Effect of Stress Concentration Factor on Maximum Stress for A Rectangular Plate With Cutout, Subjected to Tensile Load

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Abstract:-Most common requirement in many situations is a plate with a cut out, subjected to uni-axial tensile load. In almost all cases, the main objective is to reduce stress concentration factor. But in many cases, reduction of stress concentration factor will not reduce the maximum stress. It is the maximum stress that will cause the failure. Actually, the maximum stress will increase in some cases when the stress concentration factor is reduced. Such an example is also illustrated in this paper.

Keywords—Stress; SCF; Max Stress; Axial Load; Cut Out.

I. INTRODUCTION

Aim of this paper is to show that the maximum stress is the real important factor to be considered and not just the stress concentration factor. This is illustrated by considering a simple rectangular plate with a cut out, subjected to uni axial tensile load.

Three simple cases of cut out orientation and analysis will show the importance of reducing maximum stress.

A. Experimental Procedure

For the analysis, a plate of 100mm length, 50 mm width and 10mm thickness and a circular cutout of 20mm is considered. A tensile load of 100N is applied for all conditions. Finite element analysis was done using ANSYS.

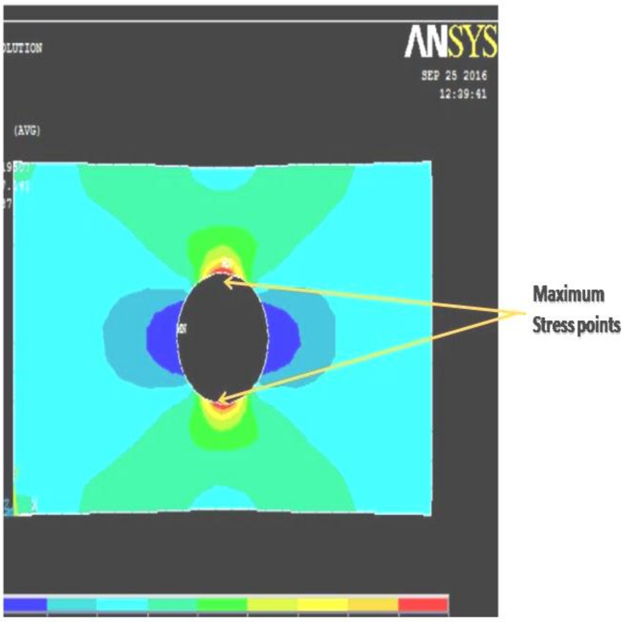

Figure-1. Stress Aattern from ANSYS.

Three cases are considered here to study the effect of stress concentration and maximum stress on variation of dimension of the cutout.

B. Equations Used to Calculate Stress & SCF

Nominal = load/ effective area …… (1)

SCF = Maximum stress/ Nominal stress …(2)

Case 1. Reducing Stress Concentration Factor by Enlarging The Circular Hole.

In first case, the hole diameter is varied from 20mm to 40 mm, in steps of 5mm. The values of the stress concentration factor and the maximum stress were calculated for each dimension of the hole and tabulated. The arrangement is as shown in figure-2.

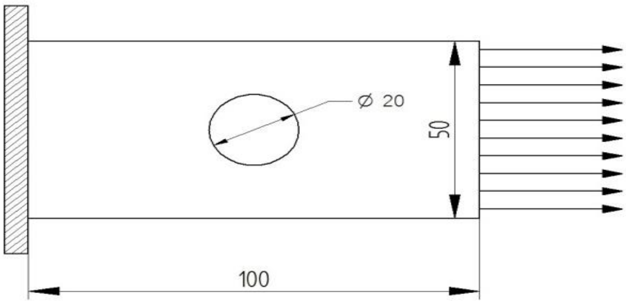

Figure 2. Rectangular Plate with Circular Cutout.

The results are tabulate as in table no1.and the corresponding graph is shown in Figure-3.

Table-1-variation of SCF				
slno	Hole dia	□nom	□max	SCF
1	20	0.33	0.75	2.26
2	25	0.4	0.87	2.16
3	30	0.5	1.05	2.11
4	35	0.67	1.38	2.08
5	40	1	2.04	2.05

Table 1: Variation of SCF

The graph of stress concentration factor vs diameter of the cutout is plotted. From the Figure-3(graph-1), it is seen that as the diameter of the cutout increases, the stress concentration factor reduces.

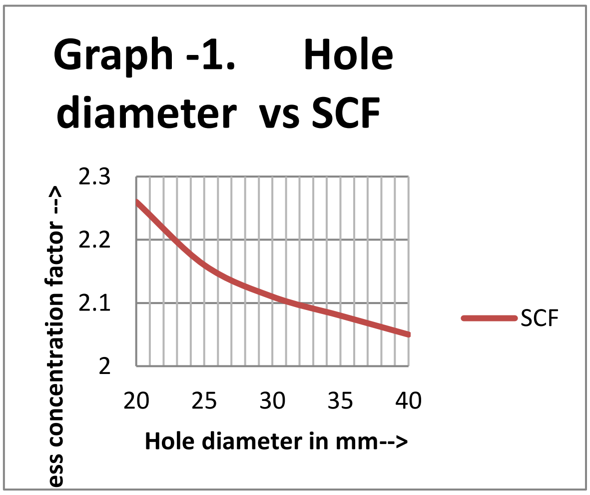

Figure3. Graph Showing SCF vs Hole Diameter.

The graph of maximum stress vs diameter of the cutout is plotted.

$$\text{Effective area of cross section} = (w-2a)*t \quad \ldots (3)$$

Where t= thickness of the plate = 10mm
2a= major diameter of the elliptical hole, varying from 20mm to45mm
And w= width of the plate =50mm.

Substituting these values in equation (3), we get

Effective area of cross section = (50-2a)*10

Since effective area of cross section reduce with increase in diameter of the cutout, maximum stress increases. This is shown in Figure-4(graph-2)

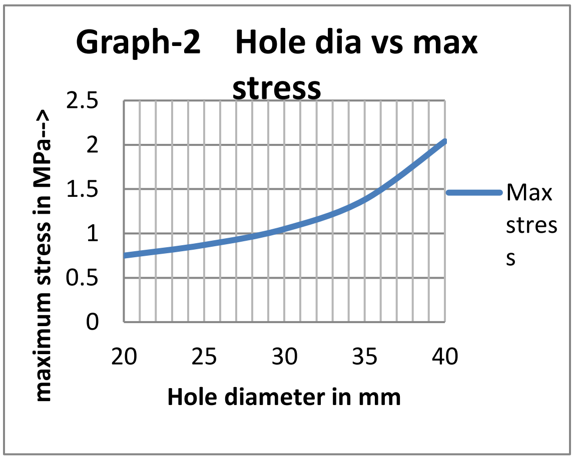

Figure4. Graph Showing Maximum Stress vs Diameter.

Case 2. Elliptical Hole in the Direction Perpendicular to the Direction of The Load.

In the second case, 2b is kept constant of 20mm and 2a is varied from 20mm to 40 mm, in steps of 5mm. The values of the stress concentration factor and the maximum stress were calculated for each dimension of the hole and tabulated.

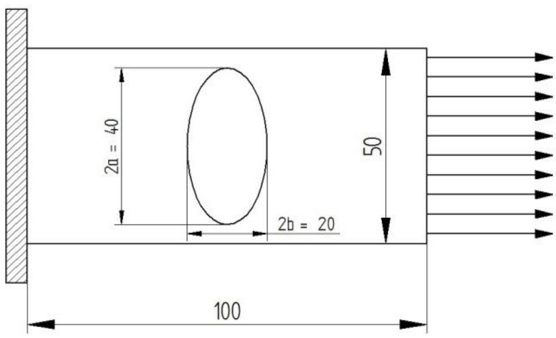

Figure5. Elliptical Cutout Perpendicular To Load.

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The stress concentration factor and maximum stress is found out. The results are tabulate as in table no2

Table-2 .2b=25mm				
slno	Hole dia	□nom	□max	SCF
1	20	0.33	0.75	2.26
2	25	0.4	0.98	2.44
3	30	0.5	1.29	2.57
4	35	0.67	1.76	2.64
5	40	1	2.6	2.6

Table 2: Stress Concentration Factor and Maximum Stress.

The graph of stress concentration factor and maximum stress vs diameter plotted. From the Figure-6(graph-3), it is seen that as the diameter of the cutout increases, the stress concentration factor increases.

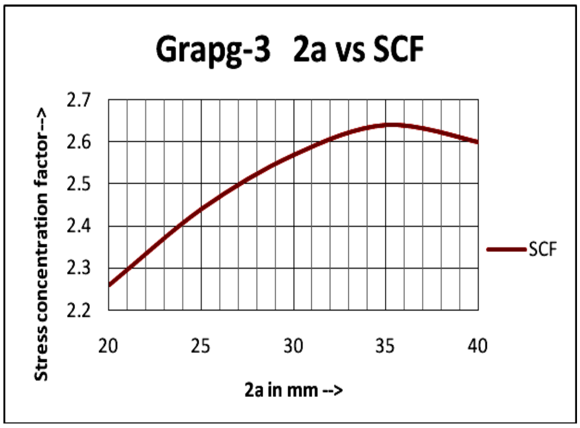

Figure6. Graph Showing SCF vs Diameter for Case-2.

Also, since effective area of cross section reduces with increase in diameter of the cutout, nominal stress increases.

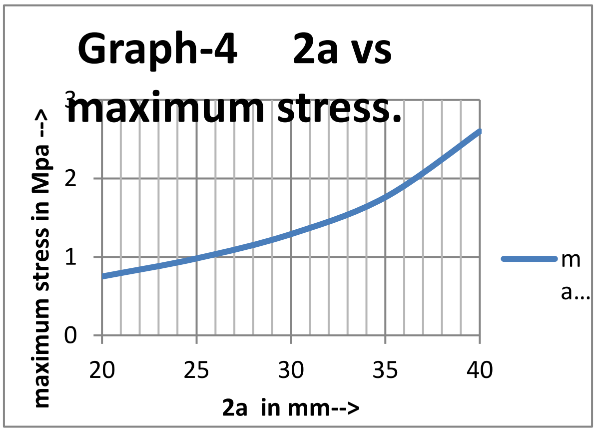

Figure7.Graph Showing Maximum Stress Vs Diameter For Case-2

But the maximum stress drastically increases, as shown in Figure-7(graph-4).This is due to combined effect of increase in stress concentration factor and reduction in effective area of cross section. So, this method cannot be used to reduce maximum stress.

Case3. Elliptical Hole in the Direction Parallel to the Direction of The Load.

In the third case, 2a is kept constant of 20mm and 2b is varied from 20mm to 40 mm, in steps of 5mm. The values of the stress concentration factor and the maximum stress were calculated for each dimension of the hole and tabulated.

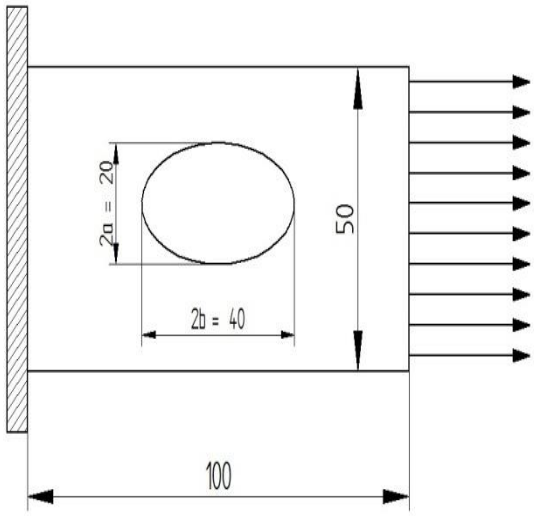

Figure 8. Elliptical Cutout Parallel To Load Axis.

The stress concentration factor and maximum stress is found out. The results are tabulate as in table no.3

Table-3. 2a=25mm				
slno	Hole dia	□nom	□max	SCF
1	20	0.33	0.75	2.26
2	25	0.33	0.67	2.02
3	30	0.33	0.62	1.86
4	35	0.33	0.58	1.75
5	40	0.33	0.56	1.67

Table 3: Stress Concentration Factor and Maximum Stress.

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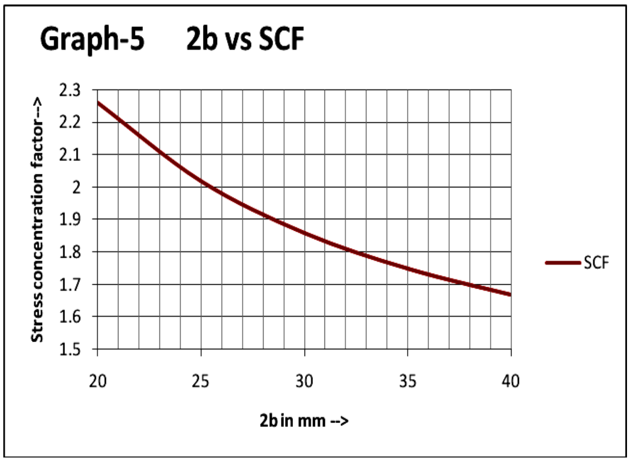

Figure9. Graph Showing Maximum Stress vs Diameter

As the effective radius of curvature paralell to the direction of the load increases at the maximum stress points, the SCF reduces, as seen in Figure-9(graph-5)

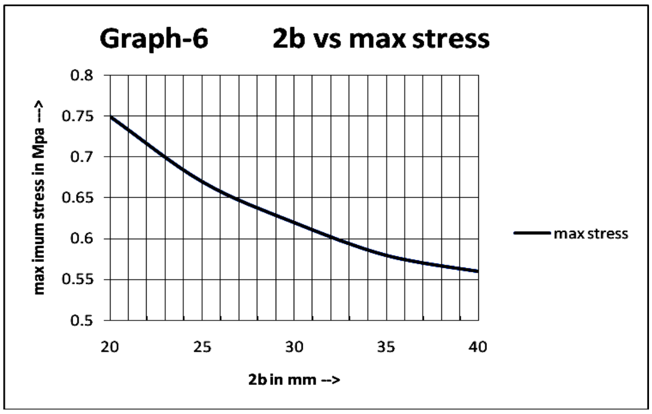

Figure10. Graph Showing Maximum Stress vs Diameter

But since effective area of cross section is constant with increase in diameter of the cutout, nominal stress is constant. Hence the maximum stress reduces. This is evident from the Figure-10(graph-6).

II. CONCLUSION

Our main focus should be to reduce maximum stress in any specimen subjected to load, rather than only targeting reduction of stress concentration factor. So, the approach in Case-3 is the best because both SCF and maximum stress are reduced to a very low level.

III. ACKNOWLEDGMENTS

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REFERENCES

[1]. Have utilized the following automatic stress calculator for elliptical hole.
[2]. Advanced Mechanical Engineering Solutions.
[3]. http://www.amesweb.info/StressConcentrationFactor/SingleEllipticalHoleInFiniteWidthPlate.aspx
[4]. ANSYS reference manual.
[5]. Google search on stress in plates with cut outs.