Simulation of bolt joint under pretension effect with experimental Investigation

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ABSTRACT

The bolt is the important part of assembly in order to join the structure without the looseness of part. The torque load is requiring effective and much amount provide to obtained pretension load without failure of structure. The aim is determines to appropriate pretension effect due to much torque through the tightening wrench without failure of threads using the UTM machine. The bolt consider as M24 and pitch 3 mm are use for testing. Determination of the maximum equivalent stress and deformation is due to pretension load simulation by Finite element simulation. The result is validating by the experimental of UTM.

Keyword: *pretension, UTM testing, Equivalent stress, Deformation, finite element simulation.*

INTRODUCTION

The design of a bolt and nut is one of the most important aspects in the mechanical structure. The bolt manufacture of joining of structure is very big role play in order to interchange ability. There are thousands of different types of bolt nut are produce in industry for joining a single and complex assembly for example automobile and various types of structure. There are the most cost effective of the bolt for economically bolt price in order to reduce cost and appropriate customer satisfaction.

Various researchers have studied the pretension effect on bolt joint. Pradip D. Jamadar (Jamadar, n.d.) Finds out pretension analysis of threaded fasteners of various types of bolt and validate by experimental method. Nomesh Kumar (Kumar, Brahamanandam, & Rao, 2011) finds out the 3 D finite element analysis of bolted joint without failure of threads up to elastic limit. Geoffrey L. Kulak et.al defines ("america bolt book.pdf," n.d.) The behaviour of individual fasteners subjected to tension. Bertlomiej Zylinski and Ryszard buczkowaski (Poboznego, 2010) simulate the bolt joint using the finite simulation method. Q.M. Yu and H.L. Zhou (Yu & Zhou, 2015) study on pre-tightening process of threaded connection and establish the relationship between tightening torque and pretension effect. Toshimichi Fukuoka (Fukuoka & Takaki, 2003) analyzed of bolted joint during tightening process. Jeong Kim et.al (Kim, Yoon, & Kang, 2007) modelling of bolt structure and analyzed using finite element simulation. Shigley (*No Title*, n.d.) Introduce to the load and stress analysis and fasteners design. J.G. Williams's et.al (Williams, Anley, Nash, & Gray, 2009) performance analysis of externally loaded of bolted joint and validate by the experimental methods. J.K et al (Wang et al., 2017) investigate the effect of preload variation of stiffness.

The bolt subjected to important characteristics as the pretension effect and the tightening torque (Bickford, 1995). The torque is determined as when the torque is given by the torque wrench. The maximum torque given through the bolt as produce the effect of pretension in bolt. This process is very vital role play without the overturning and without the damage the part. This preload is determines as correct for joining the perfect joint avoiding the plastic deformation of threads.

PROBLEM FORMULATION

In this paper obtain the effect on M24 under the pretension load to check the thread failure and deformation. The bolt is use in the threaded connection of pressure vessel to joining the flange of pressure vessel. The test is setup on UTM machine. From universal testing machine the proof load, ultimate and breaking load is obtain. The tensile load from the experimental is uses to simulating the behaviour of bolt in finite element method.

The threaded portion is the weakest part of thread in assembly of structure. The preload prevents the sealing of the pressure vessel, and also it can provide that bolt works safely and reliably. The looseness of the bolt due to less amount of preload tends to induce leakage of sealing of pressure vessel.

EXPERIMENTAL SETUP

The bolt is use as specimen to perform the tensile test. The jaw in which one side of threaded part and other side of bolt head fixed the load applied up to the proof load. And reading is noted before the failure of thread. The setup is show in fig.

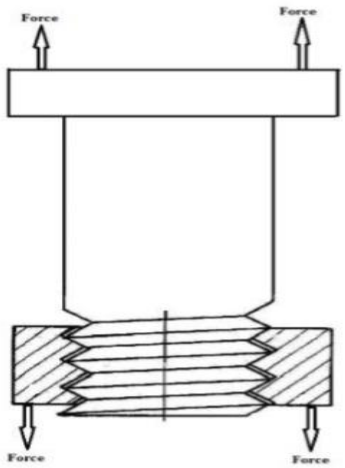

Figure 1 setup of tensile test

TENSILE TESTING FOR THREAD FAILURE CALCULATION

Proof load is defined as maximum tensile force that can be applied to a bolt that will not result in plastic deformation. The proof load determine by the testing the load condition without permanent deformation occur in bolt. The tensile test done by the UTM machine in order to determine proof load without permanent

deformation occur in the bolt. The tensile testing is done by UTM machine having capacity 1000 KN. The bolt M24 and pitch 3 are used for the tensile test.

TENSILE TEST RESULT

The load applied on bolt assembly is obtained the deflection of M24 as the behaviour curve initial straight that the strain is proportional to strain or elongation is proportional to the load giving a line relationship. This load is known as the proof load. After increase in load the plastic deformation occurs and strain is not totally recovered. Thus the permanent deformation occurs there are two points is known as lower yield point and the upper yield point. After increase in load the mark deformation in the material. The maximum load which the bolt assembles can with stand without failure is called the ultimate strength.

Table 1 Tensile test result

Size	Pitch (mm)	Area of root of thread (mm^2)	Tensile stress area of thread (mm^2)	Proof load (KN)	Breaking load (KN)
M24	3	324	353	215.4	287

FINITE ELEMENT ANALYSIS

The finite element simulation is consists of three basic procedure pre-processor, processor and post processor. In pre processor includes the three dimensional of bolt assembly, material selection and meshing of complete model and the boundary condition. While the post processor is give the result as the stress distribution and deformation.

The model is created using the CREO parametric in which the 10 mm thickness plate is joining the overlap to each other using the M24 bolt and nut. The model is export in IGES form for further analysis.

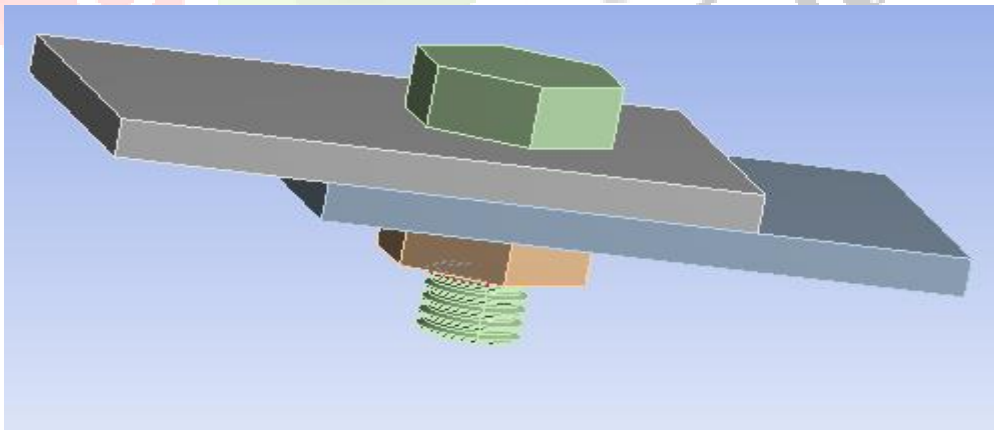

Figure 2 model of bolt joint

MATERIAL DEFINITION

The material of bolt, nut and plate is mild steel. Mechanical properties of both materials are shown in the Table

Table 2 Material properties

Material	Elastic module (GPa)	Poisson ratio	Yield strength (MPa)	Ultimate strength (MPa)	Density (kg/m^3)
Mild steel	200	0.3	250	260	7850

CONTACT INFORMATION

Four contacts define between the components in this model. In which the bolt to upper plate and nut to lower plate considering frictional contact. The friction coefficient value is generally 0.05. Other bolt threads to nut threads and upper plate to lower plate is considering bonded contact. The formulation is done by the pure penalty method and detection method on Gauss Point.

MESHING

The model meshed with hexdominent methed whereas the finer elements for the bolt and nut, and coarse element meshing for plate. There are total 20394 nodes and 8477 elements.

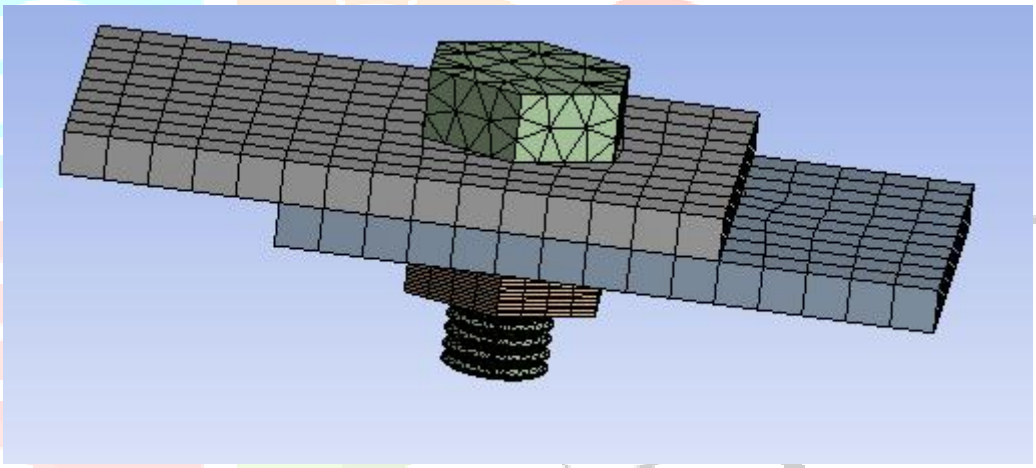

Figure 3 meshing

Table 3 Node and element for nut-bolt and plate table no

Sr. No.	Component	Node	Element
1	Plate	2411	303
2	Nut	5349	1020
3	Bolt	12634	7154

BOUNDARY CONDITION

The surface of bolt head is fixed, all surface of upper and lower flange symmetric boundary condition is applied. The pretension load 35 KN is applied to bolt body. And the forces 185 KN is applied to nut surface which indicate the amount of tighten torque. This value is providing according to the experimental procedure from universal testing machine.

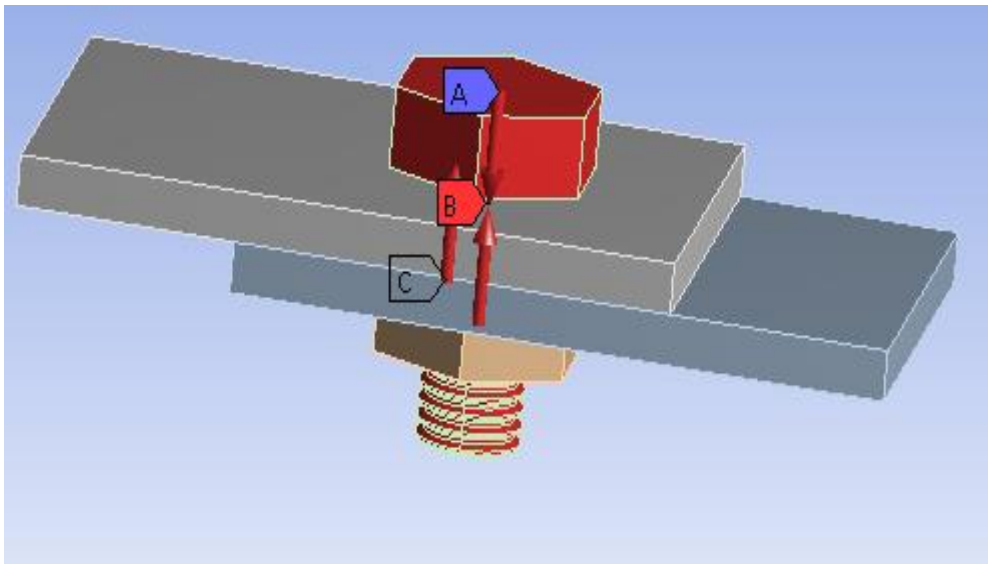

Figure 4 boundary condition

RESULT

The von misses stress distribution over bolt is obtained using the finite element analysis. The calculating result of the stress distribution of bolt and plate structure is analyzed. The simulation method for M24 is the same magnitude of force and bolt pretension.

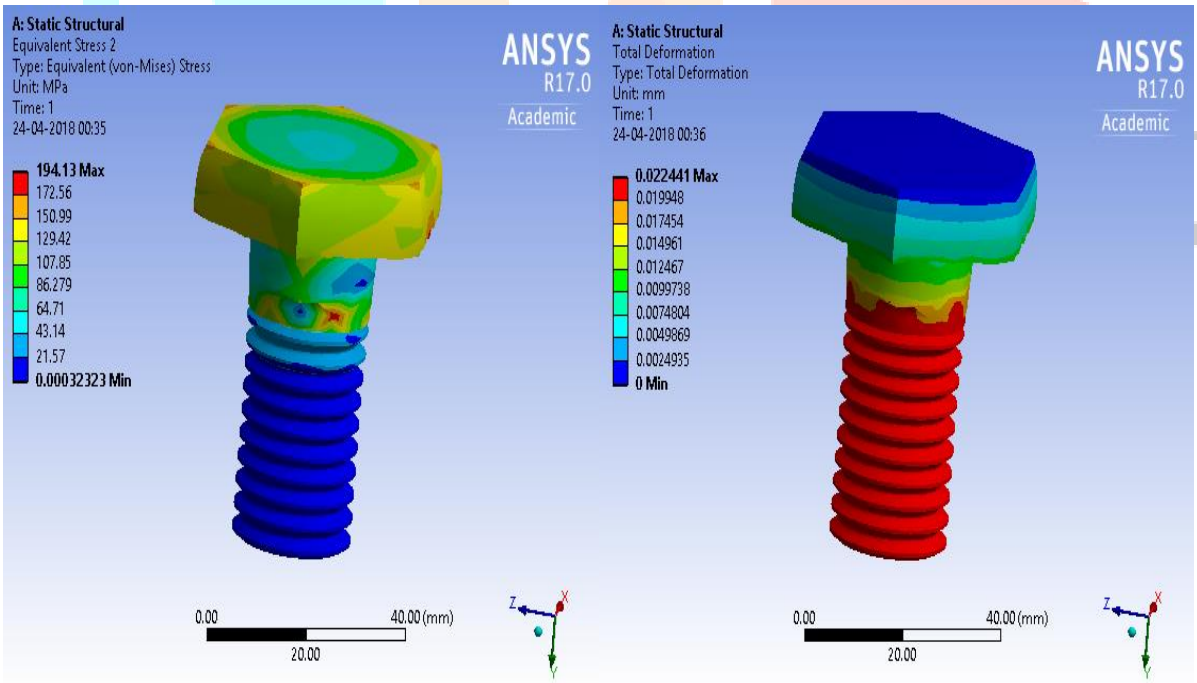

Figure 5 equivalent stress and deformation simulation

STRESS DISTRIBUTION

As shown the pretension load applied 35KN in M24 bolt and nut 194.13 MPa stress value is obtained.

DEFORMATION

As shown the pretension load applied 35KN in M24 bolt and nut 0.0224 mm deformation value is obtained.

DISCUSSION

The result during the experimental is limited when load applies only the displacement is obtained. While in the simulation method we plot the stress distribution and deformation.

In the present paper, a 3-D finite element model of bolt joint has been simulated. The induced stress of bolt and deformation has been presented. Comparing the result of Experimental and Numerical methods of the final stress in the bolt is varying 12 %, and the comparing final deformation of bolt M24 that the result from experimental and the simulation method are varies 3.75%.

CONCLUSION

In this paper, experimental and numerical technique is used for calculation of failure load, stress and deformation of M24 bolt model. The bolted joint is considering pretension effect using finite element simulation. The simulated value is validating from the experimental method within an acceptable 12% error.

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