International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 5, ISSN No. 2455-2143, Pages 164-167
Published Online September 2019 in IJEAST (http://www.ijeast.com)

SHIFTING THE MAXIMUM STRESS FROM A CRITICAL SECTION

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***Abstract*—Maximum Stress in any specimen is the most important factor for failure of specimen. Mechanical engineers are putting constant Efforts to see the possibility of reducing Stress concentration factor and thereby reduce the maximum stress. But in many causes it will become very difficult to reduce it because of many constraints. In such causes some alternate methods must be used. Some normal methods are:**
1) Reinforcing more material in critical section or location
2) selecting a different material to withstand more stress
3) changing the shape and size of the cutouts
But this paper establishes an intelligent method of "Shifting the maximum stress from a critical section to another location". Effort is also made to get overall stress reduction by drilling four symmetrical holes of 10mm diameter at specific locations

Keywords— Critical section, stress concentration, Maximum stress, optimization.

I. INTRODUCTION

In many applications of a thin plate with cutouts, especially in aerospace applications, the possibility of reinforcing some more material at the critical point will not be possible due to space constraints. Main aim of this paper is to shift the point of maximum stress in a given specimen from the point of critical section to another point where more material can be reinforced to reduce the stress, so that net maximum stress in the material is less and hence the material will not fail.

The Stress concentration factor and hence the maximum stress is dependent upon the shape of the specimen and not on the material, a standard shape of fixed-free and beam is considered with length 100mm, width 50mm and having a 20 diameter hole at the centre subjected to uni-axial loading is considered for analysis.

Initially, the maximum stress with this specimen at the critical section X-X and at points A and A are simulated using Ansys program. The specimen is shown in fig-1.

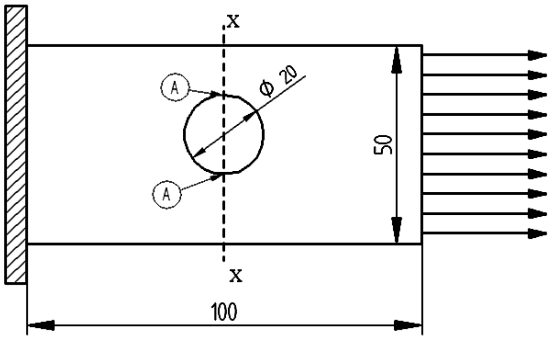

Figure 1. Initial Specimen for analysis.

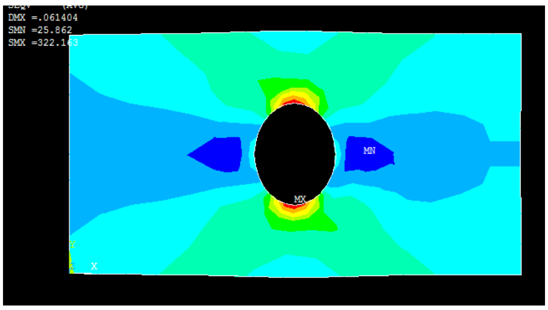

Figure 2. Stress distribution in basic specimen.

II. EXPERIMENTAL ARRANGEMENT

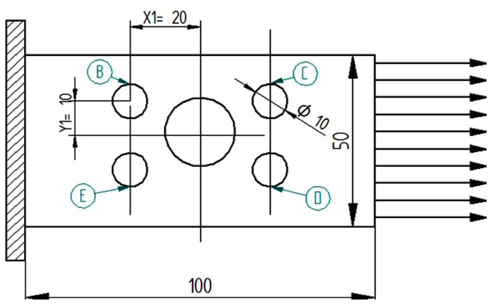

Figure 3. Four symmetric cut-outs around the main cut-out.

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2.1 Four cutouts:

Figure-3 shows that there are four symmetric holes of 10mm drilled at X=20 mm and Y = 10 mm from the centre of the 20mm hole.

2.2 Basis for fixing 10mm diameter:

At section AA, the effective width = 50-20=30mm. So, in any section, the effective width must be equal to or greater than 30mm. It is known that smaller the cutout, grater the stress concentration factor. So, we have to think of largest size cutout. But if we make another 20mm cutout, then the stress distribution will be same as that at 'A.' So, 4 symmetrical holes are drilled around the initial cutout of 20mm, such that effective width of the plate is 30mm. So, at any section BB, there are two cutouts and hence the maximum possible diameter of each cutout = (50-30)/2= 20/2= 10mm. So, most ideal diameter is 10mm and any attempt to reduce it will increase maximum stress to a large extent. Any diameter more than 10mm will reduce the effective width of the plate and hence reduce the strength of the plate.

2.3 Experimentation.

The Stress at points A-A (shown in fig-1) is measured by keeping Y=10mm constant and for various distances of X. The results are shown in Tabale-1.

Similarly, X=20mm is kept constant and stress is measured for various distances of Y. The results are shown in Table-2

For each of the above values of X and Y, maximum stress that occurs at some other non-critical point is also tabulated, as shown in both the tables.
For all the above experimentations, force was kept constant at 100N/ mm^2. The results were compared to the stress at 'A' for the plate with initial single cutout of 20mm, as in figure-2. Stress at the critical point A for single 20mm cutout at the centre from the experiment is 322N/mm^2.

III. RESULTS AND DISCUSSIONS

Table -1.Stress for various X values at Y=10mm.

Stress at A	X	Y	MAX stress
258	16	10	429
283	18	10	368
309	20	10	371
315	22	10	350
321	24	10	321

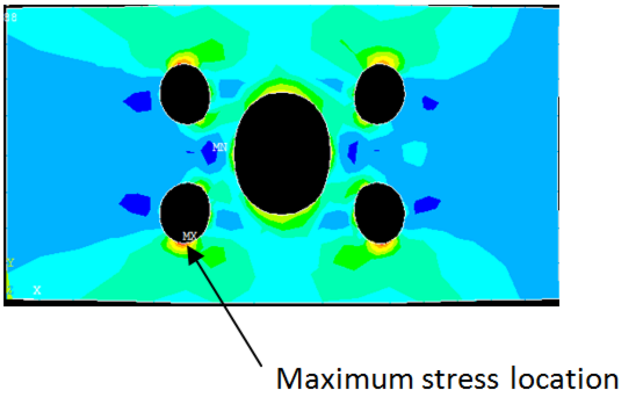

Figure 4. Maximum stress shifted to another point C.

From figure-4, it is clear that the maximum stress has moved from the critical point 'A' to another point 'E'(indicated in figure-2). This was the main aim of the experiment.

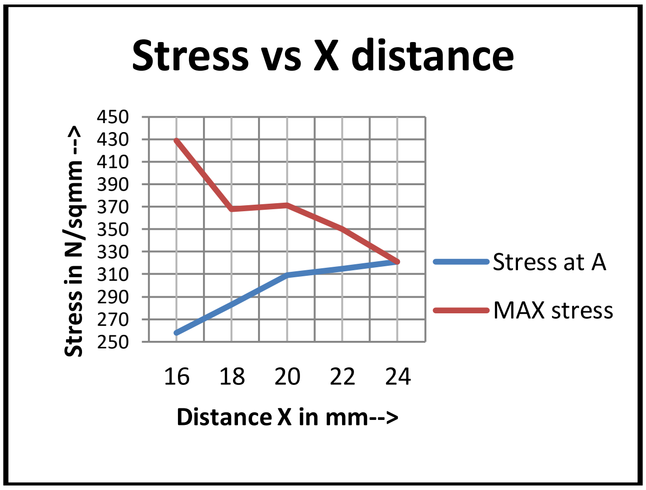

Figure 5. Stress at 'A' and maximum stress for each value of X

From figure-5, it is evident that as the distance X increases from 16mm to 24mm, stress at 'A' increases but maximum stress decreases. They will both will converge to the same value of 321 N/mm^2, at X=24mm. This means that the effect of the 10mm holes beyond 24 mm has no effect of stress alteration at the point 'A'. So, there is no pint in increase it further. Also, the values less than X=16 makes the 10mm hole too close to the 20mm circular cutout. This will result in tearing of the plate along across the cutout in to the 10mm hole.

Table -2.. Stress for various Y values at X=20mm.

Stress at A	X	Distance Y	Max stress
269	20	8	324

309	20	10	371
316	20	12	409
340	20	14	462

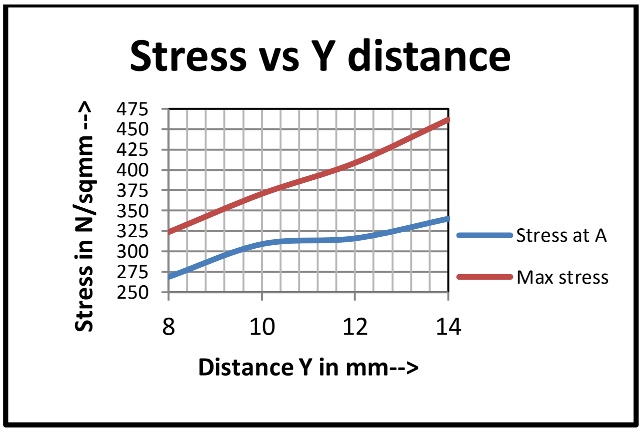

Figure 6.Stress at 'A' and maximum stress for each value of Y.

From figure-6, it is evident that as the distance Y increases from 8mm to 14mm, both stress at 'A' and maximum stress increases. They will both move almost in the same manner. This is because the loading will be along X- axis.

3.2 Optimization.

From the above tables and graphs, the best values of X and Y are selected and experiment is conducted.

From figure-5, X=22 and Y=8 must give least maximum stress.

Experimental result indicates stress at AA = 314 N/mm^2 and even maximum stress = 314 N/mm^2.

This condition is shown in figure-7. Since the maximum stress is still at critical section, this is effective only to reduce the maximum stress of plate with only 20 mm cutout, having stress at AA as 322 N/mm$^{2.}$

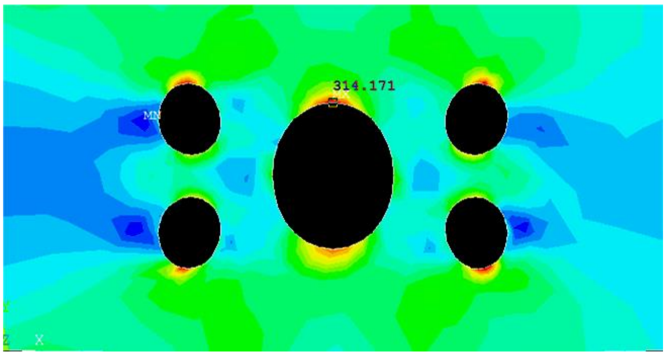

Figure 7. Lowest maximum stress for X=22mm and Y=8mm.

Also, from both tables it is evident that for X=16 and Y=8, stress at AA should be least but maximum stress at some other point should be high.

Experimental result indicates that Stress at AA = 247 N/mm^2 and maximum stress will be at D= 390 N/mm^2.

This condition is shown in figure-8

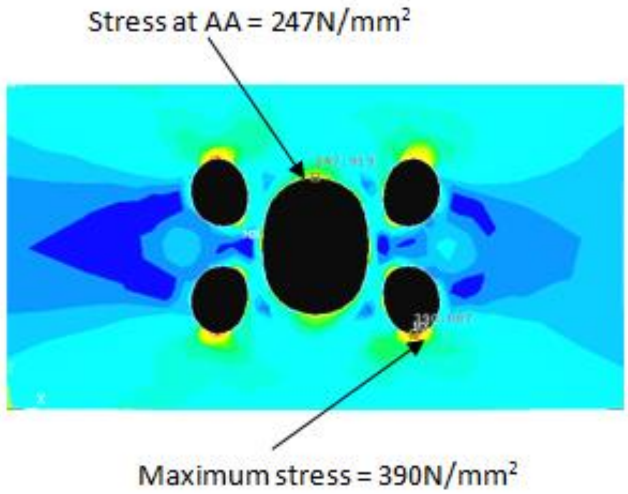

Figure 8. Least stress AA, with maximum stress at point 'D'.

IV. CONCLUSION

- Main aim of this paper is to shift the maximum stress from the point A of the critical section to a point which is not critical. That has been achieved by arriving at optimal values of X=16mm and Y=8mm from the centre of the main cut out of 20mm.
- On comparing to the initial plate with only one cutout of 20mm at the centre having stress at A as 322, in the final condition, stress at A is reduced to 247.
- This is a reduction stress of {(322-247)/322}*100 =23.3%. at the point A compared to initial plate with 20mm cutout subjected to same loading condition.
- The stress can be further reduced by using elliptical holes at four locations as explained in my own paper in reference [8].

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