# Hardness And Micro Structure Analysis Of Aisi 1020 Steel With Carburizing Treatment Using Coconut Shell Charcoal

**Muslih Nasution**

**Abstract:** AISI 1020 steel has been carburized to obtain high hardness properties by carburizing process in quenching variation with water cooling media, salt water solution and oil. Each steel has different characteristics, such as physical properties, mechanical properties and chemical properties. Therefore, a specific treatment is neededto extend life than planned, among other through heat treatment by Carburizing with Quenching variations using water cooling media, salt water solution and oil which aims to increase hardness. Results of vickers testing show that AISI 1020 steel (original) has an average hardness value of 191.3336 VHN, while steel that has undergone a process of carburizing at 900°C for 7 hours and cooled with water, salt water and oil has an average hardness value of 395.3990 VHN, 674.8970 VHN, 621.2040 VHN, respectively.

**Keywords:** AISI 1020 steel, Carburizing, quenching variation, vickers, optical microscope

## 1.1 BACKGROUND

In the material field, there are two ways of heat treatment to increase the value of steel hardness, namely heat treatment and plastic deformation. Carbon steel that heated until reach austenite temperature and then cooled quickly will form a martensitic metal structure that has higher hardness than pearlite and ferrite structures, and this process is called quenching. Specification ofAISI 1020 steel is has low carbon with a carbon composition ranging from 0.20 to 0.30%. This steel is generally used in various industrial components, for example for gear components in plate bending machines. Thesematerials can undergoheat treatment by carburizing followed by a quenching process to get hardness and resistance to wear. One of the heat treatment processes for hardening metals is carburizing. Carburizing is the process of giving or adding more carbon content to the surface compared to the inner parts, so that the surface hardness is increased and the inner partsstill has hardness. Desired metal microstructure properties can be obtained through the process of steel heating and cooling at a certain temperature. Therefore, to get maximum hardness, fast cooling is needed, namely with oil media, salt solution and water. Carburizing process is influenced by several factors, namely holding time or length of the carburizing process, heating temperature, carburizing media and length of the steel cooling process. For carburizing media, the use of a percentage of active carbon material and chemical material that functions as a steelenergizer will produce different hardness in steel. According to Surdia (1995), steel begins to show the structure at 723°C and at 1550°C the steel is completely melted. This means that the ability of steel decreases at higher temperatures. Sudden cooling makes C (carbon) atoms does not get out, causing stress in the C atoms and not have a good position.

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The type of steel that can and needs to be quenched is steel with C (carbon) level below 0.3% and is smaller than 0.9%. Steels with levels of C (carbon) below 0.3% cannot be hardened but only the surface. Such steel can be added with element C in the process of solid carbonization with carbon energizers to diffuse into steel. Coconut charcoalas a source of solid carbon in steel, is changed first in the form of grain. The grains will help the process of changing carbon from solid matter to gas through heating. Heating is carried out at temperatures between 850°C to 950°C. The carbon gas produced will diffuse into the steel structure so that the carbon content will increase (Mujiono and Arianto, 2008). According to the theory and studies as explained above, the author is interested in conducting a study entitled "Hardness And Micro Structure Analysis of Aisi 1020 Steel with Carburizing Treatment Using Coconut Charcoal"

## 2 RESEARCH METHODS

**Research Site and Testing**

Vickers testing of AISI 1020 steel is conducted by carburizing with coconut charcoal and a mixture of sodium carbonate at a temperature of 900°C and then cooled using a water-cooling medium, salt solution and oil. The carburizing test was conducted at PTKI (Study of Industrial Chemical Technology) on 5December 2016 to 10December, 2016, at Southeast Medan (Menteng).

**Tools and Materials**

The materials used for vickers testing process include the following:

### 3.2.1 Tools

1. Chainsaws
2. Calipers
3. Gloves
4. Tweezer
5. Furnace(Steel Heater Ovens)
6. Vickers hardness testing machine
7. Optical microscope

The material used for testing is AISI 1020 Steel, where the original specimen can be seen in Figure 3.10.

***Figure 3**.10AISI 1020 Steel*

## 3 RESEARCH PROCEDURE

1. Provide 4 specimens of AISI 1020 steel with a thickness of 10 mm and a diameter of 35 mm according to the JISstandard and cut using a lathe as shown


***Figure 3.11** Final Specimen Size*

2. **Give a name to each specimen**
3. Provide 15gr of coconut charcoal powder, weighing using a digital scale as can be seen in Figure 3.12.

***Figure .3.12** 15gr of coconut shell charcoal powder*

4. Prepare sodium carbonate($NaCO_3$) powder as much as 10% of 15 gr coconut charcoal powder, that is1.5gr for per each ingredient, as shown in Figure 3.13.

***Figure 3.13** 1,5 gr ofNaturium Carbonate.*

5. Mixing coconut charcoal powder with sodium carbonate ($NaCO_3$) and weighed into 3 parts, then stirring evenly using a glass plastic bag for 15 minutes to prevent failure in carburizing process, as can be seen in Figure 3.14.

***Figure 3.14**. Mixing the coconut charcoal powder with Sodium Carbonate into 3 parts then stir with a plastic bag for 15 minutes*

6. Provide specimen pack material and insert specimens into pack containers by mixing coconut charcoal powder that has been stirred with sodium carbonate and then the pack is tightly closed, as can be seen in Figure 3.15.

***Figure 3.15** Specimens that have been inserted into the pack*

7. Process of pack carburizing is carried out at temperature of 900°C for 7 hours. The expected structure is austenite and with rapid cooling using water, salt and oil solutionmedium.

***Figure3.16*** *Carburizing Process*

8. Then cooled using water, salt water and oil media
9. Carburizing process is complete.

**Hardness Test**

Hardness testing is carried out at PTKI Medan, located on Jalan Medan Tenggara (Menteng) using the Vikers process testing machine. The testing stages are as follows:

***Figure 3.19*** *vickershardness testing*

# 4 RESULTS AND DISCUSSION

## 4.1 Results of Hardness Test

### 4.1.1 Hardness Test Without the Carburizing Process

Hardness test is performed on three test points of AISI 1020 steel (original specimen), using a force of 10 kg on vickers hardness test equipment. HV (Hardness Vickers) value ofAISI 1020 steel (original specimen) can be calculated using vickers hardness equation as follow:

$$VHN = 1{,}8544\ \frac{P}{d^2}$$

$$d^2 = \frac{0{,}313 + 0{,}313}{2}$$

$$d^2 = 0{,}313$$

$$VHN = 1{,}8544 \times \frac{10}{0{,}313^2}$$

$$VHN = 189{,}2844 \text{ VHN}$$

According to the equation above, VHN value of each AISI steel specimen testing (original specimen) for point 2 is 190,500 VHN and point 3is 194,217 VHN, as shown in table 4.1.

Table 4. 1 Result of Hardness Testing for original AISI 1020 steel

Results of hardness test with three testing points, using a force of 10 kg on the vickers hardness test equipment fororiginal specimen of AISI 1020 steel can be obtained with an average vickers hardness value is 191.3336 VHN.

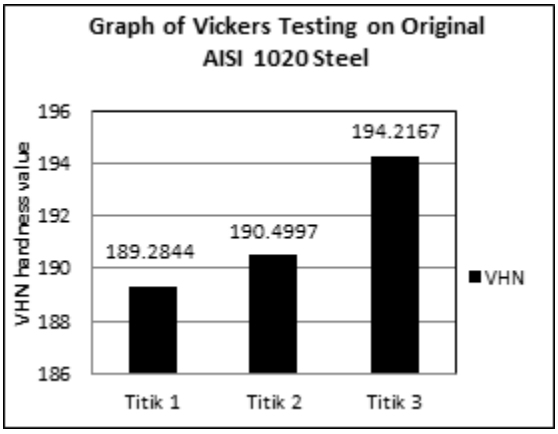


***Figure 4.1*** *Graph of Vickers Testing on Original AISI 1020 Steel*

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**Results of Carburizing Using Water Cooling Media.**

**Hardnessresults at the first point:**

$$d^2 = \frac{0{,}231 + 0{,}231}{2}$$

$$d^2 = 0{,}231$$

$$VHN = 1{,}8544 \times \frac{10}{0{,}231^2}$$

$$VHN = 347{,}5197 \text{ VHN}$$

Table 4.2 Result of Hardness Testingfor carburizing process with water cooling media

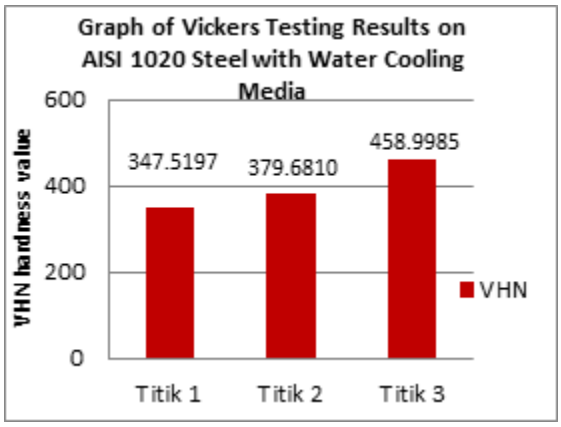


***Figure 4.2*** *Graph of Vickers Testing Result on AISI 1020 Steel with water cooling media*

**Results of Carburizing Using Salt Water Cooling Media.**

**Hardnessresults at the first point:**

$$d^2 = \frac{0{,}181 + 0{,}181}{2}$$

$d^2$ =0,181

$$VHN = 1{,}8544 \times \frac{10}{0{,}181^2}$$

$VHN = 566{,}0389$ VHN

Table 4.3 Result of Hardness Testing for carburizing process with Salt water cooling media

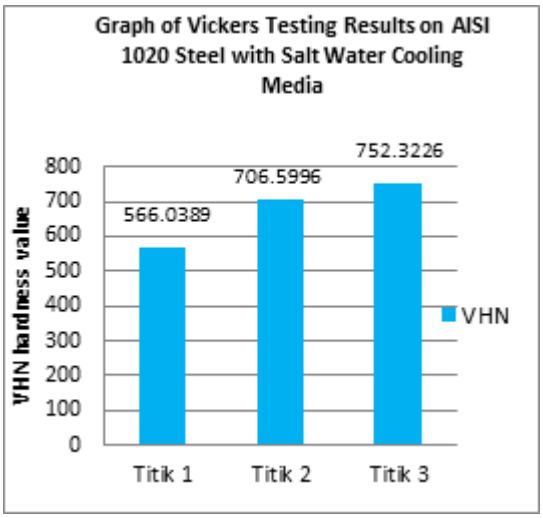


***Figure 4.3*** *Graph* ***of Vickers Testing Result on AISI 1020 Steel*** *with Salt water cooling media*

**Results of Carburizing Using Oil Cooling Media.**

**Hardnessresults at the first point:**

$$d^2 = \frac{0{,}213 + 0{,}213}{2}$$

$d^2$ =0,213

$$VHN = 1{,}8544 \times \frac{10}{0{,}213^2}$$

$VHN = 408{,}7372$ VHN

Table 4.4 Result of Hardness Testing for carburizing process with Oil cooling media.

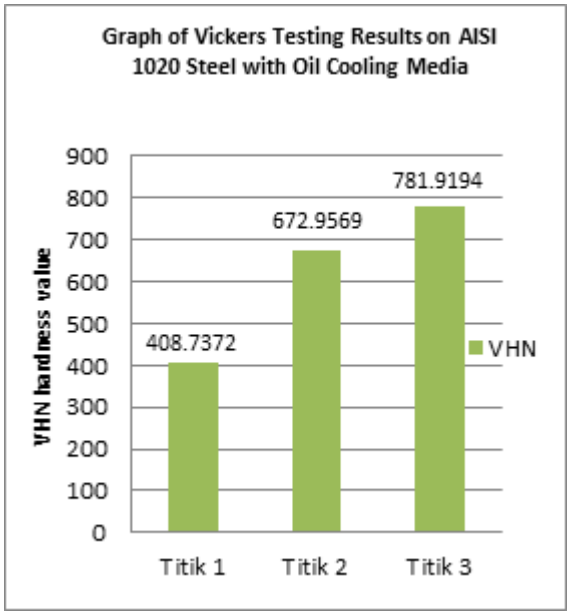


***Figure 4.4*** *Graph of Vickers Testing Result on AISI 1020 Steel with Oil cooling media.*

Comparison of originalAISI 1020 steel with AISI 1020 Carburizing steel with Quenching Variations

Table 4.2Comparison of AISI 1020 Steel Hardness Values

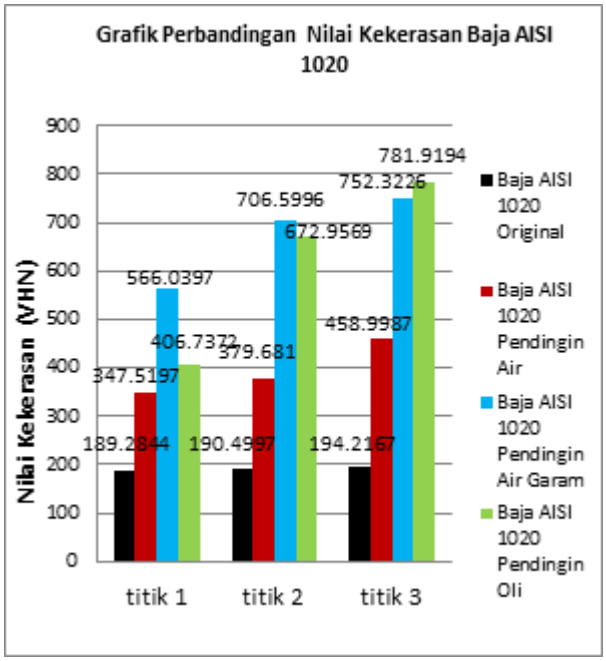


***Figure 4.1*** *Graph of AISI 1020 Steel Hardness ValuesComparison*

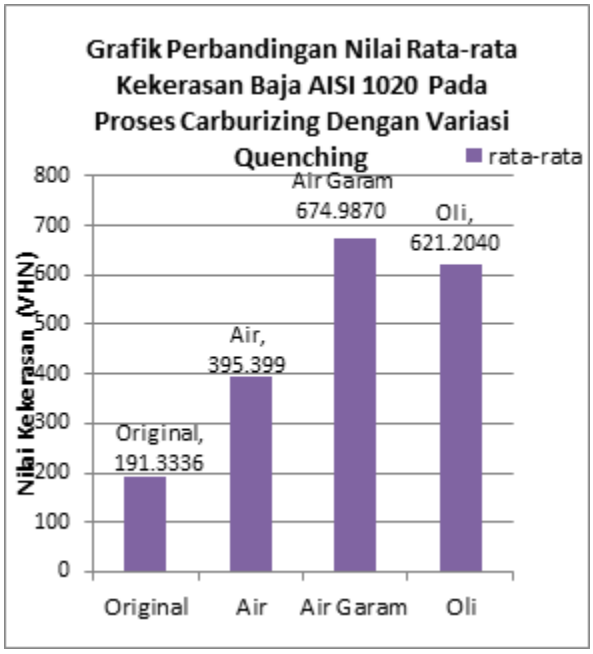


***Figure 4.2****Graph of Average Hardness ValueComparison of AISI 1020 Steel in Carburizing Process with Quenching Variations*

Figure 4.5 above shows the comparison of the average hardness value of AISI 1020 steel between the original steel and steel that has been through the carburizing process with quenching variations using Water, Salt Water and Oilcooling media.The lowest hardness value is carburizing process with Salt Water cooling media, namely 347.5197 VHN. The highest hardness value is found in AISI 1020 steel in the carburizing process with Oil cooling media, namely 781.9194 VHN. It can be explained in Figure 4.6.

## 4 RESULTS OF MICRO STRUCTURE TEST

**4.1.1 Micro StructurePhotographs of the Original Specimen.**

Microstructure of the tested materials was obtained using an optical microscope at magnification of 500X on each test specimen. Optical microscope shows the shape of ferrite and martensite.

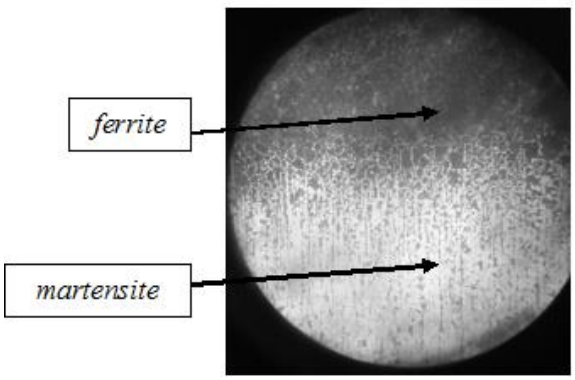


***Figure 4.7****Microstructure of original AISI 1020 steel specimen*

**4.1.2 Micro Structure Photographs of AISI 1020 Steel Specimen in the Carburizing Process with Water Cooling Media**

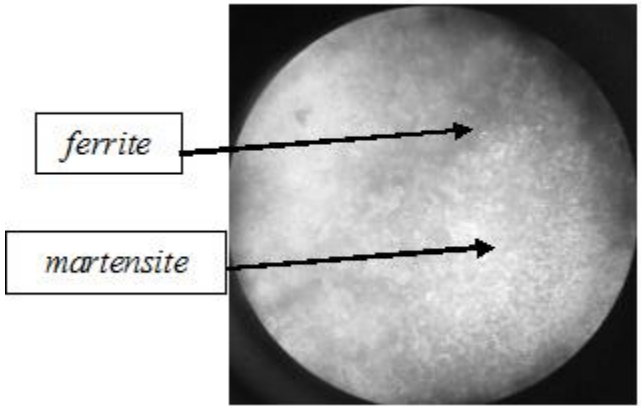


***Figure 4.8*** *Micro Structure of AISI 1020 Steel Specimen in the Carburizing Process with Water Cooling Media.*

**4.1.3 Micro Structure Photographs of AISI 1020 Steel Specimen in the Carburizing Process with Salt Water Cooling Media**

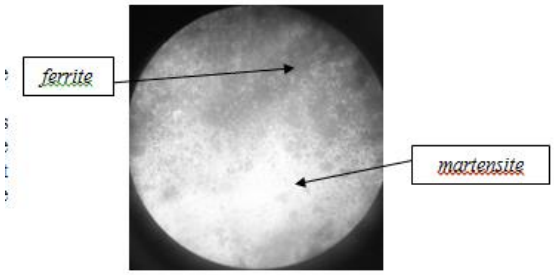


***Figure 4.9*** *Micro Structure of AISI 1020 Steel Specimen in the Carburizing Process with Salt Water Cooling Media*

**4.1.4 Micro Structure Photographs of AISI 1020 Steel Specimen in the Carburizing Process with Oil Cooling Media**

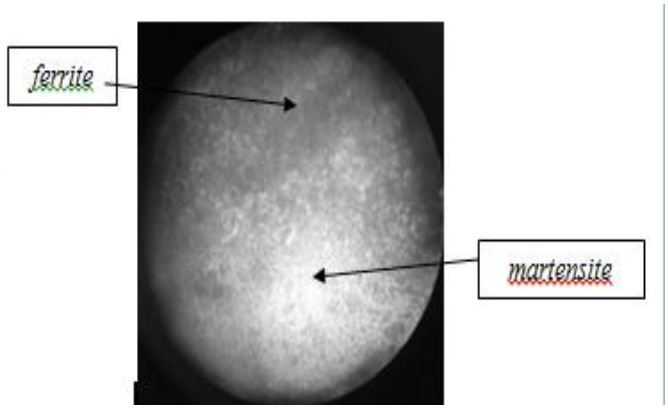


***Figure 4.10*** *Micro Structure of AISI 1020 Steel Specimen in the Carburizing Process with Oil Cooling Media*

## 5 CONCLUSION

According to research finding and data analysis, some conclusions can be drawn is as follow:

1. In the AISI 1020 steel test, the VHN hardness value will increase if the carburizing solid process is carried out with specimens mixed with 15 grams of coconut charcoal powder and naturium carbonate as an energizer (10% of charcoal) and heated at 900°C for 7 hours and with quenching variation usingwater,salt water, and oil cooling medium, compared to specimens testing without heating or original specimens.
2. Increasing the average hardness value of AISI 1020 steel through the carburizing process which is mixed with coconut charcoal powder with quenchingvariations media has differentresults. The average hardness value in the Vikers test is as follow:
    1. Averagehardness value of original specimenis 191.3336 VHN.
    2. Average hardness value of specimens with packs carburizing using water quenching media is 395.3990 VHN
    3. Average hardness value of specimens with packs carburizing using salt water quenching media is 674.9870 VHN
    4. Average hardness value of specimens with packs carburizing using oil quenching media is621.2040 VHN

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