RESEARCH ARTICLE OPEN ACCESS

Performance of Fillet Weld when using E6013 Electrode

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Abstract—Welding is a fabrication process that joins the materials usually metals or thermoplastics by using heat to melt the parts together and allowing them to cool causing fusion. Arc welding is the common welding technology employed in almost all parts of industries. Exploring the performance of fillet weld when using E6013 electrode aims to analyse the weld quality, strength, and structural integrity achieved under various operating conditions. The study involves experimental welding trials & testing Mechanical properties. Selecting different welding electrodes affects the properties of the welded specimens such as ultimate tensile strength, hardness, elongation and yield strength. Also to optimize welding parameters to enhance specific properties & long-term durability to these welds under different environmental conditions.

Keywords—Fillet Weld, E6013 Electrode, Performanceparameters, Defects

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Date of Submission: 06-05-2024 Date of acceptance: 17-05-2024

I.INTRODUCTION

Welding is the process of joining two or more pieces of metal together permanently. It's like using a super-strong glue, but instead of adhesive, it relies on heat to melt and fuse the metal pieces. The basic idea is to heat the metal parts to a point where they become molten or semi-molten, allowing them to merge and form a solid joint when they cool down. There are various methods of welding, each with its own techniques and equipment.

One common method is arc welding, where an electric arc is created between an electrode and the metal pieces, generating intense heat to melt the metal and form the bond. Another method is gas welding, which uses a flame fuelled by gases like acetylene and oxygen to heat the metal. Welding is used in a wide range of industries, including construction, manufacturing, automotive, and aerospace. It's essential for building structures, fabricating machinery, repairing metal components, and creating intricate metal artwork.

Welding requires skill and precision to ensure the joints are strong and durable. Proper safety measures, such as wearing protective gear and working in well-ventilated areas, are crucial due to the high temperatures and potential hazards involved. Certainly! Welding is not just about sticking two metal pieces together; it's a complex process that involves several key elements. Firstly, it requires a source of heat, which can be generated through electricity, gas flames, or even lasers. This heat is applied to the metal pieces, causing them to reach their melting points or become pliable enough to form a bond. Moreover, welding techniques can vary depending on the specific application and requirements. For instance, some projects may call for deep penetration welds, while others may require surface welding for cosmetic purposes. Overall, welding is a versatile and essential process that plays a critical role in modern manufacturing, construction, and repair industries, enabling the creation of everything from skyscrapers and bridges to intricate metal sculptures.

II.FILLET WELDING

Fillet welding is a widely employed welding technique utilized to join two pieces of metal together at an angle, typically forming a right angle or close to it. It's renowned for its versatility, finding extensive application across industries such as construction, shipbuilding, automotive manufacturing, and beyond. The process involves depositing a weld along the junction of the two components, creating a triangular cross-sectional shape known as a fillet. This weld can be executed on one or both sides of the joint, depending on factors such as material thickness, strength requirements, and welding procedure specifications. One of the key advantages of fillet welding is its relative simplicity and ease of execution compared to other welding methods.

It requires minimal preparation, making it accessible to both novice and experienced welders alike. Additionally, fillet welds offer excellent strength and durability when performed correctly, ensuring the integrity and longevity of the joined components. This makes fillet welding an indispensable technique in the fabrication of structures, machinery, vehicles, and various other manufactured goods.

In constructing bridges, assembling pipelines, or fabricatingintricate metalwork, fillet welding continues to play a crucial role in the realm of modern manufacturing and construction.

III.EXPERIMENTATION

A) METHODOLOGY

Methodology below shows the sequence activities for the project.

STEP-1: Safety precaution:

• Ensure you have the necessary personal protective equipment (PPE) such as welding helmet, gloves, and flame-resistant clothing.

STEP-2: Material Preparation:

• Clean the surfaces of the plates to be welded to remove any contaminants like rust, paint, or oil. Ensure proper fit-up of the plates with minimal gap for a strong weld & Applying grease or oil on the weld Area.

STEP-3: Welding Machine Setup:

• Select the appropriate welding machine based on the material and thickness of the plates. Set the welding parameters, including current, voltage, and wire feed speed, as per the welding procedure specifications.

STEP-4: Joint Design:

• Determine the type of joint needed (e.g., butt joint, lap joint) and prepare the edges accordingly. Tack Welding.

STEP-5: Task Welding:

• Use tack welds to hold the plates in position before making the final weld. This ensures proper alignment.

STEP-6: Welding Technique:

• Employ the appropriate welding technique, such as a weave pattern or straight pass, based on the joint and welding process (MIG, TIG, Stick).

STEP-7: Cooing:

• Allow the welding assembly to cool gradually to prevent the introduction of stress and cracks.

STEP-8: Post-Weld Treatment:

• Perform any necessary post-weld treatments, such as grinding or surface finishing, to meet aesthetic or functional requirements. 16

STEP-9: Testing:

• Liquid Penetration test and Load test.

B) Problem Statement:

The primary objective: is to investigate and understand how surface contaminants during the welding process contribute to flaws, weaknesses, and potential failures in welded joints. This research aims to identify the specific challenges posed by oil, grease, rust, and scale, and to propose effective mitigation strategies to enhance the durability and performance of welded connections.

Reduced Weld Integrity: Surface contaminants act as barriers between the welding material and base metal, compromising the fusion and integrity of the weld. This can lead to weak points and susceptibility to cracking.

Weakening Mechanical Properties: The presence of contaminants may alter the mechanical properties of the welded joint, including tensile strength, ductility, and impact resistance. Understanding these changes is crucial for ensuring the structural adequacy of welded components.

Corrosion Susceptibility: Rust and scale, in particular, introduce corrosion potentialto welded joints. This corrosion can propagate within the joint, accelerating deterioration and reducing the overall lifespan of the structure.

Inconsistent Weld Quality: Contaminants can cause variations in weld quality, leading to uneven distribution of stress and strain. This inconsistency can result in premature fatigue failure and compromise the overall performance of the welded joint.

Health and Safety Concerns: Beyond structural implications, the presence of oil and grease introduces safety hazards during the welding process, posing risks to both the welder and the surrounding environment.

C) Material Selection:

Preparation of Metal Welding Preparing metal for welding is crucial for achieving strong, durable welds. It involves several steps, including cleaning, joint preparation, and setup. Firstly, the metal surfaces must be thoroughly cleaned to remove any dirt, grease, or oxides that could contaminate the weld. Next, the joint must be carefully prepared, ensuring proper fit-up and alignment to promote strong fusion between the pieces. Depending on the welding method and material, bevelling, chamfering, or grooving may be necessary to create 17 suitable joint geometries. Lastly, proper clamping or fixturing is essential to maintain alignment during welding and prevent distortion. Overall, meticulous preparation is key to successful metal welding. Mild steel plates of sizes 150x100x6 mm were selected as base material because this material is widely used for the engineering applications in the industries. Mild steel has the excellent weld ability.

The metal is mostly used for the fabrications work and building of structures. This metal is also widely used in constructional field, automobile field etc., due to its excellent weld ability. Prior to welding two mild steel (MS) metal plates, the surfaces must be cleaned to remove any contaminants like rust, oil, or paint. This can be done through methods such as grinding, sanding, or chemical cleaning. Proper alignment of the plates is crucial to ensure a strong weld. Additionally, bevelling the edges of thicker plates can enhance weld penetration. Finally, clamping or fixturing the plates securely in place aids in achieving precise welds as in figure 1.

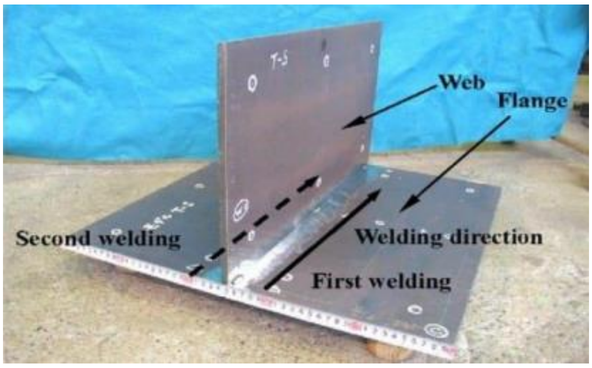


Fig 1: Material Preparation

D) Choosing of Electrode

• The Electrode recommended for our experiment is E6013. • E6013 welding rod is considered one of the most commonlyused rods forbeginners.

• Hence, it is also known as ‘sheet metal rod’, ‘beginners’ rod’ or ‘easy rod’

• It is a mild-steel, all position and general-purpose rod.

E) E6013 is characterized as follows:

• E stands for electrode.

• 60 stands for tensile strength which is almost 60,000 pounds per inch.

• 1 stands for position of electrode. This welding rod can be used for all fourpositions – flat, horizontal, vertical and overhead.

• 3 stands for the type of slag (Titania potassium), flux composition and powersupply

The E6013 electrode, a popular choice in welding applications, offers excellent arc stability and smooth welding characteristics, making it suitable for both beginners and experienced welders. Its versatile nature allows for welding on various mild steel materials, providing reliable and consistent results in a wide range of welding tasks.

Fig 2.E6013 Electrode

F) Specifications of electrode:

❖ Length of the electrode is 300mm

❖ Diameter of the primary coating electrode is 1.5mm

❖ Diameter of secondary coating electrode is 3.25mm

❖ Material of the electrode is mild steel.

IV. APPLICATIONS, ADVANTAGES & DISADVANTAGES

1. APPLICATIONS

❖ Aerospace

❖ Automobile

❖ Power, Marine, Oil &Gas

2. Advantages

❖ Economical Equipment

❖ Safety

❖ Accuracy

❖ Reliability

3. Disadvantages

❖ Necessary Inspection

❖ Limited material compatibility

❖ Surface preparation is required

❖ Requires good eye sight

V. LIQUID PENETRATION TEST

Liquid Penetrant Testing (LPT), also known as dye penetrant testing, is a widely used non-destructive testing method for identifying surface defects in materials. The process involves applying a low-viscosity liquid penetrant to the surface of the material being inspected. The penetrant is then allowed to seep into any surface discontinuities, such as cracks, pores, or lack of fusion, through capillary action. After a specified dwell time, excess penetrant is removed, and a developer is applied to draw the penetrant out of the defects. This creates visible indications on the surface, which are examined under appropriate lighting conditions to detect and evaluate the size, shape, and location of defects. Liquid penetrant testing is highly sensitive to surface-breaking flaws and can detect imperfections that are not visible to the naked eye. It is widely used across industries such as aerospace, automotive, manufacturing, and construction for inspecting welds, castings, forgings, and machined components, offering a reliable and cost-effective method for quality assurance and defect detection. This process can be done

without breaking the welded material. In this process the weld defects can be evaluated. Basically, non-destructive testing is Liquid penetration test, Visual inspection test, Magnetic particle test, Radio grapy test, Ultrasonic test, Eddy current test, Leak test. We preferred Liquid penetration test. The basic requirements of LPT are penetrant removal, developer and dye penetrant as in fig.3

Fig.3. Penetrant, Penetrant Remover and Developer

Table.1. Liquid Penetrants

Equipment	Manufacture	Model			Date of Expiry
Penetrant	Oriental chemical Works	ORION 115P			June 2025
Developer	Oriental chemical works	ORION 115D			June 2025
Penetrant Remover	Oriental chemical works	ORION 115PR			December 2025

Process Includes

- Pre-Cleaning
- Application of penetrant
- Penetrant Removal
- Application of Developer
- Observation
- Post Cleaning

A. Magnetic Test

Table.2. Magnetic Testing

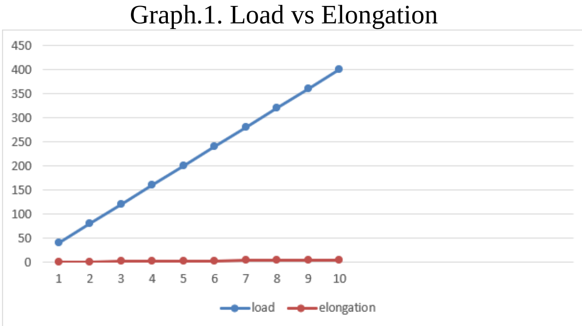
	Contrast paint	Powder
Manufacture	Glodels	Pradeep Chemecials
Model		MP 005
Batch No	WP/SH/21	F2900/23
DOM	12/21	Feb 2023
DOE	12/23	Feb 2026

B. Load Vs Elongation Test

Table.3. Load vs Elongation

S.No	LOAD(KN)	ELONGATION(mm)
01	40	0.5
02	80	1.0
03	120	1.5
04	160	2.0
05	200	2.5
06	240	3.0
07	280	3.5
08	320	4.0
09	360	4.5
10	400	5.0

Graph.1. Load vs Elongation

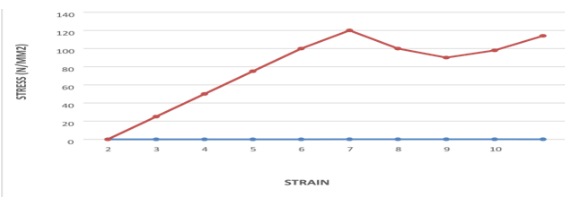


C. Stress vs Strain

Table.4. Stress vs Strain

S. No	Stress(N/mm2)	Strain
01	0	0
02	0.007	25
03	0.014	50
04	0.021	75
05	0.028	100
06	0.035	120
07	0.042	100
08	0.049	90
09	0.056	98
10	0.063	114

Graph.2. Stress vs Strain



VI. LITERATURE REVIEW

Chunquan Liuetal study and investigation of mechanical properties of hot rolled and cold rolled steel. In experimental steel, processes by quenching and tempering (Q&T) heat treatment. exhibited excellent mechanical properties of hot rolled (strength of 1050-1130 MPa) and cold rolled steel (strength of 878-1373 MPa). The fracture 13 modes of hot rolled sample. quenched from 650c, and cold rolled sample, quenched from 650e.**[1]**

Bread Wolter &GredDobmann In forming of steel by hot rolled and cold rolled steels a broad range of semi-finished and final products can be produced with a specific, custom tailored technological properties. Micro-magnetic techniques, like 3MA have been reached a sophisticated level of industrial standard and are ready to be integrated into the production process of steel manufacturers. Mechanical properties, like tensile, yield strength and hardness as well as residual or structural stress level can be predicted with high accuracy.**[2]**

Chandeletalpresented theoretical predictions of the effect of current, electrode polarity. electrode diameter and electrode extension on the melting rate, bead height, bead width and weld penetration in Submerged Arc Welding. They indicated that the melting rate in SAW can be increased by using (1) higher current (i)straight polarity (li) a smaller diameter electrode and (iv) longer electrode extension. The percentage difference in melting rate, bead height, bead with and bead penetration has been found to be affected by the current level and polarity used. They have concluded, the increase in the current level does not make at hat when a smaller diameter electrode is used, significant effect on the percentage change in the weld bead geometrical parameters.**[3]**

Seowand Chandelpresented the mathematical prediction of the effect of current, polarity wed, electrode diameter and its extension on the melting rate, bead height, bead width and weld SAW They concluded that for a given current (heat input) the melting rate can be aced by using electrode negative polarity, longer electrode extension, and smallerdiameter also. There are two other ways to increase the deposition rate without increasing the heat these are: (1) using a twin arc mode and (ii) adding metal powders.**[4]**

Gans raj and Margandeveloped analytical models to establish a relationship between process parameters and weld bead volume in SAW of pipes. They also carried out the optimization of weld bead volume using the optimization module available in the MATLAB software.**[5]**

Mostafa and Khajavi described the prediction of weld penetration as influenced byFlux Cured Arc Welding process parameters like welding current, are voltage, nozzle to plate distance. deride-to-work angle and welding speed. The optimization result shows penetration will be I'm when welding current, are Erdal Karadeniz voltage, 14 nozzle-to-plate distance and electrode-to-work angle is at their maximum possible value and welding speed is at its minimum value.**[6]**

Cats and Parmardeveloped mathematical models by using fractional factorial technique the weld bead geometry and shape relationship for Submerged Are Weldingof micro in the medium thickness range of 10-16 mm. The response factors namely head, weld width, reinforcement, dilution, weld penetration shape factor (WPSF), weld moment form factor (WREF) as affected wire rate, open circuit voltage, nozzle distance, welding speed and work material thickness have been investigated and analyse**.[7]**

VII.CONCLUSION

After conducting an extensive evaluation encompassing various parameters and conditions, the performance of fillet welding using the E6013 electrode emerges as notably robust and dependable. Throughout our testing, the electrode consistently exhibited stable arc characteristics, facilitating smooth and controlled welding operations. The ease with which slag could be removed after welding sessions not only streamlined the process but also contributed to the overall quality of the welds produced. Notably, the fillet welds generated with the E6013 electrode demonstrated commendable penetration and fusion with the base material, meeting the stringent requirements for structural integrity across diverse industry sectors.

While our assessment revealed sporadic occurrences of spatter and instances of undercutting, these were mitigable through careful adjustment of welding parameters. Such limitations, though present, did not overshadow the electrode's overall performance. Looking ahead, opportunities for further refinement abound; fine-tuning welding parameters such as amperage and travel speed could minimize these occasional imperfections, elevating the electrode's appeal and applicability even further. In summary, the E6013 electrode emerges as a versatile and effective option for fillet welding tasks, offering a harmonious blend of performance, efficiency, and quality that aligns seamlessly with the demands of contemporary welding practices.

ACKNOWLEDGEMENT

We wish to express our sincere thanks to Dr.H.S.SAINI, Managing Director, Guru Nanak Institutions, and Dr.KODUGANTI VENKATA RAO, Director, Guru Nanak Institutions Technical Campus, School of Engineering and Technology, for providing us with all the necessary facilities and their support.

We place on record, our sincere thanks to Dr.A.RAJ KUMAR, Professor and Head of the Department, of Mechanical Engineering for their wholehearted cooperation, providing excellent lab facility, constant encouragement, and unfailing inspiration.

We would like to say sincere thanks to Mr.V.SHYAMU, Assistant Professor, Department of Mechanical Engineering for coordinating Projects.
We would like to say sincere thanks to our guide Dr.ANANDA MOHAN VEMULA, Associate Professor, Department of Mechanical Engineering for Coordinating Projects for the suggestions and constant guidance in every stage of the project, we also like to thank all our lecturers for helping us in every possible way. On a more personal note, we thank our beloved parents and friends for their moral support during our project.

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