ISSN 2319-5991 www.ijerst.com

Peer Reviewed, Referred & Indexed Journal

Research Paper

DETERMINATION OF FAILURE STRENTH OF FLAT PLATE WELD JOINT USING FINITE ELEMENT ANALYSIS

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Abstract

The problem that has faced the manufacturer is the control of the process input parameters to obtain a good welded joint with the required weld quality. Traditionally, it has been necessary to study the weld input parameters for welded product to obtain a welded joint with the required quality. To do so, requires a time-consuming trial and error development method. Then welds are examined whether they meet the requirement or not. Finally the weld parameters can be chosen to produce a welded joint that closely meets the joint qualities. Also, what is not achieved or often considered is an optimized welding parameters combination, since welds can often be formed with very different parameters. In other words, there is often a more ideal welding input parameters combination, which can be used.Welding is a process of permanent joining of two materials (usually metals) through localized coalescence resulting from a suitable combination of temperature, pressure and metallurgical conditions. Depending upon combination of temperature and pressure from high temperature with no pressure to high pressure with low temperature, a wide range of welding processes has been developed.Finite element analysis (FEA) has become a practical method of predicting stresses and deflection for loaded structures. FEA identifies the load path, which can be difficult using classical analysis with complex structures. Welding is the process of joining two pieces of metal by creating a strong metallurgical bond between them by heating or pressure or both. Welding enables direct transfer of stress between members, eliminating gusset and splice plates necessary for bolted structures. Two types of fillet weld are possible. A single transverse fillet weld and double transverse fillet weld. Strength of single transverse fillet weld is improved by the application of restraining force.

Keywords: Finite Element Analysis (FEA), Weld Joint, Flat Plate, Failure Strength, Welding Process, Stress Analysis, Deformation, Weld Quality, Process Parameters, Structural Integrity.

I. INTRODUCTION

The problem of connecting plates was first solved through riveted connections but the development that occurred during World War-II saw the welded joints replace riveted joints in most applications. The ship building industry was perhaps in the fore front and large ships in excess of 10,000 in number were build with welded structures welding technology, indeed provided several advantages. The ease of processing and weight reduction was the identifiable advantages in the beginning. The automation and variety of welding processes have now become the most obvious advantages the technological developments have included several steels and even non-ferrous metals in the lists of weldable materials.

Fabrication of structural components inherently involves the cases when repairs are necessary. This is due to the prolonged time of structure operation, and the effect of various phenomena, like corrosion, fatigue, or rheology. Quite often repairs are caused by the events of random nature, but even so, the outcome can be invariably the failure of structure. If this is the case, then the best remedy is to replace the element that has failed with a new one, but due to economic factors and complicated nature of this operation, it is often far easier to fix the problem locally. This study describes a truss that has suffered failure. One of the means used to fix the problem was replacement of the damaged plates and fabrication of a welded joint composed of five plates. To better evaluate this solution, the properties of the joint were examined.

Research Objectives

- To investigate the influence of welding joint location on the fatigue strength of steel weldments under cyclic loading conditions.
- To evaluate the fatigue life of steel components welded at different locations relative to the neutral axis and critical stress regions.
- To analyze stress concentration and crack initiation behavior associated with various weld joint placements.
- To compare the performance of different weld joint types (e.g., butt joint, T-joint, lap joint) located at strategic positions in the structure.
- To validate experimental findings with finite element simulations (FEA) for fatigue performance prediction and stress distribution analysis.
- To recommend optimal welding joint locations for improved fatigue resistance in steel structural applications.
- Let me know if you'd like this in a project report format or if you want to add specific industry standards or applications (like automotive, aerospace, etc.).

II. REVIEW OF LITERATURE

Dr.Ali Sadiq Yasir The welding process is one of the oldest joining processes between the materials, this paper try to find the effect of welding joint location in the steel on the fatigue strength of steel. The welding process done by electrical arc welding to joining steel samples at different locations at (X/L=0.25, X/L=0.5, and X/L=0.75), where (X) the location of welding zone centre and sample subjected to fully reversed bending stress, then comparing the fatigue test results with un-welded sample. The experimental results show that the welding joint decrease the tensile strength of steel and the fatigue failure strength also decreased specially for that with (X/L=0.5 and X/L=0.75) and failure occur at welding zone, but the sample with (X/L=0.25) had less effected by welding joint and the failure occur at the support not at welding zone. The results show fatigue life affected by the welding joint when draw (S-N) diagram for each sample especially for sample with (X/L=0.5 and X/L=0.75).

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In the last decades, advances in steel manufacturing made possible the use of high-strength steel (HSS) and ultra-high strength steel (UHSS) for several applications, such as bridges, cranes, offshore structures, oil pipelines and automotive parts. Capacity of withstanding loads with reduced cross-section and minimum weight could be efficiently increased. Since most structures need to be joined, welding procedures are a major issue in mechanical design of HSS elements. Particularly in construction codes and design documents, it is normally assumed that fatigue resistance of as-welded joints is independent of strength level. Nevertheless, fatigue loaded as-welded components with high quality welds or post-weld treated joints could experience benefits from the use of HSS as the base material (BM). The purpose of the present work is to analyse fatigue behaviour of ultra-high strength steel butt-welded joints, by means of experimental testing and a fracture mechanics approach. Sheets of steel S960MC and S960QL were joined with different welding techniques: Gas Metal Arc Welding (GMAW), Laser Hybrid Welding (LHW) and Electron Beam Welding (EBW). Fatigue tests were performed with stress ratio R=0.1, under four points bending loading. All specimens exhibited fatigue crack initiation and subsequent propagation from the weld toe area, near the heat affected zone (HAZ). Different The Resistance Curve methodology was employed to assess the effect of microstructure, defect size, hardness, and joint geometry resulting from each technique. This fracture mechanics approach allowed to estimate the relative influence of the different geometrical and mechanical parameters of the weld and showed that joint geometry could not explain by itself the differences in fatigue strength. It was observed that microstructure and the size of defects played an important role in early crack growth, and they can reduce the benign effect of a high-strength base material.

Kotani Yuki Grinding of weld toes is generally used to improve the fatigue strength of fillet weld joints. In this study, a technique employing additional welds was applied to out-of-plane gusset welded joints and the relationship between the shape of the additional weld and fatigue strength was investigated. The shape of the additional weld was controlled by changing the aiming position. When there was more distance between the first weld toe and the aiming position of the additional weld, the flank angle and toe radius tended to be smaller and larger, respectively. In the nominal stress range of 150 MPa, fatigue life was extended to 2.7 times that of weld joints without additional welds. Although the toe radius of the additional weld was smaller than that created by grinding, the resultant fatigue strength of the additional weld joint was almost equivalent to that of the grinding case. This can be explained in terms of stress concentration, since the flank angle and toe radius in the additional weld toe can be improved without reducing the throat thickness.

Xingyuan Xu 1, Song Zhou 2, Jinlan An 2, Yanqing Huang 2 Welding is prone to several defects. To test the fatigue properties of the welded defective joints of high-speed rail bogies, SMA490BW steel cruciform welded joints were employed with artificial defects treatment. Consequently, fatigue tests were conducted on the specimens. Fatigue fracture morphology was studied via scanning electron microscopy. The ABAQUS (version 2022) finite element software was used to calculate the stress distribution and concentration factor of cruciform welded joints with defects. The results show that the fatigue limits of 1 and 2.4 mm defect specimens were approximately 57.2 and 53.75 Mpa, respectively. Furthermore, the stress concentration factor of no, 1 mm, and 2.4 mm defects were 2.246, 4.441, and 6.684, respectively, indicating that the stress concentration factor of 1 and 2.4 mm defects increased by 98 and 198%, respectively, with respect to the no-defect case.

III. EXISTING SYSTEM

The existing system for determining the failure strength of flat plate weld joints mainly relies on traditional welding methods and experimental testing. Manufacturers select welding parameters such as current, voltage, welding speed, and electrode type through a trial-and-error approach. After welding, the joints are inspected using visual inspection, penetration testing, hardness testing, and destructive mechanical tests to evaluate their strength and quality. Although these methods help assess the performance of welded joints, they require significant time, labor, and material resources. Finite Element Analysis (FEA) is used only to a limited extent, with most industries depending on physical testing to validate weld quality and structural performance.

IV. PROPOSED SYSTEM

The proposed system focuses on determining the failure strength of flat plate weld joints using Finite Element Analysis (FEA) to improve the accuracy and efficiency of weld evaluation. Instead of relying solely on conventional trial-and-error experimentation, the system develops a three-dimensional model of the welded flat plate and performs structural analysis under different loading conditions. The welded joint is analyzed to determine stress distribution, strain, deformation, and failure locations before physical fabrication. By simulating various welding conditions and load cases, the proposed approach helps identify the optimum weld design and process parameters while reducing the need for repeated experimental testing. This method minimizes material waste, lowers development time and cost, improves prediction accuracy, and enhances the reliability and safety of welded structures. The proposed FEA-based approach provides engineers with an effective tool for optimizing weld performance and ensuring the structural integrity of flat plate welded joints in industrial applications.

V. RESULTS AND DISCUSSIONS

5.1 MODAL ANALYSIS RESULT TABLE

Modes	Deformation (mm)	Frequency (Hz)
Mode1	197.21	5530.3
Mode2	80.089	9705.3
Mode3	154.87	10302
Mode4	98.076	10582
Mode5	174.92	11391

5.2 RESULTS TABLES

5.2.1 Static analysis results

At load (N)	Deformation (mm)	Stress (N/mm^2)	Strain
60	3.307e-5	1.4981	2.15e-5
80	4.960e-5	2.237	3.23e-5
100	5.7873e-5	2.606	3.77e-5
120	6.6141e-5	2.9783	4.30e-5

5.2.2 Static structural results

At load (N)	Deformation (mm)	Stress (N/mm^2)	Strain
Structure steel	2.307e-5	1.4981	2.15e-5
Stainless steel	2.960e-5	2.237	3.23e-5
Aluminum alloy	3.7873e-5	2.606	3.77e-5

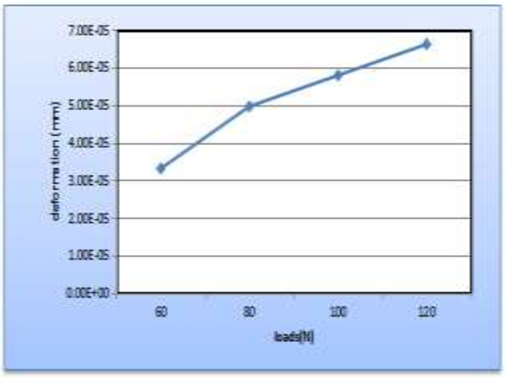
5.3 FATIGUE ANALYSIS RESULTS

At load (N)	Life	Damage	Safety factor	
			Min	Max
60	1e-11	2.1806	0.8978	15
80	1e-11	73.857	0.5984	15
100	1e-11	365.7	0.51303	15
120	1e-11	412.5	0.4489	15

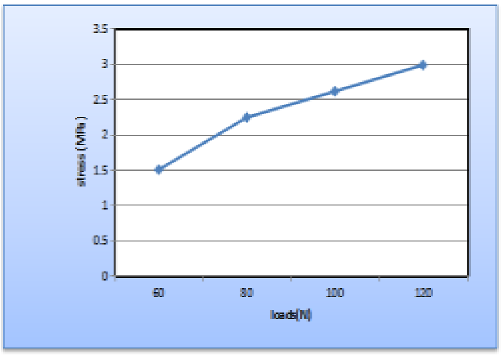
This project is the study the effect of the location of welding joint on the fatigue life and fatigue strength of steel plates and finding the best location for welding joint. The scope of this work is applied mechanics and the design of welding joint location.
The welding joints modeling in SOLID WORKS software and analysis in ANSYS software. The welding pieces materials is steel And applying the different loads (60N,

80N, 100N, 120N) on the welded plates for finding the strength, life of the component.

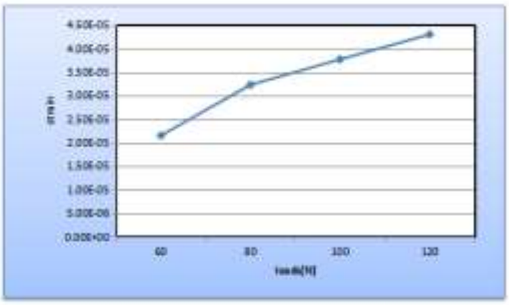
VI. GRAPHS



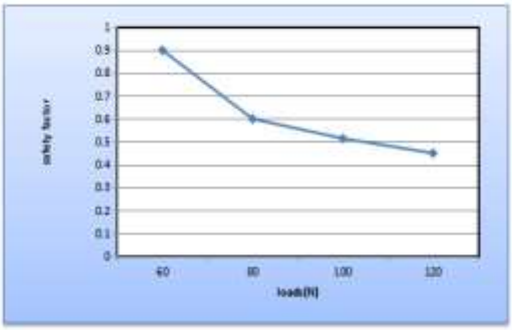
Graph 6.1: Deformation Plot



Graph 6.2: Stress plot



Graph 6.3: Strain plot



Graph 6.4: Safety factor

VI. CONCLUSION

The problem of connecting plates was first solved through riveted connections but the development that occurred during World War-II saw the welded joints replace riveted joints in most applications.

The ship building industry was perhaps in the fore front and large ships in excess of 10,000 in number were built with welded structures welding technology, indeed provided several advantages.

The ease of processing and weight reduction was the identifiable advantages in the beginning. The automation and variety of welding processes have now become the most obvious advantages the technological developments have included several steels and even non-ferrous metals in the lists of wieldable materials.

Fabrication of structural components inherently involves the cases when repairs are necessary.

This is due to the prolonged time of structure operation, and the effect of various phenomena, like corrosion, fatigue, or rheology.

Quite often repairs are caused by the events of random nature, but even so, the outcome can be invariably the failure of structure.

If this is the case, then the best remedy is to replace the element that has failed with a new one, but due to economic factors and complicated nature of this operation, it is often far easier to fix the problem locally.

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The welding joints modeling in SOLID WORKS software and analysis in ANSYS software. The welding pieces materials is steel And applying the different loads (60N, 80N, 100N, 120N) on the welded plates for finding the strength, life of the component.
Almost all fabrication of structures today involves welding. Therefore the effects of welding on the life of structures subjected to cyclic loading must be considered for economical and safe design.
The vast majority of component fatigue failures take place at the welded connections when the welded structures subjected to fatigue and impact loading.
By observing the static analysis the stress, deformation and strain values are increases by increasing the loads. Minimum stress value at 60 N load
By observing the fatigue analysis the safety factor increases by decreasing the loads. Safety factor maximum value at 60N load.

VII.REFERENCES

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