IOSR Journal of Mechanical & Civil Engineering (IOSRJMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X
PP 61-64
www.iosrjournals.org

Analysis of Stresses in Bolted Flange - A Review

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Abstract:*The modern world depends largely on various mechanical components to survive, one of the components is flange and any pipe interconnection requires flange. Flanges are primarily used where a connecting or dismantling joint is needed. Flange joints may include joining pipe fittings, valves or any integral component within the piping system. This paper reviews on behaviour of bolted flange and its analysis***.**

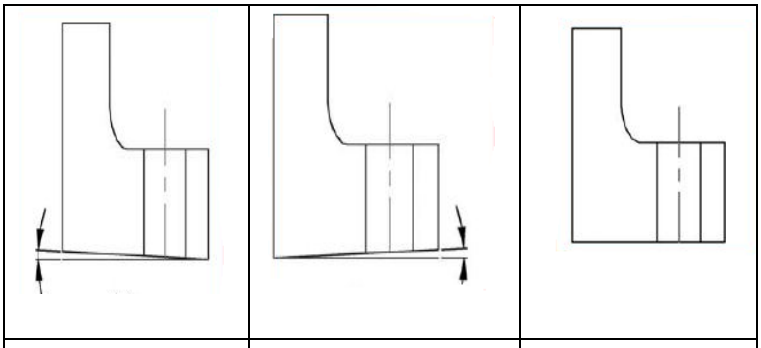
Keywords -*Bolted Flange, Flanges, mechanical components, Analysis*

I. INTRODUCTION

With the rapid advancement in Technology for high pressure and temperature applications, it is necessary to analyse the stresses and behaviour of bolted flange. Bolted flanges forms a part of pressure vessel and piping components, they are widely used in chemical and nuclear power industries.Flange is the most essential part of the pressure vessel,condenser,heat Exchanger and storage tank. Flanges are used on shell of a vessel or an exchanger to permit disassembly and removal or cleaning of internal parts. A bolted flange joint involves the interaction between the bolting, flange and gasket. Some previous study like G. Mathan[1] conducted experiments on gasketed flange joint and analyzed bending loads in flange joints through FEA and results were compared with experimental studies.

II. LITERATURE REVIEW

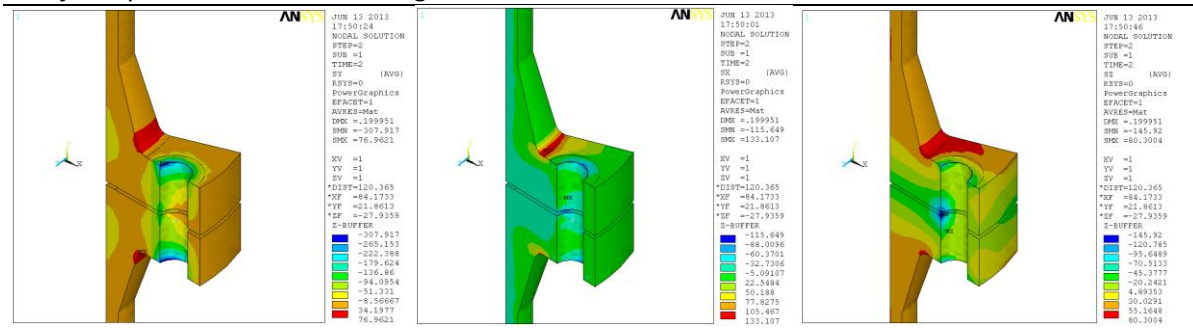
M. Murali Krishna et.al [2] studied the sealing performance of bolted flange joints with gaskets using finite element analysis; three dimensional finite element analysis (FEA) of bolted flange joint is done.Analysis shows that the distribution of contact stress has dominant effect on sealing performance and gaskets play an important role in the sealing performance of bolted flange joints.M.Abid [3] discussedon parametric study ofbehaviour of flanges with different surface profiles. Stresses in flanges and bolts are obtained by varying flange thickness, taper angle and bolt prestress but keeping the flange dimensions (hub length and hub thickness) constant. He concludes that, to achieve 'no-leak' condition from a flange joint, a flange having positive taper angle, elliptical hub, and thickness atleast six times the bolt diameter is required.



a) concave profile	b) convex profile	c) flat surface

Fig.1Flanges with different surface profiles.

Vishwanath V. H [4] discussed analysis of Bolted flange connections by implementing the design method for gasketed bolted flanged connections as per ASME Boiler and Pressure Vessel Code and validated the results with finite element analysis software ANSYS. Axial, radial and tangential stresses are obtained by varying flange thickness from 44.4 mm to 55 mm; bolt preloads are varied from 35 % of yield strength to 75% in step of 5% and to obtain uniform stress numbers of bolts are varied from 6, 8 and 12 bolts [4].



Axial stress Radial stress Tangential stress

Fig.2 Stresses in Flange [4]

Toshiyuki [5] discussed the characteristics of a pipe flange connection with a spiral-wound gasket. The contact stress distribution and the new gasket constants are obtained by using the axi-symmetrical theory of elasticity and the finite element analysis taking account a hysteresis and non-linearity of the gasket. The experiments were also conducted to measure an amount of gas leakage and a variation in axial bolt force, in results it was found that contact stress distribution tends to be uniform as Young's modulus of the gasket decreases and the gasket thickness increases. stress distributions in the pipe flange connections were analyzed by using FEM.

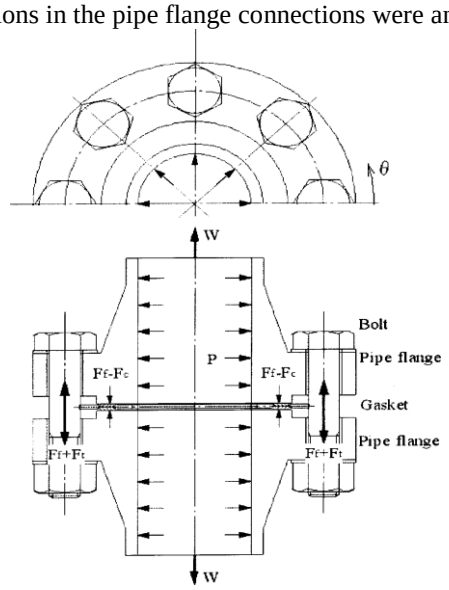
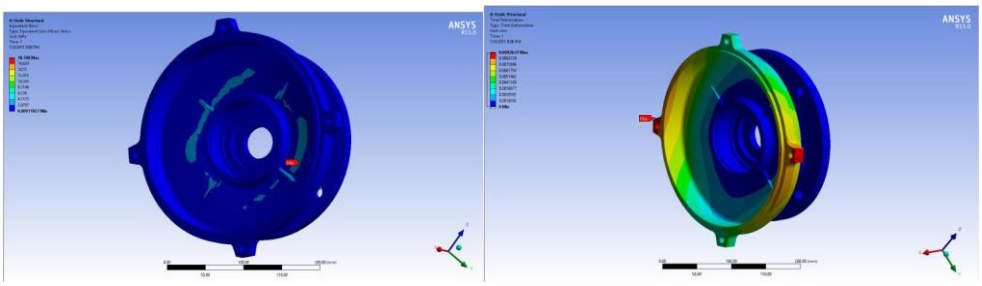


Fig.3 A pipe flange connection with a spiral-wound gasket subjected to internal pressure [5]

III. STRESS ANALYSIS OF FLANGE USING FEA

In industry there are various requirement of motion for which prime movers like Motor or Engines are used. Motors are widely used as prime movers as they give uniform motion and control of speed and direction as compared to engines.[6] Flange mounted motor is a motor in which flange is bolted to wall on which whole motor is mounted. So that entire weight of a motor acts on flange. Bhale Pritish[6] discussed about static and dynamic analysis of motor flange using FEA. The following results were found,



a) Stress Distribution b) Deformations

Fig.4Static Condition[6]

Figure indicates the stress distribution and deformation changes of flange because of the load. The maximum deformation is occurs at the end of the flange where bolt is to be applied to the motor assembly. In this motor there are only two components is motion, i.e. shaft and rotor. [6]

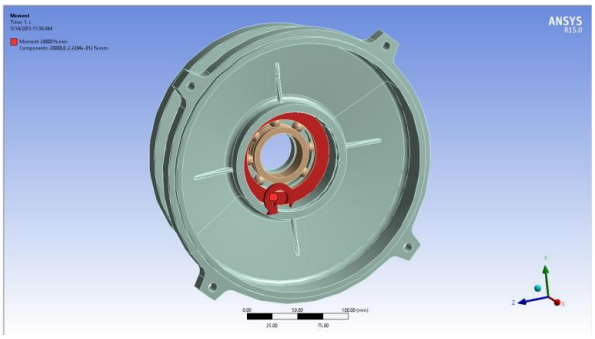
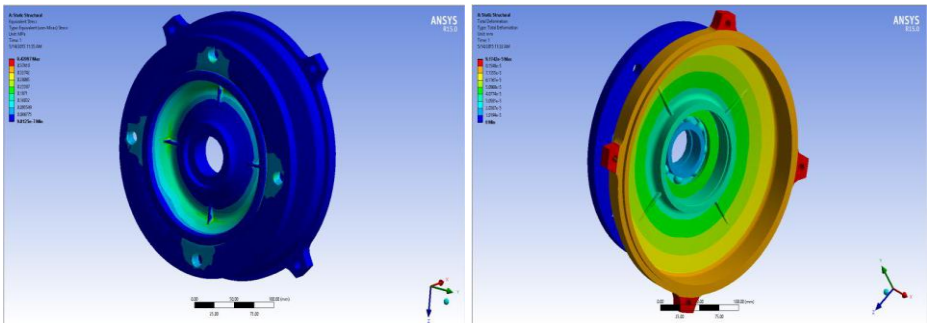


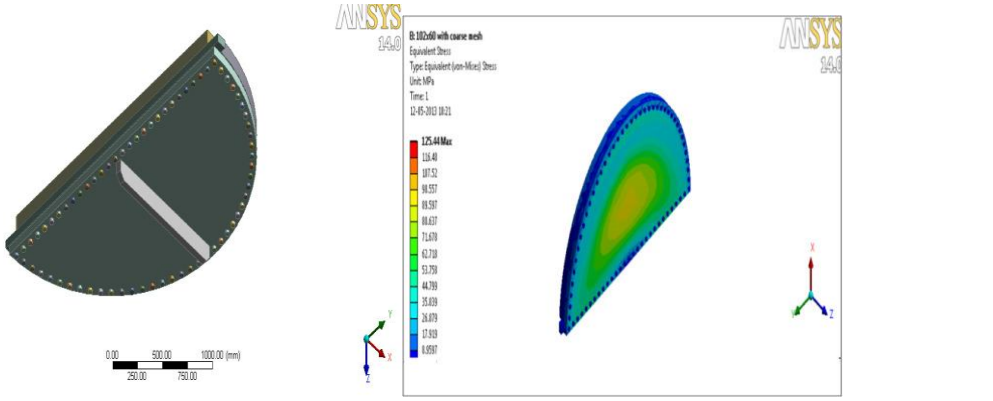
Fig.5Torque application[6]



a) Stress Distribution b) Deformations

Fig.6Dynamic Condition[6]

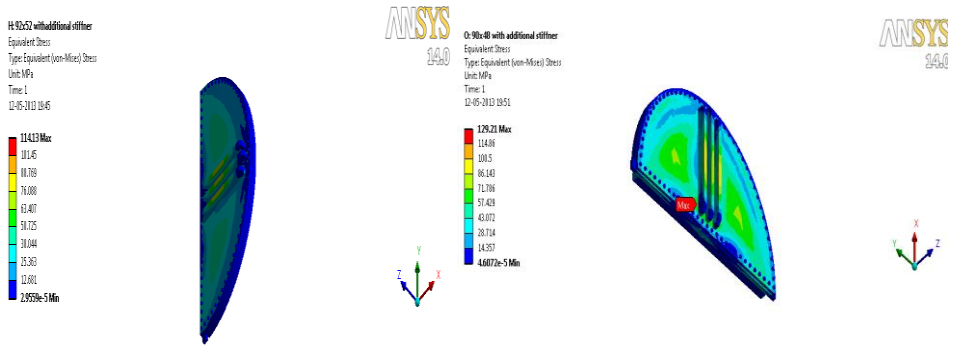
The maximum stresses are developed at the bearing region and maximum deformation occurs at the end of the flange where bolt is to be applied to the motor assembly[6]. P. M. Desai [7] discussed on design, analysis and optimization of body flange & cover flange by using FEM approach and its validation by analytical as per ASME Code. Numerical Simulation techniques are used for analysis of ring type flange. The result of numerical simulation overcomes the limitation of analytical approach which is observed from the results of suggested model. The optimum Value of thickness of Cover Flange and Body Flange are 48 mm and 90 mm respectively.



a) Symmetry Model of Flange b) Finite Element Analysis of Flange

Fig.7 Modelling and Analysis of Flange [7]

The finite element analysis results of this modified design are shown in Fig.8. The value of stress obtained from new model is 114.13MPa as shown in the Fig. 8(a) which is far away from allowable stress limit of 138MPa. A new model has been prepared by decreasing the thickness of cover flange and body flange from the 52 to 48 and 92 to 90 respectively. The stress obtained for the above model is 129.21MPa as shown in figure (b) which is within the allowable limit.



a) Total deformationb) Von-misses stress

Fig.8 Deformations and Stresses in Flange [7]

IV. CONCLUSION

Bolted flange connections are analyzed by using design method for gasketed bolted flange connections as per ASME Codes Section VIIIand results are validated with Numerical simulations.

Acknowledgements

Authors are thankful to the Management of WIT Solapurfor their continuous encouragement and support.

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