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ANALYSIS OF MICRO STRUCTURE AND MEDIUM HARDNESS OF CARBON STEEL ISSE INTRODUCTION WATER, OIL AND AIR IN THE HARDENING PROCESS USING COOLING MEDIA

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Abstract-*Hardening is a heat treatment process applied to produce hard workpieces. In the production process components and production equipment often experience friction and pressure, so components that have a hardness level that are able to accept this friction and pressure are needed. This research is an experimental research. The specimens used in this study were S45C clothes with a diameter of 25 mm and a thickness of 20 mm. The number of specimens tested amounted to 27 specimens. The specimens will be given Hardening heat treatment with temperature variations of 920 oC, 950 oC, 980 oC with a holding time of 35 minutes, followed by rapid cooling using water, SAE 30 oil and air. After that the specimen will be tested for hardness using the Hardness Rockwell Cone (HRC) standard. The results of the study showed that the highest Rockwell Hardness value ratio was obtained in a water cooling medium at a temperature of 920°C with the highest average hardness value of 55.1 HRC. Furthermore, the highest Rockwell hardness value using oil cooling medium occurs at a temperature of 920°C with the highest average hardness value of 30.8 HRC. While the lowest Rockwell hardness value occurs in air cooling media at a temperature of 920°C with the highest average hardness value of 21.6 HRC. The microstructure results show that more martensite is formed in the Hardening process with water and oil cooling media. While in the air cooling medium the amount of ferrite and pearlite increases. In conclusion, there are significant differences in hardness values in the Hardening process on medium carbon steel with water, oil and air cooling media. The hardness value of the results of the Hardening process with oil cooling media is between the hardness values of water and air cooling media at each temperature warmup.*

Keywords: S45C Steel, Temperature, Cooling Media, Hardness, Microstructure.

INTRODUCTION

Since ancient times, humans have always needed materials to be used as tools that will help them navigate life. At first humans only knew stone, bone and wood to make tools, such as axes, knives, spears and so on. Higher human culture was obtained after the discovery and use of metals, namely metals that are quite abundant in nature as "free" metals such as gold, silver, copper, lead. The industrial revolution has spawned several materials processing technologies. At that time, many advances were achieved in the field of technology for making iron and steel on a large scale and cheaply. The availability of materials in large quantities and cheaply also encouraged the development of various sciences and technologies, especially in steel processing. Steel is currently a material that is often used in a wide variety of industrial activities both in the production process, as a machine component, as well as in production equipment which has led to awareness of the need to improve the quality of the steel it self

For example, in the manufacture of machine components that require a maximum level of hardness and ability to accept friction and pressure because the engine parts often experience vibration. Because of this, it takes hard and strong steel to receive the vibrations. Based on the carbon content, steel is classified into: 1. Low carbon steel: 0.1 – 0.3% carbon; (2) Medium carbon steel: 0.3 – 0.85% carbon; (3) High carbon steel: 0.85 – 1.3% carbon.

In the production process components and production equipment often experience friction and pressure. Friction and pressure that is too frequent will wear out, crack and even break machine components and production equipment so that repairs are needed so that the machine can work properly again. To overcome this, we need the right material to replace these components with materials that suit the needs and characteristics of these components. Of the three types of steel above, medium carbon steel is the right material to use because this steel is easy to form and has good ductility. The production process requires time and the operational burden of the equipment is very heavy, some components will experience a lot of friction and pressure so that they are damaged which requires replacement which requires more costs. One way to reduce the cost of replacing a tool that has been damaged is to improve the properties of steel or components in terms of hardness and resistance. There are various ways, one of which is the Hardening process. Hardening heat treatment is the process of heating steel at a certain temperature and held for a certain time followed by immersion in the cooling medium. In the Hardening process, the formation of properties in steel depends on the carbon content, heating temperature, cooling system, and shape and thickness (Amanto and Daryanto, 2003: 77). The steel will be heated to the temperature of the critical area and then it will form austenite which is a solid solution in the steel. Austenite will form martensite when the steel is cooled rapidly. The temperature variations used are 920oC, 950oC and 980oC, the selection of these temperature variations is based on the literature which states that the temperature for the hardening temperature of steel is above the critical temperature above 900oC will form an austenite structure which is a solid solution of carbon in steel so that an austenite structure will form automatically. perfect. The austenite structure will form when the object is cooled quickly, the faster the cooling process, the more martensite formed. The martensite structure will be formed perfectly depending on the cooling rate. The cooling rate depends on the cooling medium used, because each cooling medium has a different cooling speed. Cooling media commonly used today are water, oil, brine and diesel. This study used a variety of cooling media, namely water, oil and air. Water and oil were chosen because they have different properties and cooling rates.

RESEARCH METHODS

1. S45C steel material is cut and leveled with a lathe with sizes P = 20mm and D = 25mm. specimens were cut as many as 28 pieces of material with 1 raw material and 27 specimens.
2. After the above preparations are complete, take 27 specimens to prepare for the Hardening process.
3. Before the Hardening process is carried out, prepare and input the cooling media water, SAE 30 oil into each container as much as 1 liter.
4. Then arrange the 27 specimens neatly into the heating kitchen, then turn on the pre heating kitchen at 700oC with a holding time of 30 minutes.
5. When the temperature reaches 700oC with a holding time of 30 minutes, raise the temperature to 920oC with a holding time of 35 minutes.
6. Prepare equipment such as gloves, pliers and specimen collection hooks.
7. When the temperature reaches 920oC with a holding time of 35 minutes, take the first 3 groups of specimens. Take it quickly then put 1 group into the water cooling medium, 1 group into the oil and 1 group with the air cooling medium. Each cooling for 1 minute.
8. After reaching 1 minute, take the entire specimen using pliers, and dry it with a rag then put it in the specimen bag.
9. The next stage of the Hardening process is to raise the temperature by 950oC with a holding time of 35 minutes.
10. Before the temperature reaches the desired number, replace the water and oil cooling media with new cooling media.
11. when it reaches a temperature of 950oC with a holding time of 35 minutes, take the second 3 groups of specimens. Take it quickly then put 1 group into the water cooling medium, 1 group into the oil and 1 group with the air cooling medium. Each cooling for 1 minute.
12. After reaching 1 minute, take the entire specimen using pliers, and dry it with a rag then put it in the specimen bag.
13. The final stage of the Hardening process is raising the temperature to 980oC with a holding time of 35 minutes.
14. Before the temperature reaches the desired number, replace the water and oil cooling medium with a new cooling medium.
15. Same as the previous steps, when it reaches a temperature of 980oC with a holding time of 35 minutes, take the second 3 groups of specimens. Take it quickly then put 1 group into the water cooling medium, 1 group into the oil and 1 group with the air cooling medium. Each cooling for 1 minute.
16. After reaching 1 minute, take the entire specimen using pliers, and dry it with a rag then put it in the specimen bag.
17. The next process is testing the microstructure using a metal microscope.
18. Prepare 10 specimens with 9 representatives each from each cooling medium and 1 raw material. Mark each specimen by writing on the specimen cylinder and insulating it.
19. All of these specimens will be pre-cleaned with a grinding machine using sandpaper no. 100cw, 120cw, 400cw, 600cw, 800cw, 1000cw, 1500cw, 2000cw and 5000cw.
20. When all the specimens are finished, do the initial cleaning. Prepare an etching solution with a mixture of alcohol and HNO3 nitric acid.
21. Etch one specimen at a time, then rinse with soapy water and dry with a tissue.
22. After the etching process is complete, take microphotos with a magnification of 725x by taking 1 photo for each specimen.
23. After the microstructure testing is complete, the specimens will be subjected to the Rockwell hardness test with 27 specimens and 1 raw material.
24. Before carrying out the Rockwell hardness test, the surface of all specimens is cleaned of scale using a grinding machine.
25. The Rockwell hardness testing process is carried out at three points for each specimen and raw material.
26. After all the data has been obtained, do data analysis by taking the average hardness value from each test point

RESULTS AND DISCUSSIONS

Differences in Hardening Process Hardness Values at 9200C Between Those Using Media Cooling Water, Oil, Air Based on the results of the hardness test, the data that has been collected will be analyzed by finding the average of the 3 hardness test points. Furthermore, to make the data easy to read, the data will be displayed in a bar graph as shown below:

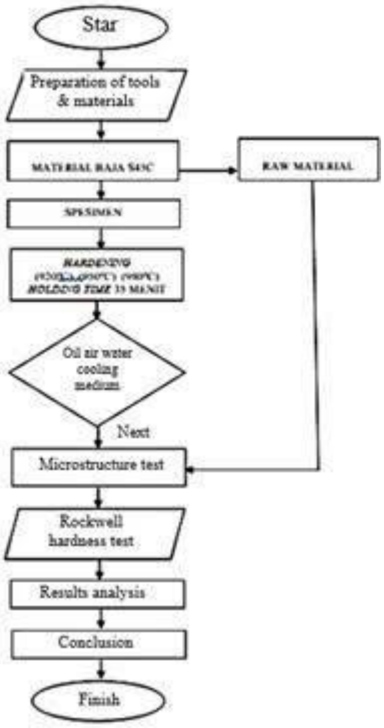

Figure 1. Graph of S45C Steel Hardness Comparison at 920ºC with Water, Oil and Air Cooling Media

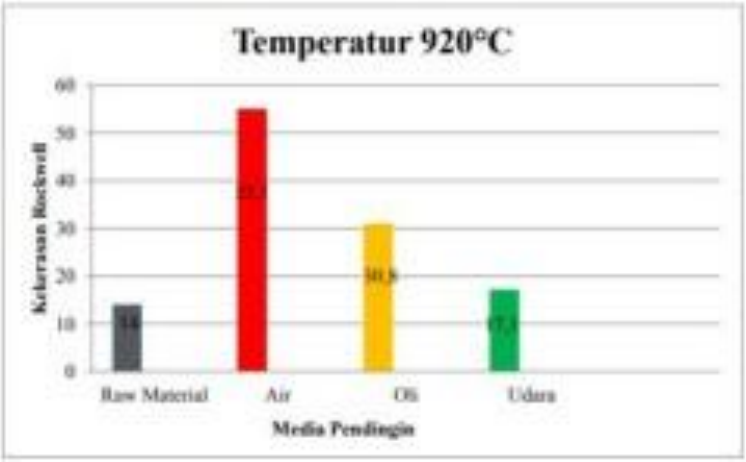

Figure 2 Graph of S45C Steel Hardness Comparison at 920ºC with Water, Oil and Air Cooling Media

The difference in the hardness value of the hardening process at a temperature of 950°C between those using media Cooling Water, Oil And Air

Based on the results of the hardness test, the data that has been collected will be analyzed by finding the average of the 3 hardness test points. Furthermore, to make the data easy to read, the data will be displayed in a bar graph as shown below:

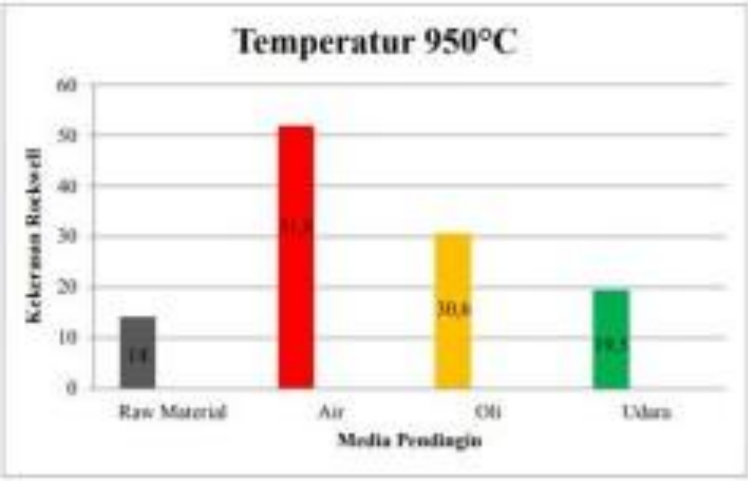

Figure 3 Graph of S45C Steel Hardness Comparison at 950ºC with Water, Oil and Air Cooling Media

From the results of the graph above, it can be seen that the Rockwell hardness value of S45C steel with a temperature variation of 950oC using water cooling media has the highest hardness value followed by oil cooling media, while air cooling media has the lowest hardness level. The highest average value of Rockwell hardness occurs in the 950ºC water cooling medium with an average hardness value of 51.8 HRC. When compared to raw materials, the average hardness value of 950oC water increases by 37.8 HRC. The highest hardness value was then obtained by the oil cooling medium with an average hardness value of 30.6 HRC. When compared to the raw material, the average hardness value of 950oC oil increases by 16.6 HRC. The lowest hardness value was obtained by air cooling media with an average hardness value of 19.5 HRC. When compared with raw materials, the average hardness value of 950oC air increases by 5.5 HRC. So in conclusion there is a significant difference between the hardness values resulting from the Hardening temperature process of 950oC with water, oil and air cooling media.

The difference in the hardness value of the hardening process at a temperature of 980°C between those using media Cooling Water, Oil And Air Cooling Water, Oil And Air.

Based on the results of the hardness test, the data that has been collected will be analyzed by finding the average of the 3 hardness test points. Furthermore, to make the data easy to read, the data will be displayed in a bar graph as shown below.

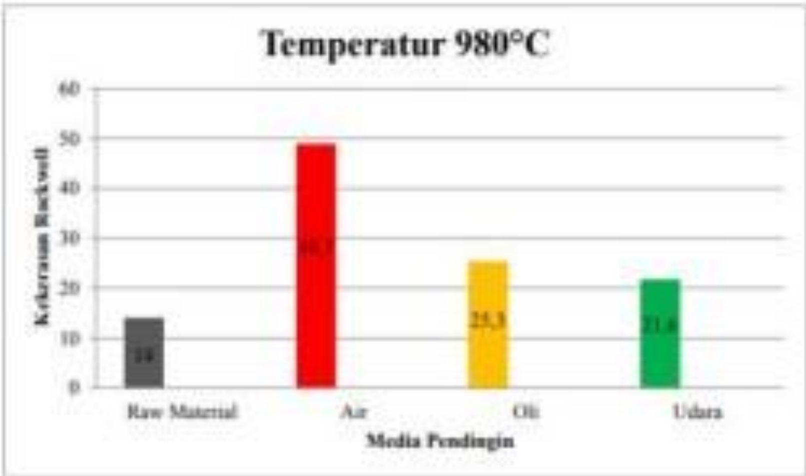

Figure 4 Graph of Comparison of Hardness of S45C Steel at 980ºC with Water, Oil and Air Cooling Media

From the results of the graph above, it can be seen that the Rockwell hardness value of S45C steel with a temperature variation of 980oC using water cooling media has the highest hardness value followed by oil cooling media, while air cooling media has the lowest hardness level. The highest average value of Rockwell hardness occurs in the 980ºC water cooling medium with an average hardness value of 48.7 HRC. When compared to raw materials, the average hardness value of 980ºC water increases by 34.7 HRC. The highest hardness value was then obtained by the oil cooling medium with an average hardness value of 25.3 HRC. When compared to raw materials, the average hardness value of 980ºC increases by 11.3 HRC. The lowest hardness value was obtained by air cooling media with an average hardness value of 21.6 HRC. When compared with raw materials, the average hardness value of 980ºC air increases by 7.6 HRC. So in conclusion, there is a significant difference between the hardness values resulting from the Hardening temperature process of 980ºC with water, oil and air cooling media.

Microstructure Photo Results

The photo results of the microstructure of the raw material show that the phases that appear are Ferrite and Pearlite. Ferrite phase is white and pearlite is dark. It can be seen that the ferrite phase dominates and the number is large and evenly distributed. The crystal arrangement corresponds to the carbon content it contains, namely 0.46% C.

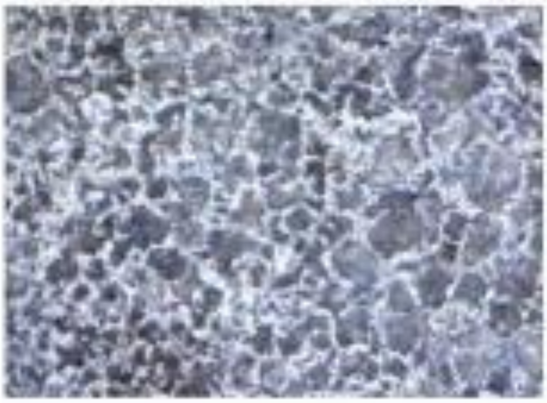

Figure 5 Photo of the Micro Structure of Raw Materials

Results of Microstructure After Hardening Process with Water Cooling Media

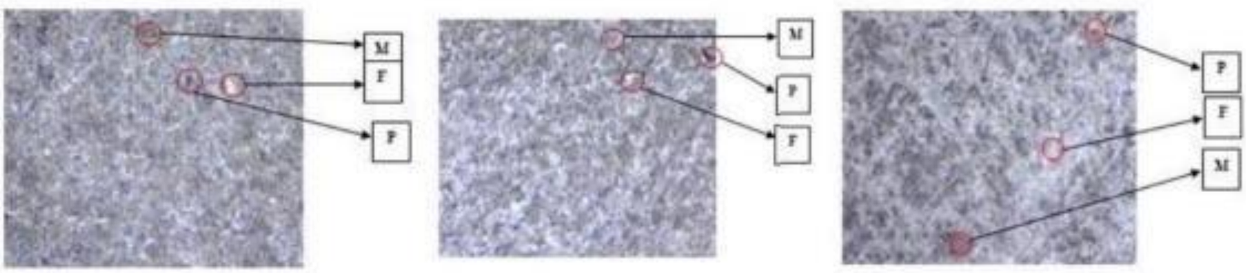

Figure 6 Water Cooling Media Temperature 920 ºC, 950ºC, 980ºC

The results of micro-photos of the martensite phase water cooling media are formed a lot, this is because the water cooling speed is very high so that the austenite does not have time to turn into ferrite and cementite so that the amount of ferrite formed is less. The higher the heating temperature in the water cooling medium, the less amount of martensite formed, while the more ferrite and pearlite and the more evenly distributed. At a temperature of 920oC, a lot of martensite is formed and is spread evenly and tightly, while at a temperature of 980oC the amount of martensite is less visible only in some parts which are brownish black.

Results of Microstructure After Hardening Process with Oil Cooling Media

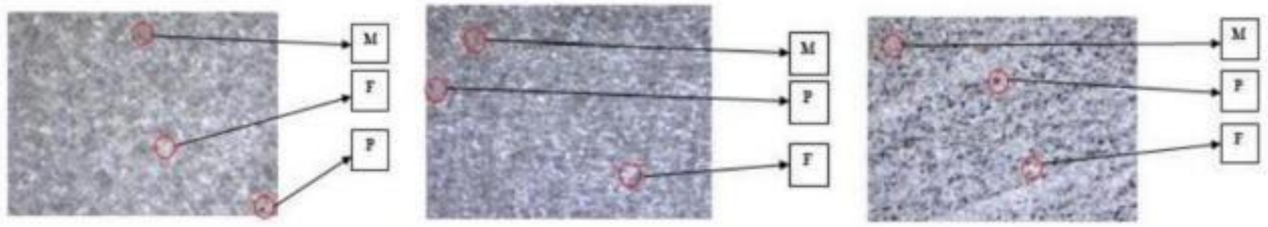

Figure 7 Oil Cooling Media Temperature 920 ºC, 950ºC, 980ºC

Photo of microstructure with oil cooling medium shows less amount of martensite formed. This shows that the cooling speed of high oil is almost the same as water cooling media. The higher the heating temperature, the wider and more evenly formed ferrite together with the pearlite, while the less martensite.

Results of Microstructure After Hardening Process with Air Cooling Media.

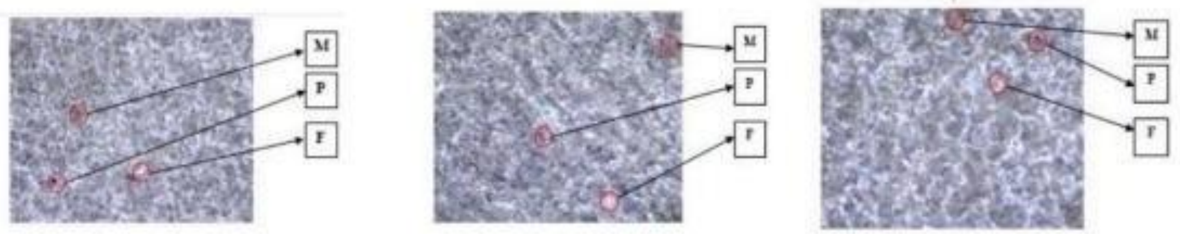

Figure 8 Air Conditioning Media Temperature 920 ºC, 950ºC, 980ºC

Photo of the microstructure with air cooling media, less martensite is formed than when using water and oil cooling media. The amount of ferrite and pearlite increases because the air cooling speed is slower than water and oil so that less martensite is formed. This is because the process of forming the martensite structure requires a fast cooling process so that the resulting martensite formation is less. At 920°C, quite a lot of martensite is formed, while quite a lot of ferrite is formed, although not too extensive. Dark spots appear which are pearlite around the martensite. The higher the heating temperature, the wider and more evenly formed ferrite along with the pearlite, while the less martensite.

CONCLUSIONS

1. There is a significant difference in hardness values in the Hardening results on medium carbon steel with water, oil and air cooling media, where the highest hardness is obtained in the Hardening process with water cooling media at a temperature of 920°C of 55.1 HRC, an increase of 41.1 from raw materials. Then, followed by oil hardness at 920°C of 30.8 HRC, an increase of 16.8 HRC from the raw material. The lowest hardness was obtained with air cooling media at a temperature of 920°C of 21.6 HRC, an increase of 7.6 HRC from the raw material. Results of Microstructure After Hardening Process with Air Cooling Media

2. There is a significant difference in hardness values in the results of the Hardening process on medium carbon steel at temperatures of 920°C, 950°C and 980°C, where the highest hardness value occurs at a temperature of 920°C with water cooling media, the average hardness value 55.1 HRC increased by 41.1 HRC from raw material. Then, followed by the hardness obtained with oil cooling media with an average hardness value of 30.8 HRC, an increase of 16.8 HRC from the raw material. For air cooling media, the average hardness value is only 21.6 HRC, an increase of 7.6 HRC from the raw material. Conversely, the lowest hardness value occurs at a temperature of 980°C, where the average hardness value using a water cooling medium is 48.7 HRC, an increase of 34.7 HRC from the raw material. Then, followed by an increase in hardness obtained with oil cooling media with an average hardness value of 25.3 HRC of 11.3 HRC from raw materials. For air cooling media, the average hardness value is only 17.1 HRC, an increase of 3.1 HRC from the raw material.

3. From the results of the micro-photos taken, it can be seen that the results of the Hardening process in the water cooling medium produce more martensite structures than those possessed by the results of the Hardening process using oil cooling media. The microstructure of the specimen with oil cooling media shows more martensite than air, this indicates that there is a difference in the cooling rate that occurs. The existing martensite content indicates that the specimen is getting harder, but with a sufficient amount of ferrite and pearlite, the specimen becomes less brittle.

4. From the results of the micro-photos taken, it can be seen that the results of the Hardening process at a lower temperature, namely 920oC, produce more martensite structures than those possessed by the results of the Hardening process at temperatures of 950oC and 980oC. This happens because when the specimen is at a low temperature, the amount of carbide that dissolves in the austenite and is also released is less. Meanwhile, at higher temperatures, the amount of carbide that dissolves in the austenite and is also released is greater. The released carbide will become a black crust after going through the quenching process.
5. The highest hardness value from the Hardening process is obtained by water cooling media and the lowest hardness is obtained by air cooling media, while the hardness value from the Hardening process with oil cooling media is between the hardness values of water and air cooling media at each heating temperature

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