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Effect of Shape of Notch on Twisting Strength of EN 8 Material

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ABSTRACT

This paper presents the comparison of twisting strength of plain bar of 40C8 material with notched bar of various shapes of notch U, V & Square. It has been found from the results that the twisting strength of notched bar specimen is more than the plain bar specimen of 40C8 material (EN 8). The results indicate that the notch geometry plays an important role in the twisting strength of the bar. The twisting strength of the notched bar (U-Shape) is greater than the twisting strength of notched bar (V-Shape) is greater than the twisting strength of notched bar (Square Shape). It can be completed that on increasing depth of notch but if width is set aside constant the results are similar. This behavior of the material is due to presence of the notch, triaxial stress state generated due to this general yield stress of a notched specimen is more than the uni-axial yield stress because it is more difficult to spread the yield zone in the presence of triaxial stresses.

Keywords: Twisting Moment; Notch Shapes; Twisting Strength; EN 8; Torsion, Triaxial Stress,

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INTRODUCTION

Automobiles need a very broad variety of raw materials for their production. Now a day's automobile industry is leading in manufacturing because of new technologies. Different types of materials are used in automobile but 40C8 i.e. medium carbon steel is mostly used in automobile parts likes shaft, stressed pin, studs, keys, crankshafts, automobile axle beams etc. It is in general used for rather stressed parts of Motor vehicle, common engineering works etc.

The chemical compositions of this material are Carbon 0.40-0.45 %, Silicon 0.05-0.35%, Manganese 0.60-1% and Chromium 0.06 %. These allow objects made of alloy steel to return to their original form in spite of important deflection or twisting. It is the mostly used form of steel because its price is moderately small while it provides materials properties are appropriate for lots of applications. It has low twisting strength, but it is economical and easy to manufacture, surface hardness of EN 8 can be improved through carburizing. The density of 40C8 is approximately 7850 kg/m3 and Young's modulus is 210 GPa [1].

Notch is a little cut that is shaped like V, U and Square that is finished on an edge or a surface. The notch effect increases stress in an area of a component near a crack, depression, etc. or a modifying in section, such as a sharp angle. It can be adequate to cause failure of the component although the calculated average stress may be quite safe. The term "notch" in a wide sense is used to pass on to several discontinuities in shape or non-uniformity in material. The fatigue "notch-sensitivity," or susceptibility of a member to succumb to the damaging effects of stress-raising notches (this susceptibility varies with different materials) is therefore an important consideration in approximately each branch of machine design involving the proportioning of members for service under repeated stress. The pronounced reduction of fatigue strength due to a sudden change in cross-section of a load-carrying element has been noted in many experimental investigations.

It has been observed that effect of Notch is affecting the strength of automobile components. In general, most of these earlier analyses were mostly qualitative and based only on a single concept of basic material behavior, such as plasticity, damping capacity, cohesive strength, work-hardening capacity, elementary structural unit, or statistical theories of fatigue. Numerous works have been done on various alloys. In this analysis the torsion testing is mainly focused. It has been observed that the analysis on the 40C8 notched bar has not been performed when material is subjected to torsion loading. That’s why the analysis is needed to be done in this area. Author beliefs that the work on 40C8 i.e. medium carbon steel is needed to be done for analyze the effect of shape and depth of notch on strength of vehicle components.

LITERATURE REVIEW

The aim of literature review is to find out the shape of research in the area of effect of shape and depth of notch on carbon and alloy steels. An extensive review of research work has been done on the effect of notch on strength of carbon and alloy steels. The following literature has been reviewed related with presented research work.

Zhang et al in 1992 [2] concluded for the spherical section assumption, which is an effective method for determining the local stress and limit load of a thick-walled tube with an external hoop direction U-shaped notch under tension, and discusses the relationships of the stress concentration factor with notch depth t, radius r of the notch root and the internal radius of the tube. Expressions for the elastoplastic local stress and limit load, which have not been considered by previous workers, are proposed. Comparison of the results of this paper with those of previous work for the case where shows that the method of this paper is simple and effective in engineering.

Fonte et al in 2006 [3] Suggested that Most of catastrophic mechanical failures in power rotor shafts occur under cyclic bending combined with steady torsion: Mode I (ΔKI) combined with Mode III (KIII). An analysis of the influence of steady torsion loading on fatigue crack growth rates in shafts is presented for short as well as long cracks. Long cracks growth tests have been carried out on cylindrical specimens in DIN Ck45k steel for two types of testing: rotary or alternating bending combined with steady torsion in order to simulate real conditions on power rotor shafts. The growth and shape evolution of semi-elliptical surface cracks, starting from the cylindrical specimen surface, has been measured for several loading conditions and both testing types. Short crack growth tests have been carried out on specimens of the similar material DIN Ck45k, under alternating bending combined with steady torsion. The short crack growth rates obtained are compared with long crack growth rates. Results have shown a significant reduction of the crack growth rates when a steady torsion Mode III is superimposed to cyclic Mode I. A 3D Finite Element analysis has also shown that Stress Intensity Factor values at the corner crack surface depend on the steady torsion value and the direction of the applied torque.

Lazzarin et al in 2006 [4] concluded that in the presence of spiky (zero radius) V-shaped notches the notch stress intensity factors (N-SIFs) compute the intensities of the asymptotic linear elastic stress distributions. They are proportional to the limit of the mode I or II stress components multiplied by the distance powered $1 - \lambda i$ from the notch tip, λi being Williams’ eigenvalues. When the notch tilt radius is dissimilar from zero, the definition is no longer valid from a theoretical point of view and the characteristic, singular, sharp-notch field diverges from the rounded-notch explanation very next to the notch. Nevertheless, N-SIFs continue to be used as parameters governing fracture if the notch root radius is satisfactorily little with respect to the notch depth.

AkiNoda et al in 2006 [5] Analysed that the stress concentration factors (SCFs, Kt) of a round bar with a circular-arc or V-shaped notch are considered under torsion, tension and bending. First, for the limiting cases of deep and shallow notches, the body force method is used to calculate the SCFs; then, the formulas are obtained as Ktd and Kts. On the one hand, upon comparison between Kt and Ktd, it is found that Kt is nearly equal to Ktd if the notch is deep or blunt. On the other hand, if the notch is sharp or shallow, Kt is mainly controlled by Kts and the notch depth. The notch shape is classified into several groups according to the notch radius and notch depth; then, the least squares method is applied for calculation of Kt/Ktd and

Kt/Kts. Finally, a set of convenient formulas useful for any shape of notch in a round test specimen is proposed. The formulas yield SCFs with less than 1% error for any shape of notch. The effect of notch opening angle on the SCF is also considered for the limiting cases of deep and shallow notches.

Livieri et al in 2008 [6] concluded the physical meaning of JV (namely, the classic J-integral applied to either sharp V-notch) is discussed. Consider a Cartesian reference frame having the x-axis parallel to the notch bisector, each mode of JV, for a given circular path, is proportional to the correspondent mode of the classic J-integral of a virtual crack having length equal to the path radius and emanating from the tip of the V-notch. Analytical and numerical results have been performed for linear elastic materials. Additionally, in order to verify the formulations of JV, experimental result of embedded cracks of sharp V-notch was considered.

Wang et al., (2010) [7] analysed the uniaxial tension tests for 20 notched bars fictitious from high strength steel Q345 individual in Chinese National Standards. As the stresses at the notched division get to the limiting values resolute from the elliptical fracture criterion, macroscopic fracture failure in the notched bar occurs.

Tanaka et al., (2010) [8] studied the two specific subjects related to the fatigue strength and life of notched bars under combined torsional and axial loading. On the basis of the electrical potential monitoring of the initiation and propagation of small cracks at the notch root, the crack initiation life decreased with increasing stress concentration, while the crack propagation life increased.

Citarella et al in 2010 [9] Worked on Comparison of DBEM and FEM crack path predictions in a notched shaft under torsion, they analyzed that the rather complex 3D fatigue crack growth behaviour of to anti-symmetric “bird wing” cracks, initiated from the two crack front corner points of a notched shaft undergoing torsion, is investigated by the Dual Boundary Element Method (DBEM) and by the Finite Element Method (FEM). Different criteria for the crack path assessment (Minimum Strain Energy Density, Maximum Principal Stress and Approximate Energy Release Rate) and for the Stress Intensity Factor (SIF) evaluation (COD and J-integral) are adopted. The SIF’s and the crack path, calculated by such different approaches, turn out to be well consistent with each other. Moreover the simulated crack path qualitatively agrees with experimental findings available from literature.

Ohkawa et al., (2011) [10] studied notch effect in austenitic stainless steel under cyclic torsion depending on the superposition of static tension. Because of a small amount of the crack face contact, the reduction of lifetime in notched specimen is revealed irrespective of superposition of static tension.

De-Souza et al in 2012 [11] analysed the manipulate of test method factors (notch shape, square or angular, and pre-cracking method, by tapping against or pressing a razor blade) on the results obtained in flat surface strain fracture toughness test according to standard ASTM D5045 using SENB specimens made of a profitable PMMA resin were investigated. Results were analyzed quantitatively by comparing the obtained KIc values and qualitatively by observing their outcome on the Moiré outer edge observed using photoelasticity, showing that, at 95% consequence level, the KIc values are precious by the pre-cracking method, with the most conservative value being obtained when usual pre-cracks were introduced by tapping onto a razor blade (KIc = 1.15 ± 0.11 MPa•m0.5). This correlates with a perturbation in the stress field close to the pre-crack tip experiential in the photo elasticity test taster when it was introduced by pressing the razor blade. Surprisingly, notch geometry barely slightly affects the results.

Torabi et al in 2013 [12] analysed U-notched Brazilian compact disk specimens made of a type of profitable graphite were used to compute experimentally the mode I notch crack toughness of material. The experimental outcome were estimated by means of the mean stress and the point stress fracture criteria. An outstanding agreement was found to exist between the results of the mean stress criterion and the experimental outcome for dissimilar notch tip radii. Also, found in this study was that the point stress measure provides weaker estimates compared to the signify stress model except when one deals with superior values of the notch tip radius.

Barsoum et al in 2014 [13] presents a finite element modeling framework to determine the torsion strength of hardened splined shafts by taking into account the detailed geometry of the involutes spline and the material gradation due to the hardness profile. The aim is to select a spline geometry and hardness depth that optimizes the static torsion strength. Six different spline geometries and seven different hardness profiles including non-hardened and through-hardened shafts have been considered. The results reveal that the torque causing yielding of induction hardened splined shafts is strongly dependent on the hardness depth and the geometry of the spline teeth. The results from the model agree well with experimental results found in the literature and reveal that an optimum hardness depth maximizing the tensional strength can be achieved if shafts are hardened to half their radius.

Gupta et al in 2017 [14] concluded that the notch effect increases stress in an area of a component near a crack, or a change in section, such as a sharp angle. It can be enough to cause failure of the component although the calculated average stress may be quite safe. They considered U and V shaped notched bar for analysis.

The objectives of research are: The objectives of this paper are as follows:-

- To identify the effect of notch shape (U, V & Square) on EN 8 bar.
- To identify the effect of depth of notch on twisting strength of EN 8 bar.
- To compare the effect of various shape of notch on strength of EN 8 bar.
- To compare twisting strength of notched bar with plain bar.

EXPERIMENTAL WORK

The twisting strength of plain shaft and notch shaft has been calculated on torsion testing machine the details are given as follows:

Experimental setup:

Torsion testing machine is design for conducting torsion and twist on various metal wires, sheet materials, tubes. Torque measurement is by pendulum dynamometer system. Machine Specifications are as follows.

Fig. 1: Experimental setup of Torsion Testing Machine

Specification	Unit	DT-6
Max. Torque Cap.	Kg-m	6
Torque Range	Kg-m	6.3
No. Of division on dial	RPM	600
Torsion Speed		0.5
Clearance Between Grips.	mm	0-420
Grips for Round Bars.	mm	4-8
		8-12
Grips for Flat Bars.	mm	1-5
Width	mm	1-5
Motor 3 Ph.	mm	0.33

Table 1

Specification of specimen:

For performing the experimental work the specimen mentioned in Fig 2, 3, 4, 5, 6,7,8 & 9 is manufactured of different notch as mentioned in Table 2

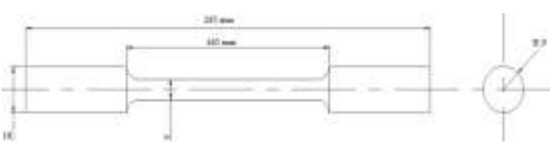

Fig. 2: Specimen without Notch (9mm Dia.)

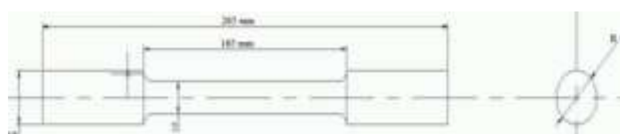

Fig. 3: Specimen without Notch (12mm Dia.)

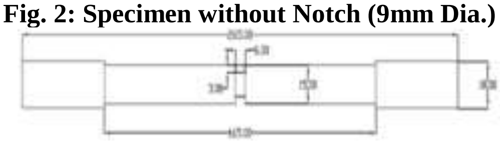

Fig. 4:Specimen with Square- Notch 3mm Depth

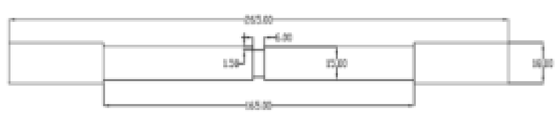

Fig. 5:Specimen with Square- Notch 1.5mm Depth

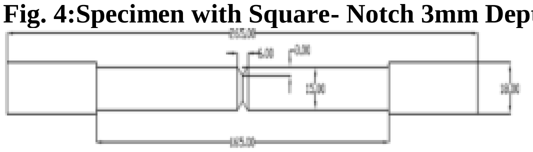

Fig. 6:Specimen with V- Notch 3mm Depth

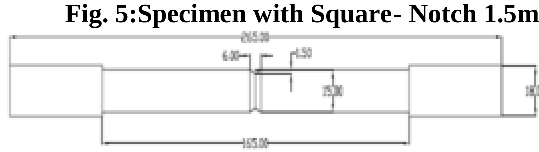

Fig. 7:Specimen with V- Notch 1.5mm Depth

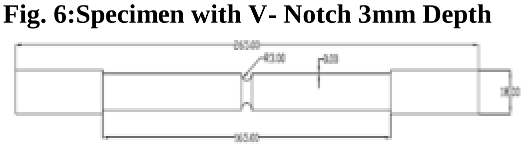

Fig. 8:Specimen with U- Notch 3mm Depth

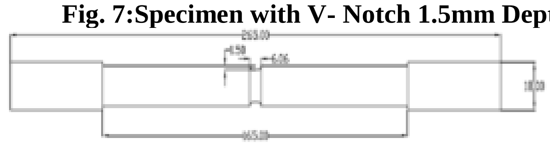

Fig. 9:Specimen with U- Notch 1.5mm Depth

S. No.	Material	Specimen							
		Square Notch		U - Notch		V - Notch		Plain	
	EN 8	3 mm Depth	1.5 mm Depth	3mm Depth	1.5 mm Depth	3 mm Depth	1.5 mm Depth	9mm Dia.	12mm Dia.
1	√	√							
2	√		√						
3	√			√					
4	√				√				
5	√					√			
6	√						√		
7	√							√	
8	√								√

Table 2

RESULTS & DISCUSSION

The experimental results have been determined on the torsion testing machine the results are summaries below

S. No.	Types of Bar	Twisting Strength Standard Value (N/mm²)	Twisting Strength Measured (N/mm²)
1.	Plain Bar (9 mm dia.)	407.78	524.29
2.	Plain bar with Square Notch (3 mm depth)	407.78	596.25
3.	Plain bar with V- Notch (3 mm depth)	407.78	623.66
4.	Plain bar with U- Notch (3 mm depth)	407.78	661.36
5.	Plain Bar (12 mm dia.)	407.78	504.53
6.	Plain bar with Square Notch (1.5 mm depth)	407.78	537.78
7.	Plain bar with V-Notch (1.5 mm depth)	407.78	621.63
8.	Plain bar with U-Notch (1.5 mm depth)	407.78	630.30

Table 3

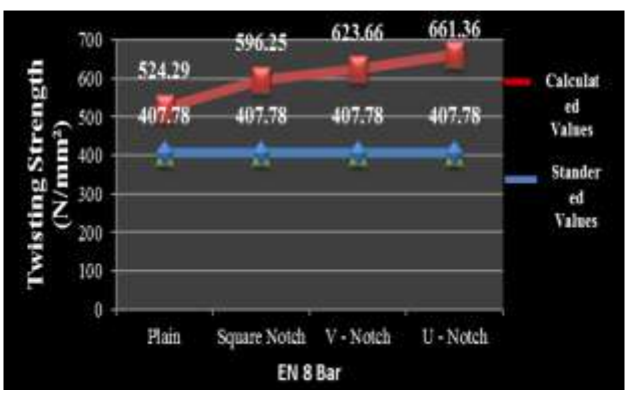

Fig. 10: Notch Effect on Twisting Strength of Bar (9 mm dia.)

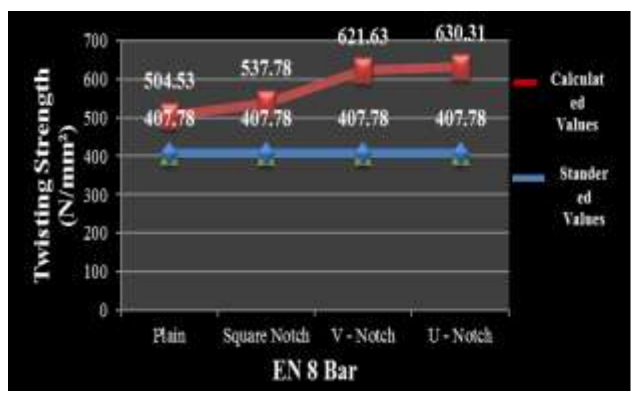

Fig. 11: Notch Effect on Twisting Strength of Bar (12 mm dia.)

The results are calculated for plain bar (dia. 9mm), same bars with Square Notch, V-Notch and U-Notch, it has been observed from the (fig. 10) that the twisting Strength are 524.29 N/mm², 596.25 N/mm², 623.66 N/mm² and 661.36 N/mm² respectively. For plain bar (dia. 12mm), same bar with Square notch, V-Notch and U- Notch, it has been observed from (fig.11) that the twisting strength are 504.53 N/mm², 537.78 N/mm², 2621.63 N/mm² and 630.30 N/mm². On comparing both the graph (fig. 10 & 11) it is concluded that the load carrying capacity of the bar with U Notch is more than the bar with Square Notch and V- notch for bar diameter 9mm & 12mm. It is evident from the results that the sharper section i.e. (Square Notch & V Notch) offers less resistance to torsion load as compared to smoother sections (U Notch). This type of unusual behavior of material is due to presence of the notch, because as a result of the triaxial stress state produced by the notch the general yield stress of a notched specimen is greater than the uniaxial yield stress because it is more difficult to spread the yield zone in the presence of triaxial stresses. So it can also be concluded for EN 8 material on growing the depth of cut resistance offered by the material reduces strength of material.

CONCLUSIONS

From the above analysis following conclusions can be made:

- It is concluded from the analysis on torsion testing machine that the twisting strength of 40C8 notched bar (i.e. Square, V, and U) is more as compared to plain bar of 40C8 material.
- It is concluded from the results that the twisting strength of smoother section is less than the sharper section.
- The shape of thread is generally, U, V Square, which are generally used in industries and these factors affect the stress carrying capacity of the thread portion. Hence the analysis will be done to make out the best shape of the thread which will ultimately improve its life.

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REFERENCES:

[1] Gupta, A., & Chauhan, P.S. (2015). Effect of hardness and notch on strength of SUP 9A: A Review. International Journal of Science and Engineering, p.3,(152-158).

[2] Zhang, Q. Y., & Liu, Y. (1992), Determining local stress and limit load in a thick walled tube with a hoop direction U-shaped notch under tension, International Journal of Pressure Vessels and Piping, p. (361-372).

[3] Fonte M., Reis L., Romeiro F., Li B. & Freitas M. (2006), The effect of steady torsion on fatigue crack growth in shafts, International Journal of Fatigue, p. (609-617).

[4] Lazzarin P., Tovo R., & Meneghetti G. (2006), Fatigue crack initiation and propagation phases near notches in metals with low notch sensivity. International Journal of fatigue, p. (647-657).

[5] AkiNoda Nao. & Takase Yasushi (2006), Stress concentration formula useful for all notch shape in a round bar (comparison between torsion, tension and bending), International Journal of Fatigue, p. (151-163).

[6] Livieri, P. (2008), Use of J- integral to predict static failures in sharp V-notch and rounded U-notches. Engineering fracture mechanics, p. (1779-1793).

[7] Wang, W. Z., Liu, W. F., & Wang, X. T. (2010), Fracture Test and Analysis of Notched Bars Fabricated from Q235 Steel at Room Temperature. Applied Mechanics and Materials, p. (1406-1414).

[8] Tanaka, K. (2010), Small fatigue crack propagation in notched components under combined torsional and axial loading. Procedia Engineering, p. (27-46).

[9] Citarella R. & Cricrì G. (2010), Comparison of DBEM and FEM crack path predictions in a notched shaft under torsion, Engineering Fracture Mechanics, p. (1730-1749).

[10] Ohkawa, C., & Ohkaw, I. (2011), Notch effect on torsional fatigue of austenitic stainless steel: Comparison with low carbon steel. Engineering Fracture Mechanics, p.(1577-1589).

[11] De souza, J., Mariano Y., Humberto N.P., Fabiano, M., & Schon, C.G. (2012), Effect of sample pre-cracking method and notch geometry in plane strain fracture toughness tests as applied to a PMMA resin. Polymer testing, p. (834-840).

[12] Torabi, A. R., Fakoor, M., &Pirhadi, E. (2013), Tensile fracture in coarse-grained polycrystalline graphite weakened by a U-shaped notch, Engineering fracture mechanics, p. (77-85).

[13] Barsoum I., Khan F. & Barsoum Z. (2014), Analysis of the torsion strength of hardened splined shafts,
Material & Design (1980-2015), p. (130-136).

[14] Gupta, A. ,Chauhan ,P.S., & Bansal, A. (2017), Effect of notch on tensile strength on EN 8, International Journal of Engineering Technology Science and Research, Vol.4 issue 7, p. (2394-3386).

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