Effects Of Various Temperatures On Impact Strength, Hardness And Metallography In ST 37 Steel For Plates By Heat Treatment And Quenching Processes

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Abstract: Heat treatment of ST37 steel which is heated from a temperature variation of 300 ℃, 500 ℃ to 900 ℃ produces a relatively increased hardness value of ST37 steel, in this study using the quenching method with water. From the results of the research obtained the hardness value of ST37 steel before the heat treatment process 52.62 VHN while after the heating process to 900 ℃ ST37 steel obtained a hardness value of up to 85.56 VHN, then in this study showed the impact strength before the heating process on ST37 steel resulted in 40 Joule / mm2, while after the heating process to 900 ℃ showed an impact strength value of 52.73 Joule / mm2. From the data carried out hardness testing and impact testing, the heating process at 900 ℃ is the most suitable for reforming, this research can also find out the effect of impact loads on the mechanical properties of materials and recognize the factors that affect material failure with impact loads.

Key-Words: - ST37 Steel, Hardness, Heat Treatment, Temperature.

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1. Introduction

In order to determine the fracture characteristics of a metal, ductility or hardness, a testing can be carried out which is called the impact test. Impact testing uses a standardized notched specimen rod. Different types of impact testing have been used to determine the propensity of the object to be hardened. With impact analysis, it is possible to identify differences in the behavior of objects not observed in tensile tests. [2]

This research aimed to find out the material characteristics of ST37 by determining the hardness and microstructure results:

- To find out the hardness value of ST37 steel
- To find out how powerful ST37 steel resists the impact load provided by the test instrument.
- To identify the form of microstructure that occurred in ST37 steel with the Quenching Method at 900 ℃ and carried out the cooling process by using Water media.

2. Historical Perpectives And Current Trens

2.1.Steel

The shaft is a product of one of the most important parts of the part or component on the machine, can be found in almost all machines that aim to forward the force together with the rotation that occurs on the shaft. An essential role or the most important in the transmission as a component that is integrated between the shaft and other components. [6]

Steel is an alloy of iron (Fe) and carbon, containing approximately 1.7%. Technically, this product is referred to as carbon steel. The manufacture of steel can be carried out with a converter, Siemens Martin oven and in an electric furnace. The steel can also be treatment, either hot or cold

1. ST37 Steel

ST 37 is a kind of low carbon steel with a carbon load of approximately 0.3%. ST 37 indicates that this material has a minimum tensile strength of ≤ 37 kg/ mm². (preceded by ST and followed by number indicating a minimum tensile strength of kg/mm²). ST 37

steel has theoretically a lower hardenability value as compared to cast iron, with the existence of pearlite and ferrite due to the presence of more pearlite than ferrite. [1]

Applications of ST 37 steel include: use for wire, nails, wire mesh, automotive equipment as well as welding fabrication raw materials. Special applications include electrode wire coating for welding applications.

2. Heat Treatment

Heat treatment is a process to change the metal structure by heating the specimen in an electric furnace, at the recrystallization temperature for a period of time, then carried out in quenching media such as air, water, brine, oil and fuel, respectively with different cooling intensities. [7]

3. Quenching

Quenching media is a material that functions in determining the cooling velocity carried out on materials that have been processed through heat treatment. The application of cooling media is therefore also important in determining the characteristics and structure of the material after it has been cooled.

There are generally two kinds of cooling media used, which are cooling media with low density and cooling media with high density. If organized in a detailed order from cooling media that has a higher density to the lowest, it is obtained, as shown below: salt water, water, fuel, oil and air. For more details, this review will only explain the effect of cooling media in general, between two density levels. [4]

4. Impact Test

Determining the fracture characteristics of a metal, its toughness and elasticity, a test can be carried out called the impact test. Impact testing involves the use of a standardized specimen rod with notches. Different types of impact testing of notched rods have been utilized to determine the propensity of objects to be fragile. Impact testing can identify differences in the characteristics of objects that are not captured in tensile testing. [3]

4.1. Izzod Method

The izzod test specimen is commonly used in other countries, however, it is now becoming less utilized. The izzod test specimen has a cross-section of a square or circle and a v notch close to the clamped point. In izzod impact testing, the pendulum impact is applied at a distance of 22 mm from the pinch and the notch points toward the pendulum.

4.2. Impact Fracture

Determining the fracture properties of a metal, its ductility or brittleness, can be done by testing with an impact test. Impact testing utilizes a pierced specimen rod that has been standardized. In general, as the fracture analysis on the material from the tensile test, the impact fracture is categorized into three types:

- (fibrous fracture), which is a mechanism involving the displacement of crystalline spheres within a material (metal) which is ductile. It is characterized by a diffuse, dimpled surface of the fibrous fracture that is light absorbing and blotchy in appearance.
- Granular/crystalline fracture, which is produced by a cleavage mechanism in the granules of a friable materials (metal). This is characterized by a level fracture surface capable of offering high reflection of light ("glossiness").
- Mixed fracture (both fibrous and Granular). A comparison of the two kinds of fracture mentioned earlier.

5. Vickers Hardness Testing Method

The hardness testing with the Vickers method utilizes an indentor in the shape of a diamond pyramid forming an angle of 136º (ASTM E 92) The indentor mass is variable between 1- 120 Kg. The Vickers hardness test is generally accepted for research applications since it provides a large range of hardness values. Therefore, Vickers can be utilized on materials that are malleable and materials that are very tough. Vickers hardness measurement or VHN. [9]

The Vickers indentor generally provides identical indentation geometries at most of the loads. Excepting for testing at considerably low loads that generate indentations with diagonals smaller than 25 μm, hardenability results will basically be the same as those resulting with testing loads of more than 1kgf.

$$VHN = 1{,}854\ P/d^2$$

Where:

VHN : Vickers Heardness Number

P : Applied load (kgf)

d : Length of the diagonal of the Indent trace

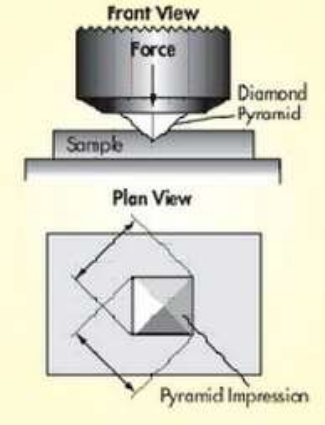

Figure 1. Vickers Hardness Testing

6. Microstructure Testing Methods

Microstructure comprises the distributions of the phases. The inclusion distribution, segregation, the processing effects of the material (decarburization, hot working, cold working), particle size and shape. Microstructure analyzes are needed to approximate material characteristics, analyze failures, and analyze processes that have been carried out on a material. In analyzing a microstructure we have to know the classification of metal materials.

The microstructure of a metal is a combination of more than one crystal structure. Commonly, metals are composed of various crystals (compound), although some are composed of only one crystal (single). However, metals with compound crystals can develop a variety of properties that can further expand their scope of applications. In metals, crystals are frequently referred to as granules. The boundary between two crystals is referred to as the granular boundary. [9]

3 Research Methods

3.1 Testing Time and Location:

Time of implementation in the Laboratory of Physical Metallurgy and Manufacturing Engineering.

3.2 Tool and Materials

- Cutting Tools, Caliper,
- Hand Glove
- Speciment Clamp,
- Furnace
- Vickers Hardness Tester
- Metallurgical microscopy
- Impact Testing Equipment Model Machine JBW-500B
- In this study, several materials of steel were used, ST37 steel.

3.3 Research Procedure

The analysis of the test utilizes the JBW-500B Model impact test equipment which is performed to obtain the impact score of the ST37 steel material and to identify the results of the metallographic test using the microstructure test equipment. The results of metallographic testing using microstructure test equipment. The study plan is shown in Figure 2, which contains information on the series of studies from the beginning until the study gets the required value.

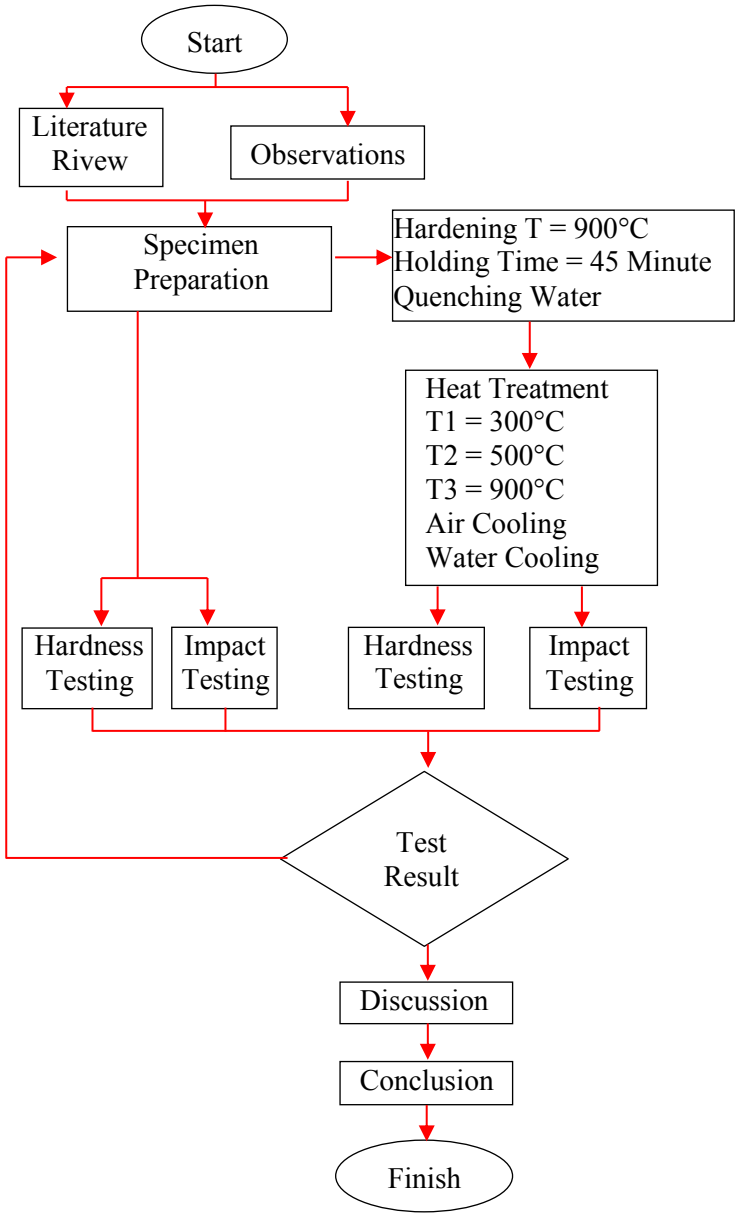

Figure 2. Research Flowchart

4 Result and Discussion

Each of the materials that are measured using a simple cutting machine, measured its length so that all ST 37 steel has a similar measurement.

Comprehensive :

- Long : 46,47 mm^2
- Wide : 08,45 mm^2
- Thick : 0,55 mm^2

Loading : Small Pendulum

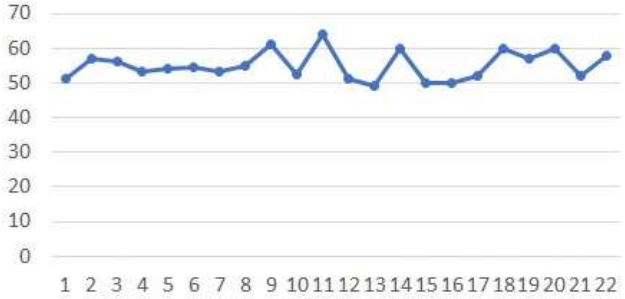

Figure 3 Graph. Hardness Value of ST37 Steel Before Heat Treatment

Figure 4.A ST37 Steel Specimen

Figure 4.B ST37 Steel Specimen

Figure 4.C ST37 Steel Specimen

Figure 4.D ST37 Steel Specimen

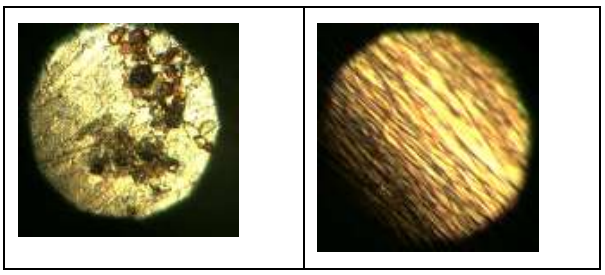

Figure 5.A Microstructure Photo 200x Magnification

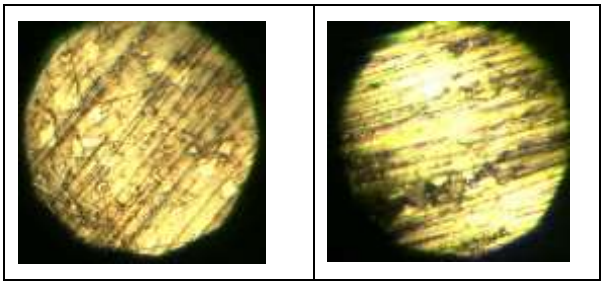

Figure 5.B Microstructure Photo 200x Magnification

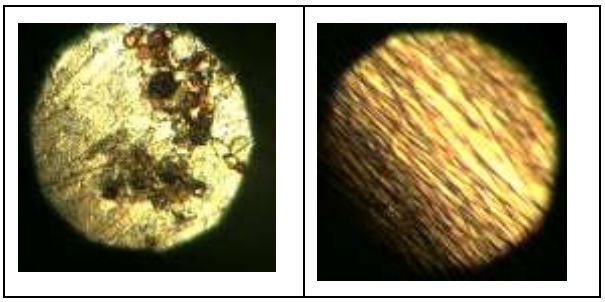

Figure 5.C Microstructure Photo 200x Magnification

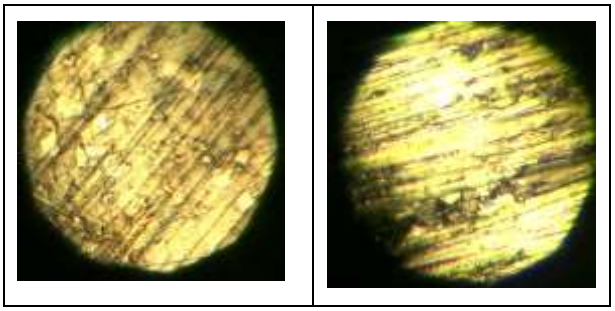

Figure 5.D Microstructure Photo 200x Magnification

Quenching Process

For low-density cooling media, the cooling process will be slow, since the heat transfer process doesn't take effect easily for molecules with large distances. Due to this slow processing, it will form a tough and ductile structure. This is due to the two phases formed, ferrite + cementite. Ferrite has malleable and ductile properties with a carbon content of 0.008%. Meanwhile, cementite has a carbon content of 1% for 3 Fe atoms, so it is tough. In this cooling medium, the recrystallization process is slow, so some carbon atoms are able to be distributed into their bonds again.

Heat Treatment Process

Figure 6. The heating process of ST37 steel specimens at 900℃

This study was carried out with a rapidly cooling process using water as the media.

A B

Figure 7.A ST37 Steel Impact Testing Results

A B

Figure 7.B ST37 Steel Impact Testing Results

Figure 8.A Heat Treatment Materials

Figure 8.B Heat Treatment Materials

Figure 8.C Heat Treatment Materials

Figure 8.B Heat Treatment Materials

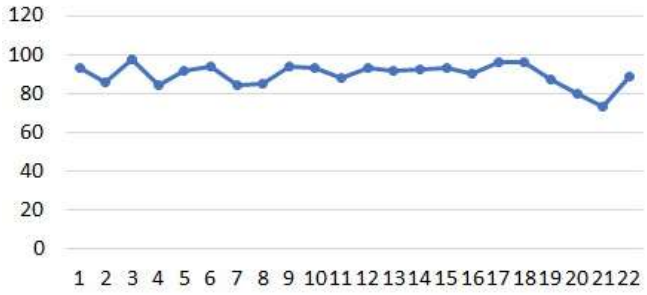

Figure 9 Graph. Hardness value after heat treatment of ST37 steel

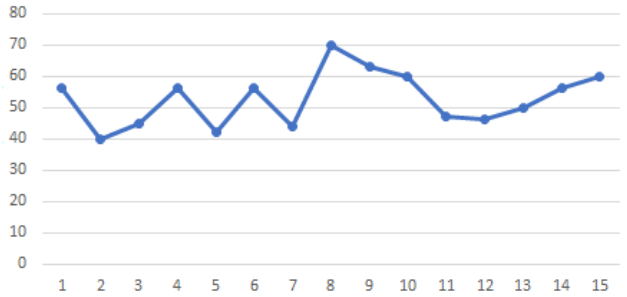

Figure 10. Graph of Impact Testing Values on ST37 Steel

5. Conclusion

Based on the research that has been done, the author made the following conclusions: ST 37 steel material:

- The results of the Hardness test show that the test object that was reheated at 900°C had a hardness of 85.56 VHN, meanwhile the highest hardness value resulted from heating at temperatures from 300°C to 400°C which had a hardness value of 52.62 VHN.
- The results of the impact test showed that the test specimens that were heated at 900°C had an impact strength of 52.73 Joule/mm2 Meanwhile, heating carried out at a temperature of 300°C-500°C had the lowest impact strength of 40 Joule/mm2, and the results of this temperature were the most different from the impact strength of the initial material.
- From the hardness and impact test data, heating at 900°C is the most appropriate temperature for reforming.

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