THE INFLUENCE OF QUENCH TEMPERING AND CARBURIZING TREATMENT TOWARD MECHANICAL PROPERTIES AND MICRO STRUCTURE OF MEDIUM CARBON STEEL FOR AUTOMOTIVE APPLICATION

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ABSTRACT Gear is one of the machine components that is widely used in industrial and automotive fields. In machinery process, gear has a very important function to forward speed, power, or torque from one engine component to other components as a mechanical drive. Today a lot of development to obtain a good quality of gear, due to many gears were damage, worn out, and broken because they were not strong enough to resist friction and pressure. In addition, broken gears due to pressure and friction make them did not last long. To increase the hardness value of gear, then it needs though material that can be used when the gear reach optimum rotation. The material that is widely used for gear application is medium carbon steel. The medium carbon steel is a metal material that has carbon composition ranging from 0.30 to 0.59%. This medium carbon steel has hardness value of 174.501 HVN without treatment. The process of quench tempering and carburizing are conducted to increase hardness and toughness value of the material. The hardness value of gear is 140 HVN. The result of the research showed the hardness value at various temperature 780°C, 810°C, and 840°C. The optimum hardness values is 165.355 HVN at the temperature of 840°C. Medium carbon steel is expected to be an alternative to produce steel material with certain mechanical properties. This research also conducted heat treatment in austenite area and then detained with holding time of 20, 40, and 60 minutes. Furthermore, quench tempering was conducted and followed by carburizing to obtain a ferrite phase and coarse pearlite and to increase hardness value after quech tempering. It is expected that after quech tempering and carburizing process, steel with better mechanical properties can be produced. This research obtained the increase of hardness value and the number of pearlite and ferrite.

I. Background of the Research

Gear is of the machine components that is widely used in industrial and automotive fields. In machinery process, gear has a very important function to forward speed, power, or torque from one engine component to other components as a mechanical drive. Today a lot of development to obtain a good quality of gear, due to many gears were damage, worn out, and broken because they were not strong enough to resist friction and pressure. In addition, the broken gears due to pressure and friction make them did not last long.

These affect the life time and the hardness value of gears. To overcome it, there should be a way to improve the mechanical properties of gears by heat treatment.

One of the cases that have been encountered on gears is crack and wear out when they reach optimum point of rotation, as the result it is affecting the life time of gears.

To improve toughness and good mechanical properties of gears, then it requires a material a that is tough and strong at the moment the gears reach optimum point of rotation. The material that is Widely used for gear application is medium carbon steel. Medium carbon steel is a steel that has carbon composition ranging from 0,30 to 0.59%. This type of steel can be formed its mechanical properties and micro structure by carrying out heat treatment process. With variety of temperature, holding time, and water cooling medium, it is expected to achieve corresponding micro structure and hardness values.

Based on the problem above, it is required a research to get hardness value and heat treatment on medium carbon steel.

II. Research Method

This research began with the preparation of specimen material in the form of medium carbon steel, with carbon composition of 0.39%. After preparation is the Heat Treatment process by preparing 9 carbon steel samples that consist of 3 carbon steel samples were heated at the temperature of 780°C with holding time 20 minutes, 3 carbon steel samples were heated at the temperature of 810°C with holding time 40 minutes, and 3 carbon steel samples were heated at the temperature of 840°C with holding time 60 minutes.

The tempering process to 9 carbon steel samples that consist of 3 carbon steel samples were heated at the temperature of 500°C with holding time 1 hour, 3 carbon steel samples were heated at the temperature of 550°C with holding time 1 hour, and 3 carbon steel samples were heated at the temperature of 600°C with holding time 1 hour.

Then the carburizing process to 9 carbon steel samples that consist of 3 carbon steel samples were heated at the temperature of 850°C by using coconut shell charcoal with holding time 1 hour, 3 carbon steel samples were heated at the temperature of 900°C by using coconut shell charcoal with holding time 1 hour, and 3 medium carbon steel samples were heated at the temperature of 950°C by using coconut shell charcoal with holding time 1 hour, and then followed by air cooling process.

The next step is metallography process. First, get rid of oxide on the surface of the sample with grinder. Sandpaper the sample surface with sandpaper size number 80, 120, 240, 400, 600, 1000, 1200 and 1500 (from coarse to fine). Polish the surface of the sample which has been refined by using diamond paste that has been mixed with water and poured on top of the velvet polishing cloth until shiny as glass surface. Clean the sample surface with water and then dry it. Etching process is by using nital 3%. Observe the sample surface and photograph by using optic microscope with 100x and 500x magnification. Then the last is strength test.

II. Result and Discussion

3.1. Testing the chemical composition

To determine the chemical composition of the samples that made with spectro test produced carbon composition in the average of 0.39% as the main alloy.

3.2. The result of hardness value

From the hardness of raw material, it is obtained 174.501 HVN. The data above showed the hardness value decreased after quench tempering and carburizing. The hardness on gear obtained from literature is 140 HVN. As can be seen in the following chart:

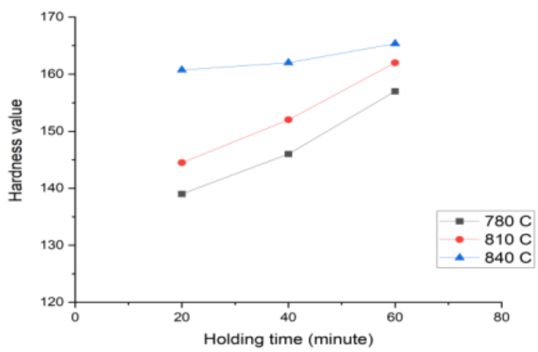

Figure 4.1 Chart between hardness value and holding time

In the chart above it can be seen that at the temnerature of 780°C with holding time of 20 minutes, the hardness value is increasing. In the A sample. the hardness values is HVN 139, the B sample is 146 HVN, and the C sample is 157 HVN, And at the temperature of 810°C with holding time of 40 minutes, the hardness value in the A sample is 144.47. the B sample is 152 HVN, and the C sample is l62 HVN. And at the temperature of 840°C with holding time of 60 minutes, the hardness value in the A sample is 160 HVN, 162 HVN, and 355 HVN. It can be seen the improvement of hardness value at the temperature of 840°C. From the chart above it can be concluded that the length of holding time will influence the increase of hardness value of the material. The highest hardness value is 165.355 HVN from the initial hardness value of 174.501 HVN and the hardness values of gear is 140 HVN.

Figure 4.11 showed the increase of pearlite volume. The number of pearlite can be seen clearly in the austenite area which is at the phase ($\alpha + \gamma$) with holding time as well as quenching and tempering treatment increases the pearlite volume.

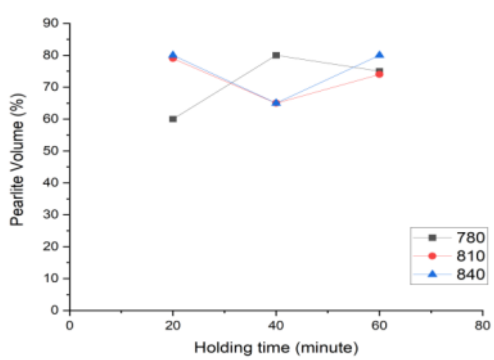

Figure 4.11 The influence of holding time toward pearlite volume at each temperature

The increase of pearlite volume fraction occurs at the temperature of 840°C with holding time of 60 minutes and the pearlite volume fraction of 84.56%. While the decrease of pearlite volume occurs at the temperature of 8 1 0°C with holding time of 20 minutes and the pearlite fraction of 67.90%. At 810°C, there is a significant increase and decrease as can be seen in the chart. At the temperature of 780°C, the increase of pearlite volume from 62.34% to 82.71% from the A sample to the B sample, and decreased to 75.92% in the C sample. The longer the holding time, then the more pearlite structure is formed on the material structure.

4.4 The influence of heating temperature and holding time toward hardness value

In figure 4.13, the influence of holding time toward hardness value in various heating temperature shows that the higher heating temperature and the longer holding time will increase the hardness value.

The increase of hardness value occurred because the increase of pearlite volume fraction, this happened due to the austenite crystals are too large, so the rapid cooling pearlite will form parallel pearlite plate structure, which growns in coarse austenite crystal grains that will lower ductility/toughness of the steel. So in order to produce the material with optimum tough and hardness, the quench tempering process was conducted. With heat treatment that is quenching with water and air tempering in order to produce a material that is hard and tough. The longer heating temperature and holding time will increase the hardness value of material.

IV. Conclusion and Recommendation

From the results of this research, it can be concluded:

1. The quench tempering and carburizing treatment can increase the hardness value and toughness of the material. Because by quench tempering process, the material will be hard and tough as well as the addition of carbon by carburizing process.
2. Higher temperature e in heat treatment and longer holding time will greatly influence the hardness value of medium carbon steel material. The lowest hardness value is 139 HVN and the highest is 165.5 HVN.
3. Higher heat treatment temperature and longer holding time will produce more pearlite phase.

5.2 Suggestion

Based on the results of this research and in line with several journals and literature, the suggestions for further research are:

1. At carburizing treatment, it is expected to use fine coconut shell charcoal so the entered carbon can be solid on the surface of material.
2. Clean the surface of material to eliminate scale in metallographic so the results of metallographic can be clearly observed.

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