Effect of notch fillet radius on tensile strength of 817M40 notched bar

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Abstract. 817M40 steel is a popular grade of hardening alloy steel to its excellent machinability. It is manufactured the mechanical components like gears, shafts, studs and bolts. Its hardness in the range of 248/302 HB. In this paper, notch fillet radius effect on tensile loading was investigated. U-shaped notched bars with three different kinds of notch were employed for tensile testing specimens. The changing the notch root radius and keeping the gross diameter, net diameter and notch depth same for all the notches. The notch root radius is varied as 0.5, 1.0 and 1.5 mm. The experimental results were validated with simulation result conduction on Finite Element Tool ANSYS Workbench. Authors belief that different notch fillet radius may have significant impact on tensile strength.

Keywords: Notch, Fillet Radius, 817M40, Notched Bar, Tensile Strength

1. Introduction

817M40 steel is a prominent grade of hardening alloy steel due to its excellent machinability. It is manufactured components such as gears, shafts, studs and bolts. Its hardness in the range of 248/302 HB.

Notch is a small cut which is shaped like V and U and which is made on an edge or a surface. The notch increases stress in particular an area of a component like a crack, depression, etc., such as a pointed angle. It is enough to cause failure for the component although the calculated average stress under safe limit. The notch fillet radius may affect the strength of notched bar.

2. Literature Review

The literature survey to find out that the scope of research in the area of effect of notch fillet radii on 817M40 steel. The following literatures have been surveyed which were related to presented research work.

Bourbita et al., (2016) analysed the formation of tiny cracks at notched member. The material used for notched member in low cycle fatigue under high temperature is super alloy single crystals. It has achieved all the test orientations and frequencies between the experimental and model prediction results. [3]

Dhakar et al., (2018) has been investigated from the results that the twisting strength of the plain bar (40C8) is less than the notched bar. The results indicate that the role of geometry notch is very important in the twisting strength of the bar. [5]

Gupta et al., (2016) conducted the tensile test on the spring steel through the Universal Testing Machine and studied the effects of notch and hardness of this spring steel. The investigational results are shown that the fracture begin at the notched section. [8]

Gupta et al., (2017) founded that the EN8 (Medium Carbon Steel) is suitable for the manufacture of heavy
parts, forging and automotive components. The experimental results showed the sharper section offers less resistance. [7]

Tsai et al., (2017) studied the mechanical properties of nano crystalline Au with various notch radius values at low temperature are studied. The formation of necking for samples with smaller notch radius values is significantly slower, indicating higher ductility. The yield stress and ultimate stress decrease with increasing notch radius. [20]

It has been observed in the literature review that effect of the notch fillet radius on tensile strength has not been analyzed for 817M40 rectangular notched bar yet. That’s why it has been observed that the analysis is needed to be done in this area. This analysis may be useful for designing the automobile components.

3. Material and Methods

3.1 Specifications of Specimen

Rectangular notch is created to manufacturing the specimens with following dimensions:

- Diameter of the bar = 20 mm
- Gauge diameter of the bar = 11 mm
- Depth of the notch = 2 mm
- Width of notch = 3 mm.
- Notch fillet radius (R) is varied as 0.5, 1.0 and 1.5 mm.

The geometry of specimen is shown in figure 1.

![Figure 1. Specimen with Notch fillet radius 0.5R](image)

3.2 Experimental Setup

The setup of experimental is demonstrated in figure 2. The setup of specifications are:

1. Make: Bharat Engineers
2. Model: AMT 20 UTM
3. Capacity: 20 Tonnes
4. Load Range: 0-20 kN
5. Least Count: 0.02 kN
6. Max. Dia.: 20mm
7. Min. Dia.: 6mm
4. Results and Discussion

A tensile test has been conducted on rectangular notched specimens with different notch fillet radius using to show the effect of notch fillet radius. These results are also validated with simulation results.

4.1 Experimental Analysis

Tensile test was conducted on Universal Testing Machine. The results found for Maximum load and Elongation which are shown in figure 3.

![Figure 3. Results for Maximum load and Elongation](image)

4.2 Simulation Analysis

Simulation results are obtained by conducting the analysis using the FEM tool ANSYS workbench. The results are shown in figures 4 to 9.
Figure 4. Maximum stress in notched bar with fillet radius as 0.5 mm

Figure 5. Maximum stress in notched bar with fillet radius as 1.0 mm

Figure 6. Maximum stress in notched bar with fillet radius as 1.5 mm
Figure 7. Total Deformation in notched bar with fillet radius as 0.5 mm

Figure 8. Total Deformation in notched bar with fillet radius as 1.0 mm
Figure 9. Total Deformation in notched bar with fillet radius as 1.5 mm

Experimental and simulation results for the tensile strength of specimen are listed and table 1. These results are compared in graphs as shown in figure 10 and figure 11. From the analysis, it has been found that Experimental and ANSYS results are very similar to each other. It can be said that the validation of the results are successfully conducted. From the results, it has been observed that Maximum deformation and stress are increased as the notch fillet radius is increased. For safe design, Notch fillet radius must be kept minimum.

| S. No. | Analysis                  | Notch Fillet Radius(mm) | Experimental Result | ANSYS Result |
|--------|---------------------------|-------------------------|---------------------|--------------|
| 1      | Maximum Deformation (mm)  | 0.5                     | 9.0                 | 9.1336       |
|        |                           | 1.0                     | 10.80               | 9.7016       |
|        |                           | 1.5                     | 27.63               | 27.52        |
| 2      | Maximum Stress (N/mm²)    | 0.5                     | 827.73              | 825.46       |
|        |                           | 1.0                     | 911.71              | 918.73       |
|        |                           | 1.5                     | 1030.62             | 1029.1       |
Figure 10. Comparison for Maximum deformation of Experimental and ANSYS result

Figure 11. Comparison for Maximum stress of Experimental and ANSYS result

The broken specimen are shown in figure 12.

Figure 12. Broken Specimens
5. Conclusion
Shafts, studs and bolts made of 817M40 are subjected to tensile and shear loading and these components have notches of different shapes. The commonly used shape is rectangular notch. Notch increases the stress concentration and it may be decreased by notch fillet radius. This paper deals with the analysis of rectangular notched bar to examine the effect of notch fillet radius on tensile strength. The analysis is first conducted experimentally then these results are verified by ANSYS workbench results. It has been found that the results are in close proximity. From the results, it has been observed that Maximum deformation and stress are increased as notch fillet radius is an increased. For safe design, Notch fillet radius must be kept maximum.

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