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(RESEARCH ARTICLE)

The effect of ultrasonic wave on hardness value and micro structure in Smaw welding of AISI 1020 Low Carbon Steel

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Abstract

This article examines how AISI 1020 low carbon steel's microstructure and hardness value are affected by ultrasonic waves. in SMAW welding with a seam angle of 60^{o} using an E7018 electrode with water cooling media and varying immersion time by adding ultrasonic waves. It was found that the hardness value increased with increasing soaking time. Meanwhile, in terms of microstructure, it was found that the longer the soaking time, the more ferrite and pearlite grains were formed. This is due to the influence of carbon filler and heat transfer to the welded steel and the welded steel area.

Keywords: Low carbon steel; AISI 1020; Hardness test; Micro structure; SMAW welding

1. Introduction

Welding technology is an inseparable part of the manufacturing process and the construction sector. The scope of use of welding technology includes steel frames, ships, bridges, railways, pipelines and so on [1].

Welding is used extensively in metal engineering and repair in the construction industry. Nowadays, the growth of metal construction includes many welding aspects, particularly in the field of design, because welding is one of the ways to build a connection that technically demands the welder to have excellent abilities in order to produce a good quality connection. The process of joining metals by melting a portion of the base and filler metals, either alone or in combination with other metals, to create a continuous metal is called welding.[2].

1.1. Welding

Welding is the joining of two or more metals which are then heated with energy [3]. Referring to the American Welding Society (AWS), welding is an interconnected metallurgical composition where the process of joining metals or metal alloys is carried out in melting conditions [4].

Shield Metal Arc Welding (SMAW) is a welding process that combines an electric arc and flux. In this welding procedure, the connecting metal substance (electrode) is coated with flux (welding slag). This layer protects the metal from external oxidation gasses. [5].

During the welding process, the metal will experience a thermal cycle, namely a heating and cooling process that occurs rapidly in the welding area, resulting in a metallurgical process, deformation, which affects welding quality such as the type of defects produced, joint toughness, tensile strength, and metal microstructure. [6]. During the welding process, the metal will experience a thermal cycle, namely a heating and cooling process that occurs rapidly in the welding area,

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resulting in a metallurgical process, deformation, which affects welding quality such as the type of defects produced, joint toughness, tensile strength, and metal microstructure.[7].

1.2. Carbon steel

Carbon steel is defined as a mixture of metal and iron where the most important element is carbon as a reinforcing material [8]. Carbon steel is a material where the main element is Fe, another element that influences its properties is carbon. Carbon steel is classified into three types based on its carbon composition: low (<0.3%), medium (0.3-0.7%), and high (0.7-1.4%).

AISI 1020 steel is a low carbon steel group because its carbon element content is less than 0.25%. AISI 1020 steel has an α + Fe3C phase at room temperature. AISI 1020 steel has relatively low strength compared to the medium carbon and high carbon steel groups, is soft, ductile, easy to shape and easy to process, and when subjected to heat treatment, the phase cannot change to martensite.

1.3. Cooler

The cooling medium used in this research is water. In the welding process, it certainly experiences heating which results in rapid thermal cycle changes which result in structural changes, deformation and thermal stress. Structural changes occur due to the cooling speed from austenite temperature to room temperature. If the cooling speed increases, it means that when cooling the temperature drops slowly to room temperature, it will create an impermeable grain structure due to the slow cooling rate. A slow cooling rate will result in a denser structure as a result of which the hardness and tensile strength values decrease [9].

The cooling process aims to accept the martensite structure. The more carbon elements there are, the more martensite structure will be formed. Martensite is formed from the austenite phase which is cooled rapidly, resulting in higher hardness. [10].

1.4. Ultrasonic

Ultrasonics is a tool that employs ultrasonic waves to break apart trapped particles. [11]. Vibrations that pass via an ultrasonic transducer are converted into ultrasonic waves. Typically, ultrasonics are employed in the domains of agriculture, manufacturing, and health. [12].

The medium's particles form density (strain) and tension (stress) due to the properties of ultrasonic waves that propagate through it. These vibrations have medium amplitudes parallel to the longitudinal direction of propagation. Periodic vibrations of the particles as ultrasonic waves flow through them create a continuous process that creates density and strain in the medium. [13]

One method for strengthening the fatigue strength of welded metal joints is ultrasonics. The process entails causing post-weld deformation to the welded joint, for example, by repairing needle damage that causes force impulses to be generated on the metal surface. [14]. The goal is to provide the welded joint with a useful residual compressive stress [15]. The application of ultrasonics increases the life of the material and eliminates the deformation of the metal material caused by welding. Ultrasonics also increases residual stress by increasing the hardness of the material

2. Material and methods

The AISI 1020 carbon steel specimen was made with a geometry of 60 mm long, 10 mm wide and 5 mm thick with a camber angle of 60° [16]. The aim of cutting is to make it easy to form test specimens on a milling machine. The cutting results are then measured and turned according to the shape and size determined for testing [17]. The number of specimens in this research must prepare as many test objects as the specimens to be tested.

The work on the V seam uses a milling machine, the workpiece that has been prepared is then sawed with a 15 cm. The material has been cut, then the workpiece is marked using a marker or etcher, the edge of the surface is measured to a depth of 6 mm and then projected at an angle of 60°. After the material is drawn, the material is checked and then milled as shown in Figure 1.

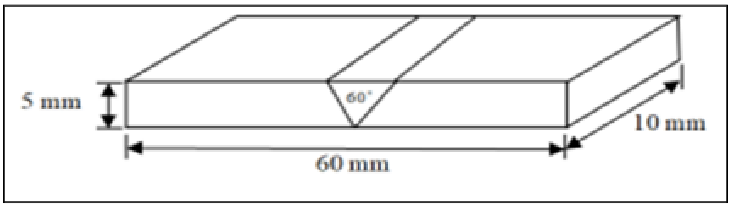

Figure 1 Research specimens

In the welding stage, the first thing to do is install the machine, then prepare the workpiece to be processed or welded using an inclined welding method. The type of seam prepared is a V seam with an angle of 60°, then install the electrode by adjusting the current and thickness of the plate. In this process, the type of electrode is E7018 with an electrode diameter of 3.2 mm, then set the ampere meter which has been prepared as a tool used to measure with the zero needle position, then one of the cable clamps is used as an electrode wire clamp. The welding tool is turned on and the electrode wire is etched until it lights up, the ammeter is set to 80 A. Then the connections are made to the workpieces simultaneously. After the welding process, the specimen is soaked in water and then subjected to ultrasonic waves with varying immersion times of 30 minutes, 60 minutes and 90 minutes. Next, hardness and microstructure tests are carried out to determine the mechanical properties and see changes in the material.

3. Results and discussion

In the material hardness test using the Rockwell Hardnest Test scale B using a press or indenter in the form of a 1.558 mm steel ball. Tests were carried out on 4 areas in each specimen, namely weld metal, HAZ (Heat Affected Zone). The pressing time of each test is 10 seconds. The following hardness test results data can be seen in table 1 and figure 2.

Table 1 Data on hardness test results

Time (minutes)	Hardness value (HRB)
30	77.175
60	80.925
90	85.05

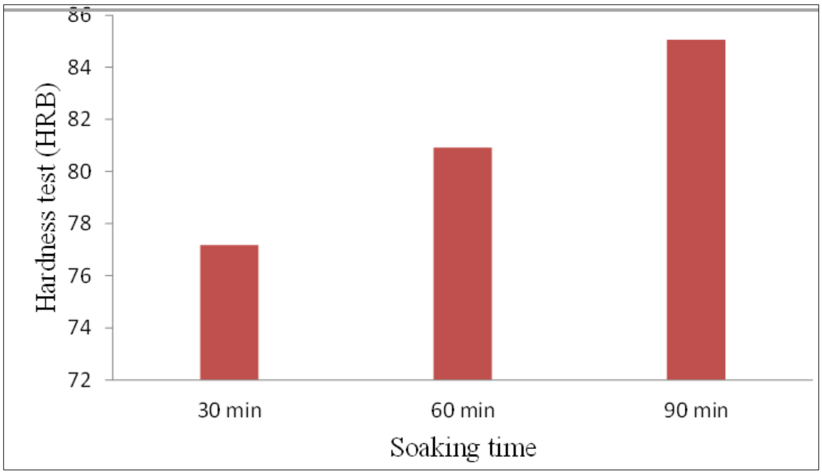

Figure 2 Graph of the relationship between soaking time and hardness value

From table 1 above, it shows the highest hardness value at 90 minutes. This shows the distribution in different zones throughout the weld metal. When the number of passes is increased, the action of ultrasonic peening also results in compressive residual stress.. This result can be explained by the fact that the welding process produces more heat when accounting for the degree of plastic deformation..

In testing the microstructure of the test specimen, it is first sanded with grain size sandpaper (240, 300, 400, 500, 600, 800, 1000, 1200, and 1500). Next, rub with etching polish, nital solution containing 98% alcohol and 2% NHO3. Using an optical microscope to examine optical specimens.

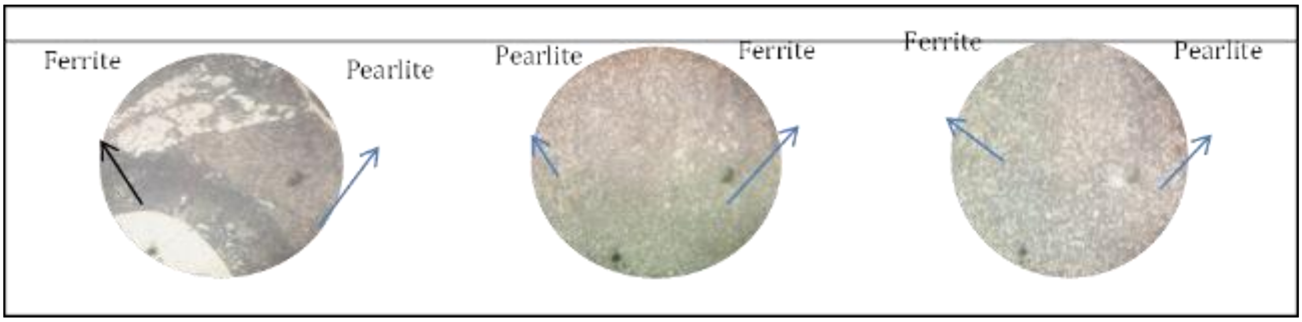

Figure 3a t = 30 min **Figure 3b** t = 60 min **Figure 3c** t = 90 min

From pictures 3a, 3b and 3c above, it shows that at a soaking time of 30 minutes the ferrite content is greater. The longer the soaking time, the ferrite content is smaller, forming small grains, as well as the pearlite content. This occurs because of the use of carbon steel filler metal and is also affected by heat transfer.

4. Conclusion

The results of the research can be concluded that the longer the immersion time, the greater the hardness value, this is due to the presence of carbon steel filler during the welding process and also the heat transfer from the welded steel to the surrounding welding area. This results in the formation of ferrite and pearlite grains in the carbon steel.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Wiryosumarto. H, “Metal Welding Technology”, Journal of Industrial Systems Engineering, Vol. 3, No. 2, Page 134, 2000.

[2] Siswanto, “Basic Concept of Welding Technique (Theory and Practice),” Journal of Mechanical Engineering, Vol. 2 No. 1, Page 56, 2011.

[3] Julian. N, Budiarto. U, Arswendo. B, “Comparative Analysis of Tensile Strength in SS400 Steel Welding Joints Using MAG Welding with Variations in Welding Current and Cooling Media as Ship Hull Material”. Naval Architecture, UNDIP, Vol. 7, No. 2, Pages 421-430, 2019. journal or book?

[4] Nugroho. A and Setiawan. E, “The Effect of Welding Current Variation on Tensile Strength and Hardness of ASTM36 Carbon Steel Plate Welding Joints”, Jurnal Rekayasa Sistem Industri, Vol. 3, No. 20, 134-142, 2018.

[5] Mizhar. S and Ivan. H.P, “The Effect of Heat Input on Microstructure, Hardness and Toughness of Shield Metal Arc Welding (SMAW) of 2.5 in Diameter Steel Pipe”, Jurnal Dinamis, Vol 2. No.14 pp. 16-21, 2014.

[6] Wiyono. T, “Determination of Dissimilar Welding of Aluminum and Low Carbon Steel Plates with Variation of Welding Time and Electric Current” Jurnal Foundry, Vol.2, No.1, pp. 20-25, 2012.

[7] Santoso. J, “The Effect of Welding Current on Tensile Strength and Toughness of SMAW Welding with E7018 Electrode”, UNES Mechanical Engineering Journal, Vol. 3, No. 11, pp. 206-220. 2006.

[8] Saifuloh. I, Haryadi. H, Zahrawani. A, and Adjiantoro, B, “The Effect of Quenching and Tempering Process on Mechanical Properties and Microstructure of Low Carbon Steel with Laterite Alloy”, Untirta Mechanical Journal, Vol. 4, No.1 pp. 56-64, 2018.

[9] Sari. N.H, “Heat Treatment of Carbon Steel: Effect of Cooling Media on Mechanical Properties and Microstructure”, J. Marcu Buana Mechanical Engineering, Vol. 6, No. 4, PP 263-267, 2017.

[10] Saputra. H and Syarief. A, "Analysis of the Effect of Cooling Media on the Tensile Strength of ST37 Steel After Welding Using Electric Welding", Journal of Ilm. T. Unlam Machines, Vol. 3, no. 2, PP 91-98, 2014.

[11] Guo. J.Y, Bian. Y.K, Zhu. X.X, Guo. N, Peng. W and Zhou. H. M, "Reducing Phytate Content In Wheat Bran By Directly Removing The Aleurone Cell Content With Teeth Roller Mill and Ultrasonic Cleaner", Journal of Cereal Science, Vol 64, PP 133-138, 2015

[12] Safitri. M, Pranaditya. A, Handoko. B, Anggoro. S, “Design and Implementation of Automatic Autoclave Temperature and Pressure Data Recording System”, IOP Conference Series: Materials Science and Engineering. Vol. 1088, No. 1, 2021.

[13] Resnick. R and Halliday. D, 1992. “Physics” 4th ed Vol.1 John Wiley & Sons New York.

[14] Yamaguchi. N, Shiozaki. T and Tamai. Y, “Micro-Needle Peening Method to Improve Fatigue Strength of Arc-Welded Ultra-High Strength Steel Joints”, J. Mat Proc. Tech, Vol. 288, PP. 116894, 2021.

[15] Yonezana. Q, Shimanuki. H and Mori. T, “Influence of Cyclic Loading on The Relaxation Behavior of Compressive Residual Stress Induced By UIT-Weld”, In The World, Vol. 64, no. 1, PP 171-178, 2020.

[16] Ghuusoon. R.M.A, Ali. Z.R, Dina. A.S., Ahmed. A. E, "Effect of Ultrasonic Peening in Mechanical Properties of Low Carbon Steel AISI 1020 TIG Welding Joints Process". Int. J. of Applied Mechanics and Engineering, Vol. 27, no. 4, PP 194-204, 2022.

[17] Gudino-Elizondo, N, Brand. M.W, Biggs. T. W, Hinojosa-Corona A, Gómez-Gutiérrez. Á, Langendoen. E, Bingner. R, Yuan, Y, & Sanders. B. F, "Rapid assessment of abrupt urban mega-gully and landslide events with structure-from-motion photogrammetric techniques validates link to water resources infrastructure failure in an urban periphery". Natural Hazards and Earth System Sciences, Vol. 22 No. 2, 523–538, 2022.