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The effect of pre-heating distance of shielded metal arc welding on the mechanical properties of AISI 1045 steel

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Abstrak: Welding is a method of joining metals by utilizing local heat to form a metallurgical bond between the metals. The most common welding is electric welding, including the Shielded Metal Arch Welding (SMAW). This type of welding uses a filler wire or electrode. To reduce weld cracks and cooling rates in the weld metal and heat affected zone (HAZ) area, it is necessary to carry out a pre-heating process. Pre-heating is the application of heat to the material to be welded using oxyacetylene welding or a gas torch. This study aims to determine the appropriate pre-heating distance for the welding process of AISI 1045 steel, classified as a type of medium carbon steel widely used in shafts, gears, and piston connecting rods in motor vehicles. The parameters used in this study were the pre-heating distances of 1.5cm, 3cm, and 4.5cm that were preheated at a temperature of 150°C, using LB-52U type electrodes with a diameter of 2mm.

Keywords: AISI 1045; electrode**;** SMAW; pre-heating distance.

1. INTRODUCTION

SMAW welding is the union of the two materials with a flux that covers the molten metal as a way of protecting the molten metal against oxidation [1]. In addition, welding is a method of joining metals by utilizing local heat to form a metallurgical bond in the metal joint [2]. Electric welding has been applied in the construction world, including making motorcycle frames, making bicycle frames, building bridges, making railroads, and making other transportation infrastructure facilities. One of the materials used is AISI 1045 steel. This type of steel is alloy steel for application in vehicles, gear, springs, and other industries. AISI 1045 steel is a medium carbon steel with a carbon content of between 0.30% to 0.60% [3].

The advantages of this electric welding include: first, it can be used anywhere, outside, in the workshop, and the water. Second, one set can weld various materials from mild steel to copper alloy with a rectifier. Third, it's easy to adjust the speed. Fourth, unification with various directions and styles. Fifth, many electrode providers are found of various sizes and diameters. Sixth, using tools is simple, inexpensive, and easy to carry. Seventh, it has a good resistant to rust, oil, and grease [4].

Carbon in steel is a retaining element that resists the shear displacement in the crystal lattice of iron atoms. Besides carbon, manganese, chromium, vanadium, and tungsten are the supporting components that are often used [5]. In applying to weld, there is sometimes a heat treatment called pre-heating. Pre-heating is defined as providing heat treatment to the material to be welded. Preheat is the heat given to the parent material to be welded to obtain and maintain the preheat temperature [6].

Pre-heating itself aims to reduce weld cracking and cooling rate in the weld metal and HAZ because welding on medium and high carbon steel materials can cause a martensite phase in the weld metal and HAZ. The martensitic phase arises because of its high carbon content and cooling rate. The addition of pre-heating temperature can increase the tensile strength [7]. In addition, pre-heating can change the size of the weld area and the HAZ and increase the tensile strength in the weld area [8]. Based on some of the descriptions above, this stydy is interested in researching SMAW welding on preheated AISI 1045 steel with a distance of 1.5 cm, 3 cm, and 4.5 cm [9]. This study aims to find the optimum pre-heating distance to the area to be welded is currently still unclear. Optimum disctance may affect the quality and mechanical properties of the welded metals as a concern of the industrial application.

2. MATERIALS AND METHOD

This study uses electric welding with underhand force on AISI 1045 steel. The variations of the pre-heating distance used are 1.5 cm, 3 cm, and 4.5 cm with a pre-heating temperature of 150°C, a welding current of 85A, and a type of welding wire 7016 LB series -52U is then subjected to tensile, and hardness testing after the welding process is carried out.

The welding process uses two samples of AISI 1045 steel with each dimensions of 6mm thickness (T), 100mm length (L), and 33mm width (W), as presented on figure 1. That dimension may provide the samples for hardness and tensile test after the welding process. Sample for tensile prepared by cutting the welded product with standar dimension of Gauge (G) length of 25.0 ± 0.1mm; Width (W) or 6.0 ± 0.1mm; Thickness (T) of 6 mm; Radius of fillet (R) of 6 mm; Total length (L) of 100 mm; Length of reduce part (A) or 32 mm; Length of grip section (B) of 30 mm; and Width of grip section (C) of 10 mm), as presented on figure 2. The difference in size, in this case, is in dealing with welding parts that are not good in the cutting process and the formation of test specimens. The following is a hardness test standard with the E18 standard.

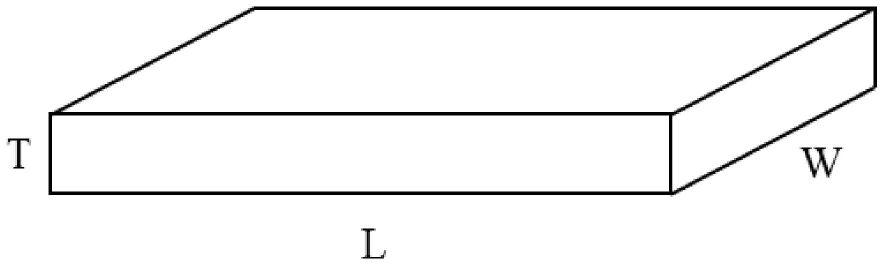

Figure 1. Dimensions of Hardness test specimens

The hardness test was using a 120° diamond cone indenter with a scale of d. The d scale was intended for thin materials with a medium-hard layer.

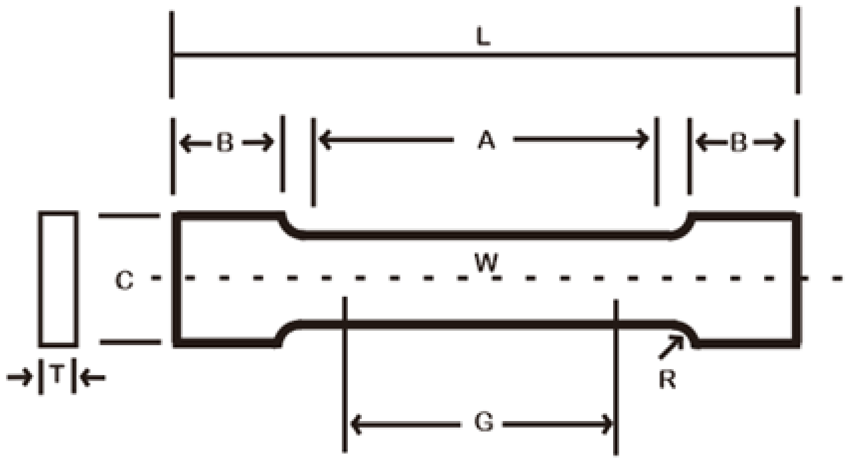

Figure 2. Tensile testing specimen size ASTM E8.

Samples for the tensile test was prepared ASTM E-8 standard separately than the hardness one. The tensilte test was performed using the MTS Landmark™ 100 kN testing machine with Multipurpose Elite (MPE) software.

3. RESULTS AND DISCUSSION

3.1 Pre-heating process

The pre-heating process in this study uses a gas torch as a flame that provides heat to the test material to be welded. The process begins by placing the test material on the welding workbench, which is then given a spot welding to facilitate the mass flowing from the welding machine to the test object. Continued by setting the flame output on the torch to 2 cm, and then the pre-heating distance process that has been determined is 1.5 cm, 3 cm, and 4.5 cm. giving the initial heat to the test material until it reaches a temperature of 150 C which is followed by the welding process. The illustration of the pre-heating distance can be seen in figure 3.

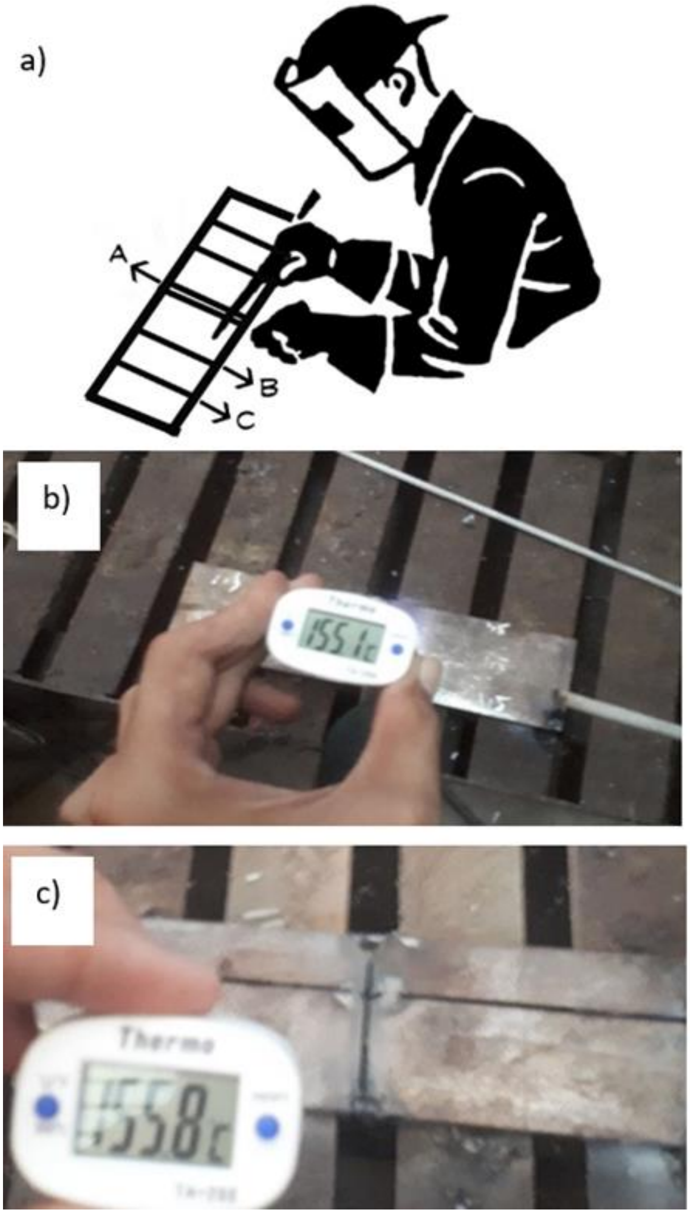

Figure 3. Illustration of the pre-heating process (a), with the distance of 1.5 cm (b) and 3 cm (c)

3.2 Welding product

The welding process in this study uses E7016 LB-52U electrodes of 2.6mm diameter and the current of 85A. Also, a certified welder has been selected to perform the welding. However, in the implementation, there are still weld defects. The welding results generally have weld defects such as weld spark, weld hole, stop-start, and surface undercut, as on figure 4 to figure 6.

Figure 4. The welding results of the 1.5 cm pre-heating distance

Figure 5. The welding results of 3 cm pre-heating distance

Figure 6. The welding results of 4.5 cm pre-heating distance

3.3 Tensile test analysis

The tensile test result shows that the greater the value of the tensile strength in material means the value of the elasticity of a material. Therefore, in the process of tensile testing, a test specimen changes the form of necking. In this study, a tensile test was carried out on as many as nine samples whose tests were carried out at the Integrated Laboratory of the University of North Sumatra, Medan.

The tensile test results came out with a variation of the pre-heating distance of 1.5 cm. Each of the tensile test results in sequence, they are 324.23 MPa, 525.43 MPa, 492.16 MPa, and in average becomes 447,27 MPa. Different results with a pre-heating distance of 3 cm resulted in tensile strength of 626.29 MPa, 731.86 MPa, and 655.07 MPa, and in average becomes 671.07 MPa. The different result was also in the tensile test with a variation of the pre-heating distance of 4.5 cm sequentially were 539.50 MPa, 721.31 MPa, and 599.04 Mpa, in average becomes 619.94 MPa.

It shows that the longer the pre-heating distance was given, the tensile strength of the weld product will increased. That result was in the same agreement with other [8][9][10] which indicating that the pre-heating procedure may increase the tensile strength. In addition, some defect may decreased the tensile strength of the weld product [4][11]. The tensile test data presented in figure 7.

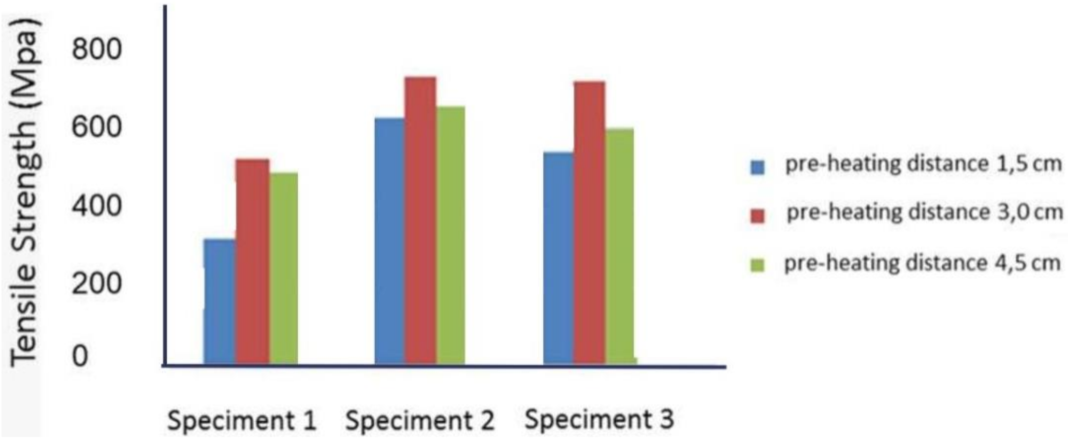

Figure 7. Tensile test results of the pre-heating specimens

3.4 Hardness test analysis

The Rockwell hardness test was carried out using a D-scale with a load of 100 kg and a diamond-type indenter. Hardness testing is carried out where the welding surface area is taken as many as five points in each specimen, and the base metal is one point. Hardness testing with a pre-heating distance of 1.5 cm on the welding results using AISI 1045 steel. The first specimen has an average hardness value of 35.1 HRD, the second has an average hardness value of 32.7 HRD, and the third has an average hardness value of 32.7 HRD. Therefore, the average hardness value is 31.3 HRD. When averaged, it produces a hardness of 33.03 HRD.

Hardness test with 3 cm pre-heating distance on welding results using AISI 1045 steel. The first specimen with an average hardness value of 32.5 HRD, the second with an average hardness value of 33.3 HRD, and the third with an average hardness value of 31.1 HRD. When averaged, it produces a hardness of 32.3 HRD. Also, hardness test with a pre-heating distance of 4.5 cm on welding results using AISI 1045 steel. The first specimen has an average hardness value of 34.7 HRD, the second has an average hardness value of 31.5 HRD, and the third has an average hardness value of 31.5 HRD. Therefore, the average hardness value is 32.5 HRD. Of the three, the middle hardness is 32.9 HRD. The complete result of the hardness test is presented on figure 8.

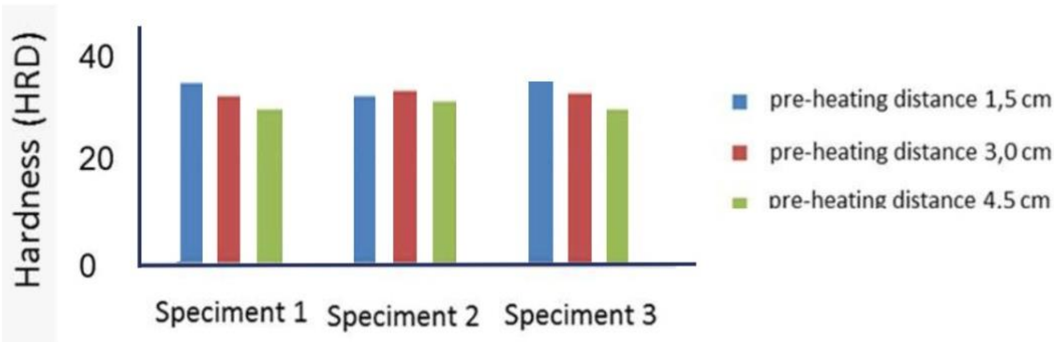

Figure 8. Hardness test results

Based on figure 8 above, after hardness testing, hardness testing of the three variations of the pre-heating distance of 1.5 cm, 3 cm, and 4.5 cm resulted in different hardness even though the difference was not too far away. In this case, the best hardness is at a pre-heating distance of 1.5 cm with an average hardness of 33.03 HRD. Pre-heating distance of 3 cm produces a hardness of 32.3 HRD. Meanwhile, the pre-heating distance of 4.5 cm has an average hardness of 32.9 HRD. It shows that the pre-heating process and other surface heat-treatment process may vary the mechanical properties of the welded materials as also presented by others [12][13][14][15].

4 SIMPULAN

The ideal pre-heating distance using AISI 1045 steel for tensile testing is a pre-heating distance of 3 cm, with the highest average tensile strength being 671,07 MPa. Therefore, it can be concluded that the longer the pre-heating length, the higher the tensile strength value. Meanwhile, the optimum hardness result was found on pre-heating distance of 1.5 cm with the average hardness value of 33.03 HRD. This optimum pre-heating distance is suggested for further SMAW process of AISI 1045 or for other medium carbon steel.

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