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Experimental & Finite Element Analysis Of strength Of an Arc Fillet Weld for 1020 Mild Steel Plates

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ABSTRACT

The aim of the recent work is to analyse experimentally and to simulate a fillet welding joint between two 1020 mild steel plates using the weld metal as 302 stainless steel and the joint are analyse for residual and thermal stresses developed in them. Then the residual stresses in weld joint are analysed for superimposed on thermal stresses. After getting the results our aim is to suggest improvement in the joint by minimizing the stresses and reducing chances of cracking by a change due to stress corrosion in weld metal. For these Literature survey had done and found that the residual stress, if not considered while designing the welded joint leads to an underestimation of the actual stresses and ultimately the part fails in its stated service life. After the weldment got prepared it is tested on UTM machine. For the analysis Finite Element method and experimental techniques are used. The transverse static load which were subjected to an arc welded lap joint is to be considered for the analysis. By varying the gap between the parent plates in the weldment the stresses are evaluated which occur during manufacturing. Finite element results are verified experimentally and analytically to determine weldment breaking strength.

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I. INTRODUCTION

Welding is a manufacturing process of creating a permanent joint obtained by the fusion of the surface of the parts to be connected each other, by a filler material and with or lacking the application of the pressure. The materials to be joined may be similar or dissimilar to each other. Heat required for the fusion of the material may be obtained by burning of gas or by an electric arc. The second method are widely used due to greater welding speed. Welding are widely used in fabrication as an optional method for casting or forging and as a substitute for bolted and riveted joints. It is use as a renovate medium e.g. to reunite a crack metal or to build up a minute part that has broken down such as a gear tooth or to repair a worn surface such as a bearing surface.

II. PROBLEM STATEMENT

For the FE & Theoretical analysis on the weldment of Arc Welded Lap-joint, three plates will be used. Two plates of uniform dimensions of 100mm X 50mm X 8mm thick will be welded with one plate with weld size of 5 mm providing the gap between them to take into account the positional error which may occur during welding or manufacturing. The analysis will be carried out using analytical, experimental & Finite Element method considering transverse loading on weldment. The gap between parent plates will be varied from 0.1 mm to 1.0 mm to take into account the positional error.

III. OBJECTIVE

In this work following objectives will be addressed.

- Static stress analysis of weldment will be carried out by FEM using ANSYS WORKBENCH
- Experimentation will also be carried using UTM to determine the breaking strength of weldment to validate the FE model & results.
- Comparison between FEM and Experimental Results.
- The stresses in the weldment are evaluated by varying the gap between the parent plates which may occur during manufacturing.

IV. RESEARCH MYTHOLOGY

This research work deals with the stresses in the weldment of welded lap-joint under static load condition. For the analysis, Experimental techniques and Finite Element method are use. The transverse static load which were subjected to an single arc welded lap joint is to be considered for the analysis. By varying the gap between the parent plates in the weldment the stresses are evaluated which occur during manufacturing. F.E results are verified experimentally and analytically to determine weldment breaking strength.

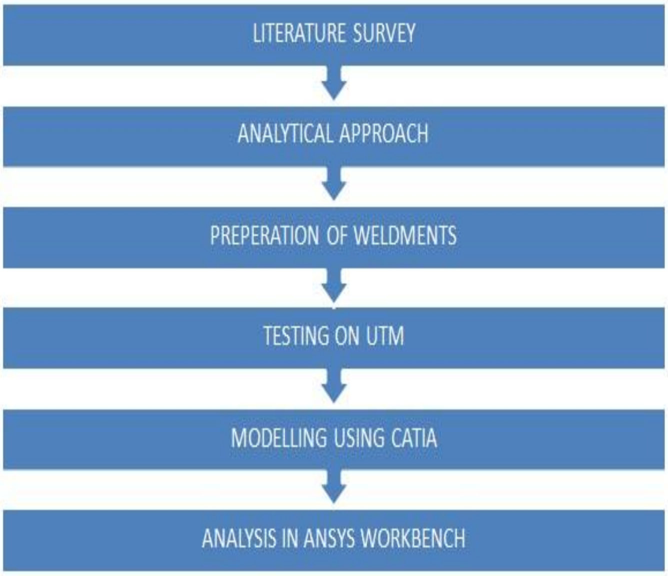

Figure 1: Flow Chart

V. EXPERIMENTAL ANALYSIS

For the FE & Theoretical analysis on weldment of Arc Welded Lap-joint, three plates will be used. Two plates of uniform dimensions of 100mm X 50mm X 8mm thick will be welded with one plate with weld size of 5 mm providing the gap between them to take into account the positional error which may happen during welding or manufacturing. The analysis will be carried away using analytical, Finite Element & experimental method considering transverse loading on weldment. The gap among parent plates will be diverse from 0.1 mm to 1.0 mm to take into account the positional error.

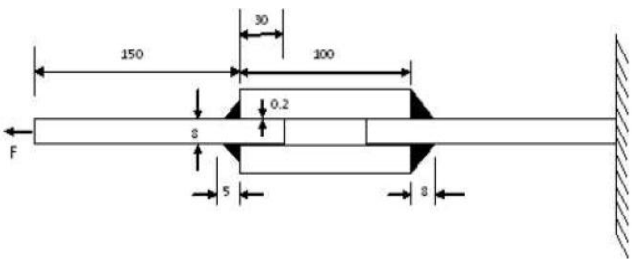

Figure 2: Dimensions for Test Specimens

Figure 3: UTM Testing machine

The prepared specimen with varying Gap 0.1mm to 1.00 mm mounted and tested on the UTM machine.

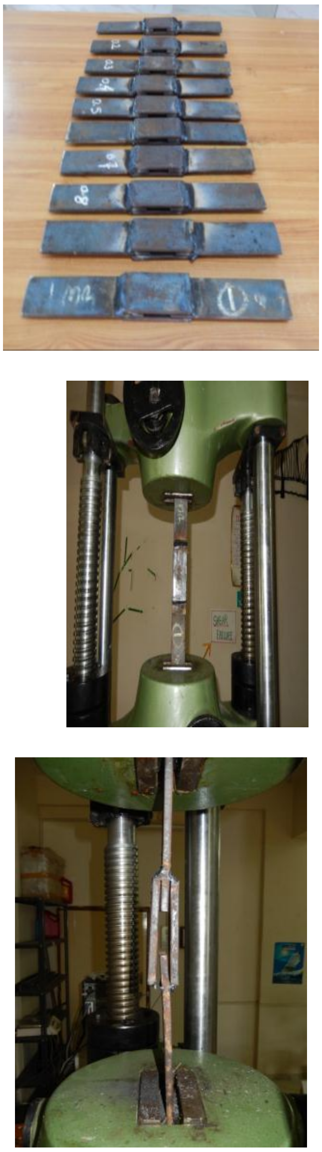

Figure 4: Specimen Prepared, Mounted and Tested on the UTM machine

It is seen that the weldment having weld size of 5.0 mm has failed under the load of 144.4 KN, which revealed the breaking strength for the weldment. The experimental breaking stress found out to be 1422.87 MPa.

VI. 3-D CAD MODELLING

3-D Cad model had modeled in Catia v5. Total 10 cad model had model for the specimen having gap varying from 0.1 to 1.0 mm between weldment. These Cad model are taken for the further analysis in Ansys.

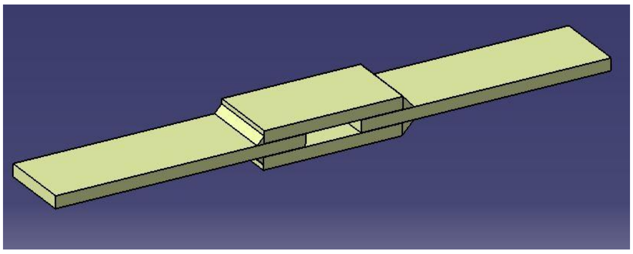

Figure 5: 3-D Cad Model

VII. FINITE ELEMENT APPROACH

For this Static Structural Analysis are performed, the modulus of elasticity taken 2 x 10^5 Mpa and poisson's ratio taken 0.3. Meshing was done for plates and weld with different element size. Element size for plate was 3mm and for weld it was 1mm which was further refined for better result. Element "Tetrahedron" are used .To perform an static finite element analysis the required constraint and load are added. The force F=144.4 KN applied from 5mm weld size side denoted by "A" and the remaining end was fixed from 8mm weld size side of the specimen denoted by "B".

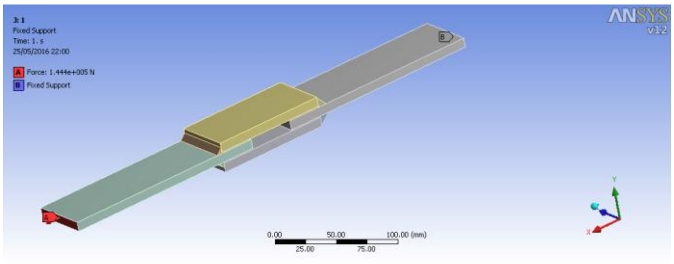

Figure 6: Boundary Condition

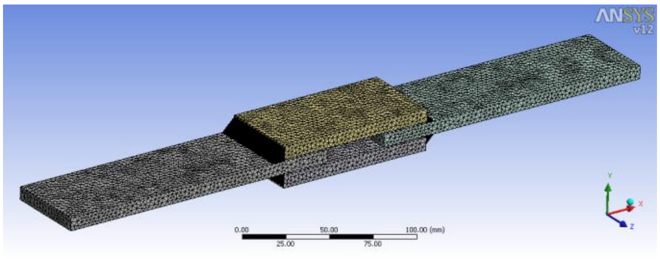

Figure 7: Meshing of Welding Specimen

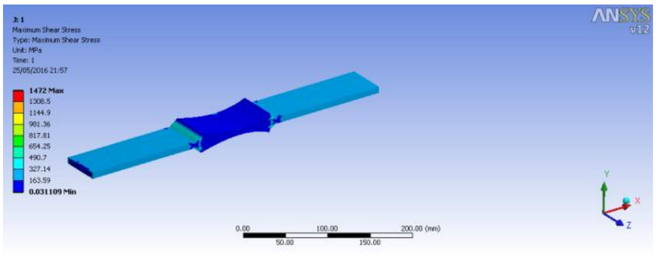

Figure 8: Analysis of 1 mm Gap Specimen having maximum shear stress

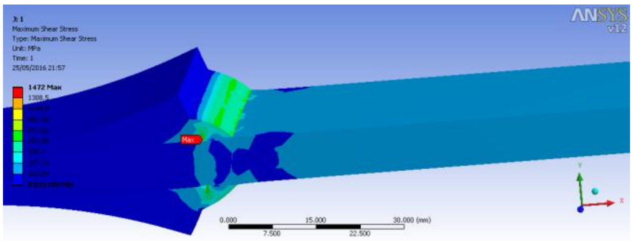

Figure 9: Enlarge View Analysis of 1 mm Gap Specimen having maximum shear stress

The variation of maximum shear stress as per weld geometry is shown in figure.10 are also studied along the throat thickness

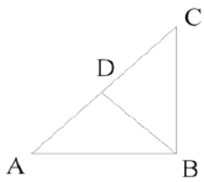

Figure 10: Weld Geometry

AB= Weld Length
BD= Throat Thickness

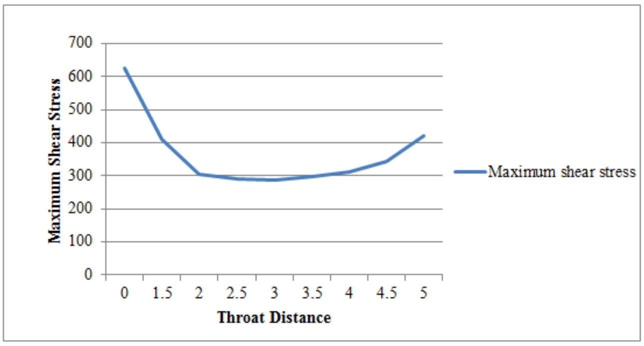

Figure 11: Graph Along Throat Distance and Maximum Shear stress

VIII. DISCUSSION AND CONCLUSION

The experimental determination of breaking strength of Arc welded Lap joint with 1 mm gap between plates revealed the breaking stress 1422.87 MPa. The FE analysis of Arc welded lap joint for the same geometry revealed the maximum shear stress of 1472 MPa. This investigation confirmed that the breaking stress in the weldment determined by experimentation and FE analysis are in close agreement. The static stress analysis on weldment is performed to take into account the positional error which may occur during manufacturing. For this purpose the gap between the parent plates is varied from 0.1mm to 1mm and it is observed that the maximum shear stress in the weldment varies w.r.t. gap between the parent plates. It is seen that the maximum shear stress reduces as the gap between the plate increases. This may be due to shifting of shearing zone of the weldment which resulted into increase in the throat length. Further investigations are required to verify this fact under fatigue loading and also under other loading condition like bending load etc.

The following are the FEA results of Maximum Shear Stress with the varying Gap from 0.1mm to 1.00 mm between the plates.

Sr. No.	Gap between parent plates (mm)	Maximum shear stress (Mpa)
1	0.1	584.98
2	0.2	577.63
3	0.3	380.14
4	0.4	575.76
5	0.5	331.83
6	0.6	372.53
7	0.7	1146.8
8	0.8	1461.1
9	0.9	1466.6
10	1	1472

Table 1: Result From FEA Analysis

The following are the Experimental results of Maximum Shear Stress with the varying Gap from 0.1mm to 1.00 mm between the plates.

Sr. No.	Gap between parent plates (mm)	Maximum shear stress (Mpa)
1	0.1	434.23
2	0.2	417.74
3	0.3	354.86
4	0.4	512.52
5	0.5	287.91
6	0.6	342.74
7	0.7	1106.23
8	0.8	1379.67
9	0.9	1396.19
10	1	1422.87

Table 2: Result From Experiment Analysis

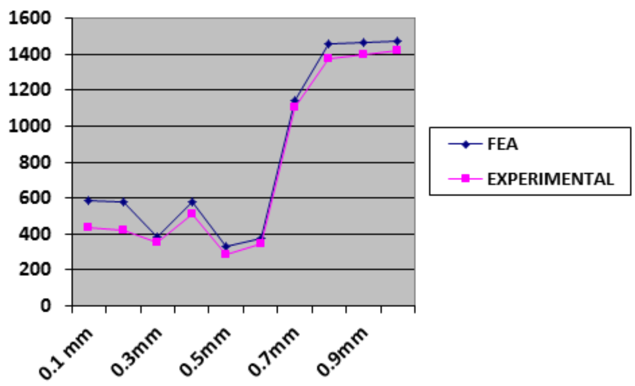

Figure 12: Comparison of Gap Vs Stress of FEA and Experiment Results

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