The Influence of Calcium Carbonate Composition and Activated Carbon in Pack Carburizing Low Carbon Steel Process in The Review of Hardness and Micro Structure

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Abstract. Carburizing is a way of hardening the surface by heating the metal (steel) above the critical temperature in an environment containing carbon. Steel at a temperature of the critical temperature of affinity to carbon. Carbon is absorbed into the metal form a solid solution of carbon-iron and the outer layer has high carbon content. When the composition of the activator and the activated charcoal is right, it will perfect the carbon atoms to diffuse into the test material to low carbon steels. Thick layer of carbon Depending on the time and temperature are used. Pack carburizing process in this study, using 1 kg of solid carbon derived from coconut shell charcoal with a variation of 20%, 10% and 5% calcium carbonate activator, burner temperature of 950°C, holding time 4 hours. The test material is low carbon steel has 9 pieces. Each composition has three specimens. Furnace used in this study is a pack carburizing furnace which has a designed burner box with a volume of 1000 x 600 x 400 (mm³) of coal-fired. Equipped with a circulation of oxygen from the blower 2 inches and has a wall of refractory bricks. From the variation of composition CaCO₃, microstructure formed on the specimen with 20% CaCO₃, better diffusion of carbon into the carbon steel, it is seen by the form marten site structure after quenching, and this indicates that there has been an increase of or adding carbon to in the specimen. This led to the formation of marten site specimen into hard surfaces, where the average value of hardness at one point side (side edge) 31.7 HRC

Keywords: the composition of activated carbon and calcium carbonate, burner temperature, holding time.

1. Introduction
Because of soft, pliant and easy to manufacture, steel is widely used as an ingredient in the manufacture of a product. To obtain a hard nature of the surface and remains soft at the core is carried out surface hardening process (face hardening), so that the product can be used with its design purpose. Steel with content low carbon(below 0.3% C), can be carbon , specifically for the S-35C steel with 0.20 % to 0.35% C, which have less good properties for gilded but can disseminator [1] Process this surface hardening is influenced by the number of levels of carbon contained in the steel. Carbon steel is a mixture of iron and carbon and sulfur (S), phosphorus (P), silicon (Si) and manganese (Mn) [5]. Properties of carbon steel depend on the carbon content, and therefore carbon steel can be grouped based on the levels of carbon [2]:

- The extra low carbon steel, carbon content more than 0.08%
- Low Carbon Steel (Low Carbon Steel), the carbon content of 0.08 – 0.35%.
Carbon Steel Medium (Medium Carbon Steel), the carbon content of 0.35 - 0.5%.

- High Carbon Steel (High Carbon Steel) 0.55 -1.7% carbon content.

According to Kuswanto [3], the quality low-carbon steel can be improved, particularly for improved than not afford hardened be able to be hardened. This can be done by way do carburizing process. Where one of the method is to use a solid carbon media or pack carburizing. The depth of the carbon atoms also diffuse sufficiently successful for the benefit of the technique is ± 1000 μm to do this carburizing process, required a stove burner that is usually installed permanently. The furnace is operated with fuel coal or charcoal, so it should be shunned from flammable materials. Due to limited land, it is necessary to design a stove that can be moved (mobile) so can be operated the safe area and when not in use can be placed in that which does not take up large areas. In this study, the authors designed and made the pack carburizing furnaces mobile[4.5], as well as doing test, carburizing products practice student products, in order to obtain properties better is hard, wear-resistant, tough and resilient through heat treatment.

2. Material

One effort to improve the quality of metal mainly hardness is the process carbonization, According to research conducted by Kuswanto [2] which examined the treatment pack carburizing on low carbon steel as a material alternative for the cutter, where the process of pack carburizing in the kitchen space is gradually warming underway, the first phase of 200 °C for 1 hour, second phase of 500 °C for 1 hour and 700 °C for 1 hour, the last in carburizing temperature of 900 °C for 2 hours. Further cooling is done slowly, where the kitchen is turned off and waits until it goes down at a temperature of 350 °C. After reaching that temperature, the kitchen door was opened to remove the carburizing box. Outdoors kitchen carburizing box lid is opened, all specimens out to be cooled in the open. The process of heating and cooling of the specimen can be seen in the image below.

![Figure 1. Initial data test material:](image)

Table 1. Vickers hardness test data micro initial test material

| Specimen | Hardness | No | Diagonal 1 d1 (mm) | Diagonal 2 d2 (mm) | Diagonal rata-rata d (mm) | P (Kg) | Hardness (Kg/mm²) |
|----------|----------|----|-------------------|-------------------|----------------------|--------|------------------|
| Bahan baku Mikro Vickers | 1 | 0.062 | 0.062 | 0.06200 | 0.3 | 144.69 |
| 2 | 0.062 | 0.062 | 0.06200 | 0.3 | 144.69 |
| 3 | 0.0615 | 0.0615 | 0.06175 | 0.3 | 145.87 |
| 4 | 0.062 | 0.061 | 0.06150 | 0.3 | 147.06 |
| 5 | 0.061 | 0.061 | 0.06100 | 0.3 | 149.48 |
Table 2. Mikro vickers hardness data after carburizing pack

| Spesimen | Hardness | No | Diagonal 1 (mm) | Diagonal 2 (mm) | Diagonal rata-rata (mm) | P (Kg) | Hardness Value |
|----------|----------|----|----------------|----------------|------------------------|--------|----------------|
| A        | mikro Vickers | 1  | 0,05           | 0,05           | 0,05                   | 0,3    | 222,48         |
|          |          | 2  | 0,051          | 0,0505         | 0,05075               | 0,3    | 215,95         |
|          |          | 3  | 0,056          | 0,0565         | 0,05625               | 0,3    | 175,79         |
|          |          | 4  | 0,059          | 0,059          | 0,05900               | 0,3    | 159,78         |
|          |          | 5  | 0,061          | 0,0615         | 0,06125               | 0,3    | 148,26         |

Figure 2. Low carbon steel micro Structure A before the process of carburizing, B After carburizing process

Test results concluded. Vicker hardness prices rose by 26%. and the depth of the carbon atoms also diffuse sufficiently successful for the benefit of the technique is ± 1000 μm [2].

Figure 3. Furnace pack carburizing

3. Method

Research process conducted through the stages of preparation of the furnace, active carbon manufacturing process, the manufacturing process the test material, the pack carburizing, quenching process, the testing process to test the material to see the magnitude of the diffusion of carbon atoms on the surface of the test material (carbon steel low) [5,6].
3.1. Materials Research

Materials used in this study are:

- Low carbon steels as a material that hardened surface
- Media carburizing, Charcoal active selected shell coconut and activators selected for each of calcium Carbonate (CaCO₃).
- Heating Temperature is 950 °C
- Holding time for 4 hours.

Instrument used for the process of carburizing this is designed furnace with coal fuel

Pack carburizing process was made a furnace with shape:

1) The furnace is made up of steel frame
2) Material furnace room made of refractory bricks
3) Air is blown by the blower
4) Material from the coal

Furnace is designed mobile [5].

Carburizing process, Coconut shell is very good in use as activated charcoal for media carburizing [8], large granular activated charcoal that is in use 30 mesh and then mixed with calcium carbonate (CaCO₃) with the composition of the three variations of composition:

a. Variations 1-1 kg of activated carbon, 20 % CaCO₃
b. Variation 2-1 kg of activated carbon 10 % CaCO₃
c. Variation 3-1 kg of activated carbon 5% CaCO₃

After mix homogeny calcium carbonate and activated carbon for each composition, and then input into 3 pieces of steel box 4 cm, a steel box with one variation. Then add 5 test material of low carbon steel for each box, set each test material by 2 cm, input again a mixture of calcium carbonate and activated carbon material covering the test, after which each is in a steel box lid. Tick each frog based composition.

After combustion in the furnace chamber carburizing pack is perfect, the input box in the room stove. Then steel lid, heat control heat at a temperature of 950 °C [9, 10], and hold for 4 hours. Holding time 4 hours have a higher hardness values for all media quenching [6,7,8] The choice of temperature is based on the chemical composition of carbon steel is used, namely 0.082 %C. Atom diffusion process will occur at a temperature of approximately 0.5 melting point. Base on Fe-C phase diagram, it is known that carbon steel has a melting point of ± 1600 °C [3]. After carburizing, carbon steel in quenching simultaneously into room temperature water to obtain a hard coating on its surface. Metallography process to view the microstructure of the test material after the process of carburizing and hardness test to determine the hardness on the surface material testing.
4. Results and Discussion

4.1 Micro structure

Test material that is low carbon steel test material in the form of bars with diameter 16 mm length of 5 cm. In this test there are 2 kinds of test materials; (1) The test materials without carburizing treatment. The test material with carburizing treatment, the test material after the process of carburizing process is carried out quenching with water as the cooling medium. After test material quenching there in the waste 1 cm, which examined the microstructure is a length of 4 cm. It aims to see the extent to which carbon of activated carbon diffuses into the steel with activator calcium carbonate (CaCO₃). Amount of activator the will affect the diffusion of carbon into the steel. Photo microscope of each test material to 200 x magnifications, the microstructure taken at the edges and the middle side of the test material, the data of data is as follows:

![Flow Diagram Research](image-url)
Figure 6. The microstructure without treatment

Figure 7. The activated carbon composition of 1kg with 20 % CaCO$_3$

Figure 8. The activated carbon composition of 1kg with 10 % CaCO$_3$
4.2 Hardness

Hardness defined as the ability of a material to withstand the load indentation or penetration (emphasis added). Violence is one of the mechanical properties (mechanical properties) of a material. Test equipment used is a Rockwell hardness tester. From the hardness testing performed on untreated carburizing steel and steel with carburizing treatment obtained average hardness as shown in Figure 10.

Figure 9. The activated carbon composition of 1kg with 5% CaCo₃

Figure 10. Graph HRC hardness test material
5. Discussion

From microstructure formed on low carbon steel test material without carburizing treatment (Figure 6) looks ferrite (white) and pearlite (dark), ferrite was shaped coarse grains, of value hardness on the edge 1 (Figure 10) 12 HRC, showed carbon steel this is a soft and relatively low carbon steel, microstructure formed on the material composition test with 20% CaCO₃, better diffusion of carbon into the test material carbon steel, case this can be seen with martensitic structure after quenching process, this indicates that there has been an increase or addition of carbon into the test material. This martensitic formation causes the surface of the test material becomes hard. Hardness average at one point (the edge) 31.7 HRC, then hardness showed a decrease to the side of the center (point 5) 14.7 HRC as in Figure 10.

The composition of 10% CaCO₃ showed a decrease of violence in point 1 (side edge) with violence an average of 21.8 HRC (Figure 10) and formed in the form binate micro structure. While the composition of the 5% CaCO₃, the hardness value at point 1 (side edge) equal to the values to violence on the test material without treatment carburizing is equal to 12 HRC (picture 10), and the hardness at the center side is 5.5 HRC is lower than the hardness value of materials carbon steel test without carburizing treatment by 9 HRC. The decline in violence in the composition of 10% and 5% CaCO₃ is because of decreased diffusion of carbon into the test material carbon steel during carburizing process, decrease carbon diffusion is caused lower percentage of CaCO₃ in the activated carbon.

From Figure 10, can be seen in the test material with a composition of 5% CaCO₃, a decline in violence from the side edge (point 1) to the side of the center (point 5), hardness is lower than the test material without treatment carburizing, this was due to warming test material, while at the carbon fusion of activated carbon does not occur.

6. Conclusions

The microstructure and hardness testing on steel process results carburizing and steel without the process of carburizing, it can be concluded:

- From microstructure formed on the test material low carbon steel without treatment carburizing form of ferrite (white) and pearlite (dark), ferrite was shaped coarse grain, of the value of hardness at the edge of the side 1 to 12 HRC.
- Microstructure formed on the test material with a composition with 20% CaCO₃, better diffusion of carbon into the test material carbon steel, it is seen to form martensitic structure after the quenching, this indicates that there has been an increase or addition carbon into the test material. The formation of martensitic This causes the surface of the test material to be loud, where violence was the average of her on the side of a single point (the edge) 31.7 HRC then the hardness shows a decrease to the side of the center (point 5) 14.7 HRC
- Microstructure formed on the test material with a composition of 10% CaCO₃ in the form binate, a decline in violence in point 1 (side edge) with an average hardness of 21.8 HRC.
- Microstructure formed on the test material with a composition of 5% CaCO₃ in the form of ferrite pearlite fine grains of hardness value at point 1 (side edge) equal to the values to violence on the test material without treatment carburizing is equal to 12 HRC, and the hardness at the center side is 5.5 HRC lower than the hardness value of the test material carbon steel without treatment carburizing by 9 HRC.
- CaCO₃, an ingredient energizer in the pack carburizing, the fewer the number of materials energizer then the hard carbon of activated carbon diffuses into the steel.
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