Stress Analysis of Bolted Joint by using FEA
Mr.R.M.Deshmane1 Mr.A.M.Naniwadekar2 Mr.P.R.Patil3
1P.G. Student 2,3Assistant Professor
1,2,3Dr.J.J.Magdum College of Engineering, Jaysingpur, India

Abstract—Various types of the loads acting on the mechanical joints. The parameters such as type of bolts, its size, number of bolts, the way of location of bolts for clamping and arrangement in different types of machinery and cars has a special importance. Improper determination of configuration of bolts may call for failure in the structure. Therefore, it is very important to determine suitable bolted joint arrangement at the shortest possible time. Research is presented with different configuration by connecting two plates with the same number of bolts by changing arrangement (circular, rectangular, square and diamond) and stress distribution was assessed and analyzed by numerical methods.

Key words: FEA, Stress analysis, Bolts, Shear stress of a joint, Bolted joint

I. INTRODUCTION

Most products are made from more than one piece of material, so when the product is assembled or fabricated the pieces needs to be joined. Mechanical joints are classified into two groups: permanent joints and temporary joints. The decision to be made in this case which type of joint is to be used depends on simplicity, whether detachable or permanent, cost and strength. Joints are an extremely important part of any structure. Whether held together by bolts or rivets or weldments or adhesives or something else, joints make complex structures and machines possible. Bolted joints, at least, also make disassembly and reassembly possible. And many joints are critical elements of the structure, the thing most likely to fail. When designing fastener joints, always design the most stable joint that provides the greatest bearing area. The strength of the joint could be varied by locating the joint in the optimum place and by choosing the optimum method to join the same.

II. FINITE ELEMENT ANALYSIS

FEM is a calculative technique for approximate solution of engineering problems with boundary conditions and certain loading. In present study, solid modeling was carried out using CATIA Software. Three-dimensional view of the plate combined with bolts circular, rectangular, square and diamond arrangements is shown in fig. 1, 2, 3 & 4.

Fig. 1: 3D Model of Circular Pattern
Fig. 2: 3D Model of Rectangular Pattern
Fig. 3: 3D Model of Square Pattern
Fig. 4: 3D Model of Diamond Pattern

As shown in fig. 1, 2, 3 & 4 two plates of dimension 500*180*25mm are connected by 8 bolts with a bolt size of M10*1.5*25mm. The bolts are placed in four different arrangements i.e; circular, square, rectangular and diamond. In order to simplify the model, hexagonal bolt head and nuts are idealized as circular and washers are not modeled. Bolts holes are assumed to be equal with bolt size. Finite element software (ANSYS) is used for stress analysis. The elements used in plate assembly model are first order Hexa and Penta elements. Finite element models for stress analysis are discretised into number of elements and nodes as shown in Fig. 5, 6, 7 and 8 respectively. Bolt joint model has been meshed by first order Hexa and Penta elements. Element type used is SOLID 185.
Stress Analysis of Bolted Joint by using FEA
(IJSRD/Vol. 4/Issue 04/2016/336)

After meshing (Discretisation) of geometric model, the material is specified for both plate and nut-bolts. Two material models were used in this model, one for the plate elements, and the other for the nut-bolts. The material for the plate is considered as hot rolled steel (HR) and the yield stress considered for the plate is 340 MPa. The material of bolt used is EN8 grade steel having its yield stress 950 MPa, Poisson’s ratio 0.3, modulus of elasticity 205*10^9 Pa. More details of material and their properties are given in Table 2.

<table>
<thead>
<tr>
<th>Component</th>
<th>Poisson’s Ratio μ</th>
<th>Young’s Modulus E (Pa)</th>
<th>Density ρ (kg/m^3)</th>
<th>Yield Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate</td>
<td>0.3</td>
<td>205*10^9</td>
<td>7800</td>
<td>340</td>
</tr>
<tr>
<td>Nut-Bolt</td>
<td>0.3</td>
<td>210*10^9</td>
<td>7800</td>
<td>950</td>
</tr>
</tbody>
</table>

Table 2:

The loading condition is specified in ANSYS software. Main focus of this dissertation is on the stress analysis of threaded fastener (Bolt) under shear loading. Hence left end of one plate is constrained (fixed) by keeping DOF zero for all nodes at the end surface of plate. Then a force of 1000-5000 N is applied gradually at the right end face of other plate.

After application of load the finite element model is solved in ANSYS for the stress results. The different stress component values for 5000N obtained in finite element analysis of M10 Circular pattern is shown in Table 3 and the contour plot of stress distribution for component i.e. equivalent stress, maximum principal stress, minimum principal stress is shown in fig. 9, 10 & 11 respectively.
The different stress component values for 5000N obtained in finite element analysis of M10 Rectangular pattern is shown in table 3 and the contour plot of stress distribution for component i.e. equivalent stress, maximum principal stress, minimum principal stress is shown in fig. 12, 13 & 14 respectively.

Fig. 12: Equivalent Stress Distribution

Fig. 13: Maximum Principal Stress Distribution

Fig. 14: Minimum Principal Stress Distribution

The different stress component values for 5000N obtained in finite element analysis of M10 Square pattern is shown in table 3 and the contour plot of stress distribution for component i.e. equivalent stress, maximum principal stress, minimum principal stress is shown in fig. 15, 16 & 17 respectively.

Fig. 15: Equivalent Stress Distribution

Fig. 16: Maximum Principal Stress Distribution

Fig. 17: Minimum Principal Stress Distribution

The different stress component values for 5000N obtained in finite element analysis of M10 Diamond pattern is shown in table 3 and the contour plot of stress distribution for component i.e. equivalent stress, maximum principal stress, minimum principal stress is shown in fig. 18, 19 & 20 respectively.

Fig. 18: Equivalent Stress Distribution
Stress Analysis of Bolted Joint by using FEA

Fig. 19: Maximum Principal Stress Distribution

Fig. 20: Minimum Principal Stress Distribution

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Equivalent Stress (MPa)</th>
<th>Max. principle Stress (MPa)</th>
<th>Min. principle Stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular</td>
<td>109.84</td>
<td>91.026</td>
<td>56.644</td>
</tr>
<tr>
<td>Rectangular</td>
<td>78.033</td>
<td>63.063</td>
<td>42.256</td>
</tr>
<tr>
<td>Square</td>
<td>90.12</td>
<td>127.45</td>
<td>114.39</td>
</tr>
<tr>
<td>Diamond</td>
<td>127.65</td>
<td>163.02</td>
<td>176.25</td>
</tr>
</tbody>
</table>

Table 3: Stress results for all patterns

III. RESULT AND DISCUSSION

From the above results we can see that the maximum value of equivalent stress observed in bolts connected in rectangular array pattern (78.033MPa) is less than in circular (109.84MPa), square (90.12MPa) and diamond array pattern (127.65MPa). This FEM analysis shows that for connection of two members with threaded fastener, the rectangular array pattern is more effective than connecting same members with circular, rectangular, square and diamond array pattern by keeping number of bolts same.

IV. RESULTS AND CONCLUSION

Stress analysis of bolted joint using Finite Element Method is carried out with different types of patterns and satisfactory results are achieved. From above results, it is concluded that for connection of two members with threaded fastener, the rectangular array pattern is more effective than connecting same members with circular, square and diamond array pattern by keeping number of bolts same. It is also concluded that even by changing the orientation of bolts (i.e. Circular, Rectangular, Square and Diamond array configuration), stresses induced in all the specimens are within the yield limit of the material. Hence, instead of connecting the two steel plates with the help of eight number of M10x1.5x25 mm bolts, we can use same number of M8x1.25x25 mm bolts for the same loading conditions, as the maximum shear stress produced is sufficiently less than the permissible limit.

Further there is scope to reduce the number of bolts from eight to six for the same loading conditions, as the maximum shear stress produced is sufficiently less than the permissible limit.

REFERENCES