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Cracking Propagation and Fatigue Weld Strength Analysis using Finite Element Analysis

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Abstract: - Welding is the main manufacturing process in many engineering applications. Welding is done by fusion of the parts to be welded. Any cracks in the weld will reduce the strength of the joint. Many techniques are available which comes under both destructive and non-destructive techniques. Since non-destructive testing methodologies requires time and setting up, it is always better to apply finite element techniques which works through virtual simulation and helps the designer with number of simulations. It also gives stress at every critical location and so the propagation or the value of stress helps in improving the designs. In the present work, finite element analysis is applied to find the strength of the joint under cracking. The results are represented which shows strength reduction of the joint.

1. INTRODUCTION:

Welding is the process used for permanent joining of the process. It is a very old technique and is based on melting the edges of the parts to be joined by fusion process. Welding is classified in to number of types like gas welding, thermit welding and electric arc welding. In the present work, the parts joined by electric arc welding process are considered. Through arc craters due to improper welding process or improper cooling process, the cracks will initiate in the assembly after certain period of loading. The present work is concerned to the strength of joint for different cracking propagation patterns.

2. LITERATURE REVIEW:

Fracture is very important parameter of reducing the strength of the welded structures. Lot of literature has been done to find the fatigue crack life on welded configurations. J.J. Janosch[1] in his article "Welded Assemblies of E-36-4 Steel as a function of the penetration of the Weld subjected to tensile and bending loads" has conducted tests to reveal degree of incomplete fusion below by which discontinuity will be created has no effect on fatigue strength after certain limits. In his study, he mainly concentrated on effect improper penetration on weld strength. He has applied finite element method for finding the propagation of micro cracks with further loading. He has represented graphs for fatigue life with depth improper weld continuity. T. BNykanen[2] has analysed one sided flllet welded T-joints for strength using fracture mechanics parameters. Plane strain Linear elastic fracture modeling is considered for results. Paris crack growth model is considered for crack propagation and stress flow lines. The strength reduction with improper penetration of weld has been analysed. Weld length , height and plate thickness effects are analysed. Drazan Cozak[3] has studied the effect of fracture parameters on weld strength and cracking. Single edge notch , three point bend specimens are considered for analysis. The comparison has been done between experimental analysis techniques to numerical techniques. The finite element analysis has been used for finding the threshold crack loads. Nenad Gubeljak[4] has discussed causes of the brittle fracture of the welds. He has concluded the brittle regions in the welds are the potential sources for cracking. Unstable fracture component was analysed for which different hardness is observed two brittle weld regions. The formation of different hardness is attributed to multipass welds also attributed to AC welding. Even the metallic inclusions or alloying of the materials are also the source for weld brittleness. Peter Bernasovsky[5] has analysed various types of cracks in the welds. Mainly they are classified to hot cracks, cold cracks, Lamellar tearing and reheat cracks. They are mainly found in the heat affected Zone(HAZ) from where they propagate to the parent metal. He has selected the cracks on real structures to find the fatigue fracture effect experimentally. Teppel Okawa[6] in his article discussed methods to improve fatigue crack life with opening and closing of cracks and resulting residual stresses on the system. Further fatigue life improvement techniques like UIT has been discussed. The analysis has been done for variable loads. A comparison has been done with the calculated values with experimental values. Slight variation is observed between the results

3. METHODOLOGY:

A plain strain approach is used to defined the finite element process. 4 noded Plane42 element is used for meshing the geometry of 100mmX100mm with 10mm thickness of the plates. A triangular weld is considered to join the members. A cracking pattern is considered at the end of the triangular weld. During welding the pressure vessel members, only outer weld will be provided due to improper space availability for the lower regions. The present is mainly concentrated on this type of welds. So the members has only X constraint during loading, but free to move in the other directions.

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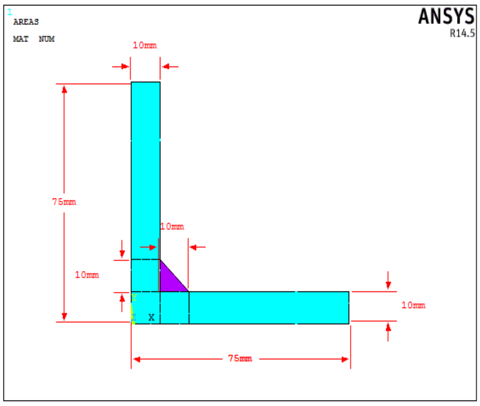

Fig1: Geometry of the Weld

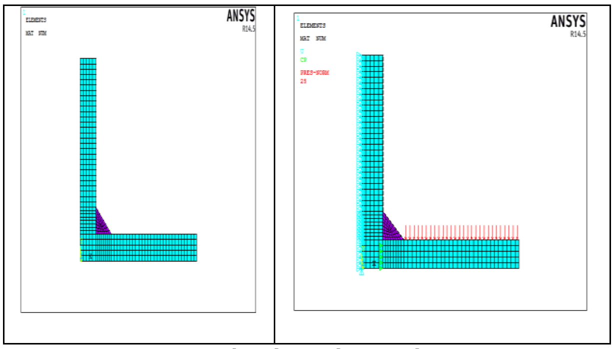

Fig2: Mesh and Boundary Conditions

	Mild Steel Plates	Weld
Young's Modulus(GPa)	200	120
Poison's ratio	0.3	0.22
Tangent Modulus(Mpa)	250	200

Table1 :Material Details of the Mild Steel and Weld Material

4. RESULTS &DISCUSSION :

Case 1:

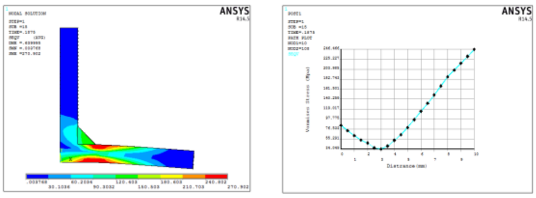

Fig3: Stress and Stress behaviour across the cross section for Full Weld

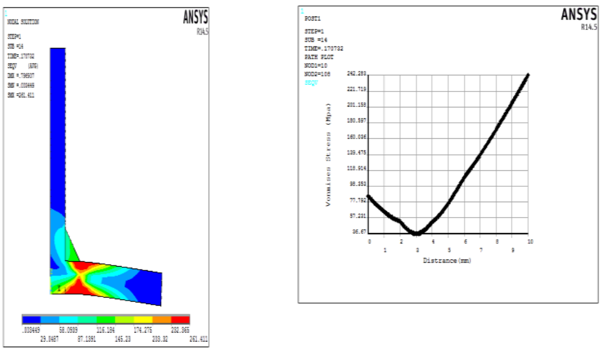

Fig4 :Stress and Stress behaviour across the cross section for 80% weld

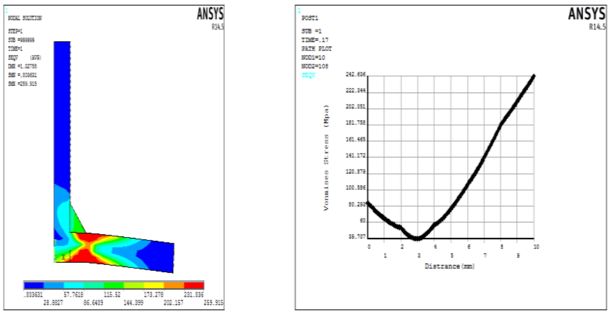

Fig5 :Stress and Stress behaviour across the cross section for 60% weld

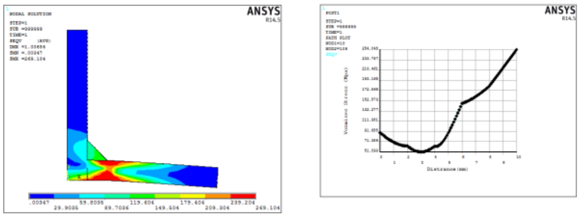

Fig6 :Stress and Stress behaviour across the cross section for 40% weld

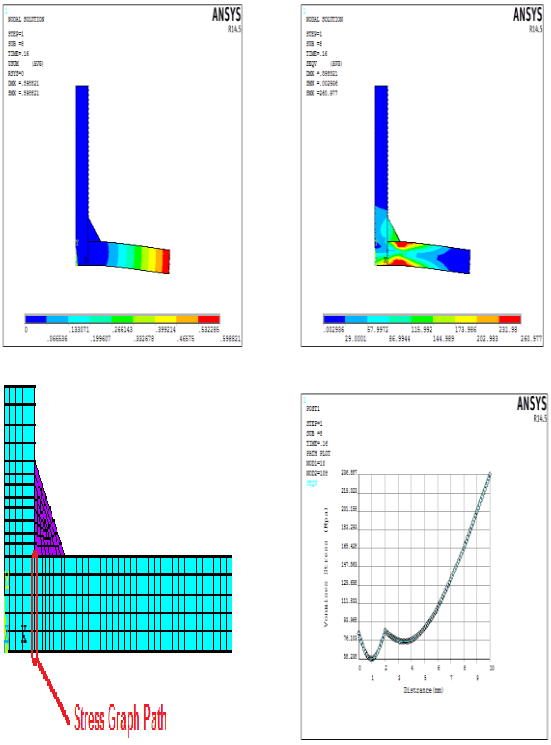

Fig : 7 : Stress and Stress behaviour across the cross section for 20% weld

Weld Condition	Deformation(mm)	Maximum Stress(Mpa)
Full	0.639	270.9
80%	0.796907	261.411
60%	1.32755	259.915
40%	0.796	269.104
20	0.598	260.977

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Table: Comparative Structural Analysis

Weld Condition	Minimum Stress Across the Section(Mpa)	Fatigue Stress For Alternating Stress(Mpa)
Full	24.049	147.4745
80%	26.67	144.08
60%	29.707	144.811
40%	51.092	156.215
20	58.238	164.519

Table: Minimum Stress and Alternating Stress in the Structure

6. CONCLUSIONS:

Weld strength analysis has been carried out and a comparison for stress, deformation and minimum stress across the section has been obtained. The results shows increasing minimum stresses across the geometry. This is very important parameter in the fatigue life of the joint. This will increase either mean stress of the joint or alternating stress in the member if it is negative stress. In the present problem the stress is a negative in nature and so it increases the fatigue stress. Increase in the fatigue stress reduces the life of the joint. For better life of the joint, it is always desirable to have lesser alternating stress which has greater influence on the durability of the components.

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