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Research Article

COMPARISON OF ORBITAL AND MANUAL WELDING FOR MANUFACTURING STAINLESS STEEL HEAT EXCHANGER

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ABSTRACT: The main purpose of this study, the fabrication of tube-to-tube sheet welds of an acid cooler exchanger, which is produced with stainless steel material, was examined using different welding methods. The tubes were subjected to two different welding methods using a tungsten electrode. In orbital welding, the machine places the tube on a mandrel and automatically performs the welding based on the manually inputted tube diameter. At the end of each tube weld, the mandrel is transferred to the next tube by the welder. In manual welding, the entire tube-to-tube sheet weld is performed by the welder. Welds were made using the same material, same diameter, and same thickness of tubes for both orbital welding and manual welding. As a result, the test results and quality controls for both weldingmethods were examined.

1. Introduction:

Heat exchangers are crucial components used to facilitate the transfer of energy from one fluid to another. Typically employed for heat transfer purposes, heat exchangers facilitate the exchange of heat or mass between two contacting fluids.

For heat exchangers to function effectively and efficiently, the quality of welding is of paramount importance. Welding is a critical process that joins the components of the heat exchanger, ensuring the overall integrity and performance of the system. High-quality welds are essential for maintaining structural integrity, preventing leaks, and optimizing heat transfer efficiency.

This study focuses on two commonly used welding methods in heat exchangers: orbital welding and manual welding. Orbital welding is an automated process that provides precise and consistent welds. On the other hand, manual welding is a method performed by skilled welders using their expertise and experience. Each method has its advantages and factors toconsider, and understanding their suitability for different applications is crucial.

n addition to welding methods, this article also addresses testing and quality control procedures associated with orbital and manual welding in heat exchangers. The quality of welds can be evaluated through various non-destructive testing methods such as visual inspection, radiographic examination, ultrasonic testing, and liquid penetrant testing. Thesetests ensure compliance with required standards and specifications, guaranteeing the overallreliability and performance of the heat exchanger.

This study aims to enhance the understanding of the critical role of welding in the manufacture and performance of heat exchangers by examining orbital and manual welding methods, along with associated testing and quality control procedures. It seeks to assist engineers, designers, and technicians in making informed decisions regarding heat exchanger selection, manufacturing, and maintenance for various industrial applications.

Welding is a manufacturing method used to join materials together. Welding applications arecommonly preferred in various industries, ranging from the fabrication of steel structures to the manufacturing of vehicles used in transportation. Due to the popularity of welded joints,efforts have been made to improve welding techniques [1].

Irfan et al. demonstrated that a hybrid shell-and-tube heat exchanger provided higher thermal efficiency compared to traditional designs. It showed an increased potential for energy savings and lower pressure drop. These findings emphasize the industrial applicability and performance advantages of hybrid heat exchangers [2].

Bouchenna et al. showed that a heat exchanger based on earth materials performed well compared to heat exchangers made with traditional materials. This design has high energy- saving potential and reduces environmental impact [3].

Antonio et al. emphasize the importance of economic optimization in heat exchanger designand demonstrate how to achieve the most cost-effective and performance-efficient design.
Such an approach can be used to enhance the efficiency of industrial processes and energy systems while reducing design costs, providing economic benefits [4].

Danie et al. showed that an advanced control system design improved the performance of plate heat exchangers. This design offers advantages such as more precise temperature control, lower energy consumption, and longer lifespan [5].

2. Orbital Welding

Orbital welding is a commonly used welding method in the manufacturing of heat exchangers. In this method, a welding head or torch is rotated and moved at a constant speed along the welding line of the heat exchanger. The welding head automatically applies the welding metal to the connection points of the heat exchanger. Orbital welding is a preferred method to achieve high-quality and consistent welding joints. However, proper implementation of quality control and testing is crucial to ensure the compliance of the welding joints with the required specifications.

Figure 1. Orbital welding

Figure 2. Tubes for orbital welding

The advantages of the orbital welding method are as follows:
Orbital welding achieves the welding process with minimal error and provides higher quality weld joints. This results in more durable and efficient heat exchangers. The consistent rotationat a constant speed ensures uniformity among the weld joints, which is crucial for material quality and performance. Orbital welding is an automated method, requiring less human intervention. This reduces the chances of human errors and variations in the welding process. The welding head rotates around the workpiece, allowing for precise and repeatable welds.
The orbital welding head can effectively work in tight spaces and areas with limited accessibility. This flexibility in design enables the fabrication of heat exchangers with complex geometries and restricted installation conditions.

The control of orbital welding involves ensuring the welding process and weld joints complywith requirements. This includes the following factors:

During welding, parameters such as current, voltage, and speed are regularly monitored to ensure compliance with the standards required for the weld joint. Tests conducted before and after welding evaluate the material quality, cleanliness, and compliance with acceptance criteria. These tests ensure that the weld joints meet the necessary standards and specifications. Specific standards and specifications exist for orbital welding. These guidelines provide a framework for ensuring compliance and facilitate the documentation process. The quality control process encompasses verifying compliance with these standards and the proper documentation of necessary certifications and records.

3. Manual Welding

Manual welding, also known as hand welding or conventional welding, is another commonly used welding method in the manufacturing of heat exchangers. In this method, a welder performs the welding process using welding equipment. Manual welding is a process that relies on the experience, skill, and observation abilities of the welder.

Advantages of manual welding in heat exchanger manufacturing include:
Manual welding can be easily applied to different heat exchanger designs and materials. Thewelder can adapt the welding process to the specific details and requirements of the welding joint. Manual welding can be less costly compared to automated welding methods. It may require less specialized equipment, making it an economical option. Manual welding allows for quick adjustments and corrections during the welding process. Any issues or errors that arise can be quickly detected and rectified by the welder.

The control of manual welding involves evaluating the skills of the welder and ensuring the compliance of the weld joints with requirements. Additionally, having an experienced and skilled welder involved in the manual welding process is crucial for maintaining quality andreliability.

The following factors affect the control of manual welding:

Achieving high-quality manual welding requires a welder with experience and expertise. The welder's skills and ability to comply with quality standards are evaluated. Proper control of welding parameters such as current, voltage, welding speed, etc., during the welding process is essential. These parameters need to be monitored and adjusted to ensure compliance with the required standards for the weld joints. Tests conducted before and after manual welding evaluate factors such as material quality, cleanliness, compliance with specifications, and

acceptance criteria. These tests assess the suitability of the weld joint based on the standards and requirements. Specific standards and specifications exist for manual welding. Adhering to these guidelines ensures compliance and facilitates the proper documentation of necessary certifications and records.

The quality control process involves ensuring that the manual welding operations meet the required standards and specifications. This includes evaluating the skills and capabilities of the welder, monitoring welding parameters, conducting necessary tests, and documenting compliance.

4. Experimental Results

S38815 austenitic stainless steels joined using manual welding and orbital welding methodswere subjected to visual inspection, radiographic examination, and penetrant testing (non- destructive testing) as the initial evaluation. Subsequently, mechanical tests such as tensile testing, bending testing, notch testing, and hardness testing (destructive testing) were conducted.

4.1 Non-destructive Testing (NDT)

The visual inspection revealed that orbital welding produced a smoother weld compared tomanual welding.

According to the radiographic examination (RT) film results, the orbital welding exhibited complete penetration, while the manual welding had insufficient penetration.

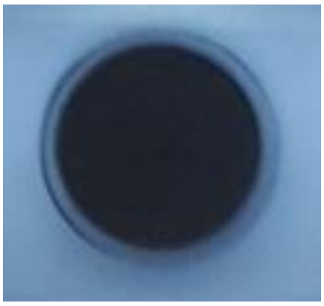

Figure 3. Orbital welding film

Figure 4. Manuel welding film

The penetrant test results indicated that the orbital welding received approval, while there were areas in the manual welding where approval could not be obtained.

4.2 Destructive Testing

The tensile test conducted on the weld joint produced a fracture within the base material in the case of orbital welding. Fracturing within the base material indicates the weld's success and superior mechanical properties compared to the base material.

In the case of manual welding, the tensile test resulted in fracture occurring within the weldzone. Fracturing within the weld zone indicates a failure in the weld, suggesting that the mechanical properties of the weld are inferior to those of the base material.

When examining the macro test images, it was observed that orbital welding exhibited a favorable and evenly distributed weld appearance. On the other hand, manual welding showedan unfavorable wavy appearance.

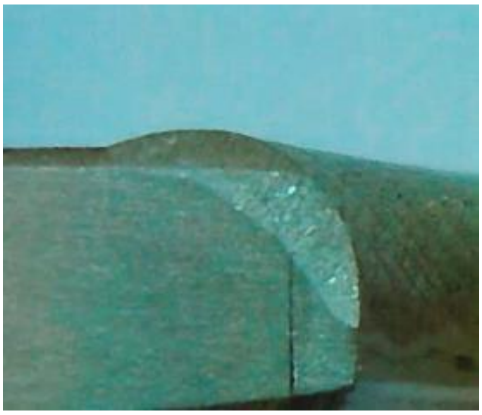

Figure 5. Orbital welding macroimages

Figure 6. Manuel welding macroimages

5. Result

This study extensively examined the manufacturing of heat exchangers using orbital welding and manual welding techniques. Considering the application methods and the tests conducted, it was observed that orbital welding produces a smoother and more uniformly distributed weldcompared to manual welding. Manual welding, on the other hand, showed variations depending on the skill of the welder and did not always progress uniformly. In terms of efficiency, orbital welding proved to be more practical, while in terms of strength, orbital welding was found to be more robust.

Taking all these factors into account, it can be concluded that orbital welding is the preferredchoice for welding heat exchangers.

REFERANCES

[1] Düzce Üniversitesi Bilim ve Teknoloji Dergisi , 8 (2020) 940- 950 (Araştırma Makalesi)

[2] M.F. Irfan, E.M. Elkanzi, K.M. Saif, S.M. Zakir Hossain, 2021

[3] Chafea Bouchenna, Florian Huchet, Carl Aramiou, Erwan Hamard, Lauredan Le Guen, Jean-Marc Paul, 2021

[4] Antonio C. Caputo, Pacifico M. Pelegagge, Paolo Salini, 2007

[5] Danie Martinez Vega, Hernando Gonzalez Acevedo, 2021

[6] Smith, J. D. (2019). Orbital Welding in Heat Exchanger Fabrication. Welding Journal,

[7] Johnson, A. R. (2021). Worker Welding Techniques for Heat Exchangers. International Journal of Welding and Joining,

[8] American Society of Mechanical Engineers (ASME). (2017). ASME Boiler and Pressure Vessel Code, Section IX: Welding, Brazing, and Fusing Qualifications. American Society of Mechanical Engineers.