TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 7545 - 7549

Effect of Tungsten Inert Gas Welding on Structure and Hardness of Austenitic Stainless Steel

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Article Info
Volume 82
Page Number: 7545 - 7549
Publication Issue:
January-February 2020

Article History
Article Received: *18 May 2019*
Revised: *14 July 2019*
Accepted: *22 December 2019*
Publication: *03 February 2020*

Abstract

Nowadays is very important to determine the exact properties of welded joints. During fusion welding process several types of microstructure with different mechanical properties is created. Each microstructure shows different behaviour during life cycle of welded joint. Presented paper is focused on evaluation of structure and hardness of stainless steel AISI 304 after tungsten inert gas welding for extension of knowledge in presented field. The paper shows microstructures of weld metal, fusion zone, heat affected zone and base material. The course of Vickers hardness shows differences in mechanical properties of each zone of welded joint.

Keywords: *stainless steel, welding, tungsten inert gas, microstructure, hardness*

I. INTRODUCTION

Welding is a way of a permanent connection between two parts or different materials is encountered in antiquity. The application of welding began fully at the beginning of the 20th century. Nowadays welding involves a large number of industrial processes and is one of the main forces of economic growth [1], [2].

The purpose of welding is to produce a rigid joint that has the desired properties. These usually mean the required strength and toughness, as well as the resistance to degradation processes that may run over the entire planned life of the joint, and finally, the resistance to sudden failure, ie safety, usually expressed in terms of integrity and fracture toughness. Welding is still the most economical way of permanently bonding various types of metals and alloys [1], [3].

In engineering practice, we are increasingly encountering the basic materials of the austenitic structure. Austenitic steels have been used since the beginning of the 20th century and their use continues to grow [4], [5].

Austenitic stainless steels generally contain more than 24% total chromium, nickel, and manganese, with Cr content >16%. The effect of chromium is manifested in the high-grade corrosion resistance of steel, while nickel and manganese are austenitizing agents lowering the temperature of the steel Ms well below room temperature. Compared to ferritic stainless steels, austenitic stainless steels have about 50% greater thermal expansion and about 30% less thermal conductivity. As a result, larger deformations and stresses occur during welding. Austenitic stainless steels are characterized by better ductility and toughness than carbon and low alloy steels. This results from their austenitic structure, which has a cubic flat center lattice. Even at the lowest cryogenic temperatures, some austenitic steels have excellent toughness. Even at temperatures above 500 ° C, they are stronger than carbon steels and retain good oxidation resistance. Austenitic stainless steels can be divided into three basic groups [5], [6]: •unstabilized

- stabilized
- austenitic steels with low interstitial content.

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For stabilization, additives having a higher affinity for carbon than chromium are used. In particular, titanium and niobium are used, to a lesser extent vanadium and zirconium, respectively. Tantalum. Their appropriate amounts depend on the carbon content. Molybdenum is added to increase strength and corrosion resistance. Austenitic steels may contain a small proportion (up to 8%) of δ-ferrite. Silicon also plays an important role in austenitic stainless steels. As the Si content increases, the oxidation and carburization resistance of the steel at higher temperatures increases. The higher Si content also reduces the viscosity of the molten metal. In totally austenitic weld metals, the ratio of carbon to Si content plays an important role [7], [8].

The weld is formed by melting the metal from the weld edges, or by mixing the molten material. If additional material is required, it is added to the leading edge of the weld bath. The most commonly used shielding gases for TIG welding are argon and helium, or mixtures thereof. Other combinations with oxygen and carbon dioxide are also used in practice. TIG welding ensures very clean and high-quality welds. Since no slag is formed, the risk of slag compounds in the weld metal is eliminated and the finished weld requires no cleaning [9], [10].

II. Experimental Material and Procedure

A. *Stainless Steel AISI 304*

Austenitic chrome-nickel metal is the maximum generally applied type of hardened metal with exceptional erosion obstruction, bloodless formability and weldability.

Referenced metallic is impervious to water, water fume, air stickiness, palatable acids, feeble natural and inorganic acids. In the wake of welding up to 6 mm thick, impervious to inter crystalline erosion even without more warm temperature treatment (low carbon content). Affirmed for warm concerns up to three hundred °C. It is well publishable and pliable via profound pulling, collapsing and bowing. Electric circular phase welding with all welding strategies is appropriate, now not suitable for fire welding. It is applied in building and atomic businesses, in layout, in delivery hardware, within the nourishment commercial enterprise and such [11]. Mechanical residences of dealt with metal AISI 304 are appeared in Table I and synthetic shape are appeared in Table II.

B. Filler Metal OK TIGROD 318Si

Non-protected hardened steel balanced out chrome-nickel-molybdenum cord for welding settled and non-balanced out Cr-Ni-Mo and Cr-Ni steels. Alright Tigrod 318Si has extraordinary fashionable intake obstruction. It is balanced out through niobium to enhance safety from inter crystalline intake. Higher silicon content improves operational residences, for example, wetting. On account of niobium adjustment, the fabric can serve up to four hundred °C. Mechanical residences of filler metallic OK TIGROD 318Si are regarded in Table III and compound structure is regarded in Table IV.

Fronius MagicWave 2500 is a cautiously managed TIG AC/DC welding supply with Active Wave innovation, defined via its extremely-calm but tremendously strong round phase. It has 250 A force, is light-weight and powerful concurrently, and has an instinctive pastime. Welding situations are recorded in Table V. Figures 1 - three are demonstrating macrogeometry and microstructure of the welded joint. The microstructure of weld metal, combination quarter, warmth prompted quarter and base metallic are regarded on Figures four - 7.

Table. I. Mechanical properties of stainless steel AISI 304

Tensile strength R_m [MPa]	**Yield point R_p [MPa]**	**Elongation A_{min} [%]**	**Hardness max. HRB**	**Structure**
540 - 680	195	45	88	austenitic

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Table. II. Chemical composition of stainless steel AISI 304 [%]

C	*Mn*	*P*	*S*	*Si*	*Cr*	*Ni*	*Mo*	*Ti*
0,07	2,0	0,045	0,03	1	18/20	8/10	-	-

Table. III. Mechanical properties of filler metal OK TIGROD 318Si

Tensile strength R_m [MPa]	**Yield point R_p [MPa]**	**Elongation A_{min} [%]**	**Impact strength *KV* [J]**
615	460	35	40

Table. IV. Mechanical properties of filler metal OK TIGROD 318Si [%]

C	*Si*	*Mn*	*Cr*	*Ni*	*Mo*	*Nb*
0,08	0,80	1,80	19,0	12,5	2,80	1,0

Table. V. Welding conditions

Welding current I_{ZV} [A]	**Voltage U_{ZV} [V]**	**Gas flow rate [$l.min^{-1}$]**	**Filer metal diameter [mm]**	**Gape [mm]**	**Welding speed [$mm.s^{-1}$]**
128	12,4	16	1,2	0,5	10

Figure. 1. The face of the weld

Figure. 2. The root of the weld

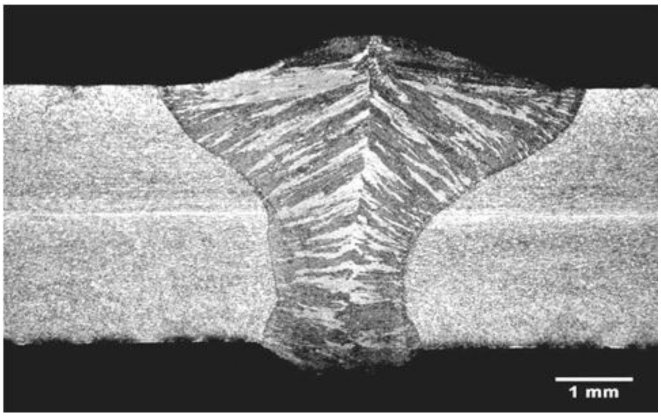

Figure. 3. Metallography of the weld

Figure. 4. The microstructure of weld metal

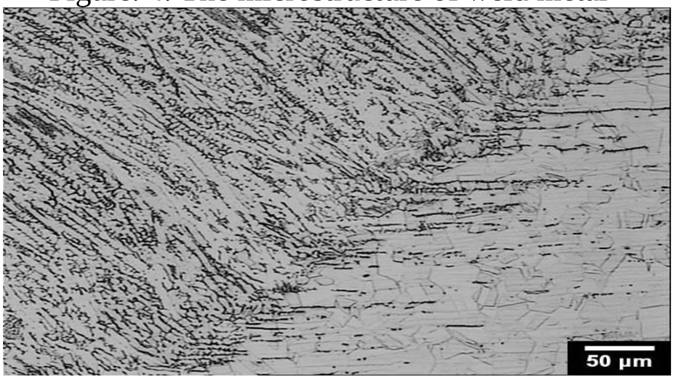

Figure. 5. Fusion zone border

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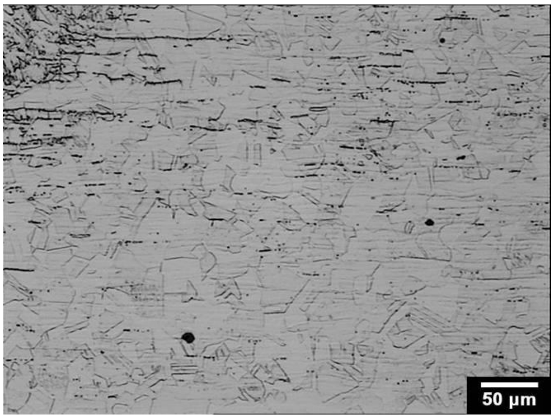

Figure. 6. Heat affected zone

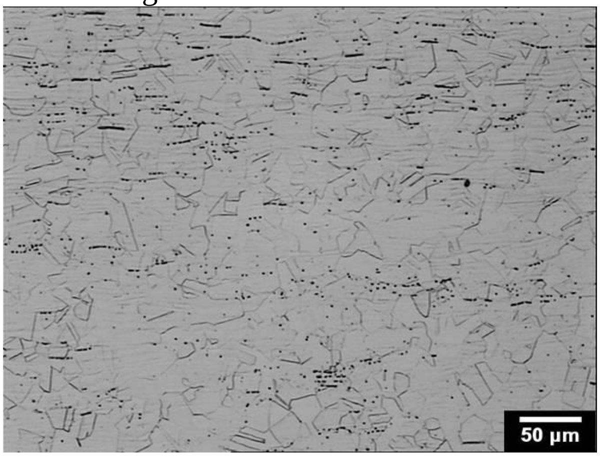

Figure. 7. Base material

RESULTS

Graphical dependence in Figure 8 is showing the course of Vickers hardness in a welded joint. Significant increasing of hardness was observed on the boundaries of fusion zone. Lowest hardness was observed in the middle of weld metal.

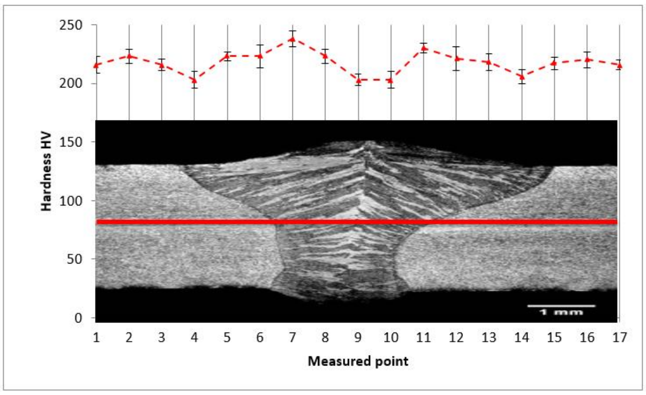

Figure. 8. The course of hardness in welded joint

CONCLUSIONS

Weld joint well formed with a slight elevation in the axial plane and a small weld metal deficit on the surface around the building boundary. The root boiled slightly overflowed.

The microstructure of the weld metal is formed by primary dendrites of austenite and peritectically excluded δ-ferrite.

Defect-free building boundary. TOO with no observable changes except for the root area where reduced δ-ferrite and a slight grain coarsening were observed.Microhardness course homogeneous with a slight increase in the boundary of the building.

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