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CORROSION BEHAVIOUR WELDED JOINT OF SS304 WITH CMT TWIN

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Abstract - *This study investigates the corrosion behaviour of stainless steel 304 (SS304) weld joints produced using Cold Metal Transfer (CMT) twin welding, a low-heat input technique that minimizes thermal damage and preserves corrosion resistance. SS304, known for its durability and high resistance to corrosion, is widely used in industries such as food processing and petrochemicals; however, conventional welding methods like TIG and MIG can introduce high heat input, leading to carbide precipitation and intergranular corrosion, especially in chloride-rich environments. CMT twin welding offers controlled heat input, potentially addressing these issues. Welded SS304 samples were produced using CMT twin welding with varied parameters to optimize joint quality. Corrosion testing, Microstructural analysis using optical microscopy, mechanical testing revealed that the weld zone exhibited fine dendritic structures due to the controlled heat input, while the heat-affected zone (HAZ) showed minimal carbide precipitation and grain growth. The findings demonstrate that CMT twin welding enhances corrosion resistance in SS304 welds compared to conventional welding techniques. Results show lower corrosion current densities, higher impedance values, and improved resistance to pitting corrosion, attributed to the low heat input that preserves chromium-rich phases, essential for corrosion protection. This study concludes that CMT twin welding is a promising method for joining SS304 in applications where corrosion resistance is critical. Further research into optimizing CMT parameters and long-term corrosion testing in diverse environments is recommended to expand the applicability of CMT-welded SS304 in corrosive industries.*

Key Words: *CMT Twin process, Mechanical properties, Corrosion behaviour analysis , Microstructural analysis, Heat-affected zone (HAZ).*

1. INTRODUCTION

Stainless steel grade SS304 is austenitic, known for its excellent resistance to oxidation, corrosion, and good mechanical properties. These features make SS304 a material of choice for a wide range of applications, including in the food processing, chemical, pharmaceutical, automotive, and marine industries. Despite its excellent intrinsic properties, the welding of SS304 can lead to changes in microstructure, which may degrade its corrosion resistance. Common issues such as sensitization, carbide precipitation, and changes in grain structure can occur in the heat-affected zone (HAZ), potentially compromising the material's performance in corrosive environments. Therefore, maintaining the corrosion resistance of welded SS304 joints is a critical consideration in ensuring the longevity and reliability of welded components. The Cold Metal Transfer (CMT) Twin welding process offers a promising solution to mitigate some of these challenges. A relatively new advancement in welding technology, CMT Twin is a low-heat-input process that uses a pulsed arc to transfer metal in a controlled manner. This unique feature results in reduced thermal distortion, finer weld bead profiles, and lower heat-affected zones compared to conventional welding techniques. These attributes suggest that CMT Twin could be especially advantageous when welding sensitive materials like stainless steel, where heat input and cooling rates must be precisely controlled to preserve corrosion resistance and minimize defects.

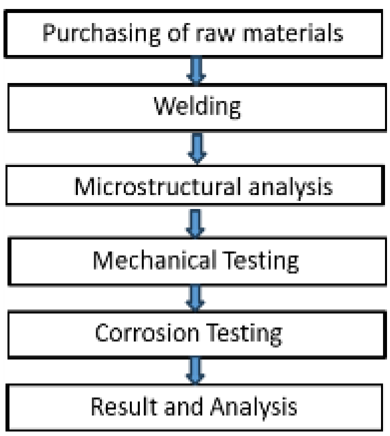
1.1 Back Ground of the work

Stainless steel grade SS304 is one of the most commonly used alloys in industries requiring materials with high resistance to corrosion and excellent mechanical properties. Its resistance to oxidation, rust, and corrosion makes it ideal for use in harsh environments, such as chemical processing, food and beverage production, marine environments, and pharmaceutical industries. The alloy consists primarily of iron, with chromium (18%) and nickel (8%) as the main alloying elements, which provide the material with its superior corrosion resistance, particularly in environments containing acidic and chloride-rich solutions. However, the corrosion resistance of SS304 can be compromised during the welding process. Welding introduces heat to the material, altering its microstructure in the heat-affected zone (HAZ), which can lead to several issues such as grain growth, sensitization, and the formation of chromium carbides.

1.2 Motivation and Scope of the Proposed Work

Sample Preparation: Prepare SS304 specimens with welded joints using the CMT Twin welding process.
Corrosion Testing: Perform corrosion tests such as salt spray, electrochemical tests (potentiodynamic polarization and electrochemical impedance spectroscopy), and immersion tests to assess the welds' corrosion resistance. Microstructural Analysis: Use optical or electron microscopy to examine the microstructure of the welded joints, focusing on the heat-affected zone (HAZ) and weld metal. Weld Quality: Assess weld quality by evaluating appearance, porosity, and defects. Corrosion Resistance: Compare the corrosion resistance of CMT Twin-welded joints with non-welded SS304 and those welded by other methods (e.g., TIG, MIG).

2. METHODOLOGY



2.1 Welding

CMT Twin Welding Machine: A welding machine capable of performing CMT twin welding. Ensure it is well- calibrated and maintained for consistent results. Welding Accessories: Includes welding helmets, protective gloves, clamps, and fixtures to secure the material during welding .Welding Parameters Control: Equipment or software to monitor and control welding parameters like voltage, current, and wire feed rate

Fig-1: CMT welding

2.2 Microstructural Analysis

Microstructural inspection of the weld zone involves analyzing the structure of the material at a microscopic level to evaluate its properties and integrity. These examinations typically include techniques such as light microscopy, scanning electron microscopy (SEM), and transmission electron microscopy (TEM). Engineers and metallurgists evaluate weld quality by studying the microstructure, including grain size, grain boundary morphology, presence of defects such as porosity or inclusions, phase distribution, etc., to identify potential defects or weaknesses and to determine whether welding parameters are specific to the weld. You can understand the impact. to weld. ingredient. This information is critical to ensuring the reliability, durability, and performance of welded parts in a variety of industries, including aerospace, automotive, and construction. The (HAZ) is referred to as heat affected zone.

2.3 Mechanical Testing

Tensile testing is a mechanical test used to determine the mechanical properties of materials, especially metals and alloys. This involves applying controlled tension to the sample, and gradually stretching it until it breaks. By measuring the force applied and the resulting elongation of the specimen during testing, important properties such as tensile strength, yield strength, and elongation at break can be calculated. This technology helps engineers and materials scientists understand how materials behave under stress and provides valuable information about strength, ductility, and overall performance. Tensile testing is important in a variety of industries, including aerospace, automotive, manufacturing, and construction, where materials must meet specific strength and quality standards to ensure the safety and reliability of structural parts and products. The tensile test is carried out to check the tensile strength of the weld on both 304 stainless the shows the result of tensile testing.

Material Current (A)	Dimensions, mm		Area, mm2	Ultimate tensile Strength (MPa)	Failure type
	Width	Thickness			
85A	12.59	1.96	24.43	465.92	Fractured a Weld
90A	12.6	1.97	24.82	170.11	Fractured a Weld
100A	12.78	1.89	24.15	813.93	Fractured a Weld

Fig-2: Tensile Testing

2.4 Corrosion Testing

Corrosion is the slow deterioration of metals caused by chemical or electrochemical reactions with their surroundings. Corrosion testing is an essential procedure used to assess a material's susceptibility to corrosion. There are many ways to test for corrosion, including electrochemical processes, accelerated testing methods, and exposure to corrosive environments. These tests aid in evaluating the functionality and robustness of materials under particular circumstances, such as those found in industrial, maritime, or atmospheric settings. Engineers and researchers can predict the long-term behavior of materials, choose the right materials for particular applications, and create strategies to mitigate corrosion issues by exposing materials to controlled corrosion conditions. This ultimately ensures the dependability and safety of structures, equipment, and products.

3. CONCLUSION

The CMT Twin process showed superior corrosion resistance compared to TIG and conventional MIG welding, attributed to reduced spatter, lower dilution, and controlled heat input.The welded joint exhibited a refined grain structure with minimal heat-affected zone (HAZ) due to the low heat input of the CMT Twin process. The CMT Twin-welded SS304 retained tensile strength and ductility comparable to the base material, further supporting the corrosion resistance due to minimized microstructural defects. A corrosion test was carried out to identify the weld quality. Thus, a Neutral salt spray test was carried out in this process. Therefore, in this test, the welded material is subjected to salt spray for 24 hours. After that, it is observed that there is no corrosion formation in the welded and heat-affected area.

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