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PERFORMANCE OF BUTT WELD USING E6010 ELECTRODE

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ABSTRACT
Butt welds are a type of joint that joins two pieces of metal along a single edge. E6010 is a type of electrode that is used for shielded metal arc welding (SMAW), which produces an electric arc between the electrode and the workpiece. E6010 electrodes have deep penetration, high force, spray arc, and easily removable slag. They are suitable for welding dirty, rusty, or greasy metals, and can be used in vertical and overhead positions. The performance of butt welds using E6010 electrodes depends on the welding parameters, such as current, voltage, speed, and angle. There may be a chance of change in mechanical properties of the welds, such as tensile strength, hardness, elongation, and yield strength may be affected by the heat input, the heat affected zone (HAZ), and the defects in the welds. The quality of the welds can be tested by methods such as dye penetration test, tensile test, and X-ray inspection.

Keywords:
Butt weld performance electrode E6010

INTRODUCTION

Welding is a fabrication process that joins materials, usually metals, by using high heat to melt and cool the parts together to create a fusion. The welded pieces unite into one entity. Welding differs from low-temperature techniques such as brazing and soldering, which do not melt the base material instead they deposit other material as joining material. In addition to melting the base metal, filler metal is usually added to the joint to form a pool of molten material (weld puddle). As it cools, the weld configuration (butt, full penetration, fillet, etc.) is stronger than the base metal. Pressure can also be used in combination with heat or alone to create welds. Welding also requires some form of protective shielding to protect the filler metal or molten metal from contamination and oxidation. Welding can use a variety of energy sources including gas flames (chemical), arcs (electrical), lasers, electron beams, friction, and ultrasound. Welding is often an industrial process, but it can be performed in a variety of environments, including outdoors, underwater, and in space. Welding is a dangerous activity and requires precautions to avoid burns, electric shock, visual impairment, inhalation of toxic gases and fumes, and exposure to intense UV radiation.

The process involves intense heat generated by an electric arc, gas flame, or laser, which melts the materials at the joint. A filler material may be added to strengthen the bond.Various welding methods exist, each suited to specific materials and applications. For example, Gas Metal Arc Welding (GMAW) utilizes a consumable wire electrode and shielding gas to protect the weld from atmospheric contamination. On the other hand, Shielded Metal Arc Welding (SMAW), commonly known as stick welding, employs a flux-coated electrode that forms its gas shield.Welding demands precision, skill, and safety precautions due to the high temperatures involved and potential hazards like fumes and radiation. Proper training and equipment are crucial to ensure quality welds and protect the welder's well-being.Overall, welding is a versatile and indispensable process, driving innovation across industries and enabling the creation of durable, complex structures essential to modern life.

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BUTT WELDING

Butt welding stands as a fundamental process within the realm of metal fabrication and joining, esteemed for its efficacy in establishing robust, continuous connections between metal components. Widely embraced across industries such as automotive, aerospace, construction, and manufacturing, its significance lies in the creation of durable and seamless welds. Initiating the butt welding procedure necessitates meticulous preparation of the metal surfaces slated for fusion. Thorough cleaning to eliminate contaminants, such as dirt, oil, and rust, is imperative to ensure optimal welding conditions. Subsequently, precise alignment and clamping of the metal pieces facilitate seamless fit-up, a crucial precursor to successful welding. Central to the butt welding operation is the application of heat to the edges of the metal pieces, typically facilitated by a welding torch or equivalent heat source. As the metals reach their melting points, a molten pool forms, enabling the fusion of the adjacent surfaces. Upon solidification, the molten metal seamlessly integrates, yielding a homogeneous bond without compromise to structural integrity. The inherent advantages of butt welding encompass not only its capacity to produce welds of superior strength but also its propensity for minimal distortion and warping of the surrounding material. Furthermore, its expeditious and efficient execution renders it a financially prudent choice for large-scale production endeavors. In conclusion, butt welding emerges as an indispensable technique in the realm of metal fabrication, underpinned by its ability to deliver durable, aesthetically pleasing welds across diverse applications. Its ubiquity underscores its pivotal role in contemporary manufacturing processes, embodying reliability, efficiency, and uncompromising quality.

EXPERIMENTATION

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.
- flame-resistant clothing

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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.

First layer welding coating:

Range = 40
Current = 60
Voltage = 30

Second layer welding coating

Range = 50
Current = 100
Voltage = 30

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:

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- 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.

STEP-9: Testing:

- Liquid Penetration test.
- leeb Hardness test'
- Tensile test.

Material Preparation:

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, beveling, chamfering, or grooving may be necessary to create 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 buildingof 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, beveling the edges of thicker plates can enhance weld penetration.

Material Preparation

Selection of Groove angle:

The selection of groove angle in welding is critical for creating strong, durable joints. The groove angle determines the depth and width of the weld joint, impacting weld penetration and strength. Factors like material thickness, joint configuration, and welding process influence the optimal groove angle selection for each application. Selection of a correct joint design of a welded member leads to perform within load service, corrosive resistant atmosphere and safety.

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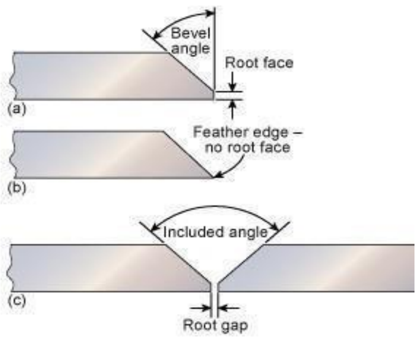

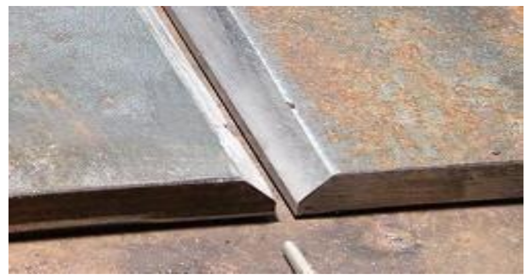

Choosing of Electrode

- The Electrode recommended for our experiment is E6010.
- E6010 welding rod is considered one of the most commonly used rods for beginners.
- Hence, it is also known as ‘sheet metal rod’, ‘beginners’ rod’ or ‘easy rod’ as Chosen.
- The E6010 Electrode is good for all welding positions and for low carbon steel because of its ability to provide deep penetration, low levels of slag, and welds that are high quality in environments where there is dirt, paint, oil, or rust.

Characteristics of E6010 electrode:

- 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 four positions – flat, horizontal, vertical and overhead.

Welding Operation:

Welding operations are integral to project success, encompassing various essential steps. It begins with meticulous planning, including material selection, joint design, and welding method determination. Thorough preparation of workpieces involves cleaning to remove contaminants and joint preparation to ensure proper fit-up, often requiring bevelling or chamfering to create suitable joint geometries.

Selection of the appropriate welding technique, such as MIG, TIG, or stick welding, depends on factors like material type, thickness, and project specifications. Adequate safety measures, including personal protective equipment (PPE) and proper ventilation, are paramount to mitigate hazards like arc flash, fumes, and heat.

During welding, precise control of welding parameters such as voltage, current, and travel speed is crucial to achieve quality welds with desired penetration and fusion. Post-weld inspection and testing verify weld integrity, identifying any defects or discontinuities for corrective action.

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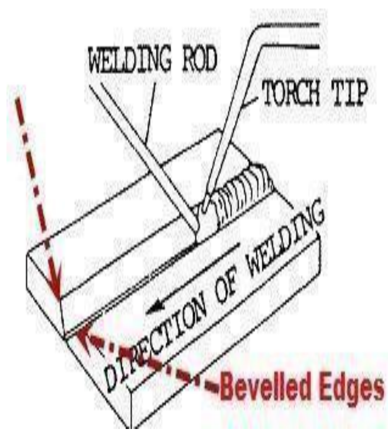
Proper handling and storage of welding equipment and materials also contribute to project efficiency and safety. Communication and coordination among team members ensure seamless workflow and adherence to project timelines. Overall, meticulous planning, execution, and oversight of welding operations are essential for project success, ensuring structural integrity, durability, and compliance with industry standards.We prepare two metal pieces to make single butt joint by using direct current and reverse current with same type of electrode.



Weldingprocess involves following steps.
Positioning and joining:
Align your metal to make sure the edges line up well. They should be smooth and align cleanly. Make tack welds. These will hold the metal together and prevent it from warpingor bending inward when the weld is finished.

First level:
In this step welding of joint in the V-groove up to half the thickness of metal plate with E6013 electrode rod of 1.5 mm thickness and 300 mm length.

Second level:

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In this step Welding a V groove using an E6013 electrode requires precise control of the electrode angle and travel speed to ensure proper fusion and penetration into the groove. The E6013 electrode, known for its versatility and ease of use, produces smooth and visually appealing weld beads while providing good strength and ductility in the welded joint.

Cleaning of Slag material

Clean the weld with a hammer, sand paper and wire brush make subsequent passes if needed.These passes should strengthen the weld and fill it in. Make sure to clean each pass

Testing and Analysis

An error in the welding process may damage weld metals significantly resulting in the loss of strength, durability, and failure of the structure. These welding testing methods like visuals inspection and others are an assurance that products are secure for the intended use.

LEEB HARDNESS TEST:

The Leeb hardness test is a prominent non-destructive method utilized across industries to assess the hardness of metals and alloys swiftly and accurately. Developed by Dietmar Leeb, this testing technique has become indispensable in various sectors including manufacturing, construction, and maintenance.

At its core, the Leeb hardness test relies on the principle of measuring the rebound velocity of a small projectile after it impacts the material's surface. Typically, a handheld device known as a hardness tester is employed for this purpose. The tester houses an impact body equipped with either a tungsten carbide ball or a diamond-tipped indenter. Upon application of a controlled force, the impact body strikes the surface of the material, creating a deformation.

Subsequently, the rebound velocity of the impact body is measured by a sensor within the device. This rebound velocity is directly related to the hardness of the material, as harder materials tend to exhibit greater rebound velocities due to their higher resistance to deformation. The Leeb hardness tester then converts this rebound velocity into a hardness value using established algorithms, providing an instant and reliable assessment of the material's hardness.

One of the key advantages of the Leeb hardness test is its portability and ease of use. The handheld nature of the testing device allows for on-site measurements to be conducted effortlessly, minimizing downtime and logistical challenges associated with transporting samples to a laboratory. Moreover, the non-destructive nature of the test ensures that the integrity of the material remains intact, making it suitable for quality control purposes where preserving the material's structural integrity is paramount.

Additionally, the Leeb hardness test offers versatility in its application, accommodating a wide range of metallic materials, including ferrous and non-ferrous alloys. This versatility extends to diverse surface conditions, such as rough, polished, or curved surfaces, further enhancing its utility across various industrial settings.

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In conclusion, the Leeb hardness test stands as a reliable and efficient method for evaluating the hardness of metals and alloys in a non-destructive manner. Its portability, ease of use, and versatility make it a preferred choice for quality control. The handheld nature of the testing device allows for on-site measurements material assessment, and rebound velocity is directly related to the hardness of the material, as harder materials tend to exhibit greater rebound velocities due to their higher resistance of deformation


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.

Equipment	Manufacture	Model	Date of Manufacture	Date ofExpiry
Penetrant	Oriental chemical Works	ORION 115P	July 2023	June 2025
Developer	Oriental chemical works	ORION 115D	August 2023	June 2025

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Penetrant Remover	Oriental chemical works	ORION 115PR	November2022	December 2025

Penetrant, Penetrant Remover and Developer

1. **PRE-CLEANING:** This can be done by using cotton waste or brush.

2. **APPLICATION OF PENETRANT:** The dye penetrant can be sprayed on theweld pool and wait for some time. This time is known as dwell time.

3. PENETRANT REMOVEL: By using penetrant remover, we can remove thepenetrant from the work piece.

4. APPLYING OF DEVELOPER: Developer can be sprayed on the work pieceand dwell time can acts under observation.

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5. OBSERVATION: Some weld defects can be evaluated on the work piece. Postcleaning. During this process developer is removed and work piece can be cleaned.

6. POST CLEANING : clean the inspected area.This can be done by using cotton waste or brush.

TENSILE TEST:

In tensile test the work piece is placed between two fixtures of Universal testing machine(UTM) and Gradual load (pull force) is applied on both sides. Thus, the material reachesits yield strength and starts breaking. From this test we can evaluate the strength of two work pieces of high-speed weld and low speed weld workpieces. After calculation of elongation, we can conclude that the work piece of low-speed welding has more tensile strength as compared to high-speed welding. So, we prefer low speed welding work pieceis best suitable for industrial application. Thus, the maximum load applied was 55kN where the fracture was observed. The load is applied till the failure is observed. Initially, the deformation was not observed till 55 kN. Thereafter, the steady deformation is observed. The deformation observed was of 20mm when the fracture has occurred. The results are as follows.

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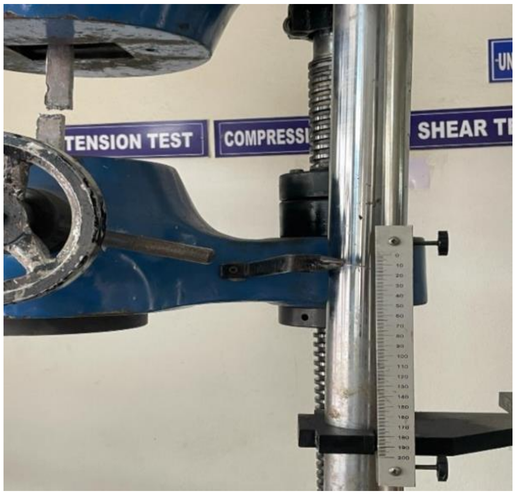

MAGNETIC TEST CONSUMBLES:

	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

Preparation for magnetic test **Formation of spatterns**

The formation of patterns by using magnetic tests, often referred to as "spatterns," is a fascinating phenomenon observed in various scientific and engineering applications. These patterns emerge when magnetic particles suspended in a fluid align themselves in response to an applied magnetic field.

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At its core, the formation of spatterns is governed by the interplay of magnetic forces and the fluid dynamics of the system. When a magnetic field is applied, the magnetic particles experience a force that tends to align them with the field direction.

LITERATURE SURVEY

- **Sanjeev Gupta** Performed the experiment to optimize the condition for performing the welding on Utra-90 specimen in which he varies the current and voltage while keeping the gas flowrate constant and observed that welding joint not made property below 50A and 200A since then burning of specimen stated.
- **. Ravinder & S.K. Jaral** studied the parametric optimization of Arc welding on stainless steel1202] and mild steel by using Taguchi method and found the control factorwhich had varying effect on the tensile strength, are voltage having the highest effect andalso found the optimum parameter for tensile strength current 80A. Are voltage 30V.
- **Dr. Simha** carried on the effect of welding process parameters on the mechanicalproperties of stainless steel -316 [18C-8N] welded by TIG welding.

LITERATURE SURVEY

- **Javed Kazi et al** represent a review on various welding techniques in international journal of modern engineering research publications in 2015. Their prime focus is on fulfilment of objectives of industrial application of welding with producing better qualityproduct at minimum cost and increases productivity. The attempt is made to understand various welding techniques and to find the best welding technique for steel. Special focuses have been put on TIG and MIG welding. For this study they analysed strength hardness, modulus of rigidity, ductility, breaking point, % elongation etc. at constant voltage on hardness testing machine and UM.
- **Naitik s Patel et al** they carried out the features highlighting the TIG as a better prospect for welding then other processes especially for joining of two dissimilar metalswith heating therapy or applying the pressure or using the filler material for increasing productivity with less time and cost constrain.
- **Jail mil 2004 171** self-drilling screw joint for cold rolled steel channel portal. The conclusion of easing by the first author that widely used bolted and plate moments connection is not suitable. They knew joint of portal frames constructed from thin cold formed channel sections. Theorder traditionally used joint configuration of a joint with two bolts is end is ending platesmay need to be sized conservatively.
- **Shah qurram Ashok bhai** steel consumption is more in industrial shed structure using hot willed steel and cold rolled steel sheets as compared to industrial shed structureusing cold formed steel sections. The weight is more in industrial shed which use of hot rolled sheets. The weight of industrial shed with cold formed sections is reduced with 32.03% than industrial shed structure with hot rolled sheets. An attempt is being carried out the comparison between hot rolled and cold milled steel.
- **D. Devakumar & D.B Jabaraj** the gas tungsten arc welding (GTAW) of sheets 2mmthickness of hot rolled medium and high tensile structural steel (HRS) is carried out to investigation of mechanical properties and composition analysis through energy dispersive analysis of X ray DAX) to find out the hardness test, tensile test, bend test to determine the mechanical properties of the weldments. The increase in the weld zone micro hardness and formation of dendritic delta ferrine microstructure, when compared with HRS parent metal having elongation grained austenite with ferrite and the HRS parent metal having fine grains of ferrite, caused the joint efficiency of the HRSweldments to increase.
- **Ruangyot Wichienrak & Somchai** cold rolled steel industry in type of batch sealingfurnace, the mechanical properties of steel sheet have variation by each position. The meters of annealing temperature and time were analysed to work out the source of mechanical properties.
- **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 modes of hot rolled sample. quenched from 650c, and cold rolled sample, quenched from 650e.

METHODOLOGY

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The methodology adopted in this paper is an intensive literature review on the various types of technologies to improve the material and equipment to be selected.Welding parameters and techniques are outlined Quality control measures are implemented .Data on weld quality and performance are collected,analyzed and validated.

CONCLUSION

After testing the weld joints by using dye penetration test the following are the defects like excess reinforcement, excess penetration and lack of penetration are observed. The weld effects are raised due to improper welding, residual stresses, distortion, inclusions, fluctuations, in voltage and current, selection of suitable electrode for material which is used for welding. The weld defect reduces the strength of weld joint. After liquid penetration test, magnetic test ,leeb harness test & tensile test are performed. We have observed that properties of hardness in cap is less than the root specimen and also hardness of welded zone is greater than heated effected zone and base metal. In tensile test we observed that the maximum elongation and breaking point. Finally, we conclude that strength of weld joint is greater than parent material.

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