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THE EFFECT OF STRONG FLOW VARIATIONS ON MICRO STRUCTURE AND VIOLENCE ON THE LOW CARBON STEEL WELDING PROCESS USING THE SMAW WET UNDERWATER WELDING METHOD

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KEYWORDS

Current Strength,
SMAW,
Micro Structure,
Wet Underwater Welding

ABSTRACT

This study uses a quantitative descriptive method, with low carbon steel material. These materials will be welded with strong stresses 60A, 90A and 120A using the welding method SMAW Wet Underwater Welding. In this study, using seam V with a 60º angle, the machine to test the hardness, while for the microstructure test using an Olympus PME microscope (Metallurgical Microcope with Inverted). The measurement of chemical composition was carried out using specimens of the Optical Chemistry Spectrometer spectrum. (SMAW wet underwater welding). Wet welding underwater welding (SMAW wet underwater welding).

The average level of hardness in raw material is 159 VHN and ferrite micro structures dominate more than pearlite. While the material after going through the welding process of SMAW wet underwater welding in the area of acicular ferrite (AF) microstructure, the most dominant specimen with a current strength of 90A, it is also very much in the ferrite microstructure weld area with the second most dominant phase (FSP) in the specimen with a current strength of 90A.. There is an influence of current strength on the hardness level of welding results of low carbon steel alloys with current strengths of 60A, 90A and 120A. Specimens with a current variation of 90A in the HAZ section have a higher average hardness level of 244 VHN when compared to variations in current strength of 60A and 120A, namely 230 VHN and 218,666 VHN. The hardness value in the HAZ region is highest when compared to weld and metal regions. This is supported in the microstructure test in which the HAZ region shows the dominant level of acicular ferrite (AF) compared to other regions. While the weld metal area has ferrite levels with the second parallel phase (FSP) which is dominant when compared to other regions.

INTRODUCTION

The development in the world of production is currently very rapid, one of the production processes that are often used is the connection process that plays an important role to support the consumption of resources and production costs, namely the welding process. According to Wibowo Heri (2016), welding techniques are used intensively in various manufacturing industries such as automotive, shipping, aircraft, railroad, bridge construction, pressure vessels, and so on. Welding techniques have advantages for production such as relatively faster processing time, low cost, and more varied forms of construction (Cary, 1989). However, the welding process also has several disadvantages, among others: the emergence of large voltage surges due to changes in the microstructure in the

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area around the welding which results in decreased strength of the material, as well as the cracking due to the welding process (Jamasri, 1999). Besides that, not all metals have good weldability.
One material that has good weldability is low carbon steel. This steel can be welded with an arc welding electrode wrapped (Wiryosumarto, 2000). In the 1990s welding techniques developed rapidly, due to the discovery of ways to use electricity as a source of heat in the welding process. Therefore at this time, the process of connecting metals for all kinds of construction can be carried out by the welding process. One of the welding methods applied today is the underwater welding process or also called underwater welding which is the development of existing welding methods, to meet the demands of workmanship in the welding process.Underwater welding is different from welding on land which has been widely studied so that references can be found easily, while welding underwater is still rarely examined so the references are limited. The application of underwater welding techniques in Indonesia is very broad because Indonesia has a large area of water. Underwater welding can be used to save costs and speed up the process of ship repair if using underwater welding, it does not take time to bring ships to the docks and be lifted from water which will take a long time and costs will also increase (Gunawan D Haryadi, 2007). Underwater welding has greater strength when compared to welding on land but its tenacity is lower (X. Chen, Y. Kithne, Y. Itoh, 2010).
The adjustment of the current strength in the welding process also affects the weld yield. If the current user is too high then the electrodes will melt too fast and will produce a wide weld surface and deep penetration resulting in low tensile strength and friability. Conversely, if the current user is too low then the electric arc is difficult to ignite, the electric arc becomes unstable. The heat that occurs is not enough to melt the electrodes and base material so that it will be less good (Arifin, 1997).

RESEARCH METHODS
This research uses the descriptive quantitative method, with low carbon steel alloy material. The material will be welded with a strong current variation of 60A, 90A, and 120A using the SMAW Wet Underwater Welding method. In this study using seam V with an angle of 60O, Vickers machine is used for hardness testing, while for microstructure testing using an Olympus PME (Metallurgical Microscope with Inverted) microscope. Testing the chemical composition of the specimen is carried out using a chemical composition specimen Optical Emission Spectrometer.

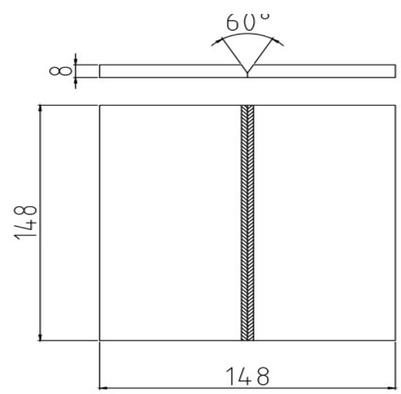


Figure 1. Dimensions of Las Specimens


Figure 2. Weld Specimens

RESULTS AND DISCUSSION

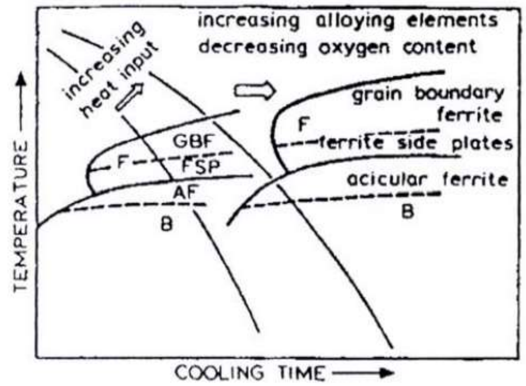


Figure 3. Diagram of Continuous Cooling Transformations (CCT)
(Source: Suharno, 2008)

In the carbon steel welding process, the ferrite structure is divided into three groups:

1. Acicular Ferrite (AF) this ferrite structure has the highest level of hardness, this structure is in the form of soft granules.
2. Ferrite Side Plate (FSP) This ferrite structure has a softer level of hardness when compared with the Acicular Ferrite (AF) structure, this structure has an elongated shape.
3. Grain Boundary Ferrite (GBF) This ferrite structure has the lowest level of hardness when compared with Ferrite Side Plate (FSP) and Acicular Ferrite (AF), this structure is shaped in large granules.

3.1. Chemical Composition Test Results

a. Raw Material

Table 1. Raw Material Composition Test Results

Content	Percentage	Content	Percentage
Fe	*95,8*	P	*0,01*
S	*0,01*	Cu	*0,12*
Al	*0,36*	Ti	*0*
C	*0,16*	N	*0,01*
Ni	*0,06*	B	*0*
Nb	*0*	Pb	*0*
Si	*0,28*	Sb	*0*
Cr	*0,15*	Ca	*0*
V	*0,54*	Mg	*0*
Mn	*0,54*	Sn	*0*
Mo	*0*	Co	*0,01*
W	*0*		

b. Welding area

Table 2. Welding area Composition Test Results

Content	Percentage	Content	Percentage
Fe	*99,45*	P	*0,02*
S	*0,01*	Cu	*0,09*
Al	*0*	Ti	*0,01*
C	*0,07*	N	*0,01*
Ni	*0,04*	B	*0*
Nb	*0*	Pb	*0*
Si	*0,07*	Sb	*0*
Cr	*0,03*	Ca	*0*
V	*0,01*	Mg	*0*
Mn	*0,16*	Sn	*0*
Mo	*0,01*	Co	*0,01*
W	*0*		

3.2. Micro Structure Test Results

a. Raw Material

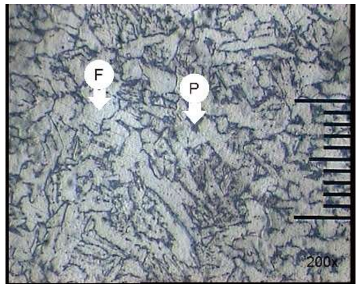
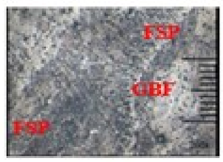


Figure 3. Raw Material

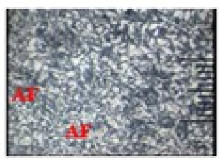
In Figure 2 shows the results of microstructure test on raw material (without welding). It is seen that the ferrite structure is more dominant when compared to the pearlite structure, the raw material tends to be soft.

b. Welding 60 Specimens A

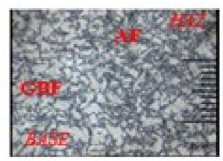


Welding speciment

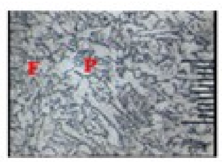
Welding-HAZ



HAZ



HAZ-main speciment

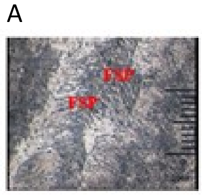


Main speciment

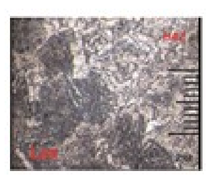
Figure 4. HAZ area 60 A

In Figure 4 above shows the results of microstructure test on weld metal, weld metal boundary with HAZ, HAZ area, HAZ boundary with parent metal and parent metal with 60A strong current. In metal welding the formation of the microstructure side plate (FSP) and grain boundary ferrite (GBF) microstructure, but the micro boundary ferrite (GBF) microstructure more dominates the area with small grain size and microstructure size of the ferrite side plate (FSP) looks small. In the weld metal boundary area with HAZ shows the formation of the ferrite side plate (FSP) microstructure, grain boundary ferrite (GBF) and the formation of AF microstructure. The microstructure of FSP and GBF is more dominant with large size. In the HAZ region shows the structure of micro-grain boundary ferrite (GBF) and acicular ferrite (AF). The grain boundary ferrite (GBF) microstructure is more dominant and with a small grain size when compared with the acicular ferrite (AF) microstructure.

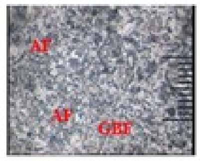
c. Welding 90 Specimens A

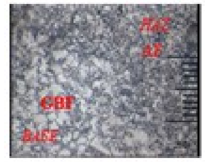


Welding speciment

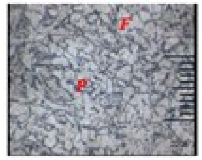


Welding-HAZ





HAZ HAZ-main speciment

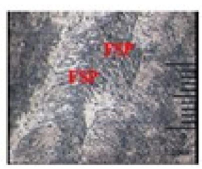


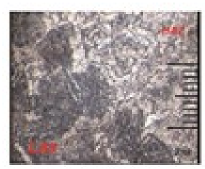
Main speciment

Figure 5. HAZ area 90 A

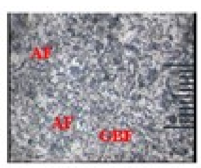
Figure 5 above shows the results of microstructure test on weld metal, welding metal boundary with HAZ, HAZ region, HAZ boundary with parent metal and parent metal with a strong current of 90A. In metal welding the formation of microstructure side plate (FSP) and grain boundary ferrite (GBF) microstructure, but the microstructure ferrite side plate FSP (microstructure) dominates the area and the size of the grain boundary ferrite (GBF) microstructure looks small when compared to the results of the micro-current test structure are 60A and 120A. The weld metal boundary area with HAZ shows the formation of a microstructure ferrite side plate (FSP), grain boundary ferrite (GBF) and the formation of an acicular ferrite (AF) microstructure. The microstructure of side plate ferrite (FSP) and grain boundary ferrite (GBF) are more dominant in small size compared to the results of the 60A and 120A micro current testing. In the HAZ region shows the structure of micro-grain boundary ferrite (GBF) and acicular ferrite (AF). Acicular ferrite (AF) microstructure is more dominant with small grain size compared to the results of 60 A and 120 A microcurrent test structures. The micro-grain boundary ferrite (GBF) microstructure is small in grain size.

d. Welding 120 Specimens A

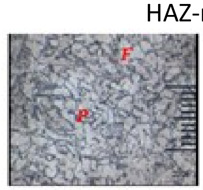




Welding speciment Welding-HAZ



HAZ HAZ-main speciment

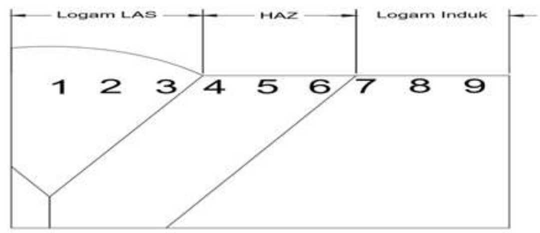


Main speciment

Figure 6. HAZ 120 area A

In Figure 6 above shows the results of microstructure test on weld metal, weld metal boundary with HAZ, HAZ region, HAZ boundary with parent metal and parent metal with strong currents of 120 A. In weld metal the formation of ferrite side plate (FSP) microstructure and ferrite grain boundary ferrite (GBF), but the grain boundary ferrite (GBF) microstructure dominates the area and the size of the ferrite side plate (FSP) microstructure looks large. The weld metal boundary area with HAZ shows the formation of a microstructure ferrite side plate (FSP), grain boundary ferrite (GBF) and the formation of an acicular ferrite (AF) microstructure. Microstructure ferrite side plate (FSP) and grain boundary ferrite (GBF) is more dominant with large grain size. In the HAZ region shows the structure of micro-grain boundary ferrite (GBF) and acicular ferrite (AF). The grain boundary ferrite (GBF) microstructure dominates with large grain size when compared to the acicular ferrite (AF) microstructure.

3.3. Vickers Hardness Test Results



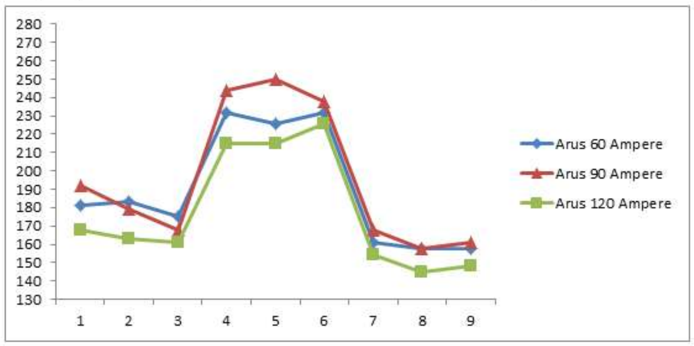


Figure 7. Graphic Distribution of Hardness Value

The blue graph shows that at points 1 to 3 is the hardness values for the weld metal area, the average hardness value is 179,666 VHN. Points 4 to 6 are HAZ regions which have an average hardness value of 230 VHN. Points 7 to 9 are part of the parent metal area which has an average hardness value of 159 VHN. From the blue graph, it can be concluded that the highest hardness value in the welding specimen with a current variation of 60 Amperes is located in the HAZ region of 230 VHN. The red graph shows that at points 1 to 3 is the hardness values for the weld metal area, the average hardness value is 179,666 VHN. Points 4 to 6 are HAZ regions which have an average hardness value of 244 VHN. Points 7 to 9 are part of the parent metal area which has an average hardness value of 162,333 VHN. From the red graph, it can be concluded that the highest hardness value in the welding specimen with a variation of the current 90 Ampere is located in the HAZ region that is equal to 244 VHN. The green graph shows that at points 1 to 3 is the hardness values for the weld metal area, the average hardness value is 164 VHN. Points 4 to 6 are HAZ regions which have an average hardness value of 218,666 VHN. Points 7 to 9 are part of the parent metal area which has an average hardness value of 149 VHN. From the green graph, it can be concluded that the highest hardness value in the welding specimen with a current variation of 60 Amperes is located in the HAZ region that is equal to 218.666 VHN.

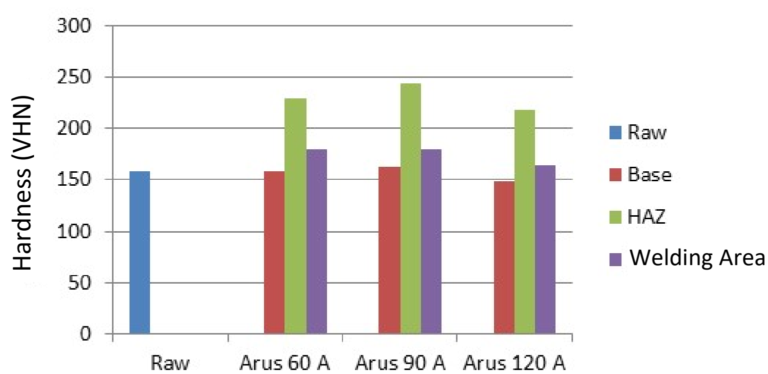


Figure 8. Graph of Vickers Hardness Test Average Value

From the results of the above analysis, it can be concluded that the welding specimen with a strong current variation of 90 A has the highest average hardness value when compared to the welding specimen with other current strength variations. Whereas welding specimens with variations in the current strength of 120A have the lowest average hardness value compared to welding specimens with other variations in current strength. The highest hardness value in the HAZ area when compared with the welding deal and the parent metal, this causes the specimens in the HAZ area to be hard but brittle. Whereas the weld area experienced an increase in hardness that was not too high when compared to the HAZ area, this made the weld area have a resilient nature. This is supported by the microstructure test that the HAZ region contains dominant levels of acicular ferrite (AF) when compared to other regions. Whereas the weld metal area has a dominant ferrite side plate (FSP) compared to other regions.

CONCLUSION

Based on the results of research on the effect of strong current variations in welding low carbon steel alloys with the SMAW wet underwater welding method, it can be concluded:

1. There is a strong influence of current on the microstructure of low carbon steel welding results with variations in the current strength of 60A, 90A, and 120A. In the HAZ region, the acicular ferrite (AF) microstructure is the most dominant specimen with a strong current of 90A, as well as in the welding area of the ferrite side plates (FSP) microstructure most dominant in the specimen with a strong current of 90A.
2. There is a strong influence of current on the level of hardness of the welding results of low carbon steel alloys with strong currents of 60A, 90A, and 120A. Specimens with variations in the current strength of 90A in the HAZ section have a higher mean hardness level of 244 VHN when compared to specimens of the strong current variation of 60A at 230 VHN and 120A at 218.666 VHN.

Some suggestions needed to improve further research are as follows:

1. For further research of this kind can be studied in depth other variables that can affect the microstructure and hardness of the specimens from the SMAW wet underwater welding.
2. Subsequent research of the same type may use other media such as seawater so that it can be known whether the media can affect the microstructure and hardness of the specimens from the SMAW wet underwater welding.

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