THE PULLOUT PERFORMANCE OF SQUARE AND DSR SCREW THREADS

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Abstract

The screw threads used for fastening purpose are subjected to various type of loading. The majority of screw thread failure occurs during tensile loading. The pullout is test is the measure of tensile loading. In this study the square and newly innovated DSR screw threads are designed. The finite element analysis is carried out for the designed models by adopting the experimental condition. The square and DSR screw threads are tested for the directional deformation, total deformation and von-mises stress.

Keywords*: Finite element analysis, Pullout test, Square screw threads. Tensile loading*

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1. INTRODUCTION

In many components the bolts may be subjected to a variety of loading conditions, such as tension, compression, shear, bending and torsion, which they must withstand without suffering any permanent deformation or damage.

The strength of bolts is specified in terms of a tensile test of the threaded fastener. The load versus elongation characteristics of a bolt is more significant than the stress versus strain diagram of the parent metal because performance is affected by the presence of the threads. Also, the stress varies along the bolt as a result of the gradual introduction of force from the nut and the change in section from the threaded to the unthreaded portion. The weakest section of any bolt in tension is the threaded portion. [1].

Threaded components are generally used in assemblies when a load-bearing connection that can be disassembled without destructive methods is required in a design. The mechanical performance of such components, and of the assemblies in which they are used, is determined through evaluation of properties such as axial or tensile strength, torsional strength, shear strength, resistance to vibration loosening, fatigue resistance, resistance to thermal cycling, and hydraulic pressure integrity [2].

In view of a finite element analysis, two primary characteristics of a bolted joint are a pretension and a mating part contact. The pretension can generally be modeled with a thermal deformation, a constraint equation, or an initial strain. For a thermal deformation method, the pretension is generated by assigning virtual different temperatures and thermal expansion coefficients to the bolt and the flange. In the case of the constraint equation method, the pretension is a special form of coupling, with which equations can be applied to govern the behavior of the associated nodes. Initial strain method is more direct approach, in which the initial displacement is considered as a portion of the pretension on the structure with a bolted joint. A contact modeling can be addressed using point-to-point, point-to-surface, or surface-to-surface elements [5].

Numerous studies have reported the deformation and damage to bolts under high tensile forces which were exerted under low strain rates, but little is known about the behaviour of bolts under high strain rates. Therefore, this paper aims to measure the tensile strength and examine the ways bolts are damaged when loaded in tension.

2. SCREW THREAD DESIGNING

The screw threads are designed according to ASTM (American Society for Testing Materials) standards. The every parameters, such as pitch (P), flank angle (θ), depth of truncation of triangular height at crest (S_1), depth of truncation of triangular height at root (S_2), effective diameter (E), major diameter (D), minor diameter (d) and depth of thread (h) of screw threads is considered during the designing.

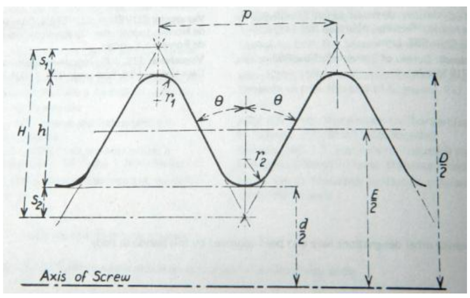

Fig: 1 Elements of basic form of symmetric thread

The relations existing between the elements for a screw having equal flank angle are given by the following equations

$$D= E+ ((1/2)\ p \cot \theta)-2\ S_1$$

$$d = E- ((1/2)\ p \cot \theta) +2\ S_2$$

$$h = (1/2)\ p \cot \theta) - (S1 + S_2)$$

The distance H is known as the height of fundamental triangle, is given by

$$H = (1/2)\ p \cot \theta\ [3]$$

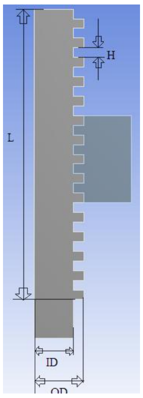

Fig: 2 Square threads.

The figure.2 describes the two dimensional square threads. The screw threads are designed by using Ansys, the product of SAS.IP.

The DSR thread is newly innovated thread. The DSR screw thread is course thread, but having the advantages of the square threads. The DSR thread is designing by keeping the advantages of square threads. The sub tooth is provided in the dedendumof square threads. The contact area between the bolt and nut is directly proportional to strength of the fastener.

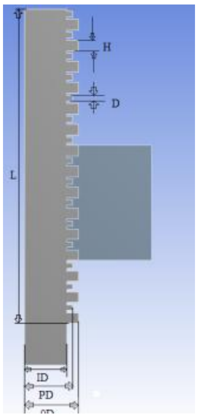

Fig: 3.DSR threads

The figure.3 illustrates the DSR screw threads. The sub teeth length is equal to pitch diameter of the screw thread and width is equal to the half of the major teeth.

Table: 1. Design parameters of square and DSR threads.

Parameters	Square threads	DSR threads
OD	10mm	10mm
MD	9mm	9mm
H	-	1mm
D	-	0.5mm

3. TENSILE STRENGTH OF SCREW THREDS

The minimum tensile strength of a screw is the tensile stress from which there could be rapture in the shank of thread (not in head or shank joint) [4].

Tensile strength at rapture of thread

Rm= max tensile force F (N)/ stress area As (mm^2)

4. FINITE ELEMENT MODEL DESIGN, CALIBRATION AND VALIDATION

The pullout phenomenon is simulated using the ANSYS14.5. The thread bolt is assembled with the mating nut, there should not be any interference between the assembled bolt and nut.

4.1 Defining Contact

The Contact Tool allows examining contact conditions on an assembly both before loading, and as part of the final solution to verify the transfer of loads (forces and moments) across the various contact regions. In square screw threads 17 edges selected to define the contact. In square screw threads also the frictional contact is established between the bolt and nut. . In DSR screw threads 41 edges selected to define the contact. The frictional contact is given between the bolt and nut.

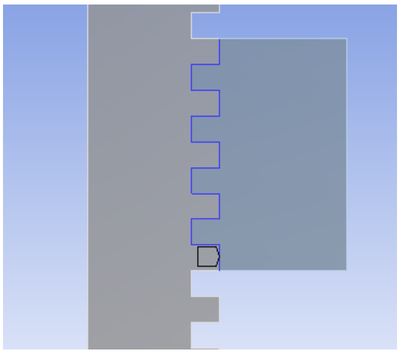

Fig: 4. Defined contact in square threads.

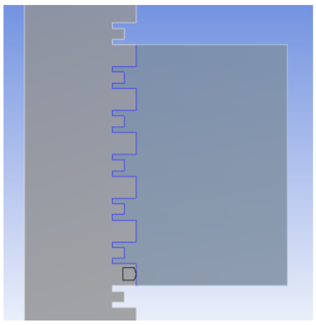

Fig: 5. Defined contact in DSR threads

4.2 Meshing

The area which surrounds the screw andincludes the areas where high stresses are expected to be developedwas meshed with a fine and uniform mesh. The goal of meshing in ANSYS Workbench is to provide robust, easy to use meshing tools that will simplify the mesh generation process. These tools have the benefit of being highly automated along with having a moderate to high degree of user control. The quad dominant meshing is adapted for the meshing of the bolt and nut assembles. This is one type of surface meshing. The Quadrilateral Dominant method (default), the body is free quad meshed. The minimum edge length in DSR screw thread is 0.25mm. At the contact region the edge size is reduced to 0.15mm. The minimum edge length in square screw thread is 1.0mm. At the contact region the edge size is reduced to 0.15mm. There are 4295 nodes and 1255 element in the two dimensional square threads. There are 5179 nodes and 1491 elements in the two dimensional DSR screw thread. The figure.7 illustrates the meshing of two dimensional DRS and square threads.

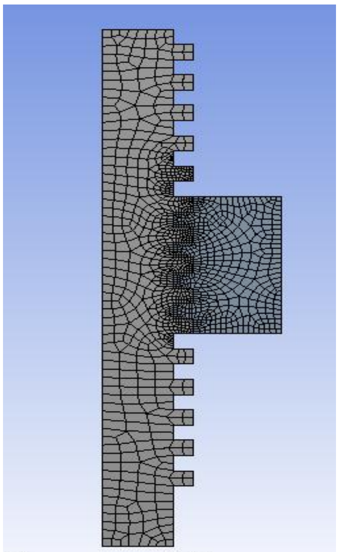

Fig: 6. Meshing of square threads.

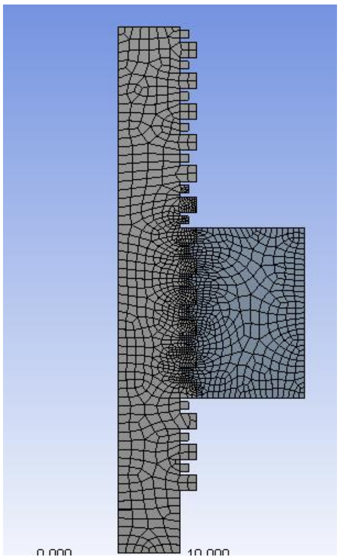

Fig: 7. Meshing of DSR screw threads

4.3 Defining Loads

The load is applied in the form of force. The force is applied on the bottom face of the bolt. The load is acting in the negative Y-axis. For experimental purpose 1000N is applied for the analysis.

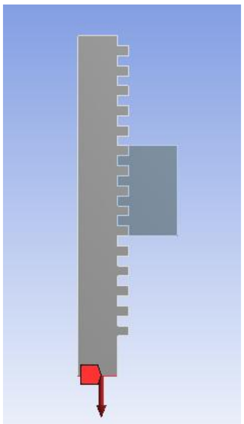

Fig: 8. Force applied for square screw threads

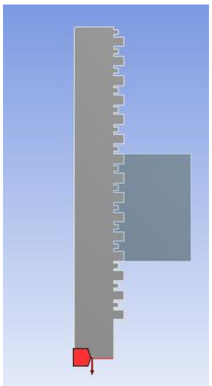

Fig: 9. Force applied for DSR screw threads

4.4 Defining Support

The Frictionless Supports are given in this case. The Frictionless Supports applied to neighboring faces that meet at an angle, the nodes on the edge are subject to two separate combinations of degrees of freedom constraints, one from each Frictionless Support. The Mechanical application attempts to identify a suitable orientation to the nodal coordinate system that accommodates both frictionless supports and, if successful, constrain its axes accordingly.

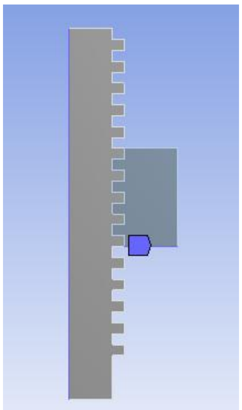

Fig: 10. Support applied for square screw threads

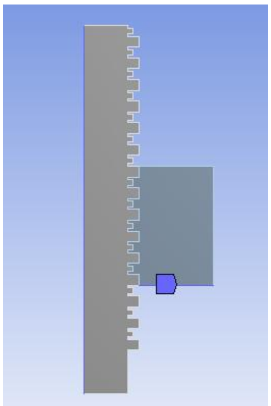

Fig: 11. Support applied for DSR screw threads

5. RESULTS

The tensile load is applied in the Y-axis, so the directional deformation is applied in Y-axis. The total deformation is also determined. The von-mises is determined for both square and DSR threads.

Table: 2 Square thread analysis results

Minimum directional deformation	-2.2349e-003 mm
Maximum directional deformation	3.5194e-006 mm
Minimum total deformation	9.9161e-006 mm
Maximum total deformation	2.2381e-003 mm
Minimum von-mises stress	1.7934e-003 MPa
Maximum von-mises stress	68.328 MPa

Table: 3 DSR thread analysis results

Minimum directional deformation	-1.7282e-003 mm
Maximum directional deformation	3.4508e-006 mm
Minimum total deformation	3.2465e-006 mm
Maximum total deformation	1.7324e-003 mm
Minimum von-mises stress	9.2818e-006 MPa
Maximum von-mises stress	79.493 MPa

5.1 Directional Deformation

The figure 12 and 13 shows the directional deformation in Y-axis. The both DSR and square threads are loaded to 1000N in vertical direction. The DSR threads are less directionally deformed.

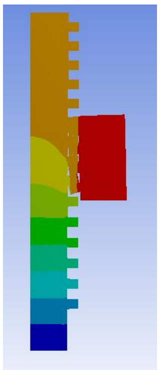

Fig: 12. Directional deformation of square screw threads

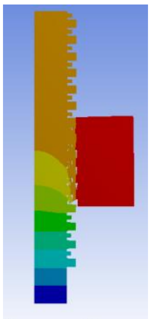

Fig: 13. Directional deformation of DSR screw threads

5.2 Total Deformation

The DSR and square threads are tested for total deformation. The DSR threads are having good values than the square threads in total deformation. The DSR thread are having less directional and total deformations, hence it can withstand more tensile strength

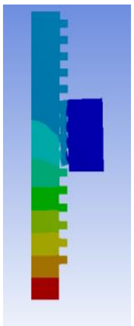

Fig: 14. Total deformation of square screw threads

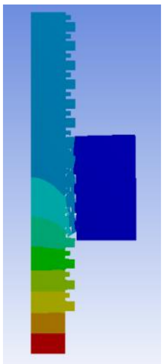

Fig: 15. Total deformation of DSR screw threads

5.3 Von-Mises Stress

The figure 16 and 17 shows the von-mises stress in DSR and square threads. The DSR threads are having more von-mises stress than square threads.

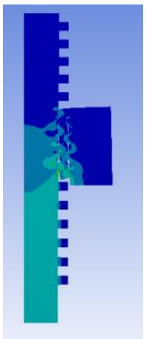

Fig: 16. Von-mises stress in square screw threads

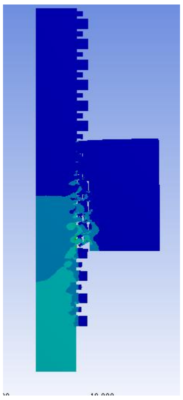

Fig: 17. Von-mises stress in DSR screw threads

The both DSR and square threads are subjected to tensile and square deformations, but the DSR threads subjected to less deformation. The total deformation is also determined for the screw threads, the DSR threads shows less total deformation against the square threads, but DSR threads are having more von-mises stress compared to square threads.

6. CONCLUSIONS

From the above experimentation we may conclude that. The DSR screw threads are having

- (i) More pullout strength than square screw threads.
- (ii) More contact area than the square screw threads.
- (iii) More adjustmental accuracy.
- (iv) Less mis-alignment

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