IJSES
International Journal of Scientific Engineering and Science
Volume 8, Issue 11, pp. 51-54, 2024. ISSN (Online): 2456-7361

Analysis of Impact Values on the Shape of Notch on ST37 Steel

Nur Fuadah[1], Badaruddin Anwar[2*]
[1,2]Mechanical Engineering Education, Makassar State University, Makassar, South Sulawesi-Indonesian-90221
*Email address: badaruddin.anwar@unm.ac.id

Abstract— *this research aims to determine the magnitude of the impact value generated by the influence of the shape of the notch on St 37 steel. This research uses an experimental method conducted on St 37 with a cross section size of 10 x 10 mm and a length of 55 mm. This study was conducted by making 3 notch shapes namely U (half circle), Ц (rectangle) and V (triangle) notches. The results showed that the average impact value produced by the U (half circle) notch was 1.44 Joule/mm^2, the average impact value produced by the Ц (rectangle) notch was 1.35 Joule/mm^2 and the impact value produced by the V (triangle) notch was 1.16 Joule/mm^2. In this case, the impact value of the V notch is lower because it does not require too much impact energy to break a specimen in contrast to the U (half-circle) notch. The U (half circle) notch requires the highest impact value of the two notches, because the surface of the specimen does not have a large angle so it requires a large impact energy to break or make cracks in the specimen.*

Keywords— *Impact, Notch, St. 37 Steel*.

I. INTRODUCTION

In the current technological era, material engineering is widely carried out as evidence of innovations that make it easier to use and utilize, so it is widely used in all aspects of people's lives. In supporting these innovations, engineers conduct various tests to further explore the material.

Impact testing is a material testing process to determine its resistance to shock loads or impacts. This test is important for understanding how a material behaves under sudden shock conditions, such as in accidents or intense repeated use [3-5].

The impact test is a test using rapid loading to the test object. In mechanical testing, there are differences in giving the type of load to the material such as pulling, pressure or twisting, while the impact test uses an impact load where the load is given quickly. In impact loading, there is a large energy absorption process from the kinetic energy of a load that swings and impacts the specimen. The energy absorption process in the specimen is converted in various responses such as plastic deformation [6-7].

In addition, in everyday life, there are many uses of this impact test, for example on materials used in bridges as aircraft frames, car bumpers, railway tracks and others. The toughness of a material against sudden loads (shock) is important in the production process to determine the extent to which it can later be used in everyday life.

Materials can easily become brittle or fracture at different temperatures even though under normal conditions the metal is ductile. This can be caused by changes in the grain structure in the material under changing temperature conditions, this phenomenon is known as the ductile-brittle transition which is important in the use of materials [1, 2, 18, 27].

The fracture surface and the fracture plane can have a number that can be shown in microscopic size towards the point of the fracture surface. This fracture is influenced by three things: three-axis stress, stress rate, and temperature. The brittleness of a material can occur under sudden loading conditions, the influence of temperature, and the presence of notches that can cause stress concentration during loading [12].

Previous studies, Yhudo Nuhgraha (2020) made a digital Charpy method impact test tool using a rotary encoder sensor and microcontroller. Impact test is one of the methods used to determine the hardness, strength and ductility of materials [28].

To determine the accuracy of the impact test equipment that has been made, a comparison is made between the automatic impact test equipment and the manual impact test equipment. The test results show that the designed automatic digital impact tester has better performance compared to manual testing [7, 10].

Based on this research, one of the things that can affect the impact price (HI) of a specimen is the notch model given to the specimen. This study aims to determine the magnitude of the impact price resulting from the shape of the notch on St 37.

II. CONCEPT THEORETICAL

Impact testing using a pendulum is a commonly used method to determine the material's resistance to shock loads or sudden impacts. There are two main types of impact tests using a pendulum, namely charpy testing and izod testing [7]. Both use basic principles that same, where a pendulum is dropped from a certain height to strike a specimen, but differs in how the specimen is positioned and struck. Several common types of impact tests:

1. Charpy Testing

Charpy testing is one of the most common impact testing methods. In this test, a pendulum is released to strike a material specimen that has grooves (*notch*) in the middle [8].

The Charpy method is an impact test by placing the test specimen on supports in a horizontal position and the direction of loading. Against the direction of the notch [9].

Some advantages of the Charpy method, among others:

1. The test results are more accurate.

Volume 8, Issue 11, pp. 51-54, 2024. ISSN (Online): 2456-7361

2. The operation is easier to understand and produces uniform stress along the cross section.
3. Testing time is shorter.

Meanwhile, the drawbacks of the method Charpy, namely:

1. Can only be installed in a horizontal position.
2. Specimens can shift from their support because they are not clamped.
3. Testing can only be performed on small specimens [10-11].

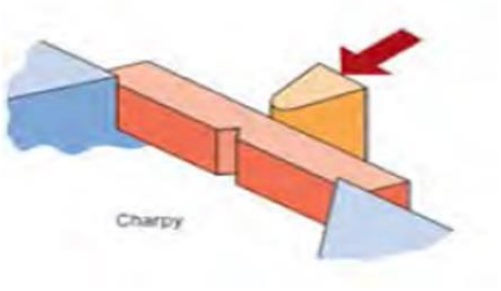

Figure.1. Charpy Method

A notch is a cut on metal that is intentionally made or formed during the manufacturing process, consisting of small defects on the product. In general, The socket is used for placing wedges or needs that require notches. Notches that having various shapes according to the place and purpose for which the notch is made.

The shape of the notch greatly influences the toughness of a material, due to differences distribution and concentration. The voltage at each notch results in different impact energy as well.

The tendency of notches has a weakness if the notch shape has parts or points that cause stress concentration in those areas, making it possible to break.

In this test using three types of notches on the specimen namely; triangular or V-shaped, rectangular and semi-circular notches. Notches are important, especially in the field of machining, besides those notches are one of several factors that cause material failure (generally fatigue failure) [15, 21, 23].

In use, the material is subjected to both dynamic and static loads. The load that is continuously applied to the material is concentrated at the notch, so that the part gradually occurs plastic deformation, cracks, fractures and finally fails. The energy required to break the specimen is measured to determine the toughness of the material [19-20].

2. Izod test (Izod Impact Test)

Similar to Charpy testing, Izod testing also uses a pendulum to impact the specimen. However, the main difference is where the specimen is held and the direction of impact. In Izod testing, the specimen is clamped upright with the groove facing the pendulum [21-28].

3. Testing Drop Weight

In this test, a load is dropped from a certain height onto a specimen to evaluate the material's resistance to direct impact. This method is often used to test materials used in construction and heavy engineering [18].

4. Ballistic Impact Testing

This test is used to determine the resistance of materials to penetration by high-speed projectiles, such as bullets. It is important in the defense and security industries [11-13].

5. Repeated Impact Testing

This type of testing involves repeated loading on the specimen to evaluate its endurance against material fatigue due to repeated impacts [14].

Interpretation of Results

1. *Material Resilience:* The height of the energy absorbed by the specimen indicates the toughness of the material. Material with high toughness can absorb more energy before breaking.
2. *Temperature:* Impact test results are often influenced by temperature. Testing can be conducted at various temperatures to determine how the toughness of the material changes with temperature.
3. *Brittle vs. Ductile Failure*: Impact tests can indicate whether a material has brittle failure or ductile failure. Brittle failure usually occurs at lower energies, while ductile failure occurs at higher energies [26-28].

III. METHODOLOGY

The method in this test uses low carbon steel/low carbon iron specimens with a length of 55 mm, a width of 10 mm, and a height of 10 mm and will be given a notch model u, rectangle and v. The tool used to determine the impact strength is used Impact Testing Machine JINAN JB-W500 specifications [16-17].

The test procedure for obtaining technical data is as follows:

A. Material

Type ST 37 steel with semi-circular (U), rectangular (Ц) and triangular (V) notch shapes

B. Testing Tool

The testing instrument used in this research is the Charpy impact testing machine [19-20]. Testing tool, the standard Charpy used has the following specifications:

1. Pendulum mass (m): 25.53 kg
2. Length of the pendulum arm (*l):* 0.6495 m

C. Data collection procedure

1. Specimen Preparation:

a. The specimen is notched in the middle. Notch semi-circle (U), square (Ц) and triangle (V)
b. The dimensions of the specimen are usually standard, such as 10 mm x 10 mm x 55 mm.

2. Specimen Placement:

Placement specimen test impact "*physically*" horizontal on test machine seat with position, the notch is behind the pendulum.

3. Test Machine Setup:

The pendulum is raised to a certain initial position, which is usually aligned with the energy scale that will used.

4. Implementation of the Test

a. The pendulum is released and strikes the specimen at the groove position.

International Journal of Scientific Engineering and Science
Volume 8, Issue 11, pp. 51-54, 2024. ISSN (Online): 2456-7361

b. The energy absorbed by the specimen when fractured is measured. This energy is calculated from difference in height pendulum before and after the collision.

5. *Measurement and Analysis*

The energy absorbed is measured in joules (*J*) and is used to determine the toughness of the material.

IV. Analysis And Discussion

A. Data analysis and calculations

In the St 37 material for the U, Ц and V notch models, the impact energy was obtained and can be shown in the table below:

TABLE 1. Energy Impact Notch Model U, Ц and V

No	U (Joule)	Ц (Joule)	V(Joule)
1	115.2	110	105
2	110	105	72.5
3	120	110	100
4	115.2	110.5	105
5	105.5	105.2	70
6	110	105.5	65.5
7	122.5	105	82.5
8	115.2	110.5	105
9	120	105.5	85.1
10	127.5	112.5	95
Average	115.07	108.33	92.50

After obtaining the impact energy values for the three notch models as shown in Figure 2, we can make a graph of the relationship between impact energy (*EI*) and the notch models U, Ц and V. This can be shown in the figure below.

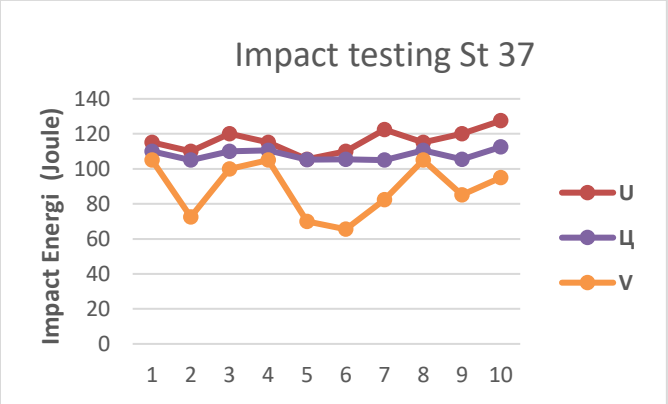

Figure 2. Graphic Impact Energy Notch Models U, Ц and V

In this test, analysis was carried out to obtain the impact value of ST37 steel material with various types of notches. To determine how much impact value is needed, it can be calculated using the following formula:

Formula description:

$$U_1 = \frac{U_s}{A}$$

U_1 = Impact Value (J/mm^2)

Us = Energy or work done to break the specimen (Joules)

A = Cross-sectional Area (mm^2). [4] [5].

On St 37 material for the U notch model, Ц and V. The impact value is obtained and can be shown in the table below:

TABLE 2. Impact value of Notch Model U, Ц and V

No	A (mm^2)	U (Joule/mm^2)	Ц (Joule/mm^2)	V (Joule/mm^2)
1	80	1,44	1,38	1,31
2	80	1,38	1,31	0,91
3	80	1,50	1,38	1.25
4	80	1,44	1,38	1,31
5	80	1,32	1,32	0,88
6	80	1,38	1,32	0.82
7	80	1,53	1,31	1,03
8	80	1,44	1,38	1,31
9	80	1.50	1,32	1.06
10	80	1,59	1.41	1,19
Average		1,44	1.35	1,16

After obtaining the impact values for the three notch models as shown in Figure 3, we can make a graph of the relationship between the impact value (*HI*) and the U, Ц and V notch models. This can be shown in the figure below.

B. Discussion

Based on the results of data analysis, this research was conducted by making 3 notch shapes with the results showing that the average impact value produced by the U (*semi-circle*) notch is 1.44 Joule/mm^2 with an average impact energy of 115.07 Joule, the average impact value produced by the Ц (*rectangle)* notch is 1.35 Joule/mm^2 with an average impact energy of 108.33 Joule and the impact value produced by the V (*triangle*) notch is 1.16 Joule/mm^2 with an average impact energy of 92.50 Joule.

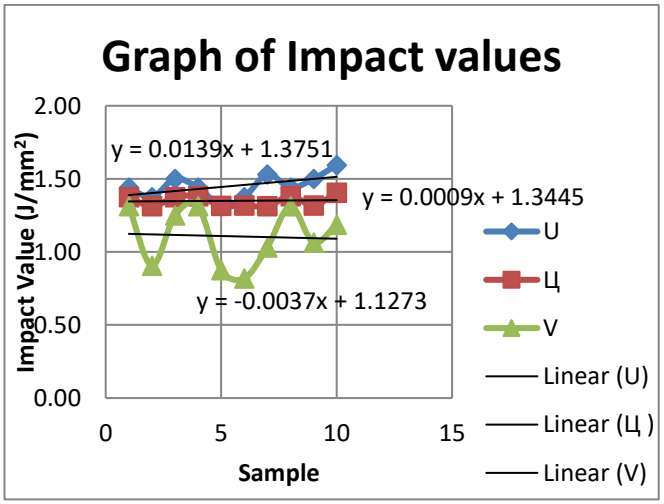

Figure 3. Impact value of Models Notch U, Ц and V

V. Conclusion

From the results of the research that has been done, it can be concluded that this study aims to determine the magnitude of the impact value generated from the shape of the notch on St 37. This study uses an experimental method conducted on St 37 with a cross section size of 10 x 10 mm and a length of 55 mm. This research was conducted by making 3 notch shapes with the results showing that the average impact value generated by the U (*semi-circle*) notch was 1.44

Joule/mm^2, the average impact value generated by the Ц (*rectangle*) notch was 1.35 Joule/mm^2 and the impact value generated by the V (*triangle*) notch was 1.16 Joule/mm^2. In this case, the impact value at the lowest V notch indicates that it does not require too much impact energy to be able to break a specimen in contrast to the U notch. The U notch requires the highest impact value between the two notches, because the surface of the specimen does not have an angle so it requires a large impact energy to be able to break or make cracks in the specimen.

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