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STRUCTURAL AND FATIGUE LIFE ANALYSIS OF TUBE FLANGE WELD JOINT

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Abstract: The welded joints are used in various mechanical and civil structures which connects two or more parts aligned in same or different directions. The strength of weld joint largely depends upon its geometric design parameters. The objective of current research is to conduct numerical investigation on tube flange weld joint under torsional loading conditions. The designing and analysis of weld joint is conducted in ANSYS 20 software to determine stresses, deformation and safety factor. The weld parameters are then optimized to study the effect of these parameters on stresses generated.

Key Words: Weld joint, Stresses, Optimization

1. INTRODUCTION

The term 'weld joint design' refers to the way pieces of metal are put together or aligned with each other. Each joint's design affects the quality and cost of the completed weld. Selecting the most appropriate joint design for a welding job requires special attention and skill.

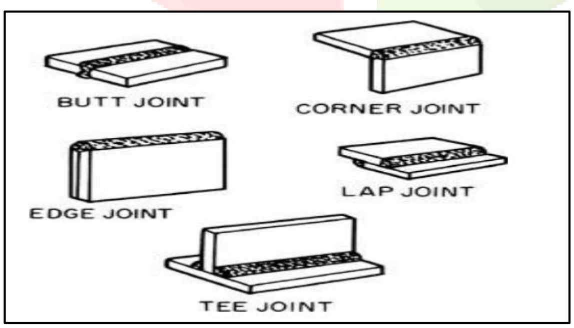


Figure 1: Types of weld Joints

The actual strength of welded joints is affected by different parameters viz. weld quality, material, thickness, stress ratio, welding technique [2]. During the welding procedure, diverse kinds of material defects and blemishes are initiated into the subsequent welded joint. Material imperfections are for instance; softening in the heat affected zone (HAZ) and residual stresses, likewise greatly affect the diminishment of the fatigue life [3]. Fatigue strength is known to be firmly related with the exact geometrical attributes of the welded joint (i.e., weld toe radius, flank angle and weld size). The bead geometry relies upon the welding parameters, the working conditions and at some places, the skills of the welder. The bead shape (specifically the toe range) changes from joint to joint even in all around controlled manufacturing operations [1, 2].

2. LITERATURE REVIEW

V. Caccese et. al. (2006) [5] has conducted experimental investigation of laser weld joint made of HSLA-65 steel material. The fatigue loading is applied on specimen using compression type load and tension type load. The findings have shown superior weld strength using laser welding method as compared to conventional welds.

Vijay Kumar et. al. (2016) [6] has conducted experimental testing on weld joint using UTM machine. The effect of weld parameters like gap size and overlap length on tensile strength of lap welded joint is investigated.

K. V. Sastry et. al. (2015) [7] has conducted structural and fatigue life analysis of weld joint using techniques of Finite Element Analysis. The analysis is conducted by varying weld bead dimensions. The FE results have shown the stress within the safe limit and Butt joint has more fatigue life as compared to other weld joints.

Akkas et. al. (2013)[8] has conducted experimental investigation on bead geometry of weld joint to investigate the effect of weld joint parameters on strength of weld joints. The "welding parameters such as the arc current, arc voltage, and welding speed which have the most effect on bead geometry are considered, and the other parameters are held as constant. Then, "the relationship between the welding parameters is modeled by using artificial neural network (ANN) and neuro fuzzy system approach and each model is checked for its adequacy by using test data which are selected from experimental results" [8].

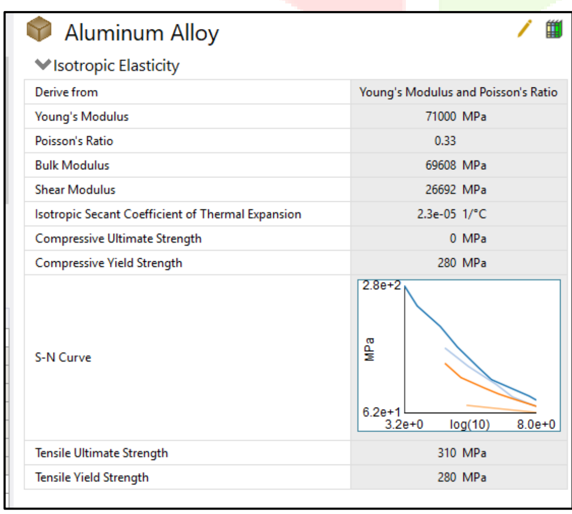
P. J. Mistry et. al. (2016) [9] has conducted experimental investigation to determine the effect of process parameters like "welding arc current, voltage, welding speed, and the contact tube to work distance on weld bead geometry such as weld penetration, weld bead width, and height of reinforcement" on the quality of weld joints. The results obtained from the analysis aided in developing improved quality of weldments in electric arc welding process.

3. OBJECTIVES

The objective of current research is to conduct numerical investigation on tube flange weld joint under torsional loading conditions. The designing and analysis of weld joint is conducted in ANSYS 20 software to determine stresses, deformation and safety factor. The weld parameters are then optimized to study the effect of these parameters on stresses generated

4. METHODOLOGY

The FE analysis process involves 3 stages which includes preprocessing (defining material properties, CAD modeling and meshing), the 2nd stage is solution of the problem and 3rd stage is postprocessing. The aluminium alloy material property is defined using ANSYS library file and details are given in figure 2 below.



Aluminum Alloy

Isotropic Elasticity

Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	71000 MPa
Poisson's Ratio	0.33
Bulk Modulus	69608 MPa
Shear Modulus	26692 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.3e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	280 MPa
S-N Curve	
Tensile Ultimate Strength	310 MPa
Tensile Yield Strength	280 MPa

Figure 2: Aluminium alloy material properties

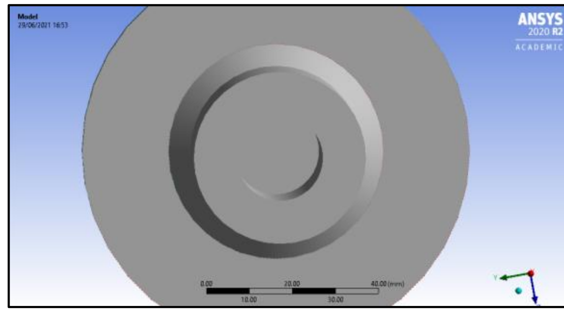


Figure 3: Tube flange joint design

The model of tube flange weld joint is developed using sketch and revolve tool of ANSYS design modeler. The sketch is first developed using dimensions from literature [4]. The weld joint model is meshed with size and curvature settings and tetrahedral elements as shown in figure 4 below.

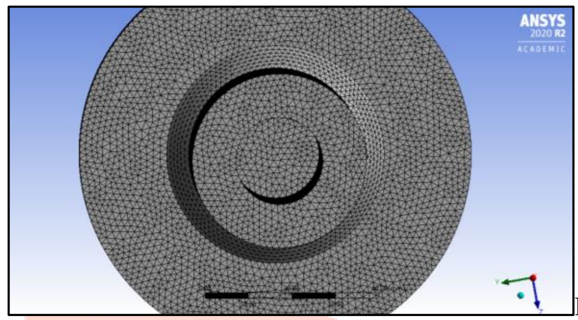


Figure 4: Meshed model of joint

The layers in meshing is set to 5 with growth rate set to 1.5 and transition set to smooth. The discretized model is used to formulate stiffness matrices associated with each element.

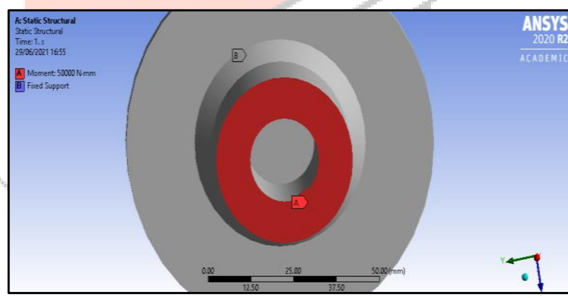


Figure 5: Meshed model of joint

The bottom face of model is applied with fixed support and front face of model is applied with moment. The boundary conditions applied on the model results in torsional loading which causes twisting of the joint model. The fatigue life assessment is also conducted on the model and this is given by the application of cyclic loading on the model. The cyclic loading is given in the form of fully reversed type and analysis type is set to stress life approach. The simulation is run and during the process, the stiffness matrices for each element is formulated, assembled and finally results are generated at nodes. The results on the other regions is evaluated by linear or quadratic interpolation function of each elements.

5. RESULTS AND DISCUSSION

Under the given loading, the stress and deformation plots are obtained which shows the location of high stress concentration and possible zones of failure. The shear stress plot is shown in figure 6 below.

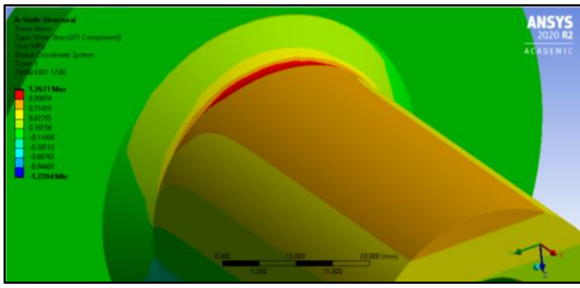


Figure 6: Equivalent stress plot of weld design

The shear stress plot shows maximum stress concentration at the corner region which is shown in red color. The stress at the region ranges from .9 MPa to 1.12MPa and the twisting of member causes high stresses at these corner regions. The stress decreases linearly as we move towards the free end of the weld design. The stress at this region ranges from .43MPa to .71MPa.

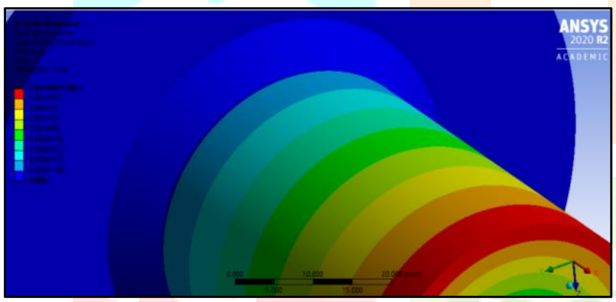


Figure 7: Total deformation plot of weld design

As it can be observed from figure 7 above, the maximum deformation is obtained on free end of weld design because of maximum distance from the supported ends.

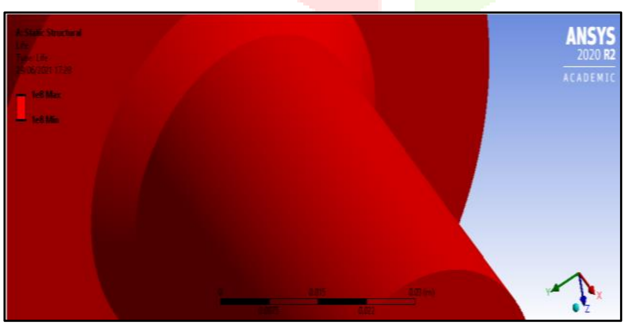


Figure 8: Fatigue life of weld design

The fatigue life plot of the component is shown in figure 8 above. From the fatigue life assessment, the component is marked to be safe and can bear 1e6 cycles which shows that the design of component is for infinite life in ideal conditions. The design of weld joint is optimized and some results are obtained.

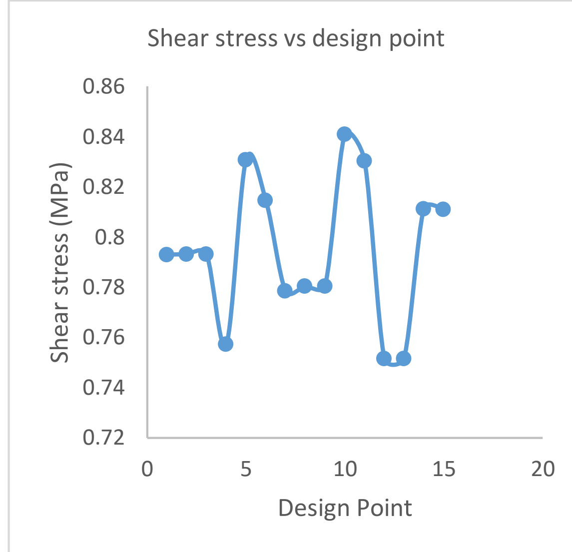


Figure 9: Shear stress vs design points

The shear stress vs design points curve is generated as shown in figure 9 above. The shear stress obtained is maximum for design point number 10 and dimensions corresponding to design point number 10 is alpha 139.07^0, h is .45mm and t is 1.0006mm. The weld design made using these dimensions will show maximum shear stress. The shear stress is minimum at design point number 12 and dimensions corresponding to design point number 12 is alpha 130.93^0, h is .454mm and t is 1.0006mm.

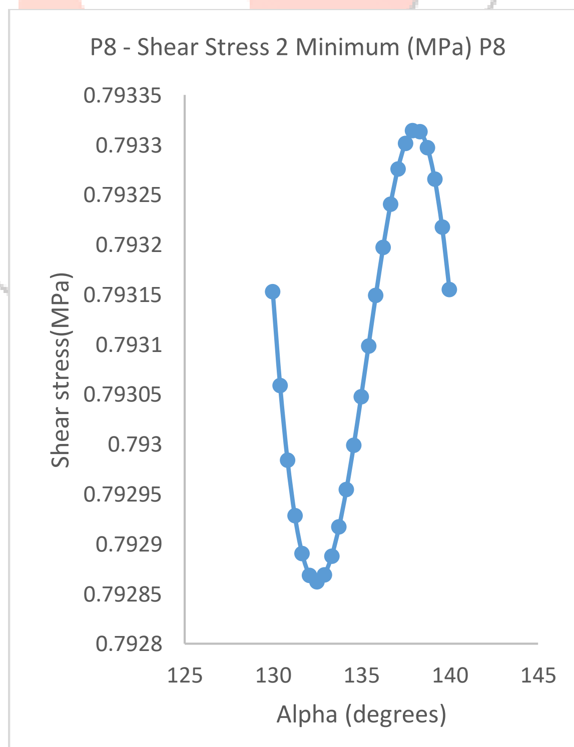


Figure 10: Shear stress vs alpha (weld angle)

The variation of shear stress with respect to weld angle i.e. alpha is shown in figure 10 above. The graph linear decrease in shear stress and reaches minimum value at alpha value of 132.5^0 and then linearly increases and reaches maximum value at 138.8^0. The shear stress then decreases thereafter and reaches to .79MPa. So the graph shows that shear stress has both decreasing and increasing trend.

6. CONCLUSION

The FE simulation is viable tool in determining structural characteristics of weld joint subjected to different loading conditions. The simulation packages significantly reduce time and cost required for analysis as compared to other experimental methods. From the analysis conducted on welded joint, it is observed that the weld angle has significant effect on shear stress generated. Under the given loading conditions (torsional load) the weld joint possess sufficient strength and factor of safety. The fatigue life assessment of the weld joint shows the component life is ideally infinite.

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