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IMPACT OF RESIDUAL STRESSES ON SHIELDED METAL ARC WELDING (SMAW) WELD JOINT

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ABSTRACT
The impact of residual stresses on meld joints is significant in various aspects. Residual stresses can influence the mechanical properties, fatigue life, and susceptibility to stress corrosion cracking of welding components. Understanding and managing residual stresses are crucial for ensuring the structural integrity and performance of welded structures. Various techniques, such as reheating, post weld heat treatment, and shot peening, are employed to mitigate residual stresses and enhance the reliability of welded joints.

Keywords:
Welding Technology, Shielded Metal Arc Welding, Non-Destructive Tests.

INTRODUCTION

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool, causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat or by itself to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized. Many different energy sources can be used for welding, including a gas flame (chemical), an electric arc (electrical), a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space. Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

MATERIALS AND METHODS

Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as “low carbon steel.” Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having a carbon content from 0.30% to 2.0%. If any more carbon than that is added, the steel would be classified as cast iron.

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Fig.1 Base Metal

V-GROOVE-GRINDING

For preparation of V-Groove 60-70 degrees horizontally the grinding requires.

Grinding is a method of reducing the size of hard materials or sharpening tools, generally accomplished in several stages. To produce desired fineness of end products,grinding is done after crushing. For example, through crushing the mineral ore to belowa certain size and finishing by grinding it into powder, the ultimate fineness depends onthe fineness of dissemination of the desired mineral

Grinding machines remove material from the work piece by abrasion, which can generate substantial amounts of heat. To cool the work piece so that it does not overheatand go outside its tolerance, grinding machines incorporate a coolant.

Fig.2 V-Groove Preparation by Grinding

ELECTRODE

The tungsten electrode in SMAW process comes in either pure condition, or alloyed with thorium, zirconium, etc. When alloyed with thorium, the alloying content varies between 1 to 2 percent. The electrodes alloyed with zirconium come with 0.3 to 0.5 percent zirconium.

Yellow indicates alloy containing 1% thorium, Red colour indicates alloy containing 2%thorium and Brown indicates 0.3 to 0.5% zirconium. The performance of these electrodes lies between that of thorium alloyed electrodes and pure tungsten electrodes. These electrodes have been known to give good results for welding some metals, with alternating current.

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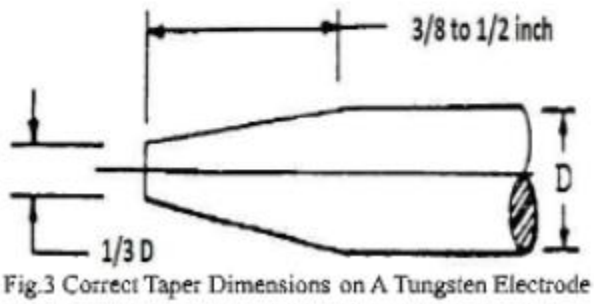

Fig.3 Correct Taper Dimensions on A Tungsten Electrode

Fig.3 Correct Taper Dimensions on A Tungsten Electrode

SHIELDED METAL ARC WELDING(SMAW)

Shielded Metal Arc Welding (SMAW), also known as stick welding, is a welding process that uses a consumable electrode coated in flux to lay the weld. Here's a quick overview:

1. **Equipment**: SMAW requires a welding power supply, electrode holder, ground clamp, and welding electrodes.
2. **Process**: The process begins by striking an arc between the coated electrode and the workpiece. As the electrode is consumed, the flux coating melts, creating a protective gas shield around the weld pool. This shield prevents atmospheric contamination, including oxygen and nitrogen, which could weaken the weld.
3. **Filler Metal**: The electrode's core material serves as the filler metal, adding material to the weld joint as it melts.
4. **Applications**: SMAW is versatile and can be used on various metals and alloys, making it suitable for construction, fabrication, repair, and maintenance work.

Fig.4 Shielded Metal Arc Welding on a Specimen

WELD QUALITY TESTING METHODS

Leeb Hardness Test

The Leeb hardness test is a non-destructive testing method used to quickly and conveniently measure the hardness of metallic materials. It's widely employed across industries such as manufacturing, construction, maintenance, and quality control due to its portability, ease of use, and efficiency. The rebound velocity of the indenter is then measured and correlated with the material's hardness. This process is facilitated by a handheld device equipped with a probe containing the indenter, a spring, and a sensor. By comparing the rebound velocity to calibrated values, the device provides a hardness reading. Widely employed across industries like manufacturing and construction, the Leeb hardness test offers a quick and efficient means of evaluating material hardness without causing damage, making it particularly valuable for assessing large or installed components.

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Fig.5 Leeb Hardness Test

DYE PENETRATION TEST

Dye penetrant inspection, also called liquid penetrate inspection or penetrant testing,is a widely applied and low-cost inspection method used to check surface-breaking defects in all non-porous material.

- **Precleaning**
  Cleaning of both the mild steel tig welded joints.
- **Application of penetrant**
  Applying the penetrant on both the tig welded joints.
- **Dwell time**
  After applying penetrant keeping them without touching for few minutes.
- Removal of excess penetrant with the waste clothe the excess penetrant is removed.
- **Developing**
  The developer is applied on the tig welded joint for better visualizations.
- **Recording**
  Recorded the defects
- Inspection interpretation
- Post cleaning.

Fig.6 Dye Penetration Test

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MAGNETIC PARTICLE INSPECTION

Magnetic particle inspection (MPI) is a crucial non-destructive testing (NDT) method widely utilized across industries to detect surface and near-surface flaws in ferromagnetic materials. Operating on the principle of magnetic flux leakage, MPI involves magnetizing the component under inspection and applying a magnetic particle suspension to its surface. As the magnetic particles align themselves along the magnetic flux lines, they form visible indications at the locations of flaws, such as cracks or discontinuities. This technique is particularly effective for inspecting welds, castings, and forgings, providing sensitive detection of defects that could compromise the integrity and safety of critical components. With its ability to detect both surface and subsurface flaws rapidly and cost-effectively, MPI plays a crucial role in quality control, maintenance programs, and manufacturing processes, ensuring the reliability and performance of industrial equipment and structures.

Fig.7 Magnetic Particle Yoke

SPECIMEN PREPARATION

Plasma cutting is a process that cuts through electrically conductive materials by means of an accelerated jet of hot plasma. Typical materials cut with a plasma torch include steel, stainless steel, aluminium, brass and copper, although other conductive metals may be cut as well. Plasma cutting is often used in fabrication shops, automotive repair and restoration, industrial construction, and salvage and scrapping operations. Due to the high speed and precision cuts combined with low cost, plasma cutting sees widespread use from large-scale industrial CNC applications down to small hobbyist shops.

Fig.8 Plasma Cutting

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Fig.9 Marking Tools for Cutting the Specimen

TENSILE TEST

A tensile test is a fundamental mechanical test used to evaluate the mechanical properties of materials, particularly metals and alloys. During a tensile test, a standardized specimen is subjected to an axial pulling force, known as tension, until it fractures. This test provides valuable information about the material's behaviour under tensile loading, including its ultimate tensile strength, yield strength, elongation, and modulus of elasticity.

As the tensile force increases, the material undergoes deformation, initially exhibiting elastic behaviour where it returns to its original shape once the load is removed. The point at which the material transitions from elastic to plastic deformation is known as the yield point or yield strength. Beyond this point, the material undergoes permanent deformation until it reaches its ultimate tensile strength, the maximum stress it can withstand before fracturing.

During the test, various parameters are continuously monitored and recorded, such as load and elongation. These data are used to construct a stress-strain curve, which illustrates the material's mechanical response under tension. This curve provides valuable information about the material's strength, ductility, and stiffness.

After reaching its maximum load, the material eventually fractures, marking the end of the test. The fracture surface can provide further insights into the material's failure mode, such as ductile or brittle fracture.

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Fig.10 Universal Testing Machine

Fig.11 Breaking of Work Piece

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RESULTS

LEEB HARDNESS TEST

Top	**T1** 227	**T2** 387	**T3** 417	**T4** 412	**T5** 398
Middle	M1 278	M2 355	M3 346	M4 444	M5 326
Bottom	B1 317	B2 358	B3 178	B4 328	B5 243

Hardness Test Values

DYE PENETRATION TEST INSPECTION

The application of penetrants on the SMAW welded joints shown these defects

- **SP:** Shielded Plasma
- **BT:** Back Tacking
- **LOP:** Lack of Penetration
- **ER:** Electrode/Rod

TENSILE TEST

Length=185mm

Width=24mm

Elongation=10mm

Thickness=6mm

Load=105KN

Area=24×6=144mm^2

Elongation %=final length-initial length/initial length*100

=195-185/200*100=5

Tensile strength=load/area

=105×10 /144

=729. 1666N/mm^2

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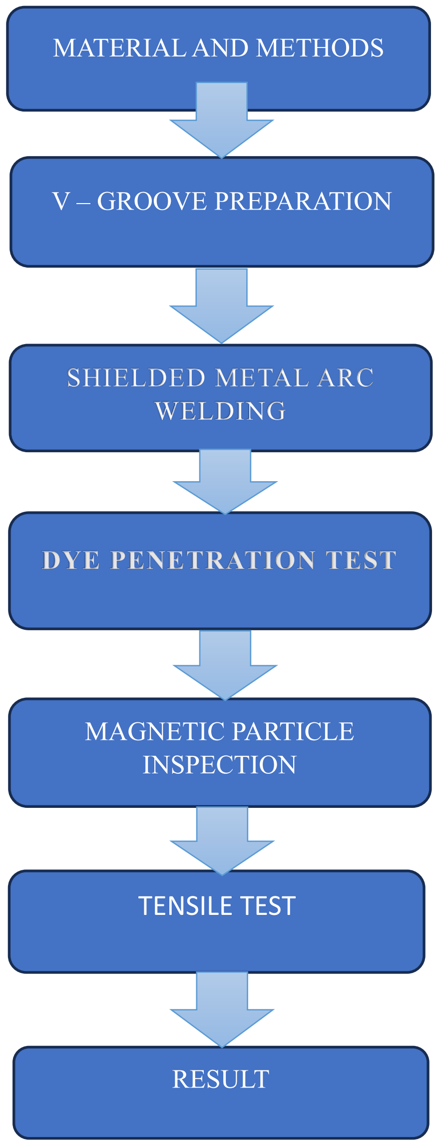
METHODOLOGY



CONCLUSION

In conclusion, the impact of residual stresses on weld joints is profound and multifaceted, significantly influencing the structural integrity, performance, and reliability of welded components. Residual stresses can lead to a range of detrimental effects, including distortion, cracking, and premature failure, compromising the safety and longevity of welded structures. The presence of residual stresses introduces challenges in design, fabrication, and inspection processes, necessitating careful consideration and mitigation strategies. Techniques such as preheating, post-weld heat treatment, and controlled welding sequences can help manage residual stresses and minimize their adverse effects on weld joints. After joining destructive and no-destructive tests were conducted to find the weld quality, strength and residual stresses. Conducted the Leebs hardness test, Chemical Composition test, Dye penetration test, Magnetic particle test

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and Tensile test from the results increasing the speed of welding with constant current increases the hardness.

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