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The effect of current gouging arc welding analysis of A283 Gr C steel to the tensile strength, hardness and microstructure

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Abstract. The research has been done to investigate the effect of gouging welding currents that tensile strength, hardness and microstructure welding A283 GrC steel. Variations of gouging current 200 A, 300 A and 400 A were compared with welding without gouging. Seam type used is a double V joint with angle 60^0 and in using SMAW welding process. The test results are the highest tensile strength of 45.98 kgf/mm^2 at 300A gouging current and the lowest yield 45.51 kgf/mm^2 in welding without gouging. It shows the process of gouging reduce the ductility of the material due to the higher heat input. The fracture mechanism is more apt to occur in the current 300A gouging with the strain of 32.96% when compared to the non-gouging welding with a strain of 36.21%. The highest test result is 51 HRC on gouging current 400 A weld metal and the lowest area is 33.33 HRC on without gouging welding base metal regions. The results of microstructure observation showed that the increasing flow of gouging or heat input then occurs coarsening of grain or grains formed larger influence the outcome of toughness and hardness.

1. Introduction

The welding process is a very important process in the production techniques, both with regard to construction and building machinery. Welding is one of the techniques of grafting melt some metals by means of the parent metal and filler metals with or without pressure and with or without metal additive resulting in a complete connection. Steel is an alloy consisting of the main elements of iron (Fe) and carbon (C), as well as other elements, such as Mn, Si, Ni, Cr, V and others are arranged in a very small percentage. And these elements will affect the quality of the steel . In the low-carbon steel has a carbon content% C <0.3%. The nature of hardness is relatively low, soft and high tenacity. Low carbon steel usually used in the form of plates, profiles, planner, screw and bolt. [1,2]

Electric arc welding with electrodes webbed or SMAW (Shielded Metal Arc Welding). The process of arc welding (figure 1) using electrodes webbed as the added material, the electric arc occurs between the tip electrode and the base material will melt the electrode tip and some basic materials, membrane electrode that also burned will melt and produce gas that protects the tip electrode, crater welding, arc welding electrical and area around the electric arc to the influence of outside air. Welding speed is very dependent on the current using strength. Type large electrode, the electrode core diameter, the material to be welded, the geometry of the connection and so forth. In welding, a high speed can cause a lack of penetration, resulting in reduced power connection and heat input received lengthy unity will become smaller. This can have an impact on the rapid cooling so as to harden the heat-affected area. In the tensile test, the workpiece will be placed vertically and then retracted. In the process of withdrawal will be given maximum tensile load, the maximum tensile load is what will determine how much force pull off the specimen. In the process of testing, the specimen will undergo stretching before fracture occurs. This fracture is caused by plastic deformation of objects work. When a workpiece plastic deformation occurs, this can be called a ductile fracture (ductile fracture), and if the contrary, it is called brittle fracture (brittle fracture). Tensile test was conducted to obtain data on the mechanical properties of a metal in which the workpiece will have developed on a large axial load and continuous so that the work piece broke. [3.4] The microstructure is the smallest structures that are present in a substance whose existence can not be seen with the naked eye, but must use a tool observer micro structure includes: scanning electron microscope-energy disversif x-ray spectrometry (SEM –EDXS).

This study will discuss the effect investigation of gouging welding currents that tensile strength, hardness and microstructure welding A283 Gr C steel.

2. Research Method

The study used an experimental method, which is a way to find a causal link between the two factors that influence. Laboratory experiments were carried out with the conditions and equipment were completed in order to obtain data on the effects of welding current to the area HAZ hardness and tensile strength SMAW with E6013 electrodes. Materials used are A283 Gr C steel plate, plate thickness 5 mm, electrodes used rotting of E7016 with \a diameter of 2.6 mm, filling of E7018 with a diameter of 2.5 mm, capping of E7018 with a diameter 3.2 mm and gouging with carbon arc a diameter 6.0 mm in welding position by using underhand position, welding currents used are 200, 300, and 400 Amper, type of seam I , a distance of 1 mm slit plate, and the angle of 60^0 hem, testing microstructure by making reference to the ASTM specimen 3E-, shape specimen test object refers to standard ASTM E-8 for tensile testing, and hardness testing.

The equipments for testing are Scanning Electron Microscope (SEM-EDXS), hardness, and tensile strength with universal testing machine.

Procedure

Wrapped metal arc welding process uses welding electrode rod wrapped with a flux or so-called shielded metal arc welding (SMAW) as shown in figure 1. For electrode rod length is usually around 230 to 460 mm and a diameter of 2.5 to 9.5 mm. Filler metal is used as the electrode rod must be in accordance with the metal to be welded, the composition is usually very close to the composition of the base metal owned. Wrapping layer consists of a cellulose powder mixed with oxides, carbonates, and other elements that are then assembled with silicate binder. Metal powder is sometimes also used as an ingredient to add filler metal and adding alloying elements (alloy).

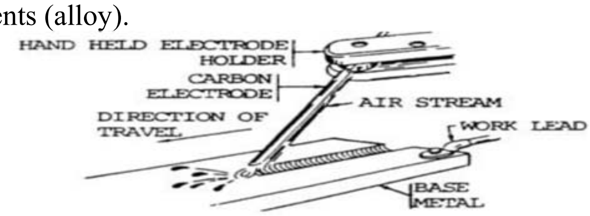


Figure 1. Scheme of gouging process

Figure 2. Welding result on A282 Gr C steel

Data analysis techniques influence the electric current of gouging on tensile strength and hardness of SMAW welding joints with E7016 and E7018 electrodes in the ratio of percentage and average between data having variation of gouging current in a welding process.

3. Results and Discussion

a. Analysis of hardness

In this research, the process of welding on low carbon steel A283 Gr C. types of welding processes carried out by varying the welding process between non gouging with the gouging current treatment of 200A, 300A and 400A. Welding current, speed and voltage remain. The welding results for each parameter testing the mechanical properties in hardness test on the area filler metal, base metal and HAZ. Following the results of the method Rockwell hardness values obtained in the form of the graph below:

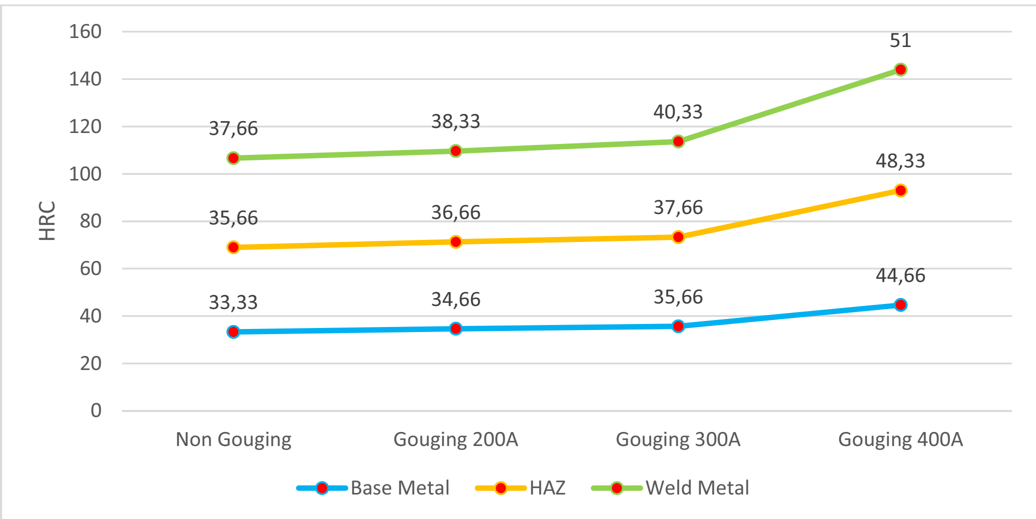
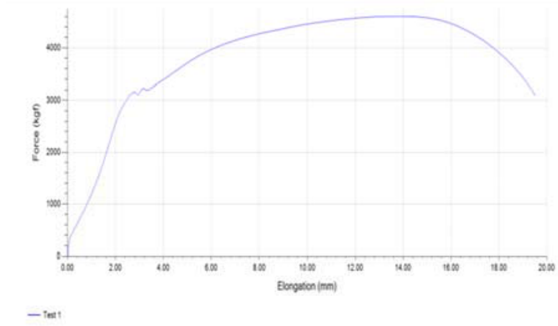


Figure 3. Correlation between hardness to variation current of gouging on base metal, haz, weld metal zone.

After performing hardness testing methods rockwell using a load of 150 kg to pushing 5 seconds on area base metal, HAZ, and weld metal is obtained hardness is highest specimen of current 400 A, at local weld metal with a hardness value of 51 HRC and the hardness the lowest is in the area of non-gouging metal base with a value of 33.33 HRC hardness. Because of the strong currents 400A gouging the metal base has begun to undergo structural changes. In the area Heat affected Zone or heat affected area is part of the parent metal adjacent to the weld boundary experiencing thermal cycling. The part closest to the boundary las experiencing high heat ensuing sudden air cooling (queenching) enabling the growth and coarsening of the grain suddenly (resedual stress) as well as a change in the phase of the phase austenite into martensite phase. While the hardness value was lowest for the welding without gouging. While in the area of weld metal or deposit welding is also an increase in hardness caused also by the influence of heat input that is different, but it can occur due to the provision of heat input is so high that alters the composition or element - alloying elements that are giving violent excess in the area ,

b Analysis of tensile strength



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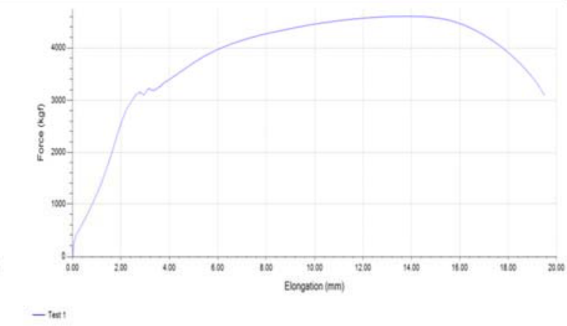

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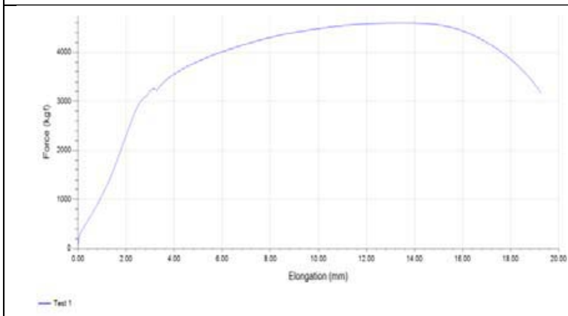

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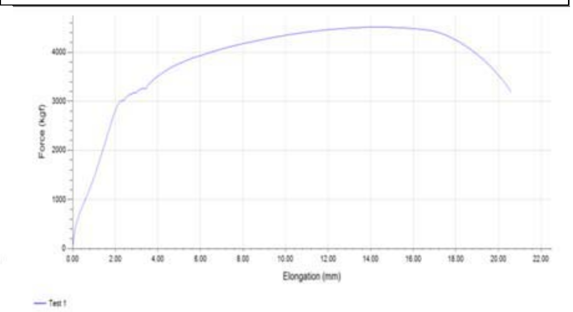

d.

Figure 4. Graphic of tensile strength test, variation of current : a. Non Gouging 400A, b. Gouging 200 A, c. Gouging 300 A, and d. Gouging 400 A.

From the above picture, the position of the fault occurred on the test specimen. It was concluded that the filler metal has bound combined with elements of the parent metal. This shows that the treatment of gouging at a welding material does not make the weld strength weakened.

Tabel 1. The result of tensile strength test

Marking	Spesimen	σ max (kgf/mm^2)	σ yield (kgf/mm^2)	σ fracture (kgf/mm^2)	e (%)	E (kgf/mm^2)
X	Base Material	44,43	31,11	76,78	38,21	116,28
Y	Non Gouging	45,51	30,55	71,95	38,21	125,70
A	Gouging 200A	45,83	31,66	72,15	33,52	136,73
B	Gouging 300A	45,98	32,53	72,45	32,96	139,50
C	Gouging 400A	45,79	31,77	72,78	35,18	130,16

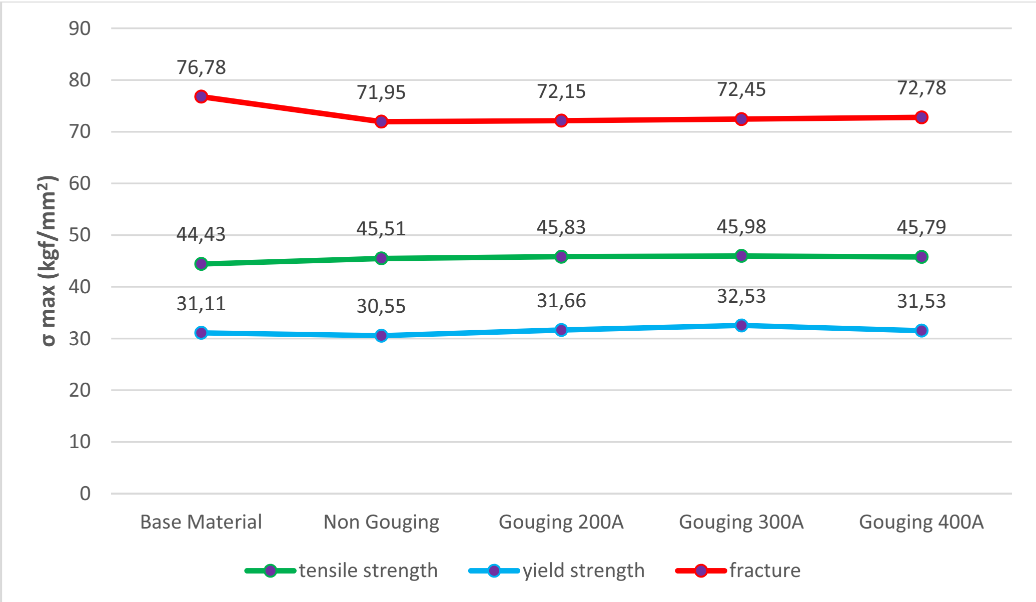

Figure 5. Correlation between tensile strength, yield strength, and fracture to variation current of gouging.

From figure 5 the highest tensile strength yield is 45.98 kgf/mm^2 with gouging current of 300 A. While the lowest tensile strength yield is 45.51 kgf/mm^2 in non gouging welding and 44.43 kgf/mm^2 at base material. When viewed on the graph of the result of tensile strength of material base and non gouging welding is still low when compared with welding using gouging, this shows that welding treatment with gouging greatly affect the ductility of material. From the above graduation diagram, the highest material yield is 32.53 kgf/mm^2 with a gouging current of 300 A. The lowest material waste is 30.55 kgf/mm^2 with welding current without gouging.

The yield point that occurs in all variables when viewed from the graph is irregular. this indicates that the welding process does not affect the material titles after the welding and gouging process. Differences occur due to differences in cross-sectional dimensions of each specimen or mixture and material alloys when produced unevenly.

From the above fracture diagram, the highest fracture material yield is 76.78 kgf/mm^2 on Base Material. The lowest material loss is 71.95 kgf/mm^2 with welding current without gouging.

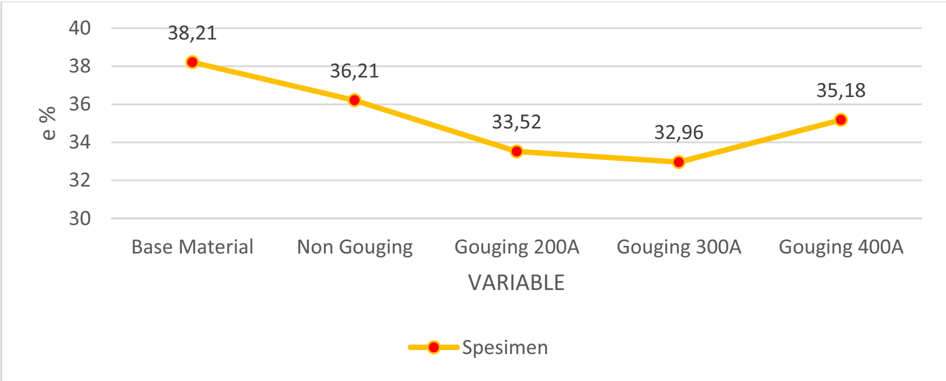

Figure 6. Correlation between tensile strainto variation current of gouging

Strain result (Fig.6) the above results is 38.21% the highest strain on the base material and the non-gouging welding 36.21%. While the results of the lowest strain that is 32.96% with gouging current of 300 A. It shows that the welding process will decrease the elasticity of the material. The results of tensile strength at the highest welding is 45.98 kgf/mm^2 with gouging current of 300 A. While the results of its low tensile strength of 45.51 kgf/mm^2 in welding without gouging. If the material do the welding process and gouging it will reduce the ductility of the material that will result in material tensile stress will increase. Otherwise, the increase in temperature that occurs in the process of welding and gouging material effect on the strain that caused the level of elasticity of the material on the wane.

c. Analysis of microstructure
In this test each specimen is Specimens Y (Non-gouging), Specimen A (gouging 200 A), Specimen B (gouging 300 A) and Specimen C (gouging 400 A) will be seen microstructure formed by the welding process and the process of gouging which has been done. The microstructure was observed on each specimen is in the area of the base metal, HAZ, and weld metal. Each specimen was taken photo micro structure in each region with varying magnification

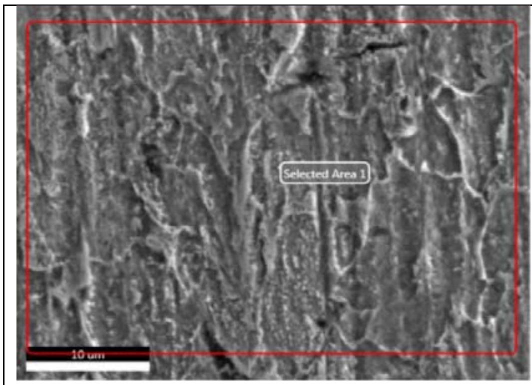	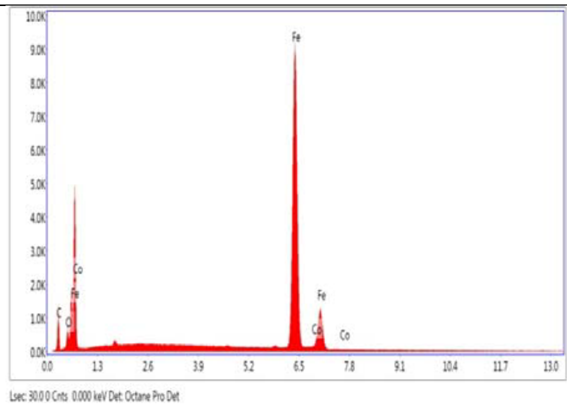
Fig.7a Micrograp after weld A283 Gr C steel on base metal	**Fig.7b.** Some peaks element from weld A283 Gr C steel on base metal

Tabel 2. Composition unsure A283 Gr C steel metal

Element	Weight %	Atomic %	Net Int.	Error %	K ratio	Z	R	A	F
C K	14.65	42.79	208.88	10.05	0.0436	1.2493	0.8637	0.2383	1.0000
O K	2.33	5.10	106.48	10.21	0.0094	1.2016	0.8883	0.3356	1.0000
FeK	81.27	51.06	4166.55	1.85	0.7891	0.9417	1.0212	1.0048	1.0260
CoK	1.75	1.04	75.61	9.95	0.0166	0.9211	1.0252	0.9940	1.0323

Weld metal or weld deposit area is the welding area that experienced revenue higher heat than the HAZ area. Weld microstructure is also very different part of the base metal. Microstructure in weld metal is characterized by long-grained structure (columnar grains).

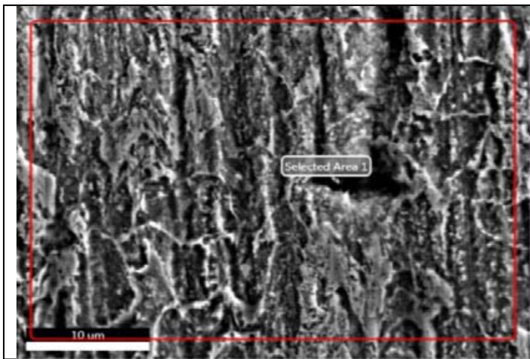

Fig.8a Micrograp after weld A283 Gr C steel on HAZ

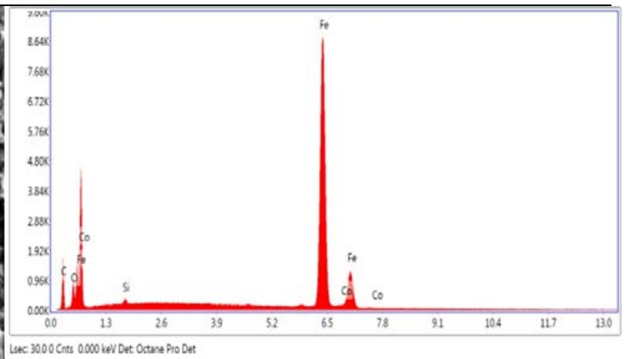

Fig.8b a peaks element from weld A283 Gr C steel on HAZ

Tabel 3. Composition unsure A283 Gr C steel on HAZ

Element	Weight %	Atomic %	Net Int.	Error %	K ratio	Z	R	A	F
C K	16.78	45.94	251.26	9.86	0.0504	1.2367	0.8692	0.2426	1.0000
O K	3.37	6.93	152.76	9.94	0.0129	1.1894	0.8937	0.3224	1.0000
SiK	0.32	0.38	37.23	18.81	0.0018	1.0918	0.9504	0.5000	1.0089
FeK	77.77	45.78	4108.81	1.86	0.7475	0.9313	1.0250	1.0057	1.0264
CoK	1.76	0.98	78.06	11.02	0.0164	0.9108	1.0289	0.9952	1.0327

Weld on base metal and HAZ microstructure can be seen in Figures 7 and 8. The test aims to determine the shape of the microstructure, composition and grain size, the material microstructure of the weld metal is determined during the process of freezing (solidification) and ɣ- transformation of austenite to α-ferrite. Several factors affect the weld metal

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microstructure, among others: the welding process, the final composition of the weld metal, heat input, and thermal cycling. The amount of heat input (heat input) in the weld metal, is heavily dependent on the welding speed, it turns out it gives a significant influence to the extent that affected by heat, both the extent of the weld region (fusion zone) capable in HAZ region .

4. Conclusion

From the above test results and analysis of current research on the strong influence of gouging on the results of the welding connection material A283 Gr C against hardness, tensile strength, and microstructure, can be summed up as follows:

1. The value of highest hardness of 51 HRC is the gouging current 400 A weld area metal, while the lowest value was 33.33 HRC hardness on without gouging welding base metal regions
2. The result of highest tensile strength in the welding that is 45.98 kgf /mm^2 with gouging current of 300 A and the lowest tensile strength is 45.51 kgf /mm^2 in welding without gouging. Welding specimen strain value was highest in non gouging welding 36.21%. While the results of the lowest strain on gouging current 300 A which is 32.96%.
3. From the observation of microstructure on base metal regions also experienced a slight change in the structure of ferrite and pearlite although this remote area with metal weld area. HAZ area is an area that is more visible structure of ferrite and pearlite transformation into austenite when viewed from the coarsening of the grain or the formation of larger grains.

5. Reference

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