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The Effect of Cast Iron Preheating on the Microstructure of Welding Results by Using Cin-2 Electrodes

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ABSTRACT

Cast iron is commonly found in engineering tools such as machine frames, vise, lathes, planers, pressing tools, V-belt pulleys and others. Cast iron is a metal which is relatively difficult to weld because it contains more than 0.3% carbon. As a matter of fact, a lot of welding workers still experience failure in welding the cast iron, so they require the proper procedures to perform welding on the cast iron like the heat treatment before the welding. This study was aimed at obtaining the effect of preheating variations on the weld joints in which the process of welding the material used the type of open V seam connection. The specimen used was a cast iron with a thickness of 10 mm and the electrode used was the JIS Z 3252 DFCNiFe electrode. The method applied in this research was the microstructure observation testing toward the welding result by using Shielded Metal Arc Welding (SMAW). Based on the results of the study, it can be concluded that by applying the preheating variation treatment on the cast iron welding, there was a change in the microstructure and it was dominated by pearlite-ferrite in the weld metal area. As a result, the rough graphite that looks like roots became smooth after experiencing the preheating treatment because the ferrite was evenly distributed in the heat affected area. To conclude, the most superior specimen for the cast iron preheating among the four specimens was the one with 425°C temperature.

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1. INTRODUCTION

Shielded metal arc welding is very dominant in the maintenance industry and it is widely used in the steel structure construction and design industry [1]. Nowadays, metal construction involves many welding elements, especially in the design field because welding joints is one of the jobs that technically requires high skills in order to produce good quality joints [2]. Welding is a manufacturing technique commonly used in industry to create a simple shape products [3]. Welding that is often used in the construction industry is the shielded metal arc welding method or commonly called Shielded Metal Arc Welding (SMAW) [4]. SMAW welding is applied to weld carbon steels, low and high alloy steels, stainless steels, ductile iron and cast iron [5]. The welding method that is widely used is the fusion welding method which is conducted by melting a portion of the metal, so that when the molten metal solidifies, the two metals can get connected perfectly. However, the fusion method has a lot of shortcomings like the emergence of residual stresses, distortion, or the appearance of cracks in the joints [6].

A lot of employees in the welding industry have failed to weld the cast iron, so they are in need of a proper welding procedures. Therefore, welding the cast iron requires several treatments, such as providing preheating [7]. Preheating aims to stabilize the specimen temperature before the welding process so that a damage does not occur during and after welding [8]. Before welding the cast iron, it must undergo the preheating treatment to prevent cracks and weld defects, the purpose of preheating is to prevent the rapid cooling that will avoid the emergence of crack [9]. As a matter of fact, the quality of welding is mainly determined by several factors, these factors include the position of the weld, the metal material being joined, the effect of heat, the right type of seam and the type of electrode used. In addition, a welder must acquire the skills in using the electric current and electrode diameter [10]. Welding is joining two or more metal parts using heat energy which causes the

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metal around the weld to undergo a complicated metallurgical change, deformation and thermal stresses, weld toughness, weld defects and cracks which have affect the safety of the construction being welded [11]. Heat treatment of steel has a very important role because it can change the microstructure and mechanical properties of the steel as needed [12]. The microstructure will affect the mechanical properties, such as strength, ductility, toughness and hardness [13].

The most used welding type in the welding process is SMAW welding. The process or the electric arc of the wrapped electrode melts the base metal due to the heat from the electric arc rising at the tip of the electrode and resulting in a frozen surface of the work object [14]. The strength adjustment of welding current affects the result of the weld. In addition, if the current used is low, it will cause the ignition of an unstable electric arc [15]. The single V groove is chosen because of the maximum UTS strength yield compared to other welded joint designs [16]. Welding joints are inevitably important to be researched and tested because the failure that occurs in the connection will be fatal [17]. The quality demand in the material joining process must comply with standards including strength, ductility, toughness, hardness and corrosion resistance [18]. In addition, the determining factor for producing a good welding joint is a clean weld surface because the weld slag on the surface can be trapped in frozen metal [19]. Hence, it is possible for welding defects to occur which later causes a reduction in the strength of the welding joint. To ensure the quality, a testing is necessary to obtain a valid data [20]. If the welder is skilled and the welding procedure is carried out according to the procedure, the quality of the work will definitely be in a better level [21]. Additionally, grey cast iron is one of the most widely used materials because of the simple manufacturing process, the ability to produce in a large scale and the competitive cost of the process [22]. The purpose of this study was to determine the effect of SMAW welding preheating temperature variations on the microstructure of cast iron, open V seam joints, using a current of 70-110 A, the electrode used was JIS Z3252 DFCNiFe (Ø 3,2). Toward the development of science and technology in the field of welding, this research is expected to contribute as a literature on a similar research, give information for welders to improve the quality of welding results and increase knowledge for researchers in the field of welding material testing.

2. METHOD

The method used was the experimental research method in which the object of research was a cast iron welded joint with a thickness of 10 mm as a result of SMAW welding with JIS Z3252 DFCNiFe electrodes (Ø 3, 2). The chemical composition was presented in table 1 and the connection used was groove V as displayed in Figure 1. In addition, the treatment given was providing three variations of the preheating temperature by burning the cast iron using acetylene. For instance, the first specimen was burned at 370ºC, the second was at 425ºC, and the last one was at 480ºC in a room whose temperature was 27ºC. To see the detail, the flow chart was presented in Figure 2. Hence, the mechanical testing was carried out by analysing the microstructure and the data obtained was in the form of a photo which would be presented as an image and the analysis would be conducted toward the test results.

Table 1: Chemical Composition of Cast Iron [24]

Steel Type	Composition,%				
	C	Si	Mn	P	S
Gray (FG)	2..5-4.0	1.0-3.0	0.2-1.0	0.002-1.0	0.02-0.25

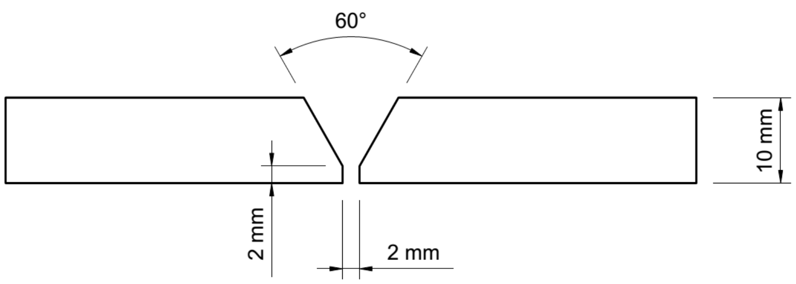

Figure 1 : Groove V [23]

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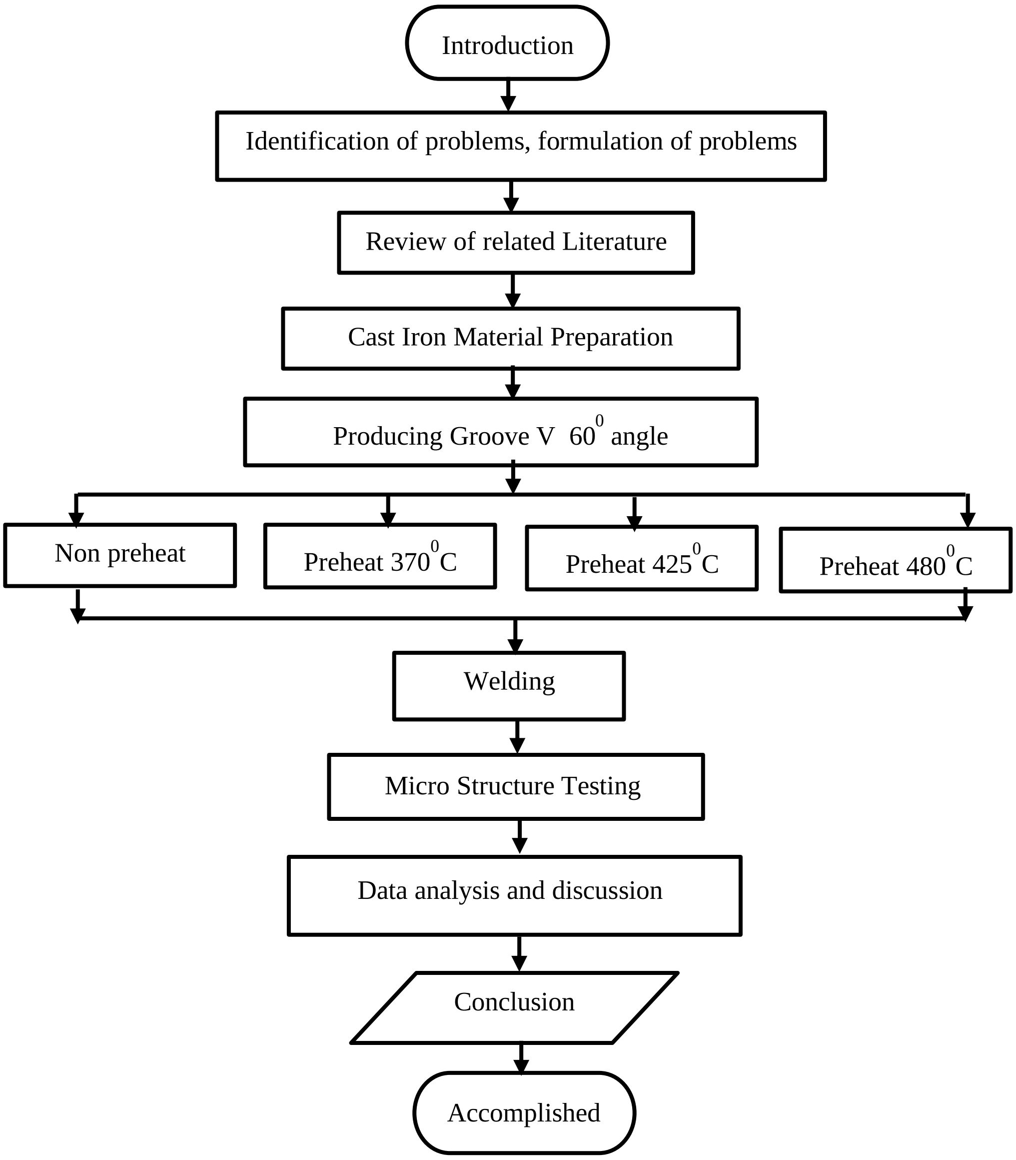

Figure 2 : Flowchart

3. RESULTS AND DISCUSSION

The object used for the test was a cast iron which had been given the preheating treatment with the temperatures of 370ºC, 425ºC, 480ºC and without preheating 27ºC. The following figure shows the microstructure of the cast iron before and after undergoing the heat treatment.

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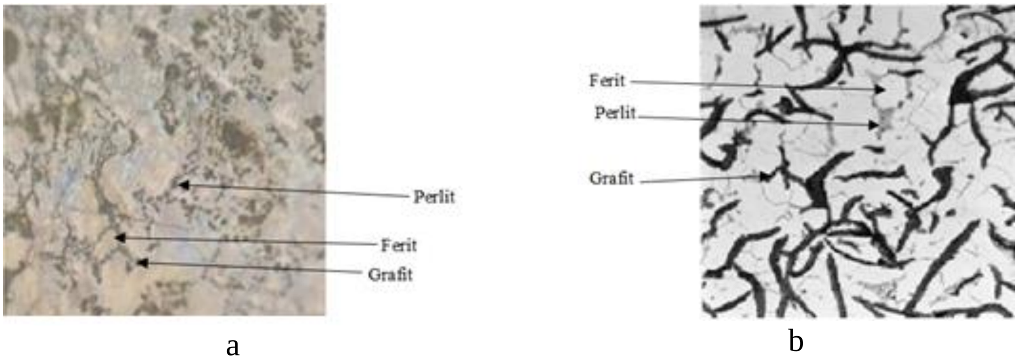

Figure 3 : (a) the results of the Base Metal Micro Structure, (b) the Micro Structure of the Base Metal According to the reference [24]

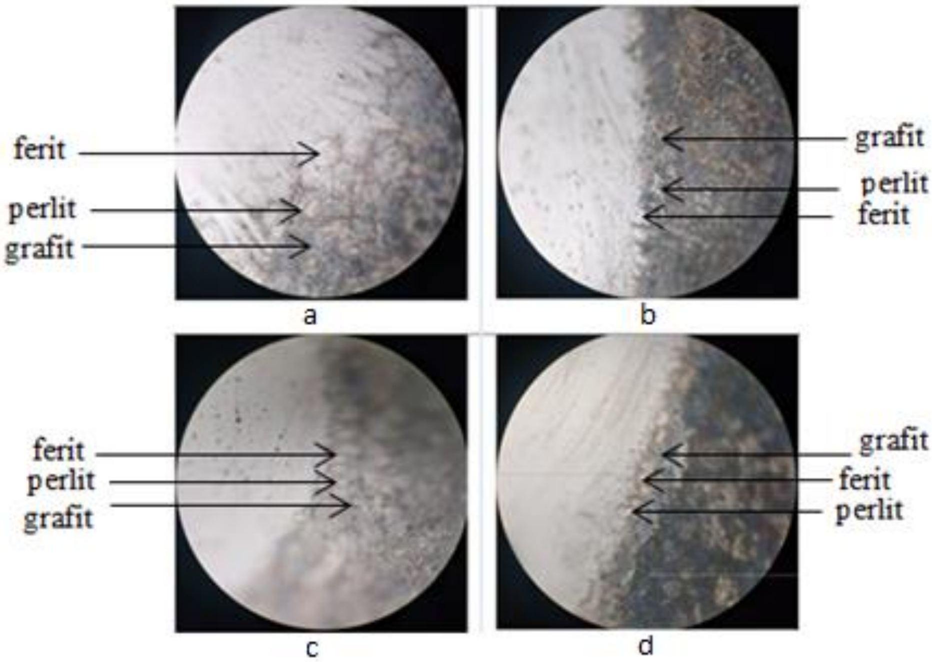

Figure 4 : Micro structure (500x zoom). (a). without preheating, (b). Preheating at temperature 370ºC (c), preaheating at temperature 425ºC and (d) preaheating at temperature 480ºC.

The findings obtained in (Figure 3.a) the microstructure of a cast iron before experiencing the heat treatment based on the regular type of the cast iron microstructure shown in Figure 2.3 in accordance with (Figure 3.b) [24] was most of the graphite being formed in the iron cast were flakes, the surrounding was covered by a ferrite or pearlite matrix, the graphite looked like roots and the surface tended to be more rugged. As a matter of fact, the graphite was found in the microstructure (Figure 4.a) which did not experience the preheating treatment and it was dominated by white ferrite grains (wide spheres). While the pearlite is much lesser (the gray spheres), the Ferrite grains cause the materials' characteristic getting softer. On the other hand, the pearlite strengthen the toughness of the steel material. In conclusion, the non-preheating process proves that the the weld metal and the base metal could not be integrated perfectly. In (Figure 4.b) with the preheating process, it can be seen that the weld metal and base metal have joined and a graphite bond was formed and by preheating at 370ºC, the microstructure was dominated by the transformation of ferrite to pearlite and the pearlite was at the grain boundaries while the amount of the ferrite was not too much (only a small part of the total amount in this area). In this area, the material property was very powerful and hard, but it was also brittle. (Figure 4.c), it was the preheating process with a temperature of 425ºC, indicating the structure formed was dominated by pearlite-ferrite in the weld metal area. Furthermore, ferrite was evenly distributed in the HAZ area and also in the base metal. In (Figure 4.d), the object was undergoing the preheating treatment with a temperature of 480ºC, it showed the structure being formed was pearlite and grain boundary ferrite. In this area, the structure of pearlite was mostly compared to that sort ferrite. In sum,this specimen has the highest tensile strength compared to the three specimens above.

4. CONCLUSION

In short, the variations in the preheating treatment on the cast iron welding experienced changes and showed that the structure formed was dominated by pearlite-ferrite in the weld metal area. In fact, at the preheating temperature of 370ºC, the welding process ran smoothly, the microstructure was dominated by the transformation of ferrite to pearlite, the pearlite phase was at the grain boundary, while the ferrite found was not too much. In addition, at the initial heating temperature of 425ºC, the welding process in melting the metal was evenly distributed between the two joints. The microstructure was dominated by pearlite-ferrite in the area of the weld joint, ferrite was smoothly spread not only in the HAZ area but also in the base metal. Moreover, at 480ºC, the welding process was categorized as good in which the microstructure formed was pearlite and ferrite and the ferrite was at the grain boundaries. The results of the analysis and discussion above are the reasons why cast iron is difficult to weld because of the graphite in the form of flakes, graphite looked like roots and tends to be more rugged. Additionally, the emergence of graphite in this shape caused the cast iron to be very sensitive which could trigger it to crack. This is the reason why cast iron is difficult to weld.

Based on data analysis and discussion of microstructure testing in this study, it can be concluded that from the test results on cast iron material with different preheating temperature variations, it shows that variations in preheating temperature had an effect on the microstructure of the welding results, meanwhile the results of welding joints from micro-testing indicated that the bond of graphite and pearlite which was not joined properly caused the weld metal and the parent metal failed to bond perfectly. These results indicate that there is an uneven preheating temperature of the metal. Furthermore, preheating at a temperature of 425ºC indicated that the structure formed was dominated by ferrite-pearlite in the weld metal area. Ferrite was smoothly spread not only in the HAZ area but also in the base metal area. In contrast, the welding without preheating was dominated by round white ferrite which was wide and it contained less pearlite. This circumstance caused the materials' characteristic to be soft. Thus, it can be concluded that the preheating process is required in welding the cast iron as can be seen in the HAZ area with preheating, there was a lot of graphite in the weld metal, while non-preheating graphite tended to gather in one part. In the welding metal area, graphite appeared more in the welding with the preheating process. Last, the appearance of this graphite strengthened the joints in the welded cast iron.

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