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Failure Analysis of Buttress, ACME and Modified Square Threaded Steel IS2062 Tie Rods in Assembly Using FEA

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ABSTRACT

Steel tie rods are being used in load carrying components such as steering systems, suspension bridges, spokes of automotive vehicles, etc.. In steel tie rods, the bearing capacity is determined by steel tie rod body strength and also the strength of the threaded connection, which can resist force. The past literature reviewed that work has been done related to triangular and trapezoidal threads and also studied failure analysis of threads. In this paper focus to analyze the failures of different threaded shapes like acme, buttress and modified square. The material has taken for this project is mild steel is2062. The tensile rupture experiments were done to test maximum allowable axial working loads for different numbers of turns of engaged threads. By carrying out these experiments, Found that Maximum and Minimum Displacement at Ultimate Load in Tensile Test. For validating the design, the models were drawn in Catia V5 and analysis was carried using ANSYS 14.0 to find out the axial displacement, von misses stresses, and sliding distance. After careful analysis, concluded that the minimum number of turns of thread engagement to avoid the breakdown of thread connection in the tie rod.

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Introduction

Steel tie rod threaded connections may fail due to tensile loading, shear loading, fatigue and dynamic loading that occur in engineering applications, where these are used as structural components.

Fig 1. Full specimens of a threaded tie rods

The tie rods may have bearing strength of the builds up to investigate the threaded connections of structural behavior in steel tie rod. The axial displacement, von misses stresses, contact pressure and sliding distance on different axial loads having the engaged thread teeth are presented and analyzed [1]. In order to choose the most suitable type of threaded connection for any practical engineering application, knowledge of the stress distribution, interfacial contact pressure, sliding distance, length and the number of turns of thread engagement can be very crucial to ensure the overall Structural safety. Stress, deformations, fatigue and failure in threaded connections have been studied for long and the existing literature is relatively rich [2]. The tie rod end is used in a sports utility vehicle the steering mechanism has considered. In this the tie rod ends have a threaded part having embracing part. The failure takes place in the threaded part which having ALSI 8620 steel [3].

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Literature review

According to Wie Duan and Suraj Joshi, it has been explained that the paper has investigated the structural behavior of two types of threaded connections, namely triangular and trapezoidal threads. They have been analyzed by using the software ANSYS. Including with the strength tests, they also investigated about the axial displacements, von misses stresses, interfacial contact pressures, and sliding distances for different axial loadings.

According to Wie Duan and Suraj Joshi has been explained that tensile ruptures having two different categories of a steel tie rod which are having lg 75-00 steel tie rod having triangle threaded and lg 100-00 steel tie rod having trapezoidal threaded from this the tensile rupture of a steel which has to be testing the maximum allowable has considered. In this the different number of thread can be engaged under the different axial loads. In this how a thread can be failure in a tie rod body which can be applicable in the bending test of a tie rod body.

According to A.H. Falah, M.A. Alfares, A.H. Elkholy has been explained that the tie rod end is used in a sports utility vehicle the steering mechanism has considered. In this the tie rod ends have a threaded part having embracing part. The failure takes place in the threaded part which having ALSI 8620 steel.

Testing results of the BUTTRESS, ACME, MODIFIED SQUARE threads

(1) To test for strength till failure, a BUTTRESS thread was drawn on mild steel IS2062 circular rod and also on a Mild Steel IS2062 nut. The tensile stresses on the cross-section of the tie rod body (with a diameter D of 20 mm), are tabulated for different no. of turns of thread engagement. The threads failed after taking loads for 64.30 kN, 86.10 kN, 107.40 kN, 154.20 kN and 178.80 kN for two, three, four, five and six no. of turns of thread engagements respectively.

Fig 3. Threaded rod of a buttress thread after the testing

(2) To test for strength till failure, an ACME thread was drawn on mild steel IS2062 circular rod and also on a mild steel IS2062 nut. The tensile stresses on the cross-section of the tie rod body (with a diameter D of 20 mm), are tabulated for different no. of turns of thread engagement. The threads failed after taking loads for 47.90kN, 97.5kN, 107.60kN, 155.10 kN and 175.80 kN for two, three, four, five and six no. of turns of thread engagements respectively.

Fig 4. Threaded rod of a ACME thread after the testing

(3) To test for strength till failure, a MODIFIED SQUARE thread was drawn on mild steel IS2062 circular rod and also on a mild steel IS2062 nut. The tensile stresses on the cross-section of the tie rod body (with a diameter D of 20 mm), are tabulated for different no. of turns of thread engagement. The threads failed after taking loads for 48.70kN, 79.70kN, 92.60kN, 111.00kN and 179.80kN for two, three, four, five and six no. of turns of thread engagements respectively.

Fig 5. Threaded rod of a modified square thread after the testing

Fig 6. Failed mild steel IS2062 tie rod with six engaged threaded turns

Thread connection assembly by using FEA

Structural behavior of mild steel IS2062 in axial displacement of buttress, ACME and modified square threads

Axial displacement having the loading of different thread Connections like buttress thread, ACME thread and modified square thread. By taking the material properties of mild steel IS2062 rod model is designed by using catia V5R19. The design part has been exported to ansys 14.0 after that two to six thread connections has been design and done their analysis.

Buttress thread

The axial loads that having how a thread can be test the strength of failure for buttress thread. The threads failed after taking loads for 64.30 kN, 86.10 kN, 107.40 kN, 154.20 kN and 178.80 kN for two, three, four, five and six no. of turns of thread engagements respectively. The tie rod body of axial displacement is gradually decreases from top to bottom. The displacement having nodes that passes through y-axis direction.

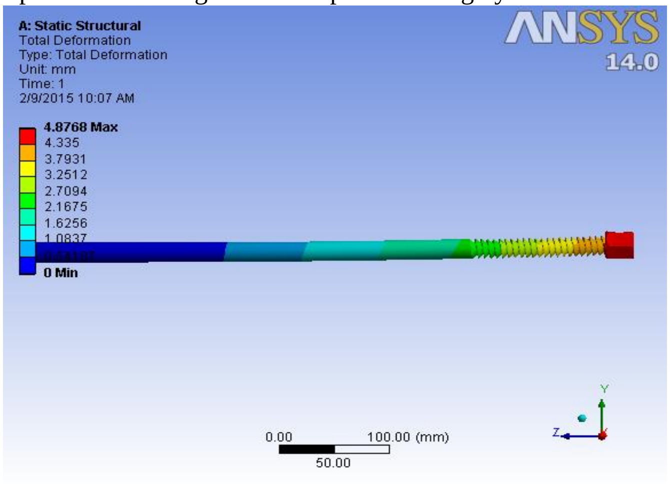


Fig 7a. Axial displacement for buttress thread in two threads engaged

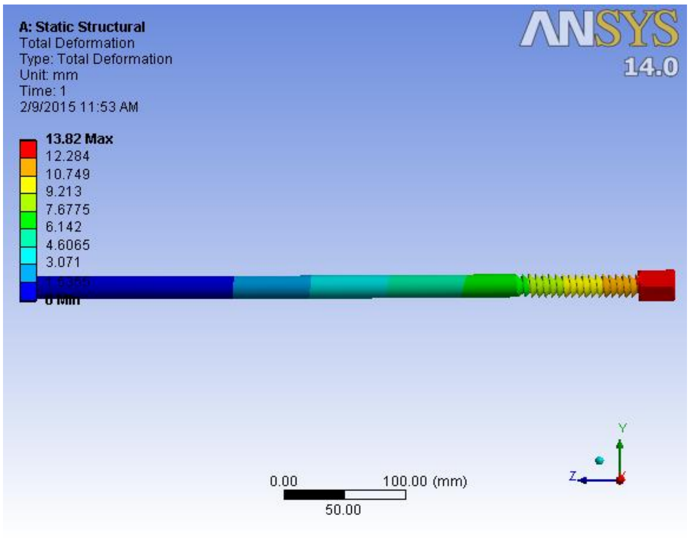


Fig 7b. Axial displacement for buttress thread in six thread engaged.

ACME thread

The axial loads that having how a thread can be test the strength of failure for ACME thread. The threads failed after taking loads for 47.90 kN, 97.50 kN, 107.60 kN, 155.10 kN and 175.80 kN for two, three, four, five and six no. of turns of thread engagements respectively. The tie rod body of axial displacement is gradually decreases from top to bottom. The displacement having nodes that passes through y-axis direction.

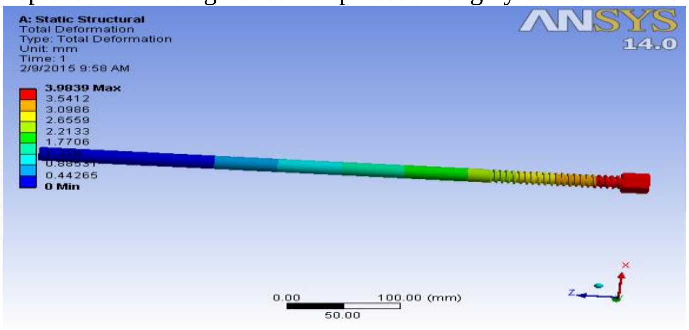


Fig 8a. Axial displacement for ACME thread in two thread engaged

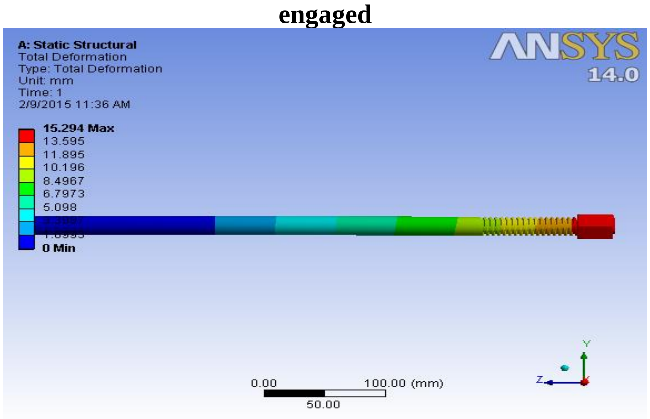


Fig 8b. Axial displacement for ACME thread in six threads engaged.

Modified square

The axial loads that having how a thread can be test the strength of failure for modified square thread. The threads failed after taking loads for 48.70 kN, 79.70 kN, 92.60 kN, 111.00 kN and 179.80 kN for two, three, four, five and six no. **of turns of** thread engagements respectively. The tie rod body of axial displacement is gradually decreases from top to bottom. The displacement having nodes that passes through y-axis direction.

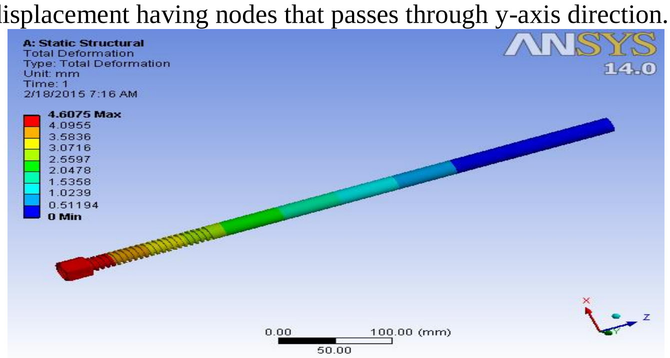


Fig 9a. Axial displacement for modified square thread in two threads engaged

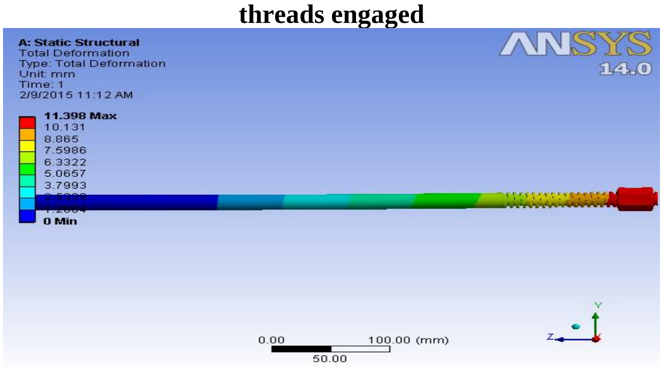
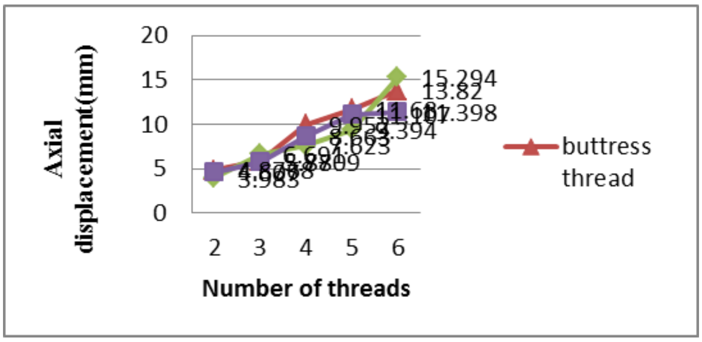


Fig 9b. Axial displacement for modified square thread in six thread engaged



Graph 3. Number of threads vs. axial displacement

Structural behavior of mild steel IS2062 in von mises stress of buttress, ACME and modified square threads

Where the axial loading of 64.30 kN the maximum von mises stress is 9211 MPa is located at the second turn of engaged thread. When the axial loading of 178.90 KN the sixth thread having a maximum von mises stress reached to the limit value of 35452 MPa. This shows that where the roots of thread is reached to plastic deformation.

Buttress thread

The axial loads that having how a thread can be test the strength of failure for buttress thread. The loads are taken as same from the above.

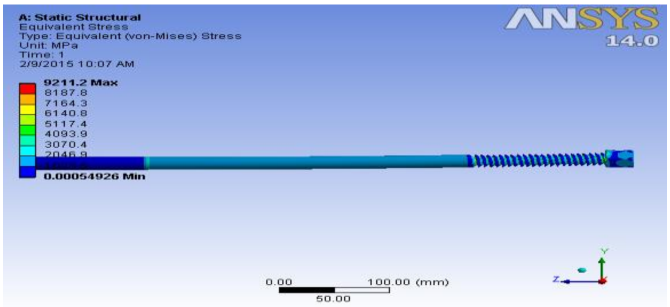


Fig 10a. Axial displacement for buttress thread for two thread engaged

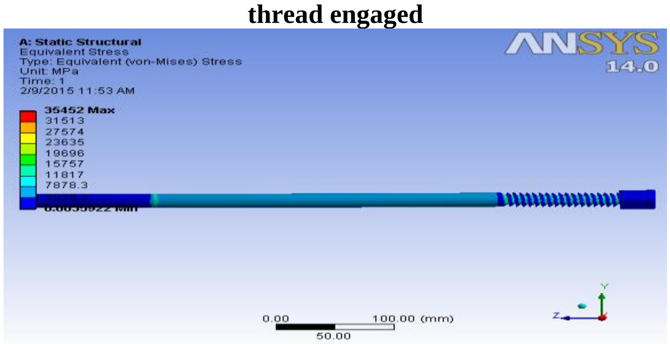


Fig 10. Axial displacement for buttress thread for six threads engaged

ACME thread

The axial loads that having how a thread can be test the strength of failure for ACME thread. The loads are taken from the above given values in acme thread.

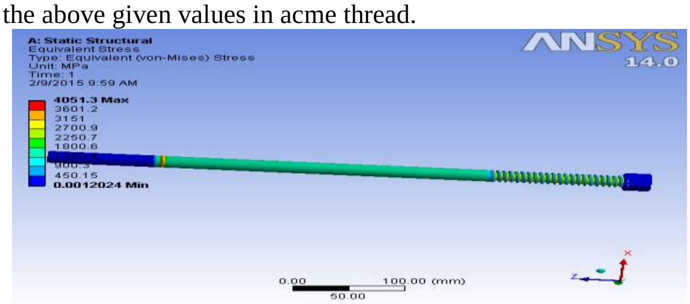


Fig 11a. Von mises stress for ACME thread for two thread engaged

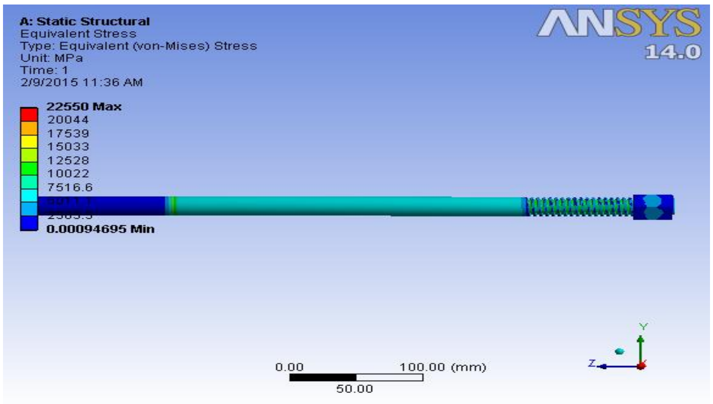


Fig 11b. Von mises stress for ACME thread for six threads engaged

Modified square

The axial loads that having how a thread can be test the strength of failure for modified square thread. The loads are taken from the above given values in modified square thread.

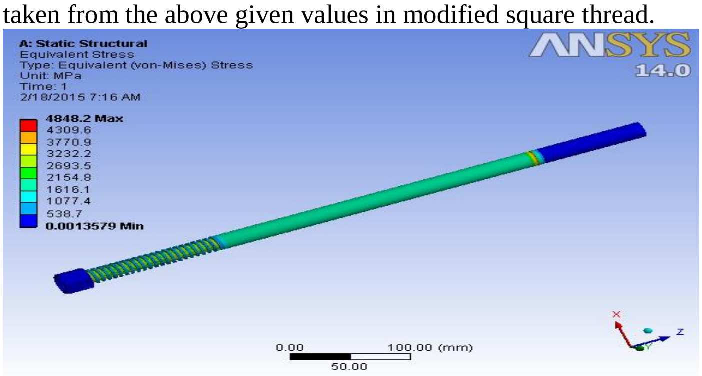


Fig 12a. Vonmises stress for modified square thread from two threads engaged

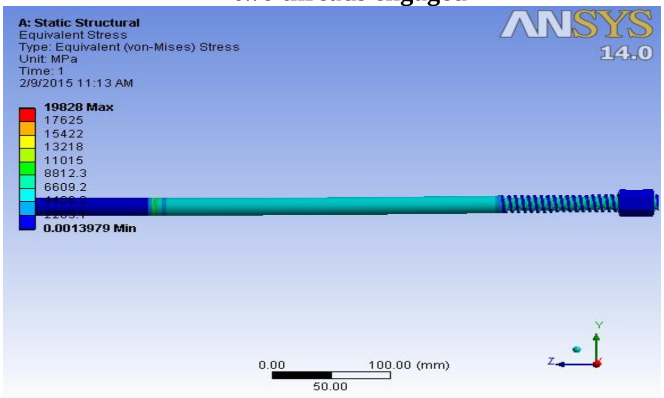
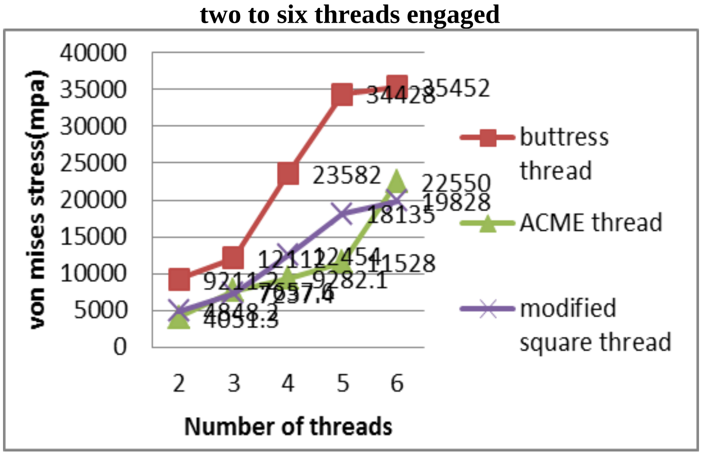


Fig 12. Von mises stress for modified square thread from two to six threads engaged



Graph 4. Number of threads vs. von mises stress

Structural behavior of mild steel IS2062 in sliding distance of buttress, ACME and modified square threads

The sliding distance on the contact surface is engaged on thread teeth under different axial loadings.

Buttress thread

In sliding distance the axial loads are increasing. When axial loads are increasing by 64.30kn, 86.10kn, 107.40kn, 154.20kn, 178.90kn, then maximum value of sliding distance are 3.8715mm, 5.0085, 6.0095mm, 8.298mm and 9.6704mm respectively. The sliding distance is located the two threaded contact surface at a point and then minimum contact pressure is considered. the sliding distance increases from bottom to top this shows how axial loading having trend basically under different axial loads.

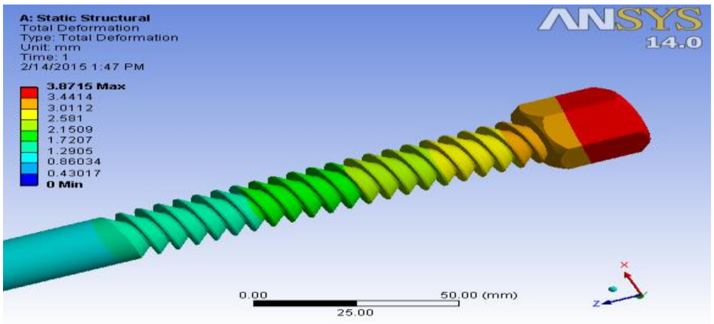


Fig 13a. Sliding distance for buttress thread for two threads engaged

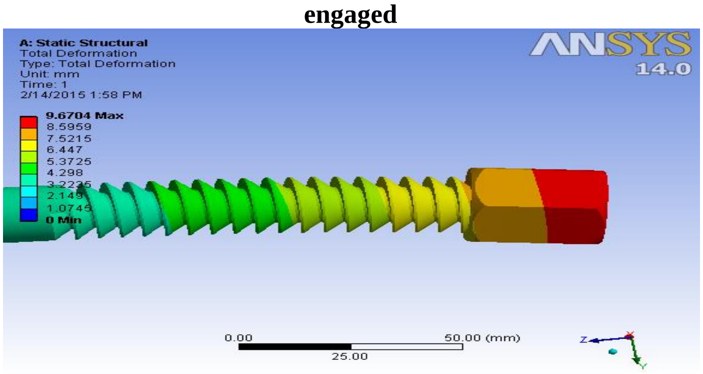


Fig 13b. Sliding distance for buttress thread for six thread engaged

ACME thread

In sliding distance the axial loads are increasing. When axial loads are increasing by 47.90kn, 97.500kn, 107.60kn, 155.20kn, 175.80kn, then maximum value of sliding distance are 2.217mm, 3.453mm, 4.501mm, 6.337mm and 7.264mm respectively. The sliding distance is located the two threaded contact surface at a point and then minimum contact pressure is considered. The sliding distance increases from bottom to top this shows how axial loading having trend basically under different axial loads.

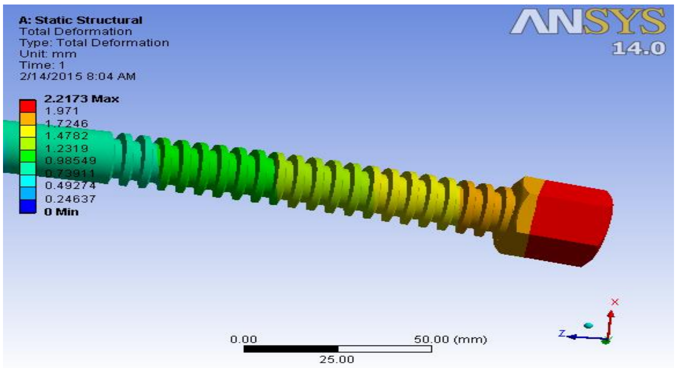


Fig 14a. Sliding distance for ACME thread for two threads engaged

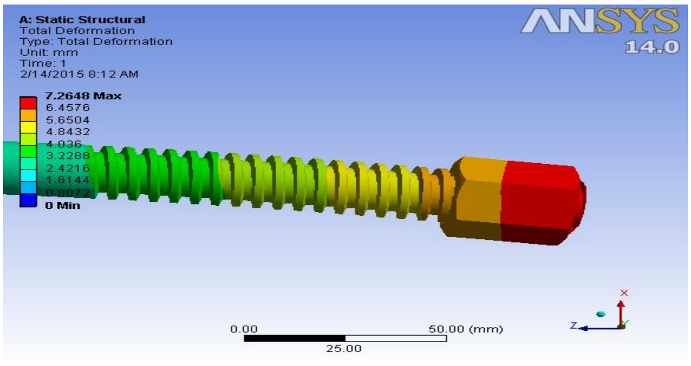


Fig 14b. Sliding distance for ACME thread for six threads engaged

Modified square thread

In sliding distance the axial loads are increasing. When axial loads are increasing by 48.70kn, 79.70kn, 92.60kn, 111.00kn, 179.80kn, then maximum value of sliding distance are 0.7541mm, 1.202mm, 1.359mm, 1.583mm and 2.532mm respectively. The sliding distance is located the two threaded contact surface at a point and then minimum contact pressure is considered. The sliding distance increases from bottom to top this shows how axial loading having trend basically under different axial loads.

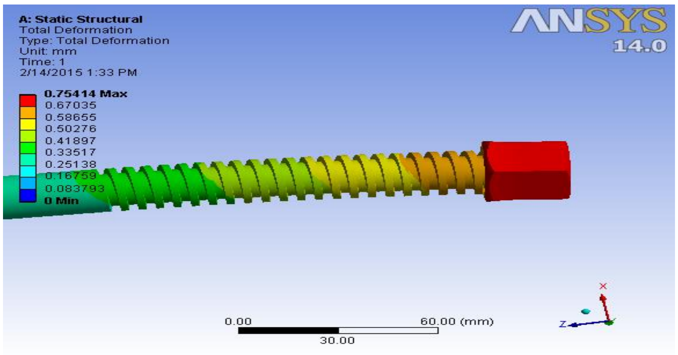


Fig 15a. Sliding distance for modified square thread from two thread engaged

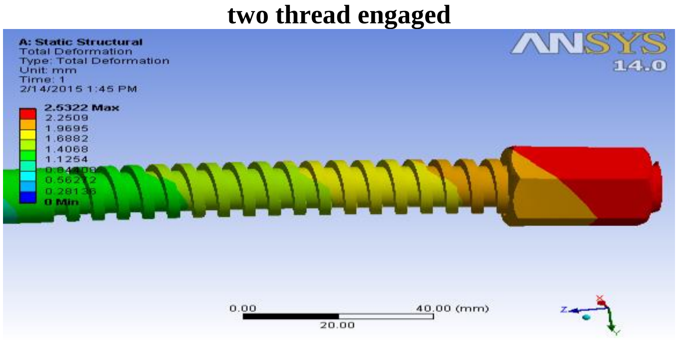
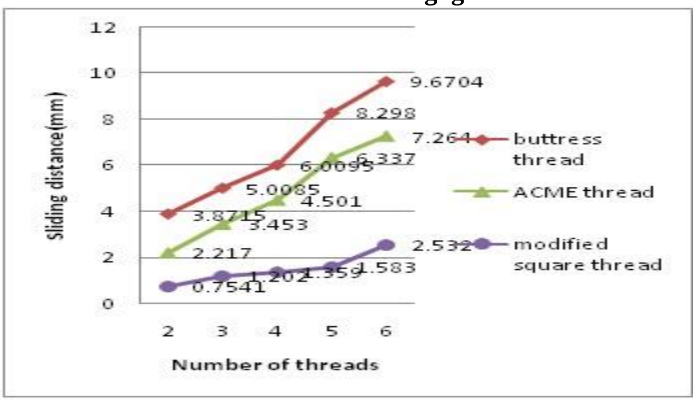


Fig 15b. Sliding distance for modified square thread from two to six thread engaged



Graph 5: Number of threads vs. sliding distance

THREADS	NUMBER OF THREADS ENGAUGED	ULTIMATE LOAD in Tensile test Report (KN)	Max DISPLACEMENT AT ULTIMATE LOAD in Tensile test Report(mm)	Min DISPLACEMENT AT ULTIMATE LOAD in Tensile test Report(mm)	DISPLACEMENT AT ULTIMATE LOAD in Ansys (mm)
BUTTRESS THREAD	2	64.300	4.600	5.100	4.876
	3	86.100	5.700	5.700	5.870
	4	107.400	10.100	10.700	9.952
	5	154.200	11.800	12.600	11.68
	6	178.900	12.900	14.200	13.82
ACME THREAD	2	47.900	3.800	4.200	3.983
	3	97.500	6.400	6.800	6.691
	4	107.600	7.300	7.400	7.623
	5	155.100	9.200	9.200	9.394
	6	175.800	15.100	15.500	15.294
MODIFIED SQUARE THREAD	2	48.700	4.000	4.700	4.607
	3	79.700	5.500	5.800	5.78
	4	92.600	8.000	8.700	8.663
	5	111.000	11.800	12.400	11.107
	6	179.800	10.800	13.400	11.398

Conclusions

(I) In steel tie rods the failure takes place at the thread teeth engaged portion then shear and bending failure occurred on it. We are strongly recommended that modified square thread connection having a nominal diameter of 20mm.

(II) While the fifth and sixth threads are engaged in Buttress thread connection failure occurs at unengaged threads and necking and breaking occurs at 11th and 22nd turns. While the sixth engagement in ACME thread connection failure occurs at unengaged threads and necking and breaking occurs at 22nd turn. Therefore the recommendations of number of turns of threaded engagement should be failed in fifth and sixth position in Buttress and sixth position in ACME thread connection having a nominal diameter of 20mm.

(III) At the roots of engaged teeth von Mises stress in the threaded connection occurs with maximum. If the applied tensile force reaches the yield limit of the tie rod material, a larger area yield occurs with unengaged threads at the middle part of the tie rod body, which forecast the failure thread position in tensile tests.

(IV) In sliding distance the values is increased from first engaged thread turn to sixth engaged thread turn under different axial loading.

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