Experimental Study Conducted Rendahsetelah Tenacity Carbon Steel Heat Treatment Austempering

R D Wijaya[1]
[1.] Studies Program Engineering, Faculty of University of Bandar Lampung, Jl. Zainal Abidin Pagar Alam, No. 26 Labuhan Ratu, Bandar Lampung

Abstract. The principle of this Austempering heat treatment is done by heating the steel to austenite tempratur then quenching the hot water bath salts ± 250-550 ° C and held at that time long enough so that the austenite transformed into bainite entirety. If the eutectoid steel is cooled rapidly in the austenite phase to a temperature between 250- 550 ° C and held at that temperature interval (isothermal) will be formed called bainite microstructure according to the name of the inventor, Dr. EC Bain. Bainite microstructure is the result of non-lamellar eutectoid reaction while perlite produced from lamellar eutectoid reaction. Bainite is a microstructure that is a mixture of ferrite phase and cementite (Fe3C). At a temperature of 350-550 ° C will be formed bainite top (upper bainite) while at 250-350 ° C will be formed under the bainite (lower bainite). In this study material used for heat treatment of austempering is low carbon steel with a solution of salt water quenching media. In this study austempering process carried out at a temperature of 300, 350, and 400 ° C with a holding time of 30 minutes. The results of this study indicate if low carbon steel austempering process is carried out hardness values decreased, namely from 144 to 116 at a temperature of 400 ° C, so the higher the austempering tempratur lower hardness value.
Keywords ; *Austempering.*Temperature. Hold time

1. Introduction

The development of science and technology today, greatly affects human life directly feel the impact of development in various fields. If the note carefully, all human needs can not be separated from the metal element, as one of the basic ingredients that can be linked into a finished product, through the work process takes place continuously. In centers such as the automotive industry to traditional industries located in these areas, also using equipment made of metal. Therefore, arise from human creativity and innovation as the industry in order to improve the properties of physical andproperties mechanicalof the metal. The process of heat treatment on the metal is very helpful to get quality metal and has physical properties include electrical conductivity, microstructure, density and better mechanical properties, especially in terms of hardness, elasticity and workmanship of the nature of origin. Most of the metal production is steel. Steels are ferrous metals are widely used in both the industries, household goods (such as machetes, crowbars, knives and others) or other work areas. In the field of workshop equipment mostly made of steel, for example eye lathe chisel, drill and more in daily use can also experience blunting (wear) or damage caused by contact with a hard object. To obtain certain steel with a hardness value It is rather difficult, even if there are quite expensive. Therefore it is necessary for a breakthrough to find an alternative to change the elasticity / ductility of steel provided particularly low carbon steel. To change the value of the ductility of low carbon steel needed some metal working processes one of them through the process by heating the steel to *temperature* the austenitethen *quenched* in a water bath salt heatabove *temperature* the martensite orprecisely at *temperatures of* bainite isup to ± 250 550 ° C and held with long time.

2. Literature Review

2.1 Austempering

Austempering hot is othermal produce bainite structures from austenite to some plain carbon steel. *Austempering* provide alternative procedures *quenching* and t*empering* to improve some toughness and ductility of steel. In the *Austempering* first steeldiaustenitisasi, then di-*quench* in a bath of saline solution in a temperature just above the steel tempratur Ms, hold isothermally to allow the ongoing transformation of austenite to bainite, then cooled to room temperature in air.advantage *Austempering* is no need ditempering.

2.2 Micro structure Bainite

If eutectoid steel cooled rapidly in the austenite phase to a temperature between 250-550 ° C and held at that temperature interval (isothermal) will be formed called bainite microstructure according to the name of the inventor, Dr. EC Bain. Bainite microstructure is the result of non-lamellar eutectoid reaction while perlite produced from lamellar eutectoid reaction. Bainite is a microstructure that is a mixture of ferrite phase and cementite (Fe3C). At a temperature of 350-550 ° C will be formed bainite top (upper bainite) while at 250-350 ° C will be formed under the bainite (lower bainite).

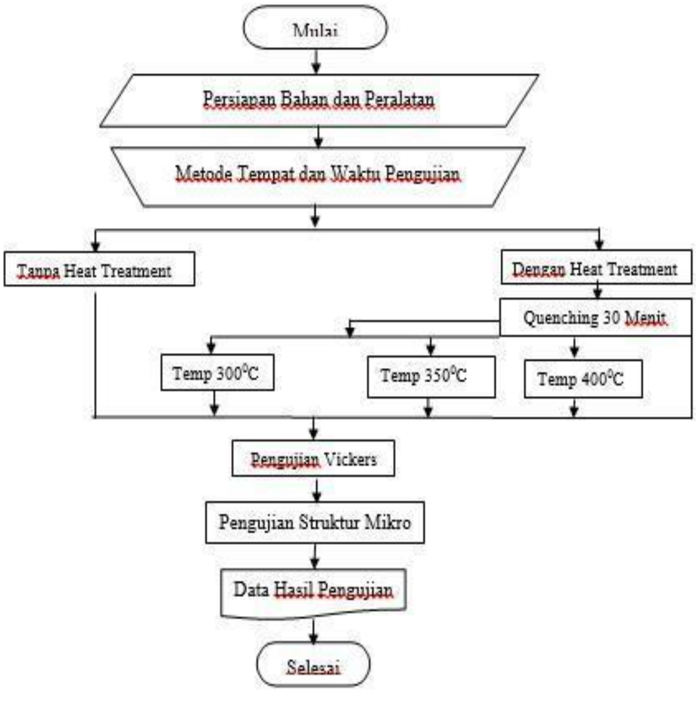
2.3 Upper bainite

At high temperature saturated carbon plates of bainitic ferrite releases carbon into the surrounding austenite by diffusion. This situation causes the bainitic ferrite is free from internal carbide carbon content in austenite increases and creates impetus for the occurrence of precipitation in the area semetit inflath bainite micro structure obtained from the transformation at high temperature shaped like feathers.

2.4 Bainite Down

On tempratur low-carbon diffuses from bainitic ferrite at a slower pace and do not complete these circumstances lead to a precipitation of carbides in the ferrite interflath and interior structure and the transformation of bainite obtained at a low temprature have acicular shape.

3. Flowchart Design Design Methodology



3.1 The research

Study was conducted at the Laboratory of Materials Engineering Degree Program in Mechanical Engineering, Gadjah Mada University (UGM).

3.2 Equipment and Materials

1. Test Equipment Hardness Vickers
2. Tool Open **Electric** (Furnace)
3. Tool **Process Cooling**
4. Polishing Machine
5. Test Equipment microstructure
6. Autosol
7. Pliers Tweezers
8. Cloth Wipe
9. Saws Iron
10. Low Carbon Steel (Mild Steel)
11. Brine ($NaNO_3$ + KNO_3)
12. Sandpaper (100-2000)
13. Resin main material used in this study is, low carbon steel and salt water for quenching.

3.4 Testing Process

Heating Material. In the heating process these materials, carbon steel will be in the oven*(furnace)*or heated with a predetermined temperature. Can be seen as shown below steel heating process.

Figure 1. Heating Process aterials Process *Quenching*

Figure 2. Process Cooling Equipment polishing process

Specimens have been heated and then cooled at *temperature* a predetermined(300, 350, and 400 ° C) using salt water media and held for 30 minutes. Before the samples testedof preparation is done is to take / cut iron finished in quenching with a size of 20x20 mm. after it was printed on a resin and then smoothed with amplas120-2000 using polishing machines.

Figure 3. Polishing Tool Hardness Testing

Figure 4. Tool Hardness Testing Vickers

Figure 5. Process Testing Micro Structure

Testing violence used is testing the hardness vickers, vickers hardness tester serves to determine the material hardness after quenching. Testing microstructure. This test was also conducted on four samples, the first sample did not get the heat treatment of *austempering* sampled both get heat treatment a*ustempering* with a temperature of 300 ° C, then the third sample to 350 ° C and samples of the four 400 ° C with time lasting 30 minutes.

3.5 Results And Discussion

1. Material: Plate Mild Steel 6 x 18 x 30 mm
2. Temperature karburising: 850 ^{0}C.
3. The time from room temperature to 850 ^{0}C: 45 minutes
4. Time hold objects 2: 30 minutes
5. Time hold objects 3: 30 minutes
6. Time hold objects 4: 30 minutes
7. temperature quenching: 300 ^{0}C, 350 ^{0}C, 400 ^{0}C
8. hold quenching time: 30 minutes
9. Media quenching: Salt Water
10. karburising Implementation:July 23,
11. Implementation quenching2017:July 23, 2017

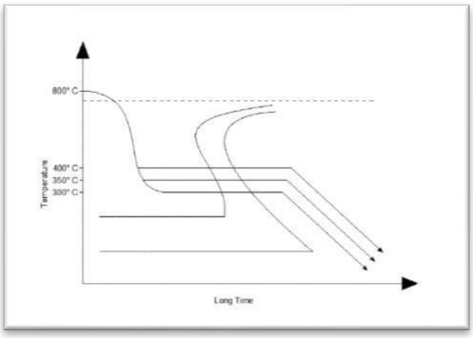


Figure 6. Austempering process diagrams and Quenching

Materials tested consists of four ingredients, austempering process on each test material was done by varying the temperature of austempering.materialfortest. The first tested hardness without getting austempering heat treatment. As for the test material 2, 3 and 4 received the heat treatment temperature variations austempering austempering the second material is 300 ^{0}C, the test material 3 is 350 ^{0}C while the test material to 4 400 ^{0}C. The purpose of execution of austempering process with different austempering temperature variation is to determine the relationship of austempering temperature variations to test material hardness.

3.6 Results Hardness Testing

1. Name Specimen: Steel Austempering, a temperature of 300 ^{0}C, 350 ^{0}C, 400 ^{0}C
2. TypeTesting:Test violence
3. Machine / Tooltest:Controlab
4. Test method: Vickers
5. Date of Testing: July 25, 2017

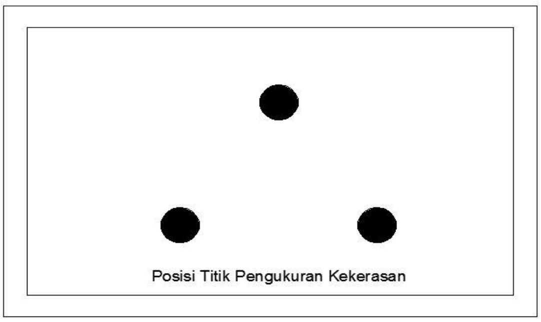


Figure 7. Schematic Point Hardness Testing

Figure 7 is explained where the dots depth hardness testing. Hardness testing is done by cutting the depth of the specimen that has been getting austempering heat treatment. After the former cutting smoothed with sandpaper # 1500. After the former completely smooth cutting new testing from one side as much as 3-point test and every point is 150 microns. With the execution of the test as above, will obtain the depth of the entry of the metal on the surface.

Table 1. Overall Hardness Testing Results

Spesimen Mild Steel

Holding Time* 30 Menit, Variasi Temperatur *Austempering

No	Kode	Posisi titik uji	d_1 (mm)	d_2 (mm)	$d_{rata\text{-}rata}$ (mm)	Kekerasan (VHN)
1	R.M	Acak	0.62	0.62	0.620	144.7
			0.62	0.62	0.620	144.7
			0.62	0.63	0.625	142.4
2	T.300	Acak	0.66	0.66	0.660	127.7
			0.66	0.66	0.660	127.7
			0.66	0.66	0.660	127.7
3	T.350	Acak	0.69	0.68	0.685	118.6
			0.68	0.68	0.680	120.3
			0.68	0.67	0.675	122.1
4	T.400	Acak	0.69	0.69	0.690	116.8
			0.69	0.69	0.690	116.8
			0.69	0.69	0.690	116.8

Keterangan :
1. Menggunakan metode uji Vikers dengan pembebanan 30 kg
2. Satuan pengukuran diagonal jejak indentor dalam mm
3. Pengujian dilakukan pada tanggal 25 Juli 2017

Table 1 shows that thesemaikin higher the temperatureaustemperingnya the hardness decreases. A high hardness is the test specimen to 2 on all points, hardness test specimen to 2 hardness is still larger than the other specimens are worth 127.4 VHN.

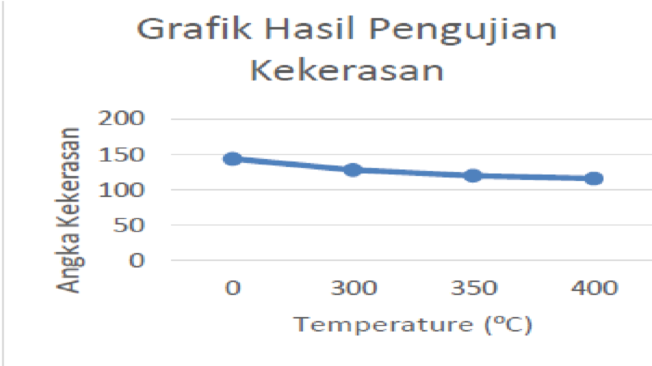


Figure 8. chart Surface Hardness Value Average .

The graph in Figure 4.3 shows the value of the surface hardness of the test specimen. If we look at the graph, austempering heat treatment temperature difference greatly affects the surface hardness of the test specimen. The test object to one or or base materials that do not get austempering heat treatment hardness value only reached 144, while the test object to the 2 already get austempering heat treatment hardness decreased to 127.4 and continues to decline according austemperingnya temperature.

3.7 Testing Results microstructure

Testingmicrostructure is done with the aim of knowing the microstructure of the steel before and after heat treatment of austempering. Pengujianya The results were as follows;

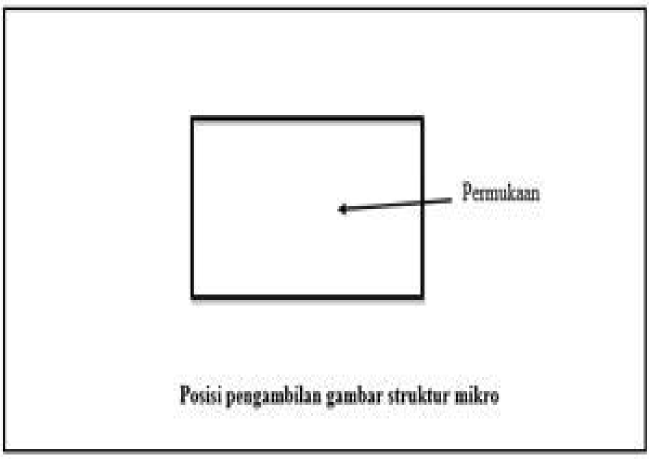
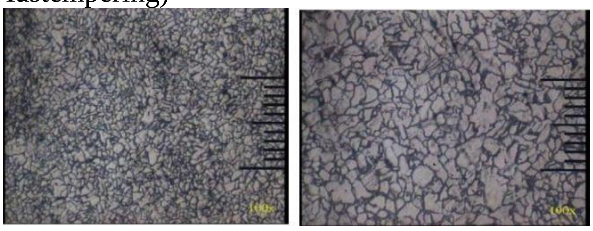


Figure 9. Position Testing Micro Structure

Figure describes shooting position microstructure. The image is taken from one part, that is on the surface. The section dilakuakan two shots with different magnification.

1. Basic Materials (Not Austempering)

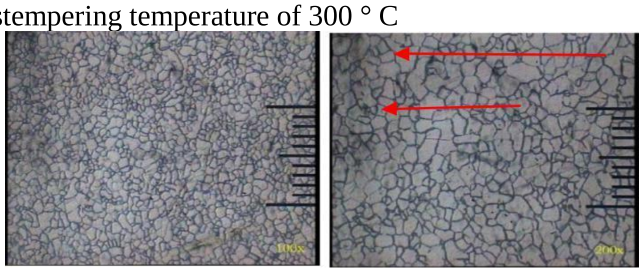


(a) 100x (b) 200x

Micro Mild Steel Structure Image Prior Austempering: (a) Pembesara, 100x; (b) Magnification, 200x

Figure shows the microstructure on the surface of the specimen that does not get austempering heat treatment. Carbon structure on the surface are still visible pearlite dominates the surface.

2. Materials After diaustempering temperature of 300 ° C



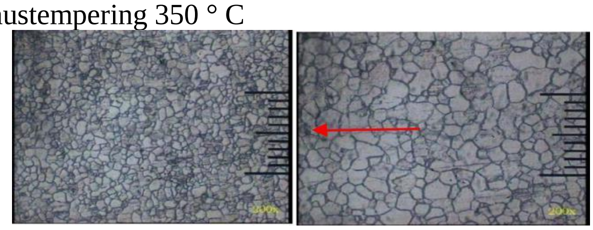
Ferrite
Semetit

(a) 100x (b) 200x

Micro Mild Steel Structure Image Once in Austempering At temperatures of 300 ° C: (a) Pembesara, 100x; (b) Magnification, 200x

Figure shows that the carbon structure on the metal surface of the test specimen are already getting austempering heat treatment at 300 ° C less than the pearlite structure Figure 4.5. From these images show that the diminishing pearlite and ferrite domination.

3. Material After diaustempering 350 ° C

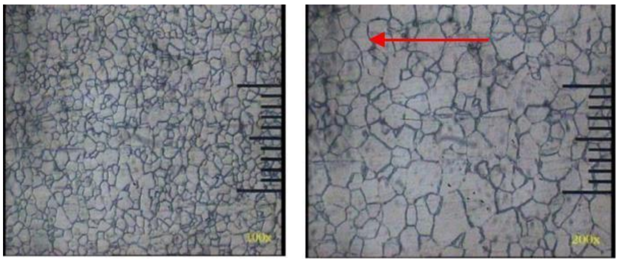


Ferrite
Semetit

(a) 100x (b) 200x

Micro Mild Steel Structure Image Once in Austempering At temperatures of 350 ° C: (a) Pembesara, 100x; (b) Magnification, 200x. Figure shows that the carbon structure on the metal surface of the test specimen are already getting austempering heat treatment at 350 ° C the structure becomes ferrite and semetit. From these images show that pearlite on the surface of the specimen are disappearing.

4. Materials After diaustempering 400 ° C Ferrite



Semetit

(a) 100x (b) 200x

Micro Mild Steel Structure Image Once in Austempering At temperatures of 400 ° C: (a) Magnification, 100x; (b) Magnification, 200x. Figure shows that the carbon structure on the metal surface of the test specimen are already getting austempering heat treatment at a temperature of 4007 ° C the structure becomes ferrite. From these images show that the surface of the ferrite dominating.

4. Conclusion And Recommendations

4.1 Conclusion

The conclusion that can be drawn from the above results are as follows;

1. There was a decrease ofviolence *raw material (Mild Steel)* after dilakuan austempering process.
2. Austempering temperatures affect the material's hardness Mild Steel. The higher temperatures are used austempering, violence tends to be lower.
3. There are differences in the shape of the microstructure of the austempering temperature. The higher the austempering temperature is used, the more subtle forms of micro structure.

4.2 Suggestion

That can be authors give is as follows;

1. Process Austempering should use high-carbon steel that is more resilient materials after austempering process.

2. The transfer of material from the furnace kemediaquenching sebaiknya done as quickly as possible, so as not to formed pearlite during theprocess of austempering.

3. Before the process austempering should the material be tested in advancethe composition of in order to knowcontent of the carbon material.

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