International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 01,January-2015

Effect of Bolt Pretension in Single Lap Bolted Joint

Chetan Mehra
ME- Tribology & Maintenance Engg.
S.G.S.I.T.S INDORE (M.P)

Amar Singh Kokadiya
ME- Tribology & Maintenance Engg.
S.G.S.I.T.S INDORE (M.P)

***Abstract* - Bolted joint are widely used mechanical fastener these are temporary type of joint and have many advantage like this joint facilities easy disassembly of component joined and have comparatively low cost However, losing of bolted joint may cause serious problem to the machine and if not attained timely it may cause catastrophic failure of the machine as well. Washers are used with bolted joint as these reduced losing at the bolted joint considerably. more over washer also help in getting leak proof joint and these can be replace as well when warm out without deteriorating the component being connected. The various type of washer are used in bolted joint e.g plain washer, spring washer etc. this work attempt numerical studies of stress analysis for bolted joint with various type of washer.**

For numerical analysis ANSYS workbench software is used. The model of the plain, bolt, nut, in washer have been made in Pro-E software .the model thus made has been imported in the ansys workbench for the analysis.
Keyward:- Ansys Workbanch, Pro-E

1. INTRODUCTION

Bolted joints are temporary type of joints used to connect two structural components. These are widely used mechanical fasteners and have many advantages like these joints facilitate easy disassembly of components joined and have comparatively low cost. However, loosening of bolted joints may cause serious problems to the machine and if not attained timely it may cause catastrophic failure of the machine as well. Washers are invariably used with bolted joint.

2. LITERATURE

Bolted joints are invariably used to connect machine/structural components. This chapter reports existing studies on analysis of bolted joints. Loosening of bolted joints is one of the problems that is often faced. With time, bolted joints in a machine
may get loose and may fail under the loading. Many researchers analyzed bolted joints for its structural analysis. These joints are made up using high strength bolts fitted in clearance holes and tightened
under careful control to develop a preload equivalent or greater than the bolt yield load. The mechanism of carrying load is by friction developed between the mating faces, and it is well established that this type of joint is considerably stronger than a riveted joint. As a consequence of the earlier works, it was noted that in order to accurately predict the physical behaviors of the structure with a bolted joint, a detailed three-dimensional bolt model is desirable, which fully includes the friction due to the contact on mating parts and pretension effect to tie. Therefore, in this paper, in order to investigate a finite element modeling technique of the structure with bolted joints, four kinds of finite element models are introduced, a solid bolt model, a coupled bolt model, a spider bolt model, and a no-bolt model. All the proposed models take into account pretension effect and contact behavior between flanges to be joined. Among these models, a solid bolt model. Additionally, the coupled bolt model, which couples the degree of freedom between the head/nut and the flange, shows the best effectiveness and usefulness in view of computational time and memory usage. Finally, the bolt model proposed in this paper is adopted for a structural analysis of a large marine diesel engine consisting of several parts that are connected by long stay bolts. All numerical simulations are carried out using implicit FEM software package ANSYS.

Bolted joint is a combination of threaded fasteners bolt and nut. It is the connective element to joint or fastened the machine components, a bolt is an externally threaded fastener designed for insertion through holes in assembled parts, and is normally intended to be tightened or released by torque a nut. A nut is a type of hardware fastener with a threaded hole. Nuts are almost always used opposite a mating bolt to fasten a stack of part together. High tensile nuts and bolts find wide application in joining part where continuous rotation and wear and tear of the nuts and bolts occurs as the nuts and bolts are subjected to variable stress in static and dynamic condition.

TRADITIONAL APPROACH AND STANDARDS FOR DESIGN OF STRUCTURAL BOLTED JOINT

Bolted joints are temporary type of joints which are used to connect two structural components. These are widely used mechanical fasteners and have many advantages like these joints facilitate easy disassembly of components joined and have comparatively low cost. However, loosening of bolted joints may cause serious problems to the machine and if not attained timely it may cause catastrophic failure of the machine as well. Washers

are invariably used with bolted joints with friction; threaded fasteners could not retain their tension without the addition of a locking mechanism and would subsequently be highly restricted in their application.

The preload results from the axial stress generated when the bolt is tightened.High thread friction results in a high tensional stress in the bolt section that limits the axial stress available and hence the preload achievable from the tightening process. Preload is difficult and expensive to measure and so usually its control is indirectly achieved by specifying a tightening torque. Friction plays a large part in determining the effectiveness of the conversion of applied torque to fastener preload. To control preload by torque control it is essential to have some limits placed on the range of the coefficient of friction 0.3.

When the application sustains purely static loading, it is desirable to keep the friction as low as possible so that the torsion stress in the bolt is minimized. In dynamic applications, a concern is that low friction will aid self-loosening. Most of the major automotive companies specify the acceptable friction range on fasteners they use so as to provide some control over the torque-tension relationship. For example, the tightening torque is usually determined by using an expression that assumes a fixed (coulomb) value for the coefficient of friction, so that a particular pre-stress is applied to the bolt when it is tightened. The target pre-stress applied to the bolt varies between industries. In the petro-chemical industry, typically a target pre-stress of 50% (ASME, 2010) of the bolt material's minimum specified yield strength is used in automotive engineering applications, this pre-stress is typically around 75% of the minimum yield strength value of the bolt material (Eccles, 1993) If the coefficient of friction increases, then the pre-stress and subsequently the clamp force, will decrease for a given torque value.

In this study, two methods were used to investigate the friction coefficient changes in the contact interfaces of bolts, nuts, washer and the clamped surface material, specifically:

1. Tests on fasteners during repeated tightening, to establish how the friction coefficient, and the clamp force generated by a constant tightening torque changed as a result of the repeated tightening.
2. Measurements of the nut face friction under conditions of constant pressure, to investigate how the friction coefficient changes with the angular rotation.

Properties and dimension of the bolt and nut

Material type	Medium carbon steel,
Modulus of elasticity, E	200 Gpa
Poisson's ratio, Å	0.30
Proof strength	580Mpa
Minimum tensile yield strength	640 Mpa
Nominal length, L	340 mm
Nominal diameter, D	16 mm
Height of bolt, H	70.mm
Height of nut	10 mm
Width across corners, C	20 mm

Properties and dimension of the Plates

Material type	Mild steel
Modulus of elasticity	200 Gpa
Poisson's ratio	0.3
Thickness	20 mm,30 mm
Width	66 mm

COMPUTER ADIED MODELLING AND SIMULATION OF BOLTED JOINT

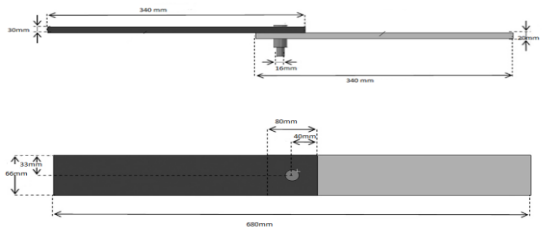
Modeling of any structure/component is the first step in its finite element analysis. For this, various software, e.g. Pro-Engineer etc, are generally used. This software has the capability of modeling complex details of a machine component. Analysis software, e.g. ANSYS, also has the capabilities of modeling. If the details of the machine component are complex, then CAD software like Pro-Engineer, etc can be used and then the model can be imported in analysis software like ANSYS using IGES format. However, bolted joints are simple to model. Therefore, in this work ANSYS software is used for modeling the bolted joint and as well as for its analysis.

The type of bolts used in connecting structural steel components in buildings and bridges can be categories as follows.

1. Low carbon steel bolts and other fasteners , ASTM A 307, grade A
2. High – Strength medium carbon steel bolts, ASTM A 325, plain finish, weathering steel finish, galvanized finish.
3. Alloy, steel bolts, ASTM A 490.
4. Special types of high strength bolts such as interference body bolts, bolts and nuts, ASTM A 449 and ASTM A 354 grade BD bolts.

The making of requirement For ASTM A307 bolts is that the manufacturers Symbol appears on top of the head of the bolt 1.10 A 307 bolts are manufacturers with hexagonal head and nut and either a regular or heavy head depending on the bolt diameter. Nuts do not need to be making. The bolt produced in diameter ranging from1/4 to 4 have a specific minimum tensile strength of 60 psi, and may be galvanized .In application A 307 bolt and nuts are tightened so that some axial force in present that will prevent movement of the connected member in the axial direction in the bolt joint. High-strength bolts are heat treated by quenching and tempering .the most widely used are A 325 high Strength carbon steel bolts.1.3 and A490 alloy Steel bolts [9].Bolts manufactured to ASTM

specification A490 can also be one of these types .Type 1 bolts are made from alloy steel, type 2 is of low Carbon marten site steel and type 3 is of atmospheric corrosion resistant steel. Bolts.

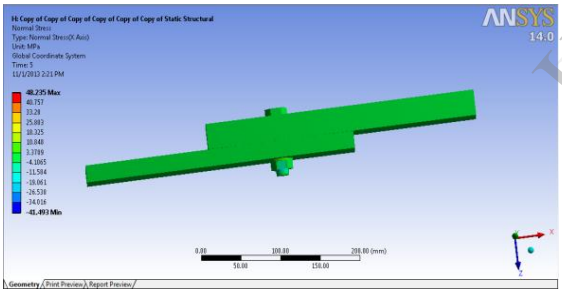


3. RESULT

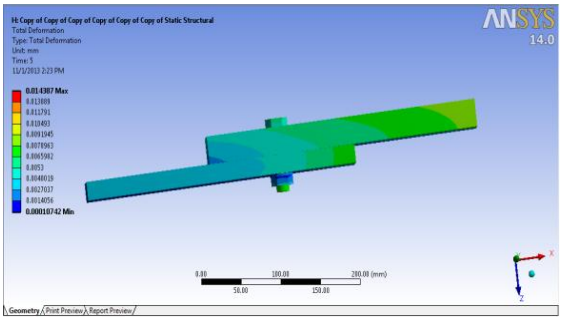
Stress analysis in single lap joint with applied different bolt pretension in bolted joint range 1000N, 2000N, 4000N, 6000N, 8000N, and
10000N to find the maximum compressive and tensile stress in different bolt pretension is applied. As shown in table….

RESULTS OF STRESS ANALYSIS IN SINGLE LAP BOLTED JOINT

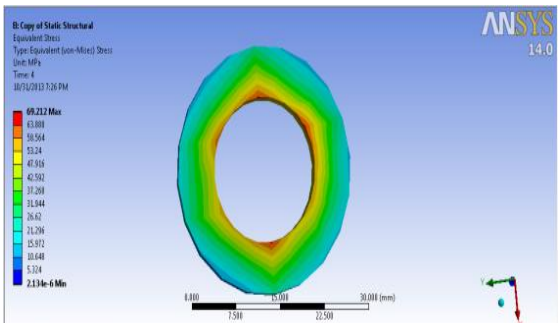
The deformation and stress analysis result obtained by the simulation methods of FEA as shown in the observation tables have been given in **Error! Reference source not found.**. This section shows the detailed results of stress analysis of the single lap bolted joint structure for a pretension load of 10000 N.



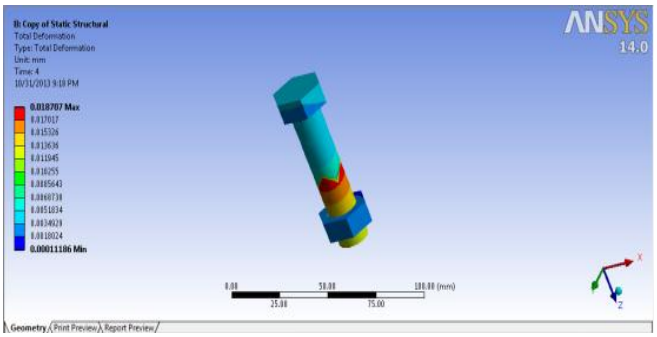
Normal Stress in single lap bolted joint



Total Deformation in single lap bolted joint



Equivalent stress in plain washer



Total Deformation in single lap bolted

4. CONCLUSION

1. Finite element method can be used for solving stress analysis problems of bolted joint structures software's like ANSYS. It facilitates proper incorporation of contact reasons in the structure.
2. Pretension load can be applied by using a pretension element as available in the software.
3. Various stresses e.g. normal, von-mises, and shear stresses developed in the structure have been analyzed.
4. Effects of increasing pretension load have been studied and it is found that with increasing pretension load the stresses induced in the structure increases.
5. Finite element analysis results improved both the standard of engineering designs and methodology of the design process.
6. Finite element method allows entire designs to be constructed, refined and optimized before the design is manufactured

SCOPE OF FUTURE WORK

In this thesis attempt has been made to model the bolt pre-load and resulting between bolt shank and clamped plates for simulating bolted joint behavior under Pretension loading conditions. In Future work, the utility of the finite element method may be checked and validated for the stress analysis of bolted joints. In future,

1. The work may be extended for stress analysis of bolted joint structures with externally applied loads.
2. More complex structures with bolted joints may be considered for the analysis.
3. Other types of joints may be considered for the analysis and a comparative study can be made.
4. Solid element bolt model also can be used for failure prediction with the help of failure Plastic strain definition provided reasonable mesh size is used for descretisation bolt geometry. Solid model approach is also useful to simulate sliding displacement between bolt and clamped plates depending on the type of applications.

5. REFERENCE

1. T. Ireman, "Three-dimensional stresses analyses of bolted single-lap composite joints." Composite Structure, 43 vol. (3), (1998), 195-216.
2. G.L Kulak, W.J Fisher and J.H Streak, "Guide to design criteria foe bolted and invert joints", (2001).
3. R. Zhang, J.U.Jianmin, "Finite element analysis based on pro-Engineer, and ansys", vol.432, (2008), 622-625.
4. W.Eccles, "Tribological aspects of the self- loosening threaded fasteners," (2010).
5. R.A.Ibrahim, C.L. Pettit, "Uncertainties and dynamic problem on bolted joints", journal of sound and vibration, vol.279, (2005), 857-936.
6. J. Kim, J.C.Yoon, B.S. Kang, "Finite element analysis and modeling of structure with bolted joints,"Applied mathematical modeling, (2006).
7. A. Ali, T.W.Yao, N. A. Aziz, M. Y. Hassan, and B. Sahari, "Simulation and Experiment work of single lap Bolted joint tested in bending ," J. Sci. Technol.vol(4) (1998),331-345.
8. H. Ahmadian, H. Jalali, "Identification of bolted lap joints parameters in assembled structures" Mechanical Systems and Signal Processing, 21 (2007), 1041–1050
9. Research council of structural connections, "Specification for Structural Joints Using High-Strength Bolts," December 31, (2009).
10. B. Kenny, and E Patterson, " Stress analysis of nut bolt connection with modification to the nut thread form", The journal of strain analysis for engineering Design, vol.20,(1985),35-40.
11. R. Friede, J. Lange, "Loss of preload in bolted joint connection due to embedding and self loosening," SDSS' Rio, Stability and ductility of steel structure, Brazil,(2010), 287-294.
12. N.G Pai, D.P Hess, "Three dimensional finite element analysis of threaded fastener loosening due to dynamic shear load", Engineering Failure analysis , vol.9, (2002) 383- 402.
13. G.Restivo, G.Marannano, G.Isaicu, "Three dimensional strain analysis of single lap bolt joint in thick composite and the finite element method",vol.45 (2010) 523-234.