre cut-out hole radius and varying reinforcement of Sic with UHMMC and results are noted. An analytical study was conducted using Roorks formula for finding the stress concentration on plates with centre/off centres circular holes.

The finite element analysis study was carried out using solid 20 node 95 element, a good agreement was shown between FEA and analytical study.

In the experimental study observed that at a constant circular cut-out hole radius 12mm on the plates the stress concentration decreases with increasing the percentage of reinforcement of Sic to the AA7075 UHMMC, and also at constant off centre circular cut-out hole radius 7mm on the plates the stress concentration decreases with increasing the percentage of reinforcement.

The stress concentration less for centre circular holes compare off centre circular holes. In the experimental study stress concentration low for the only 12.5% waits percentage of reinforcement of Sic to AA7075 at constant circular centre cut-out radium 12mm,and the remaining cases the stress concentration high compare to the analytical and FEA study.

In the analytical and FEA study observed that stress concentration decreased with increasing the circular centre/off centre cut-out holes radius, the stress concentration high for centre circular holes compare to off centre circular holes.

Keywords: AA7075, Sic, Unhybrid Metal Matrix, Stress concentration, Rooks'sEquation

I. INTRODUCTION

Stress concentration factor (Kt), is a dimensionless factor which is used to quantify how concentrated the stress is in a material. It is defined as the ratio of the highest stress in the element to the reference stress,

$k_t = \sigma_{max} / \sigma_{ref}$.

Reference stress is the total stress within an element under the same loading conditions without the stress concentrators, meaning the total stress on the material where the material is free from holes, cuts, shoulders or narrow passes. A stress concentration is often called a stress raiser or stress riser. Methods of reducing stress concentration

A number of methods are available to reduce stress concentration in machine parts, including:

A. Providing a fillet radius so that the cross-section may change gradually
B. Using an elliptical fillet
C. Using a number of small notches rather than a long one, if a notch is unavoidable
D. Using narrow notches rather than wide notches, if a projection is unavoidable

Using stress-relieving grooves

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II. LITERATURE SURVEY

Hu H, Lin B (1995)-Significant influence of plate thicknesses, aspect ratios, central circular cutouts and end conditions on the optimal fiber orientations and the associated optimal buckling loads of symmetrically laminated plates are shown. Royalance David (2000)-This module will deal primarily with uni-directionally reinforced continuous-fiber composites, and with properties measured along and transverse to the fiber direction. Oral Buykozturk, Au Ching (2005)-This work investigates the effects of different fiber orientation and mix of ply configurations on load-deformation behavior and failure modes of FRP confined concrete, with particular emphasis on the kinking Phenomenon, which is believed to be a critical physical state from a design standpoint. Within the limitation of the experimental program, the following tentative conclusions have been drawn. Zahari R, Azmee AH, Mustapha F, Salit MS, Varatharajoo R, Mohd. Rafie AS. (2008)-A progressive failure analysis of woven glass/epoxy laminated plates is developed via the non-linear finite element analysis. Naik NK, Kavala Venkateswara Rao (2008)-Investigations on high strain rate behavior of composites under compressive loading are presented.Al Qablan H,Katkhud H,Dwairi H.(2009)-This paper aims at evaluating the effect of various parameters on the buckling load of square cross-ply laminated plates with circular cutouts. Murat Arslan H, Yasar Kaltakci M, Yerli Huseyin R.(2009)-In this study, an analysis of fiber-reinforced, laminated composite plates containing circular holes has been carried out. Aljibori HS, Chong WP, Mahlia MI, Edi Prasetyo, Al-qrimli H. (2010)-An experimental study of the behavior of woven glass fiber/epoxy composite laminated panels under compression is presented. Manoharan R, Jeevanantham AK.(2011)-This paper is focused on the analysis of stress-strain and displacement for compressive load on the fiber reinforced composite laminates.

In this present work reports that stress concentration decreased with increasing centre hole/off centre hole cut out radius and also increasing the reinforcement of Sic to AA7075 UHMMC

A. Fabrication Of Unhybrid Metal Matrix Composites (UHMMC'S) Plates And Experimental Work

AA 7075/Sic metal matrix composites are prepared using sand casting method step by step operations are shown in the images. The dimensions of the samples (210*60*10 mm) are fabricated in the sand casting method by varying Sic percentage reinforced with AA7075, after that casting samples are machined in the lathe machines to obtain the required dimensions. The experimental work carrying on Universal testing Machine, the samples images are shown before and after fracturing, the maximum stress are calculated for all the samples of centre/off centre cut-out holes of the plates with varying radius.

Figure 1: Shows the step by step operations of sand casting method

Figure 2: Shows the centre cut-out hole plate before and after fracturing

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Figure 3: Shows the off centre off cut-out hole plate before and after fracturing

B. Analytical and FEA Study

The stress concentration of plates with circular holes at centre /off centre are calculated for the central circular hole in a member of rectangular cress-section By ROARK'S formula

Table 1: Shows the K_t of central/off central circular hole varying percentages of SiC

S.NO	% of Sic	K_t- 12mm central circular hole	K_t -7mm off center circular hole
1	5%	2.68431	4.90484
2	7.5%	2.210614	2.8608
3	10%	2.315882	3.42493
4	12.5%	2.10534	3.7420

$k_t = 3.00\text{-}3.13\left(\frac{2r}{D}\right) + 3.66\left(\frac{2r}{D}\right)^2\text{-}1.53\left(\frac{2r}{D}\right)^3$ (3.1)

Here k_t = Stress concentration factor and Elastic stress, axial tension

$\sigma_{nom} = \frac{p}{t(D-2r)}$ (3.2)

Off-centre circular hole in a member of rectangular cross-section By ROARK'S formula Elastic stress, axial loading

$k_t = 3.00\text{-}3.13(r/c)+3.66(r/c)^2\text{-}1.53(r/c)^3$ (3.3)

$\sigma_{nom} = \left(\frac{p}{Dt}\right)\left(\frac{\sqrt{1-\left(\frac{r}{c}\right)^2}}{1-\frac{r}{c}}\right)\left(\frac{1-\left(\frac{c}{D}\right)}{1-\left(\frac{c}{D}\right)\left(2-\sqrt{1-\left(\frac{r}{c}\right)^2}\right)}\right)$ (3.4)

Table 2: Shows the k_t-of varying radius in central/off central circular hole (analytical)

S.No	Radius(mm)	k_t- central circular hole	K_t- off central circular hole
1	2.5	2.763700583	2.572917
2	5	2.5014814	2.30667
3	7.5	2.4223437	2.1809076
4	10	2.30666	2.086677
5	12	2.23568	--------

Table 3: Shows the k_t-of varying radius in central/off central circular hole (FEA)

S.NO	Radius(mm)	k_t- central circular hole	k_t- off central circular hole
1	2.5	2.7083142	2.8264530
2	5	2.5835833	2.34866
3	7	2.333908	2.17762
4	10	2.163133	2.02797
5	12	2.18174727	---------

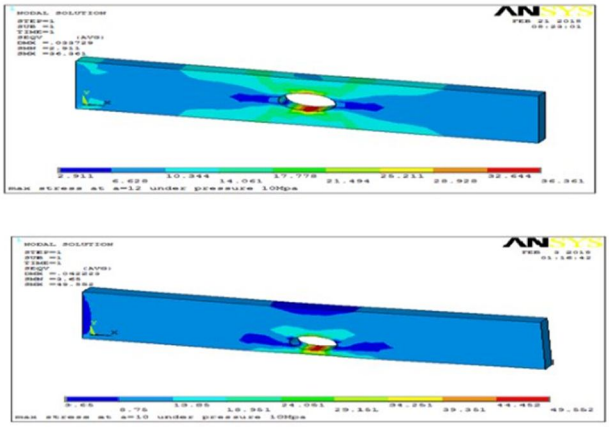

Fig 4: Shows that Max Stress of center/off centre cut-out hole radius 10mm

In the finite element analysis study ANSYS APDL software used for finding the maximum stress, solid 20 node 95 element was best fit for this 3D analysis, convergence requirement was satisfied for the quality mesh

III. CONCLUSIONS

A. In central/off centre circular hole in a member of Aluminum rectangular cross-section nominal stress and maximum stresses increases while increasing the radius but stress concentration factor(k_t) decreases.

B. By adding of silicon carbide to Aluminum in proper percentage of weight, stress concentration factor(k_t) increased in both central/off centre circular hole in a member of rectangular cross-section

C. The values obtained by ANSYS software and theoretical values are nearly equal

D. k_t experimental values are better than both ANSYS software and theoretical values of k_t because adding of silicon carbide

E. In both central/off centre circular hole cases got higher k_t value at the composition of 5% SiC and 95% Al.

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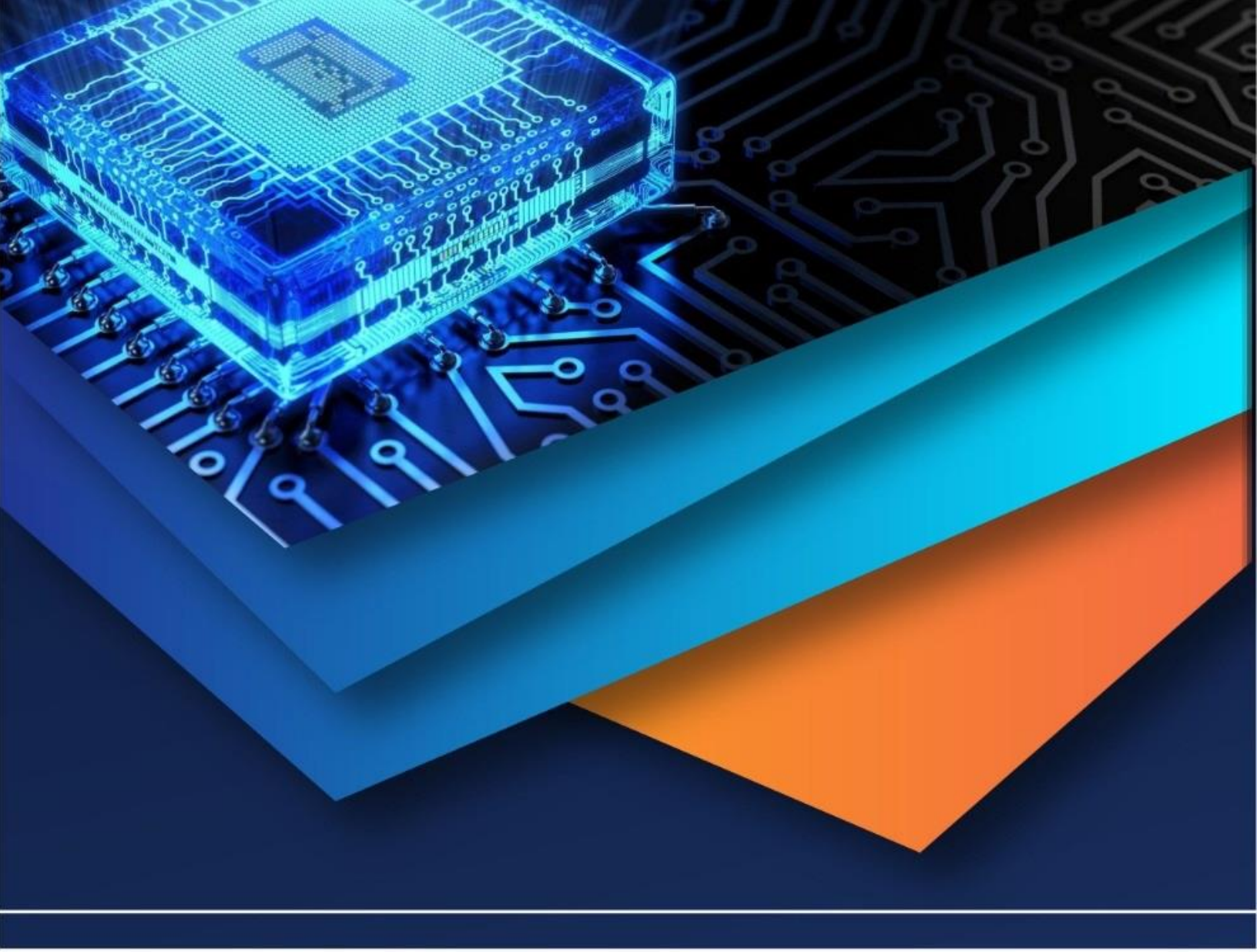

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