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Effect of heat treatment On Microstructure of steel AISI 01 Tools

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Abstract. This study discusses the influence of quenching, normalizing , and annealing to changes in hardness , tensile , and microstructure of materials tool steel AISI 01 after the material undergo heat treatment process. This heat treatment process includes an initial warming of 600° C and a 5-minute detention time, followed by heating to an austenisation temperature of 850°C. After that a different cooling process, including annealing process, normalizing and quenching oil SAE 40. Tests performed include tensile, hard, and microstructure with shooting using SEM (Scanning Electron Microscope). This is done to see the effect of different heat treatment and cooling process. The result of this research is difference of tensile test value, hard, and micro structure from influence of difference of each process. The quenching process obtains the highest tensile and hard values followed by the normalizing process, annealing, and the lowest is in the starting material, this is because the initial material does not undergo heat treatment process. The resulting microstructure is pearlit and cementite, the difference seen from the shape and size of the grains. The larger the grain size, the greater the hardness.

1. Introduction

The standard tool steel AISI 01 is a metal alloy between Silicon, Chromium, and Mangan. In the industrial world widely used dies, punch, and others. Use of this type of metal in the industry because it has good machine capable properties. In materials capable of machining, often require further processing to improve the mechanical properties and materials.

Factors affecting the manufacturing process of the dies are the strength and hardness of the metal as well as changes in the microstructure that occurs during the heat treatment process. By looking for a comparison between the Quenching, Normalizing, and Annealing processes through tensile testing, hard testing, and micro testing, it can be known which process experienced changes in the value of hardness and microstructure in this material.

This research is to determine the effect of heat treatment experienced on carbon steel AISI 01 at austenisation temperature conditions 850°C and the process of quenching, normalizing and annealing to changes in tensile values, hardness and microstructure.

2. Materials and Experimental Procedure

In this research selected materials, AISI 01 tool steel in the world of industry is widely used as a material punch maker and dies. Here is the chemical composition of AISI 01 tool steel. From Table 1

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Table 1. Chemical composition of AISI 01

NO	Composisi	Persentase (%)
1	Carbon (C)	0.9 – 1.05
2	Crom (Cr)	0.5 – 0.7
3	Vanadium (Vn)	0.05 – 0.15
4	Mangan (Mn)	1 – 1.2
5	Silikon (Si)	0.15 – 0.35

it shows that AISI 01 contains high carbon content, carbon content has an effect on hardness value of steel. The alloying elements are useful for improving the properties of steel.

The manufacture of specimens is done by various processes, starting from the process of cutting the object from the shape of the rod (shaft) with a diameter of 16 mm and the length of each 250 mm. Then the test object is latched into 12mm inner diameter.

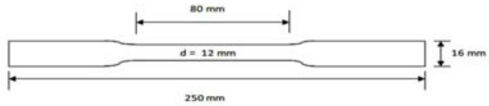

Figure 1. Specimen dimension

Before entering the test, the specimen is classified according to the group of each process. The grouping of test objects is:

- 1st group: 4 specimens for the annealing process
- 2nd group: 4 specimens for the normalizing process
- 3rd group: 4 specimens for the quenching process
- 4rd group: 4 specimens for comparative specimens which are not given heat treatment, but only hardness, tensile, and microstructure testing are performed.

After the test object is ready then start the process of heating or heat treatment. Then other tests, such as tensile tests, hard tests, and microstructures.

The heat treatment process is carried out by heating the steel in the heating kitchen by first warming up at 600 ° C with 5-minute hold time. The purpose of the initial heating is to produce a uniform heating throughout the specimen's surface to produce evenly homogeneous structures. Then proceed with the heating process at austenisation temperature with a temperature of 850 ° C - 900 ° C and held for 60 minutes. In the cooling process (immersion) is done after the steel experienced austenisation process. In this process cooling is done at a certain speed, in order to produce tensile, hard, and different microstructures. In this cooling process using methods of cooling annealing, normalizing, and quenching oil.

In testing to be performed, the dye used is oil (SAE 40), because it can reduce the occurrence of stress, while water or salt can be used for simple forms. The use of SAE 40 oil was chosen because it has a viscosity of 40 at 100 ° C. The use of SAE 40 oil as a cooling medium will cause the occurrence of the carbon membrane in the specimen depending on the oil viscosity. for the normalizing cooling process is carried out by air cooling. After the heating process, the material is removed from the kitchen heater and placed in free air. For the annealing process is done by slow cooling in the kitchen heater (furnace). The furnace temperature is lowered by turning off the furnace so that the temperature drops slowly until it reaches room temperature.

After through the process of heat treatment and cooling the test is done based on the classification of each specimen that has been through a different cooling process. In this test, three tests are tested, tensile test, hard test and microstructure. The tensile test was conducted using a tensile test machine with a maximum capacity of 30,000 kgf. This hard test is performed to determine the effect of heat treatment and its cooling variation on the hardness value of each specimen tested. The test method uses the Rockwell B hard test, as it is easier and does not damage the test specimen on the surface of each specimen. Testing of microstructure on each material must be tested by metallographic.

Table 2. Hard Test

NO	AISI 01	Annealing	Normalizing	Quench Oli
1	98,95	91,82	99,57	99,55
2	79,5	95,67	99,6	99,5
3	92	97,82	99,67	99,5
4	94	96,50	99	99,55
HRB	**91,11**	**95,45**	**99,46**	**99,52**

3. Results and Discussion

Tensile Strength Test Analysis

Based on tests that have been performed such as tensile, hard, and microstructure tests conducted on specimens under conditions following and before heat treatment with different cooling methods. After experiencing the heat treatment process each material or specimen tested tensile strength has different tens compared to the original specimens of steel AISI 01.

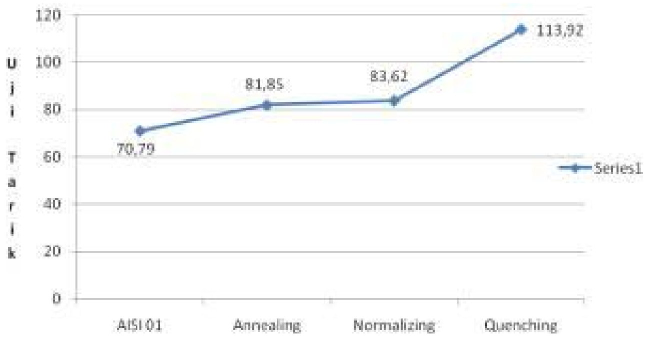

Figure 2. Tensile test graph

From the picture above diagram shows that the quenching process material has the highest tensile strength of 113.92 kgf / mm², compared with the normalizing process that has a tensile strength of 83.62 kgf / mm². The difference in tensile strength is 28.3 kgf / mm². This is because the cooling rate process is different. In the annealing process material, it is seen that the value of tensile strength has a tensile strength of 81.85 kgf / mm², slightly lower than the normalizing process which has at least a difference in tensile strength value of 1.77 kgf / mm². While the initial material (AISI 01) has a tensile strength value of 70.79 kgf / mm² lowest compared to other processes. This is because the material does not conduct heat treatment process so that there is no change of structure and phase in the material. In the tensile test chart, it can be concluded that different tensile strength values are caused by different cooling processes. The more the cooling process or the rapid cooling rate, the higher the tensile value of the material. This is also because in the process of heat treatment and different cooling rates produce different structures and phases.

Hardness Test Analysis

The heat treatment in AISI 01 steel affects the hardness value of this steel, either decreasing or increasing depending on the cooling process after heat treatment.

In Figure 3, there is a difference in the value of violence.

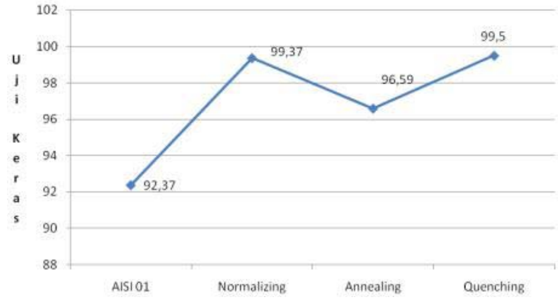

Figure 3. Hardness test graph

From the picture it can be seen that the initial material that does not experience the heat treatment hardness value is the lowest compared to the material or other specimens. This is because no structure changes. Seen on the process of annealing that experienced cooling in the furnace (furnace) has a hardness value of 95.45 HRB. The slow cooling process in the furnace results in a more dominantly soft mechanical property than the violent carbon. When compared to the material that is normalizing the process of cooling the air, obtained a hardness of 99.49 HRB. At quenching process can be seen hard value of 99.52 HRB. Quenching process difference with air cooling is 0.03 HRB. The cooling process of each specimen is different or it can be concluded the specimen that experienced cooling process faster, he will change the structure and the nature becomes harder. This is evident in the hard test graph above where the AISI 01 steel specimen after the heat treatment process is then cooled with an SAE 40 oil quenching medium which includes rapid cooling is harder than any other cooling process.

Elongation Analysis

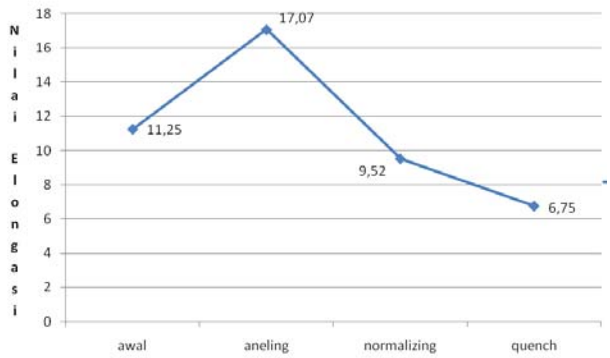

Figure 4. Elongation graph

For elongation values, in accordance with the properties produced, the specimen with rapid cooling leads to a decrease in the value of elongation. In the specimen without heat treatment the elongation value was 11.25% and the annealing specimens of 17.07% increased by 5.82%. This is because the specimen with annealing process is softer compared to the initial specimen. For normalizing specimens of 9.52% compared to the specimen quenching process which has a value of elongation of 6.75% there was a decrease of 2.77%.

So the greater the elongation value, the material or specimen will be more soft and vice versa if the elongation value is smaller then the specimen is getting harder.

Micro Structures Analysis

In the non-heat treatment specimens, the visible microstructures were pearlite and cementite visible microstructures as Fig 5 until Fig.8.

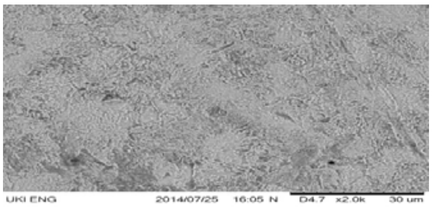

Figure 5. Microstructure of 2000 x enlarged annealing specimen

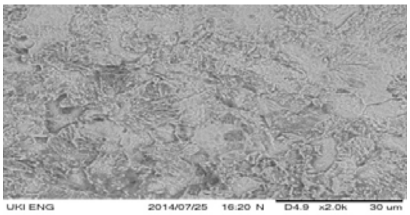

Figure 6. Microstructure of 2000 x enlarged normalizing specimen

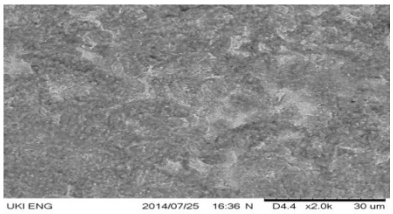

Figure 7. Microstructure specimen AISI 01 magnification 2000x

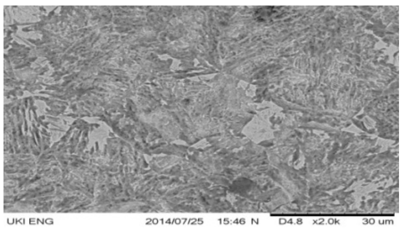

Figure 8. Microstructure of 2000 x enlarged quenching specimen

For the structure that forms pearlite has a rather dark colour while darker than pearlite is cementite. Then on the micro structure of the annealing process will form a fine pearlite structure because it can be seen from the size of the grain, because the cooling process is quite long. In the normalizing process will form pearlite and cementite with a larger size of the microstructure annealing, because the cooling process is fairly fast. In the process of quenching oil to form pearlite and cementite structure with the largest grain size due to the quenching process of oil is the fastest cooling process among other processes. Thus, the structures formed are pearlite and cementite, but have differences in grain size. When viewed from the observation of micro structures with varying magnification using the Scanning Electron Microscope (SEM) the structure or phase formed is pearlite and cementite, which can distinguish the hard and tensile values are the size and shape of the grain. The larger the grain size, the greater the value of tensile and hardness. Seen in the process of quenching oil has the highest tensile and hard value compared with other processes.

4. Conclusion

Based on research and observations made on AISI 01 tool steel material, it can be concluded as follows:

1. Differences in the cooling process may alter the mechanical properties of the material. This is evident in the SAE 40 oil quenching process which has the highest tensile and hardness value followed by the normalizing, annealing and the smallest of tensile and hard values found in the starting material or heatless specimen.
2. For elongation values in the specimen without heat treatment the elongation value was 11.25% and the annealing specimens of 17.07% increased by 5.82%. This is because the specimen with annealing process is softer compared to the initial specimen.
3. For normalizing specimens of 9.52% compared to the specimen quenching process which has a value of elongation of 6.75% there was a decrease of 2.77%.

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