"ANALYSIS OF CRACK PROPAGATION IN WELDED JOINT "

HASMUKH R. PRAJAPATI[1] , HABIBA DEDHROTIA[2]

[1] *Student of Mechanical Engineering at Samarth College Of Engineering And Technology Himatnagar, Gujarat, India*

ABSTRACT

The object of this project to experimentally investigate the Working of Crack Propagation in Cruciform Welded Joints . It experiment working on ANSYS . In this experiment the welded joint used for the structure design . The present invention relates to a heavy-weight steel plate and a method of manufacturing the same excellent brittle crack propagation stopping characteristics of the fillet and the cross welds, in particular, of the fillet and the cross welded joints, such as large container ships and bulk carriers, more than 50mm thick plate suitable as a flange material, related to things.
Process Parameter: Welding Voltage, Welding Current, penetration,
Hardness Material:
Mild steel.

Keyword : - *Cruciform structure weld joint ,welding parameter ,fatigue crack propagation, , etc….*

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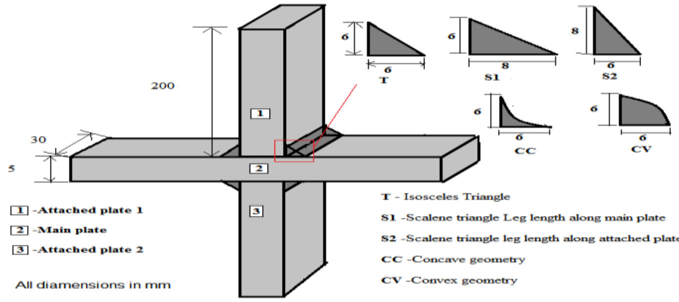
1. INTRODUCTION

What do you do if you want to cut off a steel wire, but you do not have any pliers? You could bend the wire back and forth. A small crack will form, and after a certain numbers of bending the wire will break. You have accomplished a low-cycle fatigue failure. A fatigue failure is a failure that can arise in a structure, loaded way below the static rupture limit, if the load is cyclic and are applied for enough long time. Micro cracks are formed due to high stress concentrations at small material or geometrical defects in a structure. These micro cracks grow little by little when the load is varied in time, eventually they will reach a critical size. At this critical size, the remaining material is not enough, even for a load as small as this, and a failure will occur.[3]

1.1 Joint Preparation.

A cruciform joint is prepared among three members, with two members located approximately at right angle to the third member in the form of a sign +. In the present work mild steel plate (200 mm × 30 mm × 10 mm) is considered. The cruciform joint was prepared by using manual metal arc welding technique. All three members have same dimensions as shown in figure. Model prepared for different weld geometry as shown in figure. During welding operation, heat is produced to join the working plates which also increase the temperature in the joint. The temperature affect the properties of mild steel plates, in this study temperature dependent thermal and mechanical properties of mild steel were considered shown in table. The properties of welding material were considered same as working material except the yield stress and ultimate stress shown in table . Fillet welded cruciform joint for Isosceles triangle, scalene triangle leg length along main plate, scalene triangle leg length along attached plate, concave and convex geometry referred as T, S1, S2, CC and CV through out the work. [3]



1.2 Weld Cracking.

Several types of discontinuities may occur in welds or heat affected zones. Welds in porosity, slag inclusions or cracks. cracks in the weld, it is never acceptable in crack.

Cracking is distinguished from weld failure. Welds may fail due to over load, undersign, or fatigue. Weld cracking occurs close to the time of fabrication. Hot cracks are those that occurs at elevated temperatures and are usually solidification related. Cold cracks are those that occurs after the weld metal has cooled to room temperature and may be hydrogen related. Most form of cracking result from the shrinkage strains that occurs as the weld metal cools. If the contraction is restricted, the strains will induce residual stresses that cause cracking.

There are three basic types of weld crack are below,
Centerline cracking
Heat Affected Zone cracking
Transverse racking.

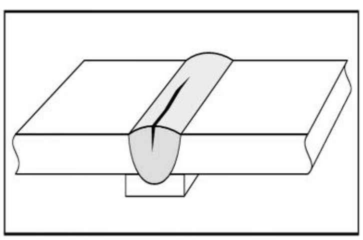


Figure 1 Centerline cracking

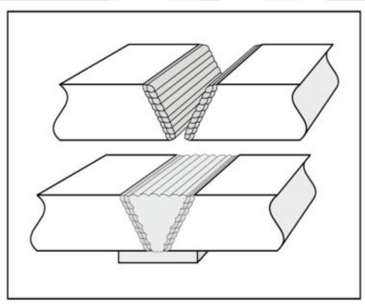


Figure 2 Buttering layers

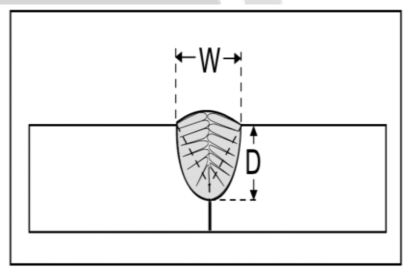


Figure 3 Bead shape induced cracking

penetration.

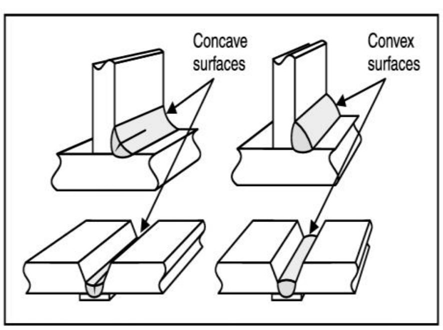


Figure 4 Surface profile induced cracking

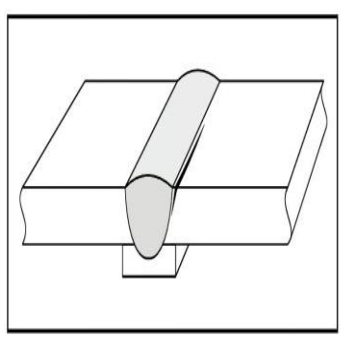


Figure 5 Heat affected zone cracking

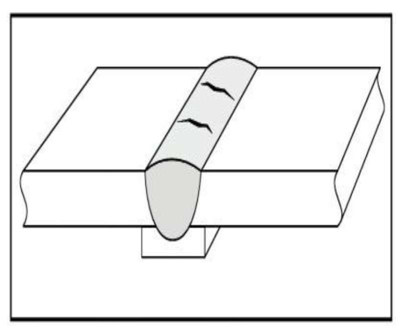
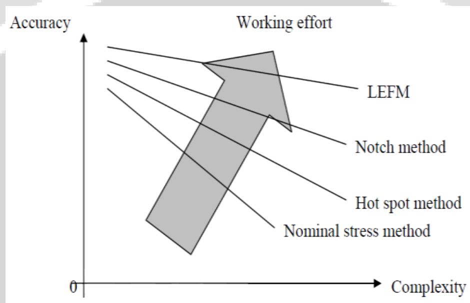


Figure 6 Transverse cracking

2. Different methods for fatigue assessment

There are essentially four different approaches for calculating the fatigue life of a structure, the nominal stress method, the hot spot method, the effective notch method and linear elastic fracture mechanics (LEFM). The nominal stress method is the oldest and most well-tried method, the others are newer and usually performed by FE-calculations. The hot spot method will only be mentioned briefly, since it has shown not to be so useful. It has shown that the hot spot method is full of special cases, exceptions and limitations that make the method very problematic. Research is now instead focusing on the effective notch method. Hopefully the effective notch method is as simple as it is at first sight, but more work and investigations needs to be done. The focus in this thesis will be on the effective notch method.

Martins son [8] has made a picture for a comparison of the different methods, see **Figure .** The nominal method is the simplest method of the four, but it is also the least accurate one, at least for complex structures. LEFM is much more accurate, but at the expense of a larger working effort. According to this picture the effective notch seems to be a promising method for fatigue assessment.



[Figure ,There are essentially four methods for dimensioning against fatigue failure. The nominal stress method is the least complex and least time consuming one, but also the least accurate one. Linear elastic fracture mechanics is considered to be the most accurate one but at the expense of complexity and more working effort.]

2.1 The nominal stress method

Nominal stress, σnom, is defined as the stress in the sectional area under consideration, here it is the sectional area of the metal plate. The local stress raising effect of the welded joint is disregarded, but the stress raising effect of the macro geometric shape of the component in the vicinity of the joint is included. A macro geometric shape is a geometric detail that affects the stress distribution all over the sectional area, for example a large cut out, or a change of the sectional area.
In the simplest cases the nominal stress can be calculated by linear elastic theory according to equation (3:1).

$$\sigma_{nom} = \frac{F}{A} + \frac{M}{I} \cdot Z$$

where
F = normal force
A = cross- sectional area
M = bending moment
I = moment of inertia
z = distance from the centre of gravity of the section to the considered location.
Sometimes it can be hard to find the nominal stress using this equation. For example if the geometry is very complicated, or if a statically in determination of the problem complicates it. Then a finite element analysis (FEA) of the structure can be used to determine the nominal stresses.

2.1.1 The Constants in Paris' Law

The fatigue life, *N*, is calculated using Paris' law, equation (3:7), with the effective stress intensity factor calculated with the strain energy release theory, equation (3:9). For this case, though, ΔKII is much smaller than ΔKI, so all the

equations for ΔKeff will give approximately the same result. The choice of equation will be negligible compared to other uncertainty factors such as, the crack initiation length and the choice of the *C*-value in Paris' law.
The variables *C* and *n* in Paris' law are an issue when simulating the crack propagation. The *n*-value is coupled to the *m*-value giving the slope of the S-N curve. Almost every studies done on welded steel joints with LEFM uses $n=3$ [8] [12] [14], that is also what the International Institute of Welding (IIW) are recommending [5]. This is despite the fact that many fatigue tests performed suggest this is only valid for certain geometries and load cases [6] [16]. In this thesis the value of $n=3$ is used since no other value are proposed for this particularly structure.

3. Modelling in ANSYS 15.0

For the simulations and calculations done in this thesis, the FE program ANSYS 15.0 is used. Three different variations of the cruciform joint are analyzed, one where the weld is not load carrying and two where the weld is load-carrying. For the non load-carrying joint, the crack assumes to start at the weld toe, but for the load-carrying joint the crack can originate either from the root or from the toe depending on the weld size and shape of the structure. In this section it is explained how the FE modelling, for the different approaches of fatigue strength determination, is made. The non load-carrying cruciform welded joint is used as example

3.1 The Geometry

All finite element analyses are made in the program ANSYS 15.0. The models are made in 2D to minimize the computational time. Figure 11 shows a sketch of the geometry. On a steel plate two other steel plates, with the same thickness, are transversely attached by fillet welds. *Δσnom,1* gives the non load-carrying joint, and *Δσnom,2* gives the load-carrying joints.

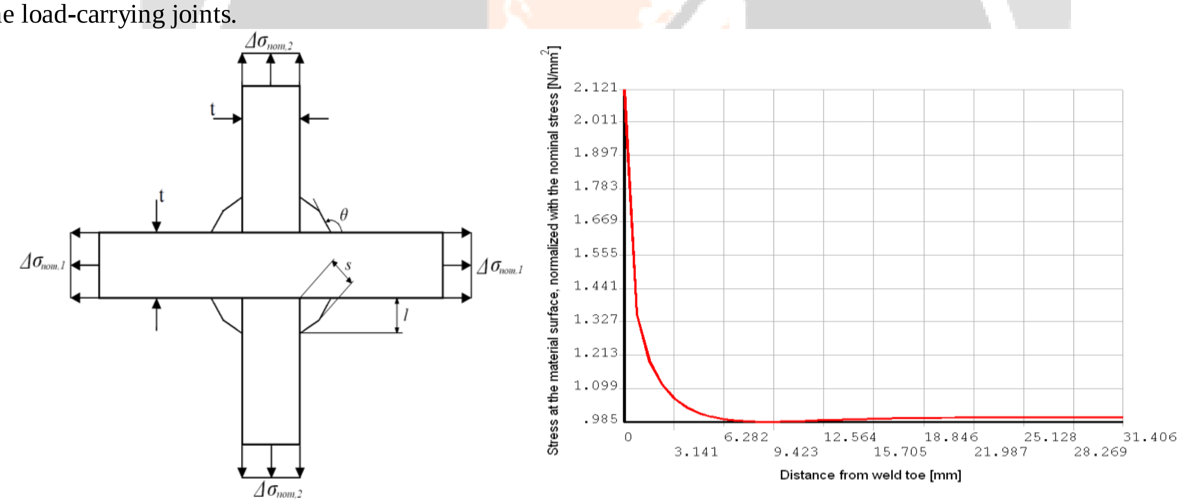
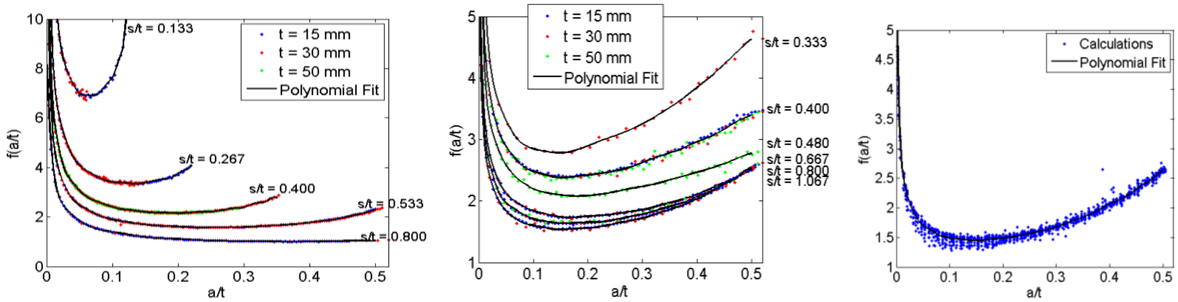


Fig - The cruciform joint used for analysis. Δσnom,1 gives a non load-carrying joint and Δσnom,2 gives a load-carrying joint

3.2 Crack increment length, *Δa*



(a) Load-carrying joint with the crack assumed to start at the weld root. (b) Load-carrying joint with the crack assumed to start at the weld toe. (c) Non load-carrying joint.

[Figure The function f from equation (3:4) is plotted versus the quotient a/t].

3.3 Tensile testing result

Types of blade	Thick	Of the	plates	Fracture location	remark
	6mm	8mm	10mm		
Base plate	5.600	8.050	9.200	Base metal	Weld has not affected strength
	5.650	8.150	9.350		
Welded plate	5.200	5.650	4.050	Welded metal	Welding strength is same unaffected.
	5.325	5.450	5.500		

[Table3.1 tensile test result]

3.3.1 Calculation of the tensile strength

- The minimum yield strength of the welded material of the ASAI grede 1018 is 53700 psi. the below formula will give us the ultimate tensile strength of that size and grade of the welding.

$y_{min} * a = s_{yield}$ So the yield strength of the

1.6mm thickness , $s_{yield} = 53700 * 0.334\ in^2 = 17936$ lbs.

This is the force in which 6 mm thickness of welding material will be able to withstand 17936 pound force without yielding.

2. 8 mm thickness, $s_{yield} = 53700 * 0.59377\ in^2 = 31885$ lbs.

This is the force in which 8 mm thickness of welding material will be able to withstand 37886 pound force without yielding.

3. 10 mm thickness, s_{yield} = 53700* 0.9277 $_{in}{}^{2}$ = 49822 lbs.

This is the force in which 10 mm thickness of welding material will be able to withstand 49822 pound force without yielding.

- The minimum tensile strength of the welded material of the ASAI grede 1018 is 63800 psi. the below formula will give us the ultimate tensile strength of that size and grade of the welding.

t_{min} * a = $s_{tensile}$ So the yield strength of the

1.6mm thickness , s_{yield} = 63800 * 0.334 $_{in}{}^{2}$ = 21309 lbs.

This is the force in which 6 mm thickness of welding material will be able to withstand 21309 pound force without yielding.

2. 8 mm thickness , $s_{tensile}$ = 63800* 0.59377 $_{in}{}^{2}$ = 37886 lbs.

This is the force in which 8 mm thickness of welding material will be able to withstand 37886 pound force without breaking.

2. 10 mm thicknes, $s_{tensile}$ = 63800* 0.9277 $_{in}{}^{2}$ = 59187 lbs.

This is the force in which 10 mm thickness of welding material will be able to withstand 59187 pound force without breaking

4. CONCLUSIONS

In this study, the fatigue behavior of fillet welded cruciform joint for different weld geometry has been studied. On the basis of results and discussion, the following conclusions to be drawn are as follows:
1.The fatigue strength of joint with scalene triangle geometry and convex geometry was higher than the triangular geometry.
2.The geometry having scalene triangle along attached plate (S2) gives better fatigue strength compared with these joints.
3.The concave geometry for considered design value gives less performance in fatigue loading conditions.
4.Cruciform joint for I, CC and CV failed at weld root region.
5. Joint with S1 and S2 failed at weld toe region.
The analysis and discussion can be concluded into some separate statements.

- The different specimen of different thickness are used to tensing tensile testing .
- The comparison of the practical tensile testing with the theoretical fatigue testing is compared.
- In tensile testing we can major that the crack is propagated actual Plate location of the material .

In fatigue testing we can observe the actual position of the crack is propagated actual point.

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BIOGRAPHIES

	1.Student of Mechanical Engineering at Samarth College Of Engineering And Technology, Himatnagar , Gujarat, India 2.ASNT NDE level-2 in RT,UT,PT,MT .