IJSES
International Journal of Scientific Engineering and Science
Volume 7, Issue 5, pp. 1-4, 2023. ISSN (Online): 2456-7361

The Differences in SMAW Welding Toughness Using V Seams on SS400 Steel with Notch Variations

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Abstract— *This study aims to determine the difference in the magnitude of the impact toughness values of SMAW welding with V seams on SS400 steel with various notches. The results showed that the highest impact value was obtained from the U seam specimen with a value of 2.53 joules/mm^2, and the lowest impact value was obtained from the V seam specimen with a value of 1.43 joules/mm^2. The average value of the SS400 steel specimen is 1.96 joules/mm^2. The significance value of the data that has been processed in SPSS is 0.255. This data has a value greater than 0.05. SS400 steel has a toughness value of 1.96 joules/mm^2 and has no significant difference between the notch shapes.*

Keywords— *Welding, SMAW, SS400 Steel, Notches.*

I. INTRODUCTION

Welding is a technique for joining two metals by melting some of the base metal and filler metal with or without added materials. One of the most popular welding techniques is shielded metal arc welding (SMAW) or in Indonesian protected electric arc welding. SMAW is a welding process in which heat is generated from an electric arc between the tip of the electrode and the metal being welded (Purba. Z, 2022). In welding, there are so many things that must be considered in doing it so that the results can be maximized.

Planning the construction of a frame or machine for welding joints, is efficient and safe, so that every type of welding work begins by developing good procedures. The specification of the welding procedure contains matters such as the welding process and type of welding, joint design, base material, filler metal, welding position, shielding gas, welding current, and seam type selection. One of the things that must be considered in welding is the selection of the seam. One of them is seam V. Seam V is a type of seam that is used by providing a gap in the metal to be joined at an angle of 60-80 degrees (Gunawan, 2019).

Proving the strength of an object or connection in welding certainly requires a test. this study uses a testing technique that is considered appropriate to test the strength of a connection, namely the impact test. (Anwar. B, 2022)

An impact test is one of the methods used to determine the strength, hardness, and ductility of a material. Impact testing is a test that measures the resistance of materials to shock loads.

This is what distinguishes impact testing from tensile and hardness testing where the loading is carried out slowly, while the impact test is carried out by shock. The basic principle of impact testing is the absorption of potential energy from the loading pendulum swinging from a certain height and striking the test load; so that the test load experiences maximum deformation resulting in fracture. (Lakshminarayanan, A.K, 2009).

SS400 steel is a type of low-carbon steel and is often used as a material in ship construction (Arif. N, 2022). In its application the steel must have good toughness; because according to its function, it must be able to withstand impacts.

Collisions or collisions with objects that are on the edge of the land such as piers and breakwaters, so that the toughness of the SS400 steel that is applied must be known through an impact test. The notches will affect the results of the impact test. So that in impact testing it is necessary to pay attention to the type of notch.

II. RESEARCH METHOD

This experimental research uses SS400 steel as a specimen material. The electrode used is E 7018 with a diameter of 3.2 mm. The electrodes were chosen based on the results of research conducted by Arif, N. in 2022. The results of his research showed that the E 7018 type electrode had a tensile strength of 46.73 Kgf/mm^2. In addition, SS400 steel has a tensile strength ranging from 400 to 560 Mpa which when converted to psi units gets a value between 58015.1 to 81221.1 and the E7018 electrode has a tensile strength of 7000 psi. The welding machine used is a SMAW welding machine with a current of 100A. Then an impact test was carried out on the specimen.

III. RESULT AND DISCUSSION

TABLE 1. Impact Test Result Data

No.	Notch Type	Specimen	A (mm^2)	E (Joule)
1	V Notch	1	80	127,5
		2	80	140
		3	80	115
2	U Notch	1	80	180
		2	80	202,5
		3	80	145
3	Rectangle Notch	1	80	117,5
		2	80	197,5
		3	80	137,5

Based on the table above, it can be calculated to find the impact value with the following Equation:

$$HI = E/A \quad (1)$$

Therefor:
HI : Impact Value (Joule/mm^2)
E : Impact Energy (Joule)
A : Cross-Sectional Area (mm^2)

International Journal of Scientific Engineering and Science
Volume 7, Issue 5, pp. 1-4, 2023. ISSN (Online): 2456-7361

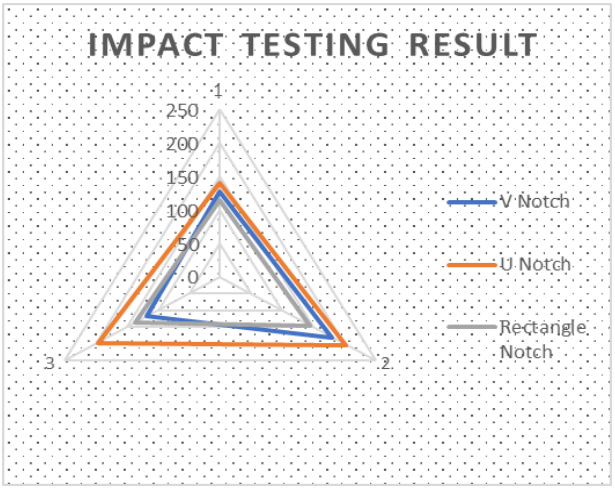

Fig. 1. Figure Impact Energy Testing Result

TABLE 2. Impact Value Testing Result

No.	Notch Type	Specimen	A (mm^2)	E (Joule)	HI (Joule/mm^2)	Average HI
1.	V Notch	1	80	127,5	1,59	1,59
		2	80	140	1,75	
		3	80	115	1,43	
2.	U Notch	1	80	180	2,25	2,19
		2	80	202,5	2,53	
		3	80	145	1,81	
3.	Rectangle Notch	1	80	177,5	2,21	2,12
		2	80	197,5	2,46	
		3	80	137,5	1,75	

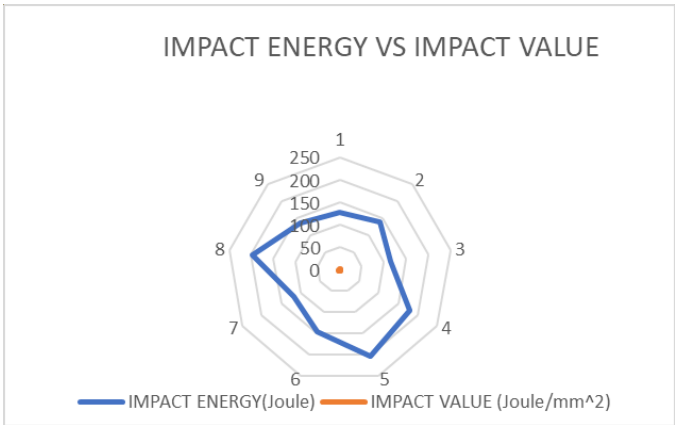

Fig. 2. Correlation between impact energy with impact value

Based on the research results, it can be said that the impact of toughness fluctuates. Based on these data it can be seen that the highest impact value is in the second specimen using a U notch (2.53 joules/mm^2). While the lowest value is shown in the first specimen using the V notch (1.43 joules/mm^2).

The average value of the data presented is that for the U notch, it is 2.19 joules/mm^2. The value of the V notch is 1.59 joules/mm^2, while for the square notch, it is 2.12 joules/mm^2. The data shows that the highest impact value is the specimen using a U-shaped notch. Meanwhile, the lowest impact value is the specimen using a V-notch. The average impact value of all types of notches is 1.96 joules/mm^2.

The parameters contained in the table are used to calculate the average value of the data from each group of test materials. Data analysis used in this study was the ANOVA test to determine whether there was a significant difference between SMAW welding using V notch, U notch, and square notch. Before carrying out the ANOVA test, an analysis requirement test was first carried out, namely the data normality test and the homogeneity test.

After carrying out the prerequisite test, proceed to the ANOVA test. If the sig value > 0.05 then Ho is accepted and H_1 is rejected. If the sig value <0.05 then H_O is rejected and H_1 is accepted. The ANOVA test aims to determine whether there is a difference in a variable. Data analysis using the SPSS data application can be seen in the table below:

TABLE 3. Anova Analysis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.553	2	0.276	1.936	0.225
Within Groups	0.856	6	0.143		
Total	1.409	8			

Based on Table 3, if the sig value > 0.05 then H_O is accepted and H_1 is rejected. If the sig value < 0.05 then H_O is rejected and H_1 is accepted. because the significance value is greater than 0.05. it can be concluded that there is no significant difference.

Based on the results of the study it can be said that the impact toughness has no data differences. This can be proven through the ANOVA test described above. Where the significance value of the calculation is 0.225. with a significance level greater than 0.05, there is no significant difference. Even though the results of the ANOVA analysis showed no difference, the table observed showed that the U notch value has a larger value than the V notch and square.

The results show that the U notch is 2.19 joules/mm^2. The value of the V notch is 1.59 joules/mm^2. while for a square notch that is 2.12 joules/mm^2. The data shows that the highest impact value is the specimen using a U-shaped notch. Meanwhile, the lowest impact value is the specimen using a V-notch. The average impact value of all types of notches is 1.96 joules/mm^2.

The difference in value generated by the shape of the notch is influenced by the stress distribution that occurs. The distribution of notch pressure will affect the impact value (Ramakrishnan, A., 2021). The V-shaped notch has a point where the stress distribution is only concentrated at one point, namely the end of the notch. In the U notch, the stress distribution is spread out on each side of the notch. The square notch has two corner points. So that the stress distribution is spread over the two points. the results of the study show that the impact value of the U notch has the greatest value and the v notch has the smallest value. the V notch has one distribution point at the end of the notch, the U notch is distributed on each side, and the square notch has two distribution points at its corners. This difference in shape makes the value of the notch The U larger than the V notch.

Research conducted by Jalil in 2017 showed that there was a large influence on the impact value of welding that had

different currents. In this study, researchers used notch V. The research conducted by Jalil did not observe the value of the shape of the notch but observed the value based on the difference in the welding current used. However, the value of the V notch shown in this study has relatively the same relative value in this study which also uses a V notch and a current of 100A. the magnitude of the impact value shown in the 2017 Jalil study used a V notch, and a current of 100 which was 1.25, and in this study it was 1.59.

IV. CONCLUSION

Based on the results and discussion that has been described, it can be concluded that the large difference in the toughness value of SMAW welding on SS400 steel with notch variations is that there is no significant difference in toughness with a significance level of 0.05, but the highest value is in the second specimen in the model notch U and the lowest value is on the second specimen using the V notch.

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