A Review on Finite Element Analysis of Curved Plate Overlapping Welded Joint

Kanchan D. Jaysingpure[1] Prof. Amol. B. Dhumne[2]
[1,2]Department of Mechanical Engineering
[1]M.E Scholar [2]Assistant Professor
[1,2]JCOET, Yavatmal

Abstract— Basically a welded joint is a permanent joint which is obtained by fusion of the edges of the two plates to be joined together with or without application of pressure and filler material. Welding is extensively used in fabrication as an alternative method for casting or forging and as a replacement for a bolted and riveted joint. Since it is related to human being, it is necessary to design and analysis the joint with prior attention to safely of its user.A better approach to the prediction of welding deformation is using the combined technologies of experiments with numerical calculation. With modern computing facilities, the Finite Element (FE) technique has become an effective method for prediction and assessment of welding residual stress and distortions various factors, the quantitative prediction and the control of welding deformation especially for a large and complex welded structure is extremely difficult. Typical welds are done on flat surfaces and their strengths are well catalogued for reference. If a lap joint is required for longitudinal plates, the reference for taking overlap length is available. When a lap joint is required for curved plates, no reference is available for it. The objective of this project is to determine optimized overlapping angle and suitable welding configuration among single end weld joint and both end weld joint.

Key words: finite element analysis, curved plate stress and vibration analysis

I. INTRODUCTION

Welding is a fabrication process used to join materials, usually metals or thermoplastics, together. During welding, the pieces to be joined (the workpieces) are melted at the joining interface and usually a filler material is added to form a pool of molten material (the weld pool) that solidifies to become a strong joint.

A. Types of Welding:

There are many different types of welding processes and in general they can be categorized as:

B. Arc Welding:

A welding power supply is used to create and maintain an electric arc between an electrode and the base material to melt metals at the welding point. In such welding processes the power supply could be AC or DC, the electrode could be consumable or non-consumable and a filler material may or may not be added. The most common types of arc welding are:

C. Shielded Metal Arc Welding (SMAW)

SMAW is a welding process that uses a flux covered metal electrode to carry an electrical current. The current forms an arc that jumps a gap from the end of the electrode to the work. The electric arc creates enough heat to melt both the electrode and the base material(s). Molten metal from the electrode travels across the arc to the molten pool of base metal where they mix together. As the arc moves away, the mixture of molten metals solidifies and becomes one piece. The molten pool of metal is surrounded and protected by a fume cloud and a covering of slag produced as the coating of the electrode burns or vaporizes. Due to the appearance of the electrodes, SMAW is commonly known as ‘stick’ welding.

D. Gas Metal Arc Welding (GMAW):

In the GMAW process, an arc is established between a continuous wire electrode (which is always being consumed) and the base metal. Under the correct conditions, the wire is fed at a constant rate to the arc, matching the rate at which the arc melts it. The filler metal is the thin wire that’s fed automatically into the pool where it melts. Since molten metal is sensitive to oxygen in the air, good shielding with oxygen-free gases is required. This shielding gas provides a stable, inert environment to protect the weld pool as it solidifies. Consequently, GMAW is commonly known as MIG (metal inert gas) welding. Since fluxes are not used (like SMAW), the welds produced are sound, free of contaminants, and as corrosion-resistant as the parent metal. The filler material is usually the same composition (or alloy) as the base metal. GMAW is extremely fast and economical. This process is easily used for welding on thin-gauge metal as well as on heavy plate. It is most commonly performed on steel (and its alloys), aluminum and magnesium, but can be used with other metals as well. It also requires a lower level of operator skill than the other two methods of electric arc welding discussed in these notes. The high welding rate and reduced post-weld cleanup are making GMAW the fastest growing welding process.

E. Gas Tungsten Arc Welding (GTAW):

A process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by a shielding gas, and a filler metal that is fed manually is usually used.

F. Gas Welding:

In this method a focused high temperature flame generated by gas combustion is used to melt the workpieces (and filler) together. The most common type of gas welding is Oxy-fuel welding where acetylene is combusted in oxygen.

G. Resistance Welding:

Resistance welding involves the generation of heat by passing a high current (1000–100,000 A) through the resistance caused by the contact between two or more metal surfaces where that causes pools of molten metal to be formed at the weld area. The most common types of resistance welding are Spot-welding (using pointed electrodes) and Seam-welding (using wheel-shaped electrodes).

H. Energy Beam Welding:

In this method a focused high-energy beam (Laser beam or electron beam) is used to melt the workpieces and thus join them together.

I. Solid-State Welding:

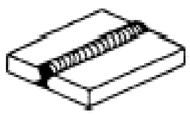
In contrast to other welding methods, solid-state welding processes do not involve the melting of the materials being joined. Common types of solid-state welding include; ultrasonic welding, explosion welding, electromagnetic pulse welding, roll welding, friction welding (including friction-stir-welding), etc.

J. Types of Welded Joints:

The weld joint is where two or more metal parts are joined by welding. The five basic types of weld joints are the butt, corner, tee, lap, and edge.

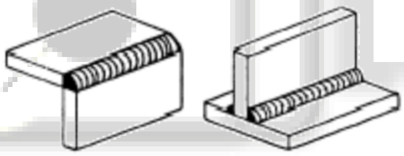
1) Butt Joint:

It is used to join two members aligned in the same plane. This joint is frequently used in plate, sheet metal, and pipe work.



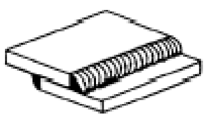
2) Corner and Tee Joints:

These joints are used to join two members located at right angles to each other. In cross section, the corner joint forms an L-shape, and the tee joint has the shape of the letter T.



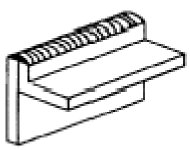
3) Lap Joint:

This joint is made by lapping one piece of metal over another. This is one of the strongest types of joints available; however, for maximum joint efficiency, the overlap should be at least three times the thickness of the thinnest member of the joint.



4) Edge Joint:

It is used to join the edges of two or more members lying in the same plane. In most cases, one of the members is flanged, as seen in the figure. This type is frequently used in sheet metal work for joining metals 1/4 inch or less in thickness that are not subjected to heavy loads.



In current industrial practice, welds and welded joints are an integral part of many complex load- carrying structures. Unfortunately, welds are often the weakest portions of these structures and their quality directly affects the integrity of the structure. Failure strength is believed to have a close relation to the precise geometrical discontinuity of the welded joint. The ultimate goal to produce welds of suitable strength and at a reasonable cost. Generally two types of plates are used in fabrications i.e. flat plate and Curved plate. There are various applications of flat plates like manufacturing of different automobile components, standard machine parts, leaf spring, Steel pipe flange etc. So producing such type of component, standard table or data (catalogue) available for selection of weld for different strength of flat plate. Also lot of work is done related to the flat plate. But there are Limitations for producing complicated components by using flat plates.

Most common basic FEA packages are suitable for this analysis ANSYS was used for The present study. With its parametric command files, design variations are easily evaluated. With any FEA package, accurate load estimation depends on the quality of the model built by the analyst. The benefits of utilizing this method are as follows:

- Accurate determination of weld loads including distribution of weld loads along the joint. The weld joint loads are resolved at each FEA node of the joint in the model. This is useful for prediction of both static failure and fatigue failure.
- Shear loads induced by mismatch of lateral deflection due to restraint or Poisson effects are included in the calculated loads. These loads are often ignored with classical analysis.

II. LITERATURE REVIEW

Chetan S Baviskar, R M Tayade1 and Vinay G Patil, “determination of failure strength of curved plate welds joint using finite element analysis” [1]. In this paper single transverse fillet weld and double transverse fillet weld are used for analysis. Weld joints form an important part of pressure vessels, they are highly essential for structural integrity of the system. Typical welds are done on flat surfaces and their strengths are well catalogued for reference. The objective of this research project is to analyze welds on curved plated and determine their strength, and create a similar catalogue for curved surfaces of certain cases.

Rahul Khot, Gawade S.S., Vinnay Patil, “FEA based validation of Weld joints to determine effect of overlap length of weld strength” [2].In this paper The standard data related to the no. of welds, thickness of plate, size of overlapping length for flat plate is available. But such a type of standard data is not available in the market for curved plate. So the objective of this paper is to analyze welds on curved plated and determine their strength, and create a similar catalogue for curved surfaces.

M. V. Dalvi, Vinay Patil, R. S. Bindu, “FEA Based Strength Analysis of Weld Joint for Curved Plates (Overlap) Specially for Designing Pressure Vessel Skirt Support”.[3] Author says that Weld joints form an important part of pressure vessels, they are highly essential for structural integrity of the system. Typical welds are done on flat surfaces and their strengths are well catalogued for reference. If a lap joint is required for longitudinal plates, the reference for taking overlap length is available. When a lap joint is required for curved plates, no reference is available for it. The objective of the project is to form certain set of guidelines or set of formulations which will serve as a guideline for overlap length in lap joint of curve plates.

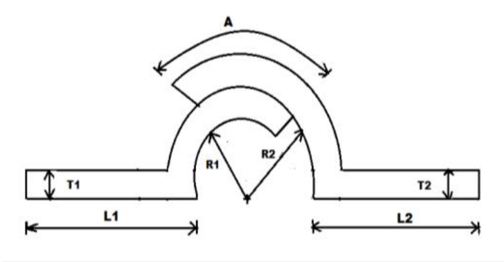
Jaesong Kima, Kyungmin Leea, Boyoung Leeb, "Estimation of the fatigue life according to lap joint weld profiles for ferritic stainless steel"[4]. In case that welded structures were applied cyclic fatigue load, the factors such as profile of weld bead, direction and size of applied load, welding residual stress and undercut have affected fatigue life. Generally, if curvature radius of welding(r) toe and welding angle are lager, the fatigue strength is greater than smaller ones. However, in case that the one side in lap joint area was welded shape(such as gap size, lap length) of lap joint is more affect than welding toe and angle on the stress value. In this study, fatigue strength for the ferritic stainless steel was evaluated through stress analysis using finite element method and fatigue test according to the lap length and gap size. In addition, to remove notch effect or stress concentration effect in the lap joint area, fatigue strength was evaluated by welding as the full penetration condition.

Kim , J.W.H.J. Kim, " Predicting Lap-Joint bead geometry in GMA welding process"[5].In this paper, The prediction of the optimal bead geometry is an important aspect in robotic welding process. Therefore, the mathematical models that predict and control the bead geometry require to be developed. This paper focuses on investigation of the development of the simple and accuracy interaction model for prediction of bead geometry for lap joint in robotic Gas Metal Arc (GMA) welding process. The sequent experiment based on full factorial design has been conducted with two levels of five process parameters to obtain bead geometry using a GMA welding process. The analysis of variance (ANOVA) has efficiently been used for identifying the significance of main and interaction effects of process parameters. General linear model and regression analysis in SPSS has been employed as a guide to achieve the linear, curvilinear and interaction models. The fitting and the prediction of bead geometry given by these models were also carried out. Graphic results display the effects of process parameter and interaction effects on bead geometry. The fitting and the prediction capabilities of interaction models are reliable than the linear and curvilinear models.

III. Problem Formulation

For designing a lap joint there is a reference for overlap of flat plates weld joint but as such no standard is available for curved plate weld joint. The objective of the project is to form certain set of guidelines or set of formulations which will serve as a guideline for welds of curve plates with an overlap and to determine effect of overlap length on strength of fillet weld joint. In the design of welded joints,

Finite element analysis (FEA) is one of the most popular engineering analysis methods for Nonlinear problems. FEA requires a finite element mesh as a geometric input. This mesh can be generated directly from a solid model for the detailed part model designed in a three-dimensional (3D) CAD system.



IV. Overview of Project

Experimental Analysis consists of fabrication of two curved MS plate welded joint. Dimensions of two plates is given below. After that we are going to do increasing the overlapping angle by 15° in between 30° to 75° for both single side welded and double side welded joint. Stress and strength of various joints will be find out by using universal testing machine. Computational analysis will comprise of stresses, buckling and vibrational analysis. In this project we are going to analyze curved plate overlapping welded joint by finite element analysis.

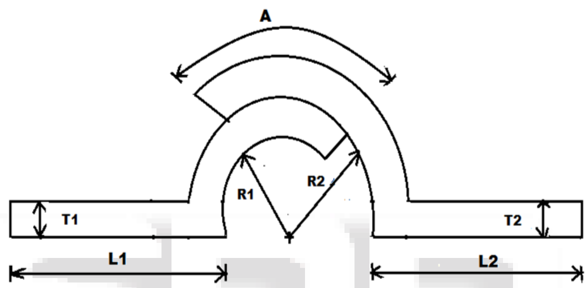


Fig. 1: curved plate overlap weld joint

Dimensions of plates

- L1= 100 mm L2 = 95 mm
- R1= 100 mm R2 =105 mm
- T1 = 5 mm T2 = 5 mm A= 30° to 75°

The following methodology will be implanted for achieve the aim and objective of research work.

- To collect all data related with curved plate.
- Procurement of material
- Fabrication of curved plate overlapping welded joints.
- Testing and Finding of readings.
- Numerical calculation for experimental analysis.
- CAD molding of joint.
- Computational analysis of joint by using ANSYS
- Validation of experimental Analysis with computational Analysis
- Conclusion

V. References

[1] Chetan S Baviskar, R M Tayade1 and Vinay G Patil, "determination of failure strength of curved plate welds joint using finite element analysis" ISSN 2278 – 0149 www.ijmerr.com Vol. 1, No. 3, October 2012.

[2] Rahul Khot, Gawade S.S., Vinnay Patil, "FEA based validation of Weld joints to determine effect of overlap length of weld strength" www.srjis.com OCT-NOV, 2012, Vol. – I, Issue-III.

[3] M. V. Dalvi, Vinay Patil, R. S. Bindu, "FEA Based Strength Analysis of Weld Joint for Curved Plates (Overlap) Specially for Designing Pressure Vessel Skirt Support" International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-1, Issue-3, August 2012.

[4] Jaesong Kima, Kyungmin Leea, Boyoung Leeb, "Estimation of the fatigue life according to lap joint weld profiles for ferritic stainless steel" ScienceDirect 1877-7058 © 2011 Published by Elsevier Ltd. Selection and peer-review under responsibility of ICM11.

[5] D.T Thao , J.W. Jeong , I.S. Kim , J.W.H.J. Kim, " Predicting Lap-Joint bead geometry in GMA welding process" Volume 32, Issue 2,August 2008, Pages 121-124 International Scientific Journal published monthly by the World Academy of Materials and Manufacturing Engineering.

