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PERFORMANCE OF FILLET WELD WHEN USING E 6010 ELECTRODE

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ABSTRACT

To evaluate the performance of a fillet weld on mild steel plates (152 mm length, 100 mm breadth, and 6.5 mm thickness), E 6010 electrode is utilized. This electrode is categorized as a rutile-cellulosic sodium type and is suitable for all positions, particularly vertical-down welding, with DC polarity. It produces a bright and clean slag on the backside, indicating minimal oxidation. Two electrode diameters are considered: 2.5mm and 3.15mm, corresponding to amperages of 50 and 70, respectively.

The fillet weld is created using an Arc Welding Machine with the E 6010 electrode. Following welding, the specimen undergoes various mechanical testing methods including Dry Penetration Test, Leeb Hardness Test, and Magnetic Particle Test. During testing, defects such as porosity, undercuts, poor start and stop are identified in the welded area. Additionally, hardness measurements are recorded at both the heat-affected zone and normal zones of the specimen.

INTRODUCTION

Welding is a crucial process in fabrication industries, widely used to join metals by creating an electric arc between an electrode and the parent metal. This arc generates high temperatures, melting the metal and allowing for fusion. One common type is Shielded Metal Arc Welding (SMAW), frequently employed in fabricating structures, process equipment, piping, and shipbuilding.

Various factors influence the mechanical properties of weld joints, including welding current, arc voltage, welding speed, polarity, edge preparation, and welding technique. Among these, welding current, voltage, and speed are primary variables, controlling fusion, penetration depth, weld puddle shape, reinforcement, and heat input. Secondary variables such as electrode polarity, angle of inclination, and welding technique affect energy absorption, base metal and weld metal melting rates.

Welding differs from other metal-joining methods like brazing and soldering, as it involves melting the base metal. Typically, a filler material is added to the joint, forming a weld pool upon cooling. This pool solidifies into a joint that can be stronger than the base material, depending on the weld configuration (e.g., butt, full penetration, fillet). Shielding is essential to prevent contamination or oxidation of the filler or melted metals during welding.

Various energy sources, such as gas flame, electric arc, laser, electron beam, friction, and ultrasound, can be employed for welding . Despite being primarily an industrial process, welding can be conducted in diverse environments, including open air, underwater, and even outer space.

OBJECTIVES

This study aims to evaluate the performance of fillet weld joints produced using the E 6010 electrode by examining weld quality, mechanical properties, and microstructure analysis. The investigation will involve an in-depth analysis of various parameters, including welding current, polarity, and travel speed, to understand their impact on weld quality and integrity. Mechanical properties such as tensile strength, ductility, and impact resistance will be assessed to determine the suitability of the welds for specific applications. Additionally, microstructural analysis will be conducted to study grain structure, phase distribution, and detect any potential defects or discontinuities within the weld zone. Through this comprehensive evaluation, we aim to provide valuable insights into optimizing welding processes and enhancing weld performance, thereby contributing to the advancement of welding technology and improving the reliability and safety of welded structures.

METHODOLOGY

3.1. Material Selection:
Mild steel, characterized by a low carbon content ranging from 0.25% to 0.30%, was chosen as the workpiece material for the project. This selection was based on its ease of welding compared to metals with higher carbon percentages.

S.no	Material	Length(mm)	Width(mm)	Thickness(mm)
1.	Mild Steel	152	100	6.5

3.2. Electrode Selection:
The E6010 electrode, belonging to the AWS E60XX series, was selected for shielded metal arc welding (SMAW) processes. Known for its deep penetration capabilities and stable arc, the E6010 electrode is commonly used in applications requiring root penetration and high deposition rates, such as structural steel fabrication and pipeline construction.

S.No	Diameter (mm)
1	2.5
2	3.15

3.3. Grinding:
V-groove cutting with a 30-degree angle was performed on the mild steel plate using a Grinding Wheel machine.

3.4. V-Groove Cutting:
V-grooving, also known as score-folding, involves cutting grooves along the bend line to establish the bend angle and line. This process thins the material and reduces the bend radius.

3.5. Welding:
The mild steel pieces were joined using SMAW with E6010 electrodes at different current ranges.

3.6. Liquid Penetration Testing (LPT):
Liquid Penetration Testing is a widely used non-destructive testing (NDT) method due to its simplicity and versatility. It detects surface flaws such as cracks, porosity, and lack of fusion. The process involves cleaning the surface, applying penetrant, allowing for dwell time, removing excess penetrant, applying a developer, and interpreting the results.

3.7. Steps Involved in LPT:
- Pre-Cleaning: Removing any contaminants from the surface.
- Application of Penetrant: Applying penetrant to the surface.
- Dwell Time: Allowing penetrant to soak into flaws.
- Removal of Excess Penetrant: Wiping off excess penetrant.
- Developing: Applying a developer to draw penetrant from defects.
- Interpretation: Inspecting the surface for indications of defects.
- Post-Cleaning: Cleaning the surface after inspection.

3.8. Leeb Hardness Test:
The Leeb hardness test, a non-destructive method, measures the hardness of materials by assessing the rebound velocity of an indenter striking the surface. A handheld Leeb hardness tester is commonly used for this purpose, with rebound velocity inversely proportional to material hardness.

3.9.Magnetic Particle Testing (MPT) :
Also known as magnetic particle inspection (MPI) or magnetic crack detection, is a non-destructive testing (NDT) method used to detect surface and near-surface flaws in ferromagnetic materials. It finds applications in industries such as aerospace, automotive, oil and gas, and manufacturing to assess the integrity of components and structures.

During the process, the test piece is magnetized using either a permanent magnet or an electromagnet. Any surface or near-surface discontinuities, like cracks, voids, or inclusions, disrupt the magnetic field, causing magnetic flux leakage at the flaw location.

Next, a fine ferromagnetic powder, typically iron particles suspended in a liquid carrier, is applied to the magnetized test piece's surface. These particles are attracted to areas of magnetic flux leakage, forming visible indications or accumulations over the flaw locations.

The inspector examines the test piece under appropriate lighting conditions, often using black or fluorescent light, to observe the patterns of accumulated iron particles. These patterns, known as indications, indicate the presence of flaws and provide information about their size, shape, orientation, and location.

Steps to Be Followed:
1. Clean the joint with remover cleaner to ensure it is free from slag/rust.
2. Apply white "contrast paint" on the weld area to enhance the visibility of the magnetic powder.
3. Magnetize the joint using a permanent yoke while dusting magnetic powder on the weld area.
4. Magnetic powder accumulates over flaws/imperfections.
5. Record and inspect the joint for indications of flaws.

3.10.Visual Inspection :

Visual Inspection of weld joints is an essential aspect of ensuring welding quality and control. It involves visually examining welds for various characteristics, including weld bead profile, size, shape, surface irregularities, discontinuities, and overall appearance. This initial inspection step is crucial as it allows for the assessment of weld quality before more advanced non-destructive testing (NDT) methods are utilized.

During visual inspection, trained inspectors or welders carefully scrutinize weld joints using their eyes or with the assistance of magnification tools such as mirrors, magnifiers, or borescopes. They meticulously search for indications of defects such as lack of fusion, incomplete penetration, undercutting, porosity, cracks, spatter, and slag inclusions. Furthermore, they assess the alignment and geometry of the weld in comparison to specified standards and requirements.

Visual inspection serves as a foundational method for identifying potential issues early in the welding process, facilitating timely corrective measures when necessary. It is a straightforward yet critical approach for ensuring the integrity and quality of welds in various applications and industries.

RESULTS

1. DRY PENTRATION TEST:

In dry penetration test we had found the defects found in the welding zone are:
1. Undercut
2. Porosity
3. Poor Start & Stop

2. LEEB HARDNESS TEST

Hardness points at different zones:

Base Metal (HL)	Heat Affected Zone (HL)	Heat Affected Zone (HL)	Base Metal (HL)
390	370	439	318
314	371	441	281
354	384	364	421

3. MAGNETIC PARTICLE TEST

In magnetic particle test we had found the defects found in the welding zone are:
1. Undercut

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CONCLUSION

In conclusion, upon subjecting the broken pieces to a visual test at 30x magnification, it became evident that there was insufficient penetration in the joint. This observation leads to the conclusion that the E6010 electrode is best suited for welding butt joints, particularly for root welds in piping applications.
Despite this limitation, the E6010 electrode remains a popular choice among welders and fabricators. Its ease of use, reliability, and ability to produce welds with good fusion and minimal defects contribute to its continued preference in the industry.
Nevertheless, it is crucial to underscore the significance of adhering to proper welding procedures, parameter settings, and implementing robust quality control measures. These measures are essential for ensuring consistent and satisfactory performance of fillet welds when employing the E6010 electrode. By maintaining high standards in welding practices, welders can maximize the benefits offered by this electrode while minimizing potential drawbacks**.**

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