RESEARCH ON THE MICROSTRUCTURE OF BUTT WELD JOINTS BETWEEN 304 STAINLESS STEEL AND 201 STAINLESS STEEL USING THE GTAW WELDING PROCESS

NGHIÊN CỨU CẤU TRÚC TẾ VI LIÊN KẾT HÀN GIÁP MỐI GIỮA THÉP KHÔNG GỈ 304 VỚI THÉP KHÔNG GỈ 201 BẰNG QUÁ TRÌNH HÀN GTAW

Truong Dung Tuan, Nguyen Quoc Manh
Faculty of Mechanical Engineering, Hung Yen University of Technology and Education

ABSTRACT

Stainless steel is commonly used in many industries because of its mechanical properties and benefits. The non-melting electrode welding method in a protective inert gas environment is always the first choice when welding different materials because of this method's good weld quality and flexibility. In this study, the non-melting electrode welding method in a protective inert gas environment (GTAW) is used to perform butt welding joints between 304 stainless steel and 201 stainless steel with ER-compensating welding wire 308L. The tensile strength of the welded joint is evaluated by a universal tensile-compression device, and the microstructure (OM) of the welded joint is checked by an electronic optical device. The test results showed the compatibility of the welding method with the selected materials and welding parameters; the maximum tensile strength of the weld achieved was 630 MPa.

Keywords: *GTAW process; Butt-joint; 304 Stainless Steel; 201 Stainless Steel; ER-308L welding rod.*

TÓM TẮT

Thép không gỉ được sử dụng rất phổ biến trong nhiều ngành công nghiệp bởi các đặc tính cơ học và những lợi ích mà chúng mang lại. Phương pháp hàn điện cực không nóng chảy trong môi trường khí trơ bảo vệ luôn là lựa chọn đầu tiên khi hàn khác vật liệu vì chất lượng mối hàn tốt, cũng như khả năng linh hoạt của phương pháp này. Trong nghiên cứu này, phương pháp hàn điện cực không nóng chảy trong môi trường khí trơ bảo vệ (GTAW) được sử dụng để thực hiện liên kết hàn giáp mối giữa thép không gỉ 304 với thép không gỉ 201 với dây hàn bù ER-308L. Độ bền kéo của liên kết hàn được đánh giá bằng thiết bị kéo – nén vạn năng, cấu trúc tế vi (OM) của liên kết hàn được kiểm tra bằng thiết bị quang học điện tử. Các kết quả kiểm tra đã cho thấy sự phù hợp của phương pháp hàn với các vật liệu và thông số chế độ hàn đã lựa chọn, độ bền kéo lớn nhất liên kết hàn đạt được là 630 MPa.

Từ khóa: *Quá trình hàn GTAW; Liên kết hàn giáp mối; Thép không gỉ 304; Thép không gỉ 201; Que hàn bù ER-308L.*

1. INTRODUCTION

Stainless steel is a type of steel with a very high resistance to corrosion in working environments, especially chemical corrosion, the Chromium element in steel, which was developed from the early stages. World War I by British expert in steel industry research: Harry Brearley [1]. Welding of different materials has been commonly used in the last three decades because of the benefits this method brings to various industrial fields such as petrochemicals [2] and shipbuilding [3]. Many welding methods have been used for welding different materials, such as in research [4]; author Behzad Sadeghian and his colleagues used finite element methods and experiments to simulate and predict. Weld joint microstructure between stainless steel and carbon steel by spot welding process. In their research, the authors studied the microstructure and tensile strength and evaluated the corrosion potential of the welded joint. In the study [5], author Junhao Sun and his colleagues used laser welding method to study butt welding joints between aluminum alloy and steel. The study results have shown that the intermetallic layer formed during the welding process has a thickness varying from 1.8µm to 6.2µm with different welding parameters when welding at a laser power of 2.85kW. In addition, the welded joints failed the tensile test, and the maximum tensile strength of the welded joints only reached 635MPa. This article studies the microstructure and tensile strength of butt-joint between 304 stainless steel and 201 stainless steel by GTAW process with ER-308L compensation welding wire.

2. MATERIALS AND PROCEDURES

2.1. Base materials and welding rod

The basic materials used in the study are plate 304 stainless steel and 201 stainless steel with a fixed thickness of 3mm. The welding rod used in the experiment is ER-308L. Tables 1 and 2 [6-8] introduce the composition of the two base metals and auxiliary welding rods.

Table 1. Chemical composition of base materials (wt. %)

Materials	C	Si	Mn	Ni	Mo	Cr	Fe
304 steel	0.08	≤ 1.0	≤ 2.0	8.0-10.5	-	18-20	Balance
201 steel	0.004	0.64	1.129	10.028	2.035	16.316	Balance

Table 2. Chemical composition of ER-308L (wt. %)

C	Si	Mn	Ni	Mo	Cr	Fe
0.01	0.45	1.65	13.78	0.08	23.9	Balance

Table 3. Welding parameters

Welding rod diameter (mm)	Welding current (A)	Welding voltage (V)	Gas shield (l/min)	Welding velocity (m/s)	Ceramic Nozzle size
2.4	105	17.5	10	4.5	6

☞

2.2. Procedure for performing the experiment

The base metal plates used in the experiment were all cut with a hydraulic cutting machine at the Faculty of Mechanical Engineering, Hung Yen University of Technical Education, to a fixed size (length x width) of 150mm x 80mm with a thickness fixed is 3mm. After cutting, the surface of the metal sheet is cleaned by sandpaper. A Miller Syncrowave 400 TIG welder from Miller was used to weld all models. The parameters of the welding mode are shown in Table 3. Figure 1 describes the type of weld connection made during the experimental welding process and the protective gas conditions during the welding process. After successful welding, seven samples with the best shape, carefully chosen to ensure the most accurate results, are selected for cutting and tensile testing. A representative sample is selected for microstructure analysis and is taken from the cutout of these seven tensile test samples.

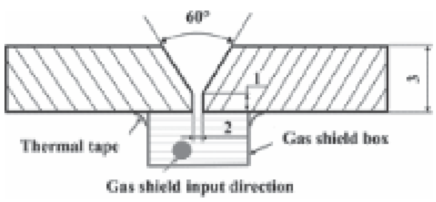

Figure 1. Typical joint and reverse side gas-shield

3. RESULTS AND DISCUSSION

The Unitest-H2-Extra Universal Tensile-Compression Machine at the mechanical processing workshop, Hung Yen University of Technology and Education was selected to test the tensile strength of seven welded samples. The tensile performance conditions of the five samples were similar. Figure 1 shows the dimensions of the butt weld tensile test specimen between 304 and 201 stainless steel; the tensile test results of seven welded specimens are present in Figure 2. Observe the results in Figure 2. We can see that the maximum tensile strength obtained after pulling five samples reaches 635 MPa in sample 5; the sample using the welding mode parameters tends to be the highest among the three parameters. The sample with the lowest tensile strength reached a value of 605 MPa in welded sample No. 2; this sample used the lowest set of welding mode parameters among the three selected parameters. The tensile test results described in Figure 2 show that the maximum tensile strength is about 12.3% greater than the tensile strength of stainless steel 304 and 201, as reported [9]. This shows that the butt weld connection between 304 and 201 stainless steel was successful in terms of tensile strength limit after welding.

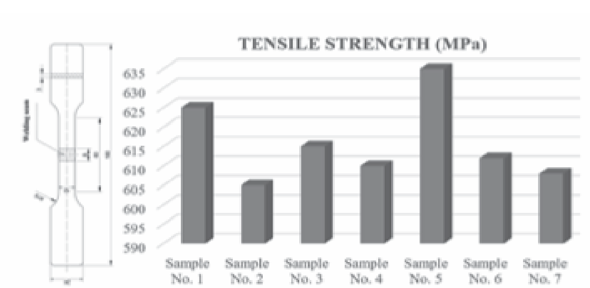

Figure 2. Dimensions and the tensile test results of seven samples

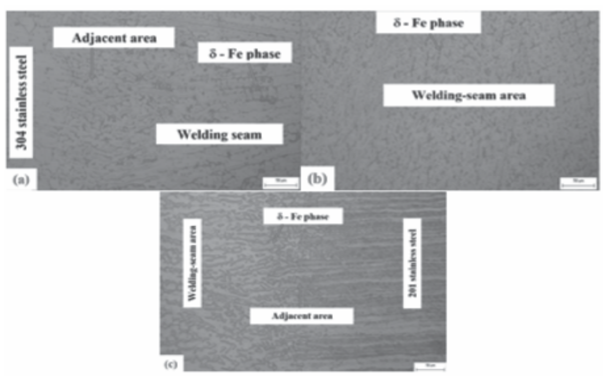

Figure 3. Microstructure of butt welded joint between 304 and 201 stainless steel using GTAW welding process

Figure 3 presents the microstructure of the areas in the butt weld joint between 304 and 201 stainless steel. Figure 3a shows the microstructure in the welding process in the heat-affected area (HAZ). In the connection area between the welding-seam and the 304 stainless steel plate, delta-ferrite fibers are interwoven on the Austenite background. The size of the Delta-Ferrite fibers in this area is short and spread evenly throughout the points. Figure 3b describes the microstructure of the weld metal area. Observing the microstructure in this area, we can see mainly the appearance of the Delta-Ferrite phase structure, in which the weld metal is formed as long fibers interwoven throughout the entire survey area. Figure 3(c) shows the adjacent between the weld metal and SUS-316L stainless steel, forming a long, branch-shaped Delta-ferrite structure interwoven and distributed relatively evenly throughout the area.

4. CONCLUSION

- With the selected welding parameters, the butt weld connection between stainless steel 304 and 201 can be successfully performed by the GTAW welding process when using ER-308L welding rods;

- The maximum tensile strength of the welded joint tested is significantly higher than that of stainless steel 304 and 201. Fractures often occur at SUS-201 stainless steel plates when tested for tensile strength.❖

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