STRESS AND STRAIN ANALYSIS OF WELDED JOINTS

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Abstract

Failure of welded structures/machine components lead to various direct losses such as the cost of repair work, the cost of the work to prevent future failure and accident compensation, and indirect losses such as decrease in production and a damage to company's image. Joints being the weakest elements in any structure/machine are likely to fail first. It is, therefore, imperative to understand the failure of these joints.

Understanding a failure occurrence and its propagation will lead to a better appreciation of welded joints from reliability point of view. It may be possible that a few cause events or failure causes may be crucial and could be minimized at design or fabrication stage leading to failure minimization of such joints. Arc welding, which is heat - type welding, is one of the most important manufacturing operations for the joining of structural elements for a wide range of applications, including guide way for trains, ships, bridges, building structures, automobiles, and nuclear reactors, to name a few. It requires a continuous supply of either direct or alternating electric current, which create an electric arc to generate enough heat to melt the metal and form a weld.

In this process, stress concentration at the welded joints is analysed. The type of joints considered is Tee Joint, Butt Joint and Lap Joint. Structural and Fatigue analysis is done on the welded joints in Ansys.

Keywords: Fatigue Analysis; T-Joint; Butt Joint; Lap Joint; Welded Joints:

1. INTRODUCTION

Welding is a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone, and with or without the use of filler material.

Welding is used for making permanent joints. It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building .Lap joints can be used in wood, plastic, or metal. A half lap joint or a halving joint is a technique of joining two pieces of material together by overlapping them. A lap may be a full lap or half lap. In a full lap, no material is removed from either of the members to be joined. Resulting in a joint which is the combined thickness of the two members. In a half lap joint, material is removed from each of the members so that the resulting joint is the thickness of the thickest member. Most commonly in half lap joints .the members are of the same thickness and half the thickness of each is removed. Weld ability is the ease of a material or a combination of materials to be welded under fabrication conditions into a specific, suitably designed structure, and to perform satisfactorily in the intended service. Lap technique of joining two pieces of material together by overlapping them. A lap may be a full lap or half lap. In a full lap, no material is removed from either of the members to be joined. resulting in a joint which is the combined thickness of the two members. In a half lap joint, material is commonly in half lap joints, the members are of the removed from each of the members so that the resulting joint is the thickness of the thickest member. Most same thickness and half the thickness of each are removed. Joints can be used in wood, plastic, or metal. A half lap joint or a halving joint.

2. LITERATURE SURVEY

One of the imperfections in butt welds is referred as the lack of penetration (LOP). Lack of penetration occurs due to weld metal fails to reach the root of the joint which is inevitable considering both the cost of the edge preparation and machining time into account [1].

The stress distribution in double fillet– welded T–Joints was investigated with a computer modelling technique. The finite element method was used for the analysis of T – joints in the plane – stress condition, under static load. Photo elastic stress analysis was employed to check the validity of the computer calculations [2].

Butt welded joints have wide applications in industry as well as in offshore constructions. The assessment of butt welded joints is a major industrial problem for two reasons. Firstly these butt welds tend to be regions of weakness in a structure due to stress concentration effects as stresses associated with welds are more variable due to inherent presence of defects. Secondly it is difficult to predict their material properties. Thus these welds are the critical links in a fabricated structure[3].

In Arc welding heat is transferred to the joint by an electrode. During manual metal Arc Welding this heat is transferred by melting the electrode. The stresses generated in welded plate are due to temperature raise and can be simple and thermal stresses. The stresses generated will cause distortion and changing the shape of the welded plates. The study of the distortion and residual stresses is found major importance in the area of shipbuilding boiler works and machine tool structures[4].

Fatigue tests of full-scale orthotropic steel decks were recently conducted to evaluate the fatigue performance of rib-to-deck partial-joint-penetration (PJP) groove welded joints. The test results indicated that rib-to-deck joints are more prone to fatigue cracks in the deck plate than in the rib wall[5].

3. WELD TYPES

3.1 Tee joint

Tee joints are used when one part must be joined to the centre of another part forming a “T”. Like the other types of weld, there are several ways that this joint can be prepared and welded, each with their own benefits and disadvantages. Most methods of welding tee joints involve welding the two joints between the parts, with either a high or low energy density beam. Like the other weld types, there are fundamental differences in the processes used with these two types of weld. When a tee is welded with either a high or low density joint energy system the process involves first placing and clamping the usually the parts in necessary configuration. If necessary, the parts may be tack welded together to make welding the final joint easer. This can, however, case complications in the final weld, which will be elaborated on later. From here, the processes begin to diverge.

In the case of low energy density welding, such a GTAW and PAW, the joint is made by making a weld bead on one, or usually both, sides of the vertical plate. This is usually done with filler wire, as there is no non-critical area for the volume of the weld bead to come from, as there is in some other weld types. This method forms a very strong weld, usually with minimal distortion. However, it is not nearly as strong as the base metal. In this case, there are relatively few problems associated with spot welding before the final weld configuration. If necessary, the parts may be tack welded together to make welding the final joint easer. This can, however, case complications in the final weld, which will be elaborated on later. From here, the processes begin to diverge.

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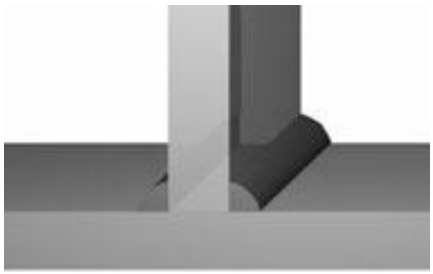

Fig 1: Low energy density welding

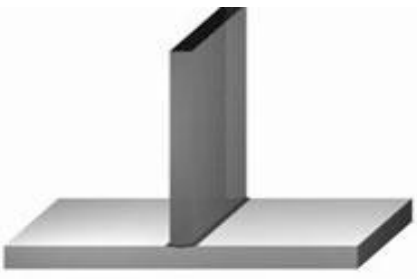

Fig 2: High energy density welding.

As mentioned earlier, preparatory spot welding can cause severe complications in high energy density beam welding. When the spot weld is created, it usually adds material other than that of the two parts being

joined. This foreign material may be included as inclusions in the weld, may evaporate under the intense heat of the beam and form porosities, or may combine metallurgical with the base metal and prevent it from crystallizing properly.

3.2 Butt Joint

The butt joint is a very simple joint to construct. Members are simply docked at the right angle and have a required length. One member will be shorter than the finished size by the thickness of the adjacent member. For enclosed constructions, such as four- sided frames or boxes, the thickness of the two adjacent members must be taken into consideration.

3.3 Lap Joint

Lap joints can be used in wood, plastic, or metal. A half lap joint or a halving joint is a technique of joining two pieces of material together by overlapping them. A lap may be a full lap or half lap. In a full lap, no material is removed from either of the members to be joined, resulting in a joint which is the combined thickness of the two members. In a half lap joint, material is removed from each of the members so that the resulting joint is the thickness. Most commonly in half lap joints, the members are of the same thickness and half the thickness of each is removed.

4. STRUCTURAL ANALYSIS

The structural analysis as the analysed stress values are less than the yield strength of steel. The Tree Joint has produced more stress than other joints, so if the load on the welded joint is more, the tree joint fails first than other joints.

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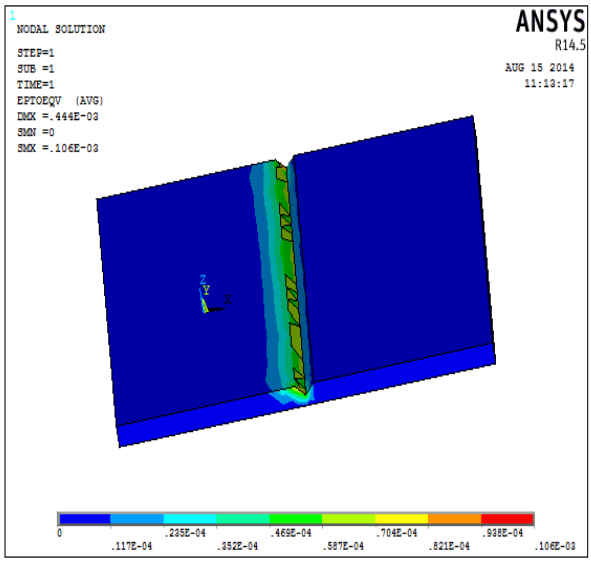

Fig3:strain for Tee joint

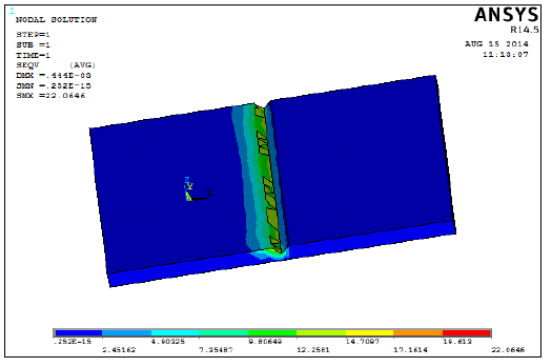

Fig 4: Stress for TEE joint

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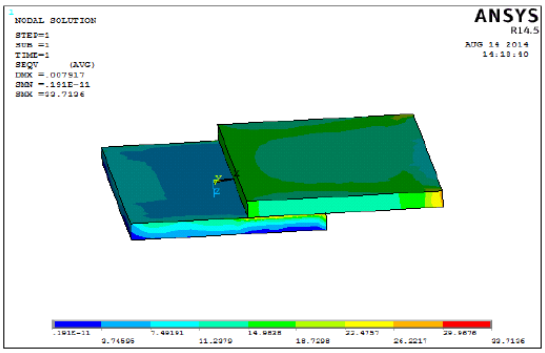

Fig 5: Stress for Lap joint

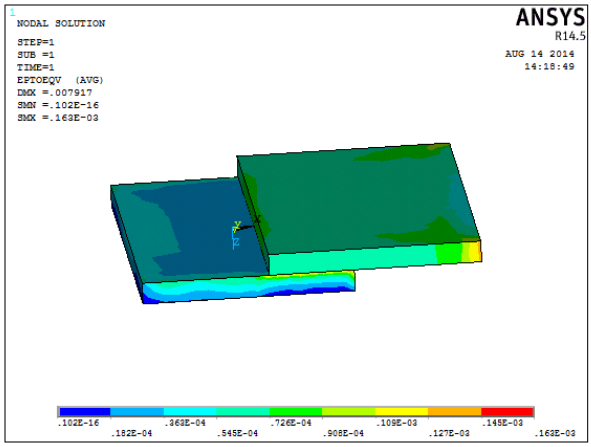

Fig6: strain for lap joint

5 RESULTS

The stress distribution in different welded Joints is investigated with a computer modelling technique. The finite element analysis is used for the analysis of joints in the plane – stress condition, under static load. Modelling is done in Pro/Engineer and analysis is done in Ansys.

5.1 Structural Analysis

All the joints are withstanding the applied pressure as the analysed stress values are less than the yield strength of steel. The Tree Joint has produced more stress than other joints, so if the load on the welded joint is more, the tree joint fails first than other joint

Type of Join	Results	
Tee Joint	Stress (N/nm^2)	34.3708
	Strain	0.164e-03
	Displacement (mm)	0.44e-0.3
Butt Joint	STRESS (N/nm^2)	22.0646
	Strain	0.106e-03
	Displacement (mm)	0.007917
Lap Joint	STRESS (N/nm^2)	33.7136
	Strain	0.163e-03
	Displacement	0.007917

5.2 Fatigue Analysis

Fatigue analysis is done to analyse the fatigue usage by applying cyclic loading. By observing the analysis results, the fatigue usage is more for Butt Joint, so the life of the Butt Joint is less than other two joints.

	Stress N/mm^2	**Cumulative Fatigue Usage**
Constrained area Event 1 Load1, Event 1 500000 Cycles Land2 Event 2 Land1, Event 2 5000 Cycles	0.10000e^{29}	0.0001
Pressure area Event 1 Load1, Event 1 500000 Cycles	0.10000e^{29}	0.5
Open area Event 1 load1, Event1 500000 Cycles		
Load 2 Event2Load, Event 2 50000 cycles Load2	0.10000e^{29}	0.0001

6. CONCLUSION

The stress distribution in different welded Joints is investigated with a computer modelling technique. The finite element analysis is used for the analysis of joints in the plane - stress condition, under static load. Modelling is done in Pro/Engineer and analysis is done in Ansys.

The types of joints are T - joint, Butt Joint and Lap Joint. Structural and fatigue analysis are done in Ansys. By observing the structural analysis results, all the joints are withstanding the applied pressure as the analysed stress values are less than the yield strength of steel.

Fatigue analysis is done to analyse the fatigue usage by applying cyclic loading. By observing the analysis results, the fatigue usage is more for Butt Joint, so the life of the Butt Joint is less than other two joints.

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