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Analysis of the Toughness of the Vertical Position GMAW Welding on Steel ST 42 with Electrode Spiral Movement Pattern

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Abstract:
This study aims to determine the toughness value of vertical position GMAW welding on ST 42 steel with a spiral electrode motion pattern. This study consisted of ST 42 steel, cut to the standard ASTM E23 specimen as many as 20 samples. The toughness value of the GMAW welding results in a vertical position, describes the strength and toughness of the material in making ST 42 steel joints. The results of the ST 42 steel impact test with spiral; the average value of impact toughness was 135.375 Joule with an impact value of 0.2461 (J/mm²), while without treatment the average impact toughness was 183.975 Joule with an impact value of 0.3345 (J/mm²). Thus, it can be concluded that the impact toughness of ST 42 steel with a spiral electrode movement pattern is smaller than the impact toughness without welding joint treatment means that the toughness of ST 42 steel without a connection is stronger than using a welded joint with a spiral electrode motion pattern.

Keywords: *Toughness, GMAW Welding, Vertical Position (3G), Electrode Movement, ST 42 Steel*

1. Introduction

Welding, according to DIN (Deutsche Industrie Normen), is a metallurgical bond in metal or metal alloy joints which is carried out in a melted or liquid state. welding is a connection of several metal rods using heat energy. In this joining process accompanied by pressure and additional material (filler material), welding techniques have been found in the years between 4000 and 3000 BC. And rapid development and progress have been experienced after the discovery of electrical energy as an energy source in welding. The most popular type of welding used in Indonesia is welding using an electric arc, namely - shield metal arc welding (SMAW) and Gas metal arc welding (GMAW).

Welding in the construction sector is very widely used, including bridge construction, shipping, and other construction industries. In simple terms, it can be interpreted that welding is a process of joining two metals to the point of recrystallization of the metal using either added material or not and using heat energy as a melting material to be welded. Welding is a work process that plays a very important role. At present, there is almost no metal that cannot be welded because many new technologies have been discovered by means of welding. Metal types of carbon steel, having a chemical composition, mechanical properties, size, shape and so on, are specified for each use. Steel usually has elements in it such as: manganese, chromium, nickel, and molybdenum, but its carbon content is what determines the iron into steel.

The development of technology in the increasingly advanced construction sector cannot be separated from welding because it has an important role in metal engineering and repair. The construction with metal at this time involves a lot of welding elements, especially in the engineering field because welded joints are one of the making of joints which technically requires high skill for the welders in order to obtain a quality connection. At present, the electric arc welding technique with wrapped electrodes has been widely used in joining rods in steel building construction and machine construction. The widespread use of this technology is due to the fact that the construction of steel buildings and machines made using this joining technique is lighter and the manufacturing process is also simpler so that the overall cost is lower. The use of low carbon steel for spatial structure formation materials such as roof structures, poles and lattice rods adds to the advantage because metal has great resistance to fracture caused by various mechanical moving loads.

In designing a construction of a machine or building that uses welded joints, many factors must be considered such as welding expertise, adequate knowledge of welding procedures, properties of the material to be welded and others. Often times, the welding must be done in a certain position because it follows the design of a steel construction such as welding the building ceiling frame, steel construction at the corner of the building and so on. In a continuous or repetitive welding process, a construction requires rapid successive welding with different welding positions.

The movement or swing of the welding electrode can also affect the characteristics of the weld, on the other hand, the shape of the electrode movement for welding is often a personal choice of the welder, regardless of the strength of the

weld. Due to the wide variety of uses of iron and steel, various mechanical properties are required in each required condition. Mechanical properties are the properties or abilities that an object has against the force or load that is physically applied to the object. The mechanical properties include hardness, ductility, toughness and good machinability. With so many properties needed, there are many methods to get the desired properties. The impact test is one of the methods used to obtain the ductility, toughness and formability of the material. The impact test is not only to obtain the maximum toughness that the material can accept, but also to determine the fracture shape of a material. To determine the shape of the electrode motion that produces the best mechanical properties, it is necessary to do research and testing.

Based on this background, the researcher is interested in examining the toughness value of the vertical position GMAW welding on ST 42 steel with a spiral electrode motion pattern.

2. Methods

2.1. Research Object

The object of research is the result of vertical position GMAW welding on ST 42 steel with a spiral motion pattern. The number of samples in this study were each material testing group using a mechanical testing device as many as 20 samples. This type of research is an experimental study that analyzes the strength and toughness of the vertical position GMAW welding on ST 42 steel with a spiral electrode motion pattern.

2.1.1. Variables dan Research Design

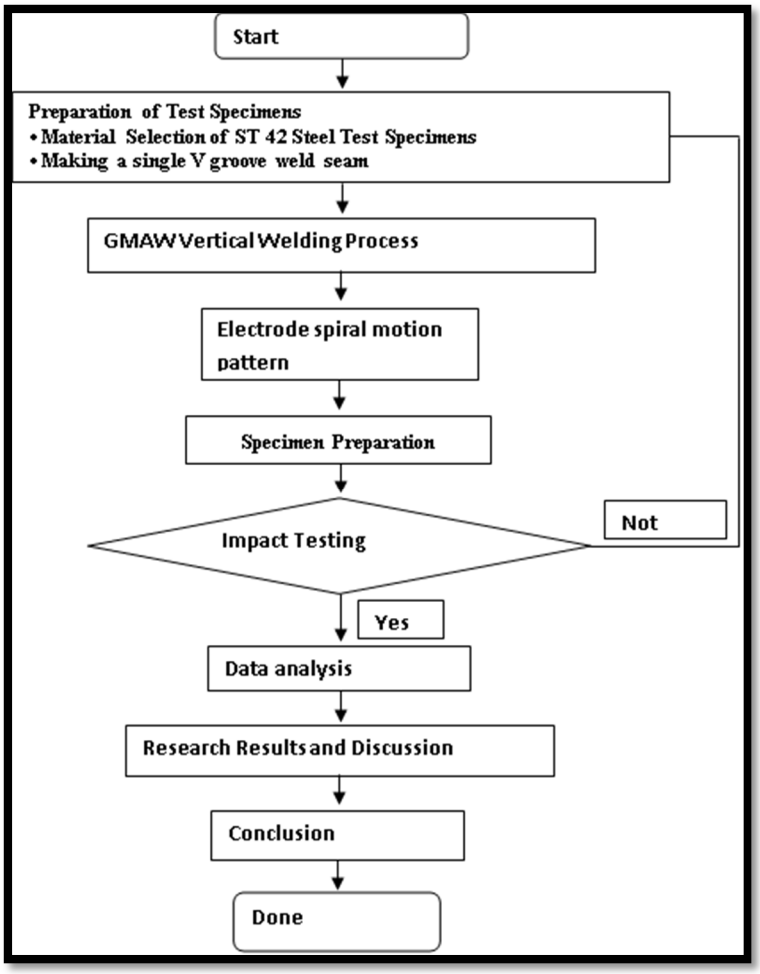

Figure 1: Research Flowchart

2.1.2. Data Analysis Technique

This study was analyzed by describing the strength and toughness of the ST 42 steel welding results with a spiral electrode motion pattern, comparing the mean and standard deviation values between the sample group and the control group, as follows:

$$X_i = \frac{\sum X_i}{n_i} \quad \text{.....(1)}$$

$$s = \sqrt{\frac{\sum(Xi-\bar{X})^2}{(n-1)}} \quad \text{..... (2)}$$

$$s^2 = \frac{\sum(Xi-\bar{X})^2}{(n-1)} \quad \text{..... (3)}$$

Source: Sugiyono, (2013:57)

3. Result and Discussion

This research is an experimental research that has been carried out in the machine shop and mechanical engineering laboratory of the Makassar State University. The impact test tool is used to determine the toughness and impact strength of the welding material.

Number	Impact Test			
	Electrode Spiral Motion Pattern		Control	
	Impact Energy (Joule)	Impact Value (J/mm²)	Impact Energy (Joule)	Impact Value (J/mm²)
1	50	0.091		
2	52.5	0.095		
3	85	0.155		
4	85	0.155		
5	102.5	0.186		
6	130	0.236		
7	130	0.236		
8	132.5	0.241		
9	135	0.245		
10	140	0.255		
11	142.5	0.259		
12	145	0.264		
13	152.5	0.277		
14	160	0.291		
15	162.5	0.295		
16	167.5	0.305		
17	177.5	0.323		
18	180	0.327		
19	182.5	0.332		
20	195	0.355		
Total	2707.5	4.922		
Average	135.375	0.246	183.975	0.334

Table 1: Toughness Value of ST 42 Steel Welding Results with the Electrode Spiral Motion Pattern
Source: Research Result 2020

Look for differences in toughness or impact strength with the percentage method of two specimens with different treatments, by calculating the average difference:

183.975 – 135.375 = 48.6

48.6 x 100 / 135.375 = 35.90 %= 36%

So, the difference value using the percentage method is 36%; this indicates that there is a difference in toughness of 36%.

From the results of research conducted using an impact testing machine, data values and calculations were obtained, showing that the average value of the toughness of the GMAW welding results of ST 42 steel with a spiral electrode motion pattern was 135,375 Joules, which is smaller than the toughness without joints, which was 183,975 Joules.

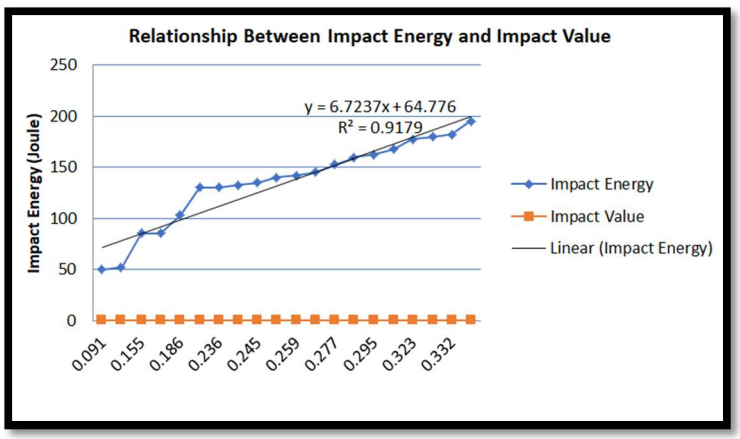

Figure 2: Graphic Toughness of GMAW Welding Results on ST 42 Steel with Electrode Spiral Movement Pattern

4. Conclusion

Based on the results of research and discussion, it can be concluded that:

- The toughness of the GMAW steel ST 42 welding result with the spiral electrode motion pattern is 135,375 Joules.
- There is a difference in toughness of 36% from the GMAW welding result of ST 42 steel spiral electrode motion pattern without welding.

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