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DESIGN, SIMULATION AND ANALYSIS OF SINGLE LAP AND L- TYPE BOLTED JOINT

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ABSTRACT
Bolted joints are most widely used joint in mechanical structures. For the proper functioning of machines and structure and safety of operators , Design and analysis of bolted joint is very crucial because when a joint fails or get loose it becomes dangerous and affects the machine functioning . This work deals with the modeling and simulation of single lap and L type bolted joint under shear stress and tensile stress using FEM approach. The Maximum stresses and deformation produced in bolt and joint assembly was analyzed by analytical method in Ansys software. Using modeling software Creo 2.0 Bolted joint 3-D model was developed and simulation of joint was carried out by using finite element analysis in ANSYS software .pretension effect on bolt join was also examined . The effect of pretention on maximum tensile stress ,compressive stress and on deformation in both single lap and L type joint is analyzed .

Keywords: - single lap bolted joint, L-type bolted joint, stress analysis, pretension, FEM analysis, 3-D modle.

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1. INTRODUCTION

In machine and structures one part is joined to another part with the help of mechanical joint. In design of machine and structural the most important factors is the fastening of components rigidly. The selection of the rigid fasteners depends upon many factors such as, accuracy of the position, ability to hold together different components against all forces acting on it, requirement of maintenance or separate components, retention of joint over time, loading condition, and environment condition. For the demand of disassembly, maintenance purpose, and inspection bolt joint is used, which is prime reason why bolt joint are mostly used.

A bolted joint consist of following elements a bolt, a nut, and a washer. The material of fastener depends upon the strength, temperature, corrosion, vibration, fatigue, and many other variables. For the purpose to transmit and distribute evenly the force or load exerted on the connected parts a washer is placed under the nut or the head of a bolt (screw) . Designing of bolted joint is not only concern with determining the number of bolt, size of bolt and placement of them but it also concerned with the determining of appropriate preload for the bolt and the torque required for getting the preload. The strength of the nut and bolt connection is determined by the applied preload and Amplitude of the load together with stress concentration. Pretension is supplied to minimize the chances of separation and amount of pretension must be more than the applicable load. Pretention and mating part contact are two main primary characteristics of a bolt joint.

Different types of load acts on bolted joints under working conditions. Tensile loading and shear loading are not only the loading conditions on bolts during the operations secondary load or force also acts on joints. This other loads effect the life and behaviour of bolt joint. Sometimes in design and analysis such other factors are not consider it play major role in the failure of structure. Different types of bending frequently occur in shear loaded joints are primary, secondary and local fastener bending as shown in figure 1.1. Bending moment acts on ends plates will generates the primary bending in joint. Shear load, compressive load and tensile loads generates secondary bending. Symmetry of joint will minimize the secondary bending in shear lap joints. Typical types of shear lap joints are shown in figure1.2

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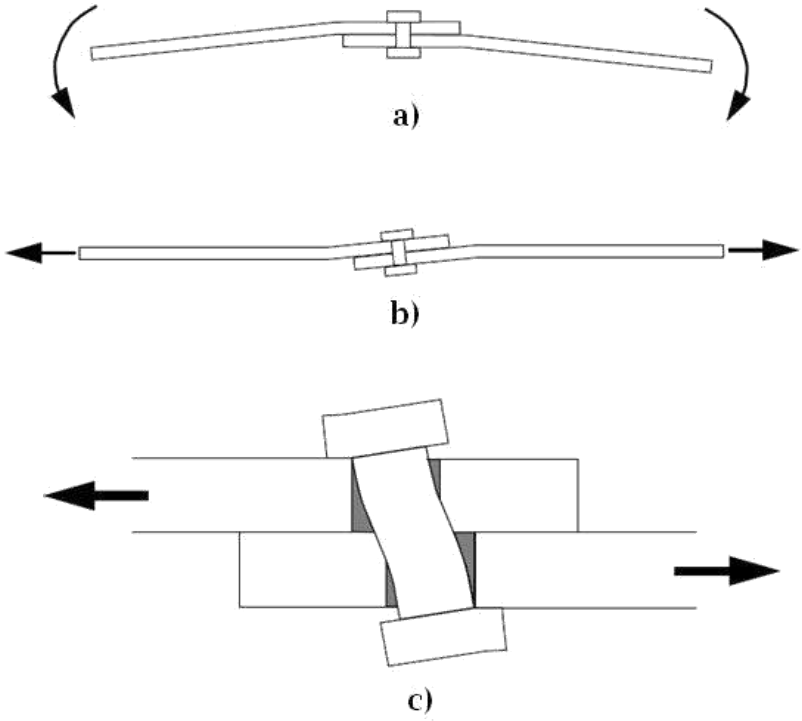
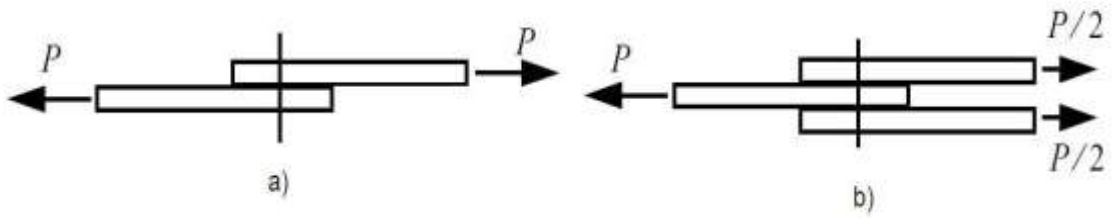


Figure 1.9 The different types of bending effects in shear bolted joints; a) Primary bending, b) Secondary bending, c) Fastener bending and tilting



Because many factors effect the behavior of bolted joints, there analysis becomes very difficult and complex.

1.1 PRETENSION

A nut and bolt joint is preloaded or tensioned by the use of torque, which can be applied either on the nut or bolt head. Because of this applied torque preload is developed which depends on the coefficients of friction between the threads and below the head of bolt or nut, bolt diameter, length, and geometry of the thread. In nut and bolt connections when nut or bolt is torque, tension preload is generated in the nut and bolt where as a Compressive load

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is developed in the part which was bolted. Pretension in bolt is used to joint or clamp two parts and which develops a friction lock between the members. In FEA the effective use of bolt pretension in connection require many additional steps. In finite elements analysis the bolt preload was first applied and then external load required is supplied

1.2 LITERATURE REVIEW

Hanamant Kate 2015, worked on to enhance double bolted lap joints fatigue life used in aircraft applications. The various factors which affects the fatigue life are depends are bolt size, Bolts number used and the position of bolts, thickness of material plate, friction coefficient, surface finish and Pretension act on the bolt. For investigation of the fatigue behaviour of bolted joint, numerical and analytical methods were used. Analytic calculation results that were the number of cycles compared with numerical results which were obtained by finite elements analysis. It was found that pretension develops Stresses (compressive) in joint, which increase the fatigue life of the joint. The concentration of stresses was decreased around discontinuity due to the induced compressive stresses.

Khemchand 2015, worked on techniques of bolt modeling and Analysis of deformation in bolted joint. For design a simple approach was described for bolted joint under action of shear forces and bending forces in FEM. Mostly Bolted joints, were subjected to preload, shear load, tensile load & bending loads, And analysis was done to determine Failure stresses, deformations, Slipping during preload, Contact pressure & sliding behaviour under this loading conditions.

Khosro Fallahnezhad 2014 investigate the behaviour and mode of failure in double-lap bolted joints. The material taken for analysis was Alluminium 2024-T3 with a thickness of 2 mm and a 6.5 mm-diameter hole. The effects of geometric parameters were examined for both single bolted and double- lap bolted fasteners. The 3-d models of doubled –lap bolted joint were developed and results was checked with the results got from experiment in which joint was loaded in tension. In general, it was found that capacity of carrying load was greater in double bolt joint than the single bolt joint. In single bolt joints, under the tensile loading the width of the plate had insignificant influence on joint behaviour. When the position of hole changed that is the hole distance from the edge was increased in single bolted joint ,it increased considerably the joint strength but in case of double bolted joint there was no change shown in the joint behaviour. When plate width changes to 30mm from 25.4 it was found that there was 28 % increase in capacity of load carrying. In case of double bolted joints when the width increases, the failure shifted mode from tension to bearing. In controlling the failure mode the geometric parameters can play major role.

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F. Esmaeili 2014, worked on, to predict double lap bolt joint fatigue life. The joint taken for analyzed was the double lap bolt aircraft joints. the various multi axial fatigue criteria was considered for the predictions. In this analysis, study was done to identify the changes in Fatique strength of joint due to torque tightening by using experimental and multiaxial fatigue analysis. Three specimens for test were prepared and each specimen was analyzes at different amount of torque i.e. 1 Nm, 2.5 Nm and 5 Nm and after it fatigue test was done at different cyclic loads. Specimens fatigue lives were determined with the help of local stress and strain distribution with the various six multiaxial fatigue criteria. Experiment results and fatigue analysis results reveals that the fatigue life of joints was enhanced because the clamp force increased by compressive stresses which appeared around the hole.

Navdeep Jain,. 2014, performed static analysis on the bolt test rig parts. The modal was made by using CAM and Analysis of each component was completed by using Hypermesh-Nastran. With loading condition was static stress characteristics and displacement characteristics of bolt M16 are analyzed. The analysis was done with various mesh for better accuracy. The Analytical and simulation results were compared.

Rashmi Gill, 2014, .worked on the study of failure of composite bolt joint. Due to mechanical fasteners the stress field generated closed the hole area was complicated. It was observed load capacity of the composite structure was reduced. Characterization of the failure of was difficult because many parameters were involved in laminated bolted composite. The method used for analysis and designing of composite bolt joint as analytical approaches, experimental tests and FEA was studied. In compare to numerical method and excremental studies the result of analytical method comes accurate and robust. It was observed that a few investigations have conducted on the contact condition of the bolt and on the use of multi-bolt joints. From some investigation it was observed that bolt holes Clearance decreases the bolt contact area, affects the load transfer, and joint bearing loads.

1.3 PROBLEM IDENTIFICATION

Based on the literature review including several research paper and reference paper following problems are identified as below:

1. Design of bolted joint includes many factors and analysis becomes very difficult so many assumptions are always considered in analysis for satisfactory design.

2. Need is felt to find an alternative approach, in which this assumption may either be eliminated, or at least so that acceptable solution may be achieved.

3. It was found that not only the primary stress affects the joint behaviour but secondary stress produced during operation also has adverse effects on joint behaviour.

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1.4 CAD MODEL FOR ANALYSIS

Cad models of single lap bolt joint and L-type bolt joint is developed in Creo/Pro-E 5.0 . figure 1.3 show the CAD model of single lap joint and figure 1.4 shows the CAD model of L-type bolted joint

The geometry model as import in IGES format has been shown in Figure

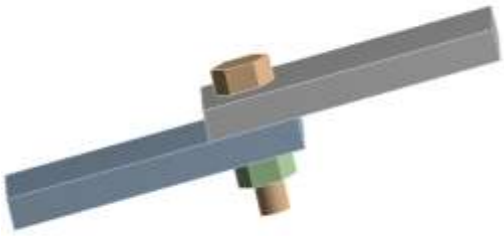

Figure 1.3 single lap joint CAD model

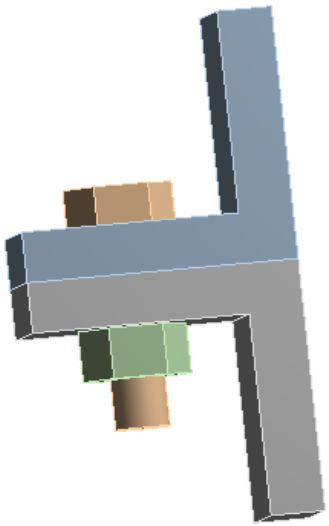

Figure 1.4 L joint CAD Model

1.5 Defining of contact in bolted joint

In single lap bolted joint five contact interactions were defined between the five solids. The upper plate is in contact with lower plate, bolt head, bolt shank, nut and bolt shank are in contact. The contact between nut and bolt is bonded and all other contacts are frictional. The

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coefficient of friction value for frictional contacts is 0.3. the figure 1.5 shows contact interaction in single lap joint whereas figure 1.6 two the contact interaction of L-type bolt joint.

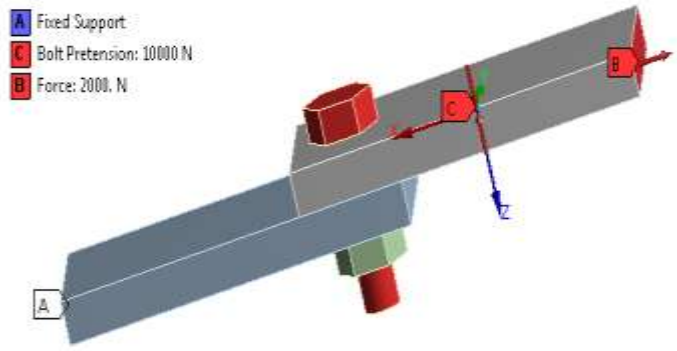

Figure 1.5 Contact Interactions in single lap joint

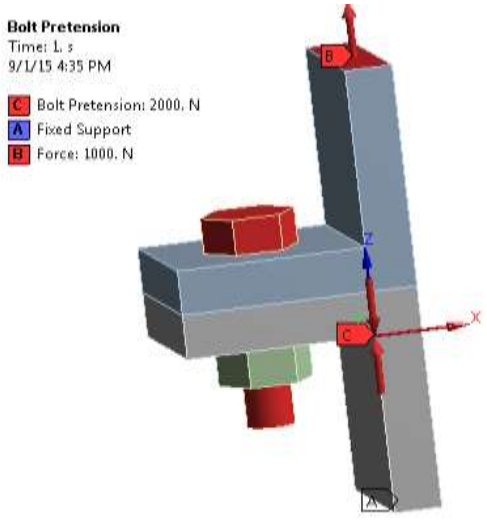

Figure 1.6 Contact Interaction in L-joint

1.6 Meshing of Bolted Joint for Analysis

The solid model of the single lap bolted joint has been meshed using brick element.

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The different element size for different parts, upper plate, nut and bolt are same mashing size, automatic mesh with medium relevance .The convergence check has been made and the results converged with the element size as specified.

Component	Meshing size
Lower plate, nut, bolt	Automatic, medium relevance

Figure 1.7 Meshing of single lap bolt joint

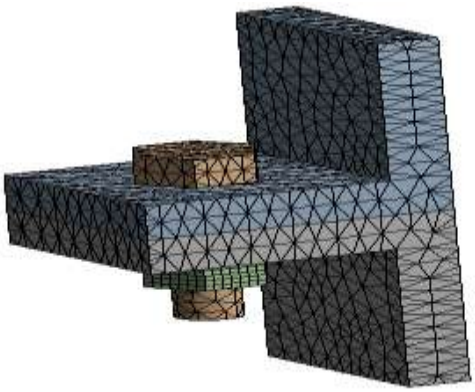

Figure 1.8 Meshing of L type bolt joint

CONCLUSIONS

stress analysis of single lap bolted joint and L-type bolted joint under the tensile stress and shear stress loading condition to determine the effect of various parameters.

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The main findings of the work can be summarized as follows:

- Structural analyses of a bolted-joint configuration performed to define basic modeling and analysis requirements and to identify factors that will have significant effect on the response.
- FEM model helps in the predicting the nature of loading on each element of assembly.
- Model may be used to find out the numbers of bolt to join parts according to the stress developed in bolts.
- Combination of Loads can be applied on the bolt joint and pretension gives minimum value of stress developed in bolt.

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