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AC8A Aluminum Quench Modification Using Banana Tree Sap Fluid

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***Abstract*—AC8A aluminum is a silicon aluminum alloy which has a Si level between 11-13% wt, the material commonly used to make pistons. There is also the weakness of a piston with a high silicon content, which is brittle or brittle along with the increase in silicon content so that a rough and large primary silicon morphology is formed. For this reason, it is necessary to modify the aluminum silicon alloy by means of quench modification to get a smooth silicon structure. Banana tree sap fluid has a faster cooling rate than water and oil, tree sap fluid also contains alloying elements from metals such as P, Fe and During the cooling process of the material, it is hoped that the metal alloy elements in the banana tree sap fluid such as phosphorus can be diffused to the surface of the material so that the metal alloy elements function as a modifier that can smooth the rough and large primary silicon structure. The purpose of this research is to refine the rough and large primary silicon structure of the piston material and also to determine the hardness of the material. The method used in this study was direct experimentation, namely carrying out a solution treatment on aluminum AC8A until it was held at a temperature of 490 °C for 1 hour and then quench modification using a ratio of 2 cooling media, namely water and banana tree sap fluid. The material resulting from quench modification was carried out by observing the microstructure and hardness test. After that, the material is continued with the aging process at a temperature of 200 oC with a holding time of 1 hour and then cooled with compressed air for the material that has been aged, microstructure and hardness tests are carried out. From the results of the study it was concluded that the highest material hardness was 62.09 HRB, namely the material with the solution treatment of quenching water and continued the aging process at 200ºC. The solution treatment process with rapid cooling can cause dislocation, so it is necessary to do the aging process.**

Keywords*—*AC8A aluminum, quench modification, banana tree sap fluid

I. INTRODUCTION

Aluminum alloy is a material that is widely used in the industrial and automotive world, AC8A aluminum material is one of the aluminum alloys which is quite widely used for automotive components, one of which is a piston. The piston is the main component in an engine that moves up and down in the cylinder to do the suction, compression, work, and exhaust steps. The main function of the piston is to receive combustion pressure and transmit the combustion pressure through the piston rod (connecting rod) to the crankshaft. Pistons accept high temperatures and pressures for it requires a material that has good durability.

AC8A aluminum is a silicon aluminum alloy which has a Si content of 11-13% wt. The high silicon content in AC8A aluminum or piston material serves as an insulator to prevent aluminum from absorbing excessive heat and also silicon can increase the hardness and wear resistance of the piston. There is also the weakness of a piston with a high silicon content, which is brittle or brittle along with the increase in silicon content so that a rough and large primary silicon morphology is formed [1].

For this reason, it is necessary to modify the aluminum silicon alloy by means of quench modification to get a smooth silicon structure. The refinement of the silicon crystal structure to remove or eliminate the rough and large primary silicon crystal structure can result in brittle properties. Quench modification is a process of material heating and cooling with a fast-cooling rate [2]. The cooling medium used in this research is banana tree sap fluid. Based on the test results, the chemical composition of the banana tree sap contains metal alloy elements such as P, C, Fe [3], and also banana tree sap fluid has a faster cooling rate than water and oil [4]. During the cooling process of the material, it is hoped that the metal alloy elements in the banana tree sap fluid such as phosphorus can be diffused to the surface of the material so that the metal alloy elements function as a modifier that can smooth the rough and large primary siliconstructure [3,5].

II. LITERATURE REVIEW

This study aims to refine the rough and large primary silicon structure of the piston material and also to determine the hardness of the material and the chemical composition of the material through quench modification using banana tree sap fluid.

As for some previous research, which became the first reference, namely the effect of adding a phosphorus modifier on hypereutectic AC8A aluminum on the mechanical properties and microstructure, resulting in the more concentration of adding phosphorus modifier to the material, the higher the hardness value and the smoother the microstructure [1]. The temperature of the solution treatment is 490 ^{o}C and the temperature of the fluid itself must be in the range of 60 ^{o}C, this is because to prevent the material from cracking / breaking during immersion due to significant temperature differences [2]. In the following research, the analysis of the effect of production process technology on the characteristics of the piston material shows that the forged piston occurs deformation which causes strain hardening. Forged pistons have a homogeneous (equi-axed) micro-structure, while cast pistons have a dendrite structure so they have higher strength than cast pistons [6]. In the study of the effect of adding Cu and solution treatment to the mechanical properties and microstructure of aluminum alloy A356 from the results of microstructure observations, the addition of Cu to A356 aluminum alloy changes the shape of the silicon particles, where before the addition of Cu the silicon particles have a sharp tip and after the addition of Cu the shape the silicon particles become more blunt [7]. Furthermore, in the study of the microstructure and mechanical properties of al-si alloys under heat treatment conditions, the results of microstructure observations showed that the eutectic silicon particles were spherical and distributed homogeneously within grain boundaries after T6 heat treatment [8]. The effect of hardening with banana tree sap quenching media on the microstructure and chemical composition of medium carbon steel. The results showed that banana tree sap fluid has the fastest cooling rate compared to water and oil, and cooling using banana tree sap fluid has a smoother microstructure or small and homogeneous throughout the surface of the material compared to water and oil [4].

A. Aluminum

Aluminum is bluish-white, harder than tin, but softer than zinc. Aluminum has a tensile strength of 10 kg / mm, and to improve the mechanical properties of aluminum metal, aluminum is added with alloying elements. Aluminum metal has its own characteristics compared to other metals, including:

- Aluminum gets tough at low temperatures
- High heat propagation speed
- Low melting point
- Has high strength
- Easy to shape
- Good conductor of heat and current
- Glossy surface (3 times more shiny than iron)
- Corrosion resistant (contains an oxide layer)
- Non-toxic

Aluminum alloys have unfavorable properties including the following:

- Due to the specific heat and high thermal conductivity, it is difficult to heat and melt a small portion.
- Aluminum has a low melting point and viscosity, so the area exposed to heating is easy to melt and drip.
- Aluminum alloys are easily oxidized and form aluminum oxides which have a high melting point. Due to this property, fusion between the base metal and the weld metal is prevented.
- Due to the high difference between the solubility of hydrogen in liquid metal and solid metal, a too fast freezing process will form a fine cavity from which pockets of hydrogen are formed.
- Aluminum alloys have a low density and therefore many of the other substances formed during welding will sink. This situation makes it easy to contain unwanted substances into it.

Aluminum Metal Alloy Elements

1) Iron (Fe): The addition of iron to aluminum can reduce the occurrence of heat cracking.

2) Manganese (Mn): Aluminum added with manganese can improve ductility in aluminum metal.

3) Silicon: The addition of silicon elements will affect aluminum resistance to corrosion but difficult to machine.

4) Copper: Elemental copper can affect aluminum metal easily machined.

5) Magnesium: The addition of the element magnesium to aluminum metal will improve the strength properties, but it is difficult in the casting process.

6) Zinc: The addition of zinc will improve the properties of aluminum metal which are resistant to corrosion and reduce the occurrence of heat cracking and shrinkage [9].

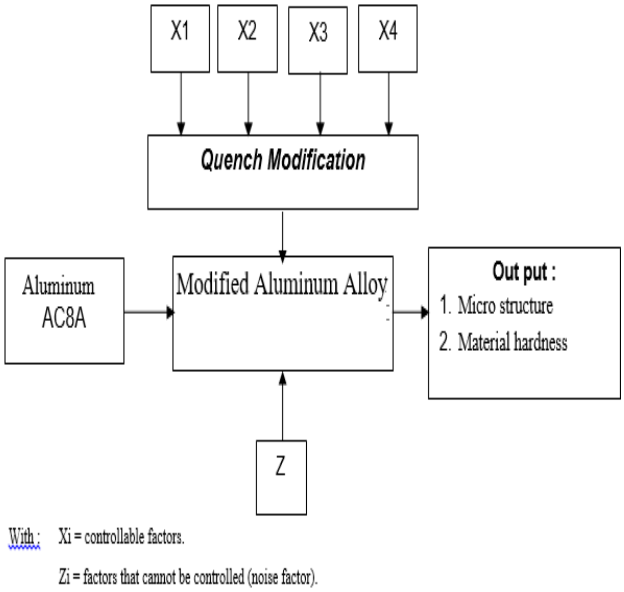

Fig. 1. Research road map.

III. Methods

This study uses a direct experimental method, as for the steps taken:

1. Extracting banana tree sap using the pressing method, fresh banana stems are crushed / shredded with a crusher (grated), then put into a cloth and then squeezed. Performed until approximately 3 liters of banana tree sap fluid collected.
2. Creating a specimen taken from the piston on the market cut by three-dimensional specimen by specimen length of 15 mm, width 15 mm, thickness 6 mm.

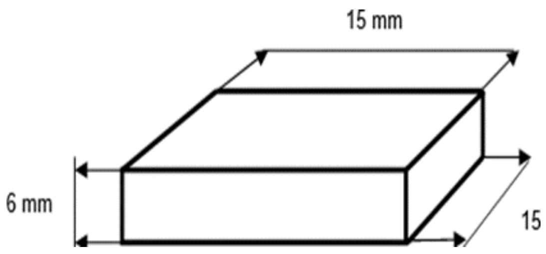

Fig. 2. Test specimens.

3. Prepare all tools and materials.
4. Put 1 specimen into the furnace and carry out the solution treatment process with a heating temperatureof 490 ^{0}c.
5. After heating the specimen to 490 ^{0}c, hold the holding time for 1 hour.
6. Remove the specimen from the furnace quickly, do quenching with banana tree sap fluid media (coolant temperature 60 ^{0}c ± 2).
7. Repeat steps 4-6 for water cooling medium.
8. Conducting microstructure observations using an optical microscope and test the hardness of the specimens: 1 specimen without heat treatment (raw material) and 2 specimens that were quench modification.
9. After completing the microstructure observation and hardness test, the 2 quenched modified specimens were put in the furnance for the aging process at a temperature of 200 °C with a holding time of 1 hour and cooled with compressed air (blower).
10. Conducted microstructure observations using anoptical microscope and tested the hardness of 2 specimens that were aged.

IV. Results and Discussion

A. Hardness Test Result Data

TABLE I. MATERIALS BEFORE HEAT TREATMENT

No	Treatment	Hardness Value (HRB)
1	Before Treatment	62,72
2		58,14
3		63,33
Average Value of Hardness (HRB)		61,40

TABLE II. HEAT TREATMEN 490°C QUENCHING AIR

No	Treatment	Hardness Value (HRB)
1	heat treatment 490°C quenching air	38,02
2		39,91
3		39,86
Average Value of Hardness (HRB)		39,26

TABLE III. HEAT TREATMENT 490 ^{O}C QUENCHING OF BANANA TREE SAP

No	Treatment	Hardness Value (HRB)
1	*heat treatment* 490°C	38,76
2	fluid quenching	39,77
3	banana tree sap	42,23
Average Value of Hardness (HRB)		**40,25**

TABLE IV. HEAT TREATMENT 490 ^{O}C WATER QUENCHING FOLLOWED BY AN AGING PROCESS OF 200 ^{O}C

No	Treatment	Hardness Value (HRB)
1	heat treatment 490oC	62,48
2	water quenching further 200oC	61,82
3	Aging process	61,97
Average Value of Hardness (HRB)		62,09

TABLE V. HEAT TREATMENT 490 °C QUENCHING OF BANANA TREESAP FOLLOWED BY AN AGING PROCESS OF 200 °C

No	Treatment	Hardness Value (HRB)
1	*heat treatment* 490°C	45,28
2	*quenching* banana tree sap fluid	51,75
3	further 200°C Aging process	50,89
Average Value of Hardness (HRB)		**49,31**

During the heat treatment process of AC8A aluminum material at a temperature of 490 °C or this solution treatment process where there is a decrease in the hardness value from before heat treatment, the material hardness value is 61.40 HRB, after solution treatment with water quenching the hardness value drops to 39.26 HRB. The same thing also happened for the solution treatment process with quenching fluid of banana tree sap where the hardness value decreased from before 61.40 HRB to 40.25 HRB. This decrease in hardness value is due to when heating the solution treatment, the metal phase of the aluminum alloy will be in the form of α mixed crystals in a nearly homogeneous solid solution. Due to the high differencebetween the solubility of hydrogen in liquid metal and solid metal, in the process of freezing too fast (quenching) a fine cavity will form, leaving pockets of hydrogen.

In the 200 °C aging process there was an increase in the hardness value for the two material samples that were dissolved by quenching water and banana tree sap fluid. For water quenching, the hardness value was 62.09 HRB, while the quenching of the banana tree sap was 49.31 HRB. The increase in hardness value in the aging process is due to the alloy elements in the solid solution gradually coming out and forming precipitates which can increase the strength of the alloy, the strengthening mechanism occurs through precipitate shearing.

B. Micro Structure Observation Data

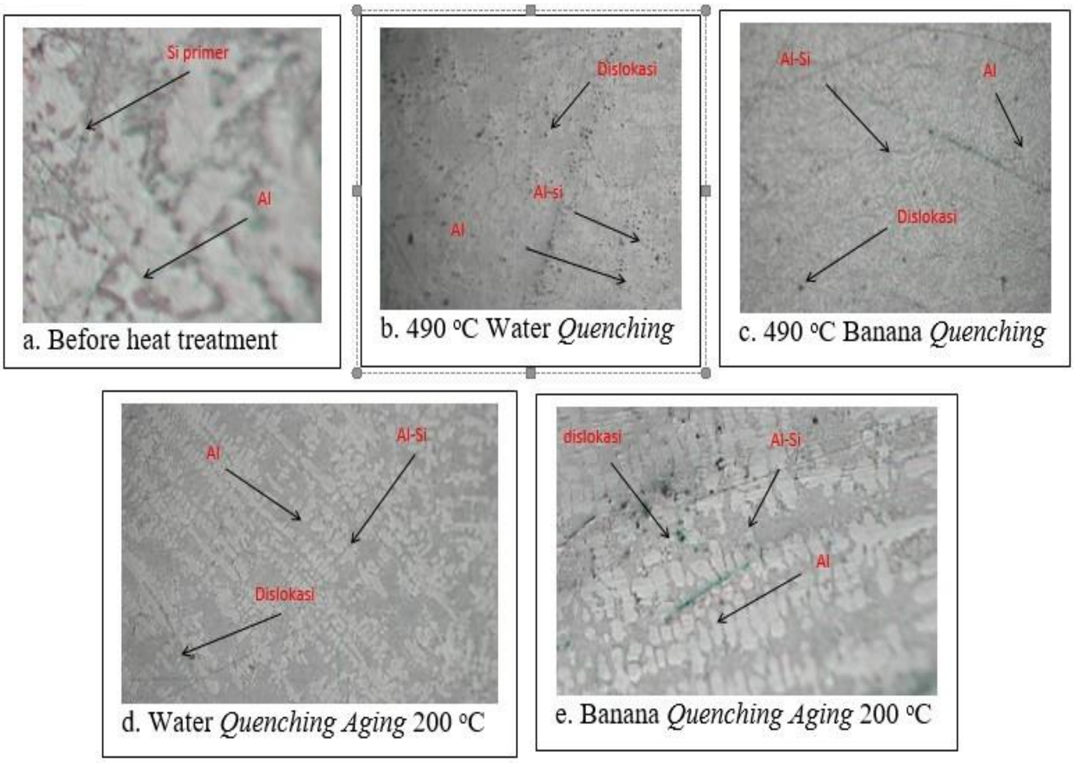

Fig. 3. Micro structure observation data.

Figure 3 a. The microstructure of the material before the solution treatment shows that there is still a large and coarse primary silicon structure and also the element of pure aluminum. In Figures 3 b and 3 c the microstructure of the solution treatment material with quenching water and banana tree sap fluid, it can be seen that the structure dominates pure aluminum with many dislocations due to the very fast cooling process, as well as the Al-si alloy structure. In Figures 3 d and 3 e, the material that has been aged is shown a reduced dislocation and an almost homogeneous structure is formed, namely Al-si and pure aluminum.

V. CONCLUSION

Based on the results of this study, the following conclusions can be drawn:

1. The highest material hardness was 62.09 HRB, namely material d with the water quenching solution treatment and continue the aging process 200 ^{o}C.
2. The solution treatment process with rapid cooling can cause dislocation, so it is necessary to do the aging process.

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REFERENCES

[1] M. Indriyati, Pengaruh Penambahan Modifier Fosfor terhadap Struktur Mikro dan sifat Mekanis Paduan Aluminium AC8A Hipereutektik. 2008.

[2] N. S. Wibowo and Nurato, “Analisis Pengaruh Ketidakstabilan Temperatur Terhadap Hasil Kekerasan Material dari Proses Heat Treatment Piston,” J. Tek. Mesin, vol. 07, no. 3, pp. 138–148, 2018.

[3] R. J. Dimu, D. Widhiyanuriyawan, and S. Sugiono, “Optimization of Medium Carbon Steel Hardening With Banana Tree Fluid Using the Taguchi Method,” Rekayasa Mesin, vol. 5, no. 2, p. pp.135-140, 2014.

[4] R. J. Pangalinan, Antonius and Dimu, “Pengaruh Hardening Dengan Media Quenching Fluida Getah Pohon Pisang Terhadap Sruktur Mikro Dan Komposisi Kimia Baja Karbon Sedang,” Rekayasa Mesin, vol. 10, no. 2, pp. 131–138, 2019.

[5] D. D. Ibrahim Goksel Hizli, Rasit Sezer, Özen Gürsoy, Selim Ertürk, Cüneyt Arslan, “Production of Modifier for Al-Si Alloys,” in International Symposium on Light Alloys and Composite Materials, 2018, no. March, pp. 54–56.

[6] I. Setyadi, “Analisis Pengaruh Teknologi Proses Produksi Terhadap Karakteristik Material Piston,” J. Sains Mater. Indones., vol. 14, no. 1, pp. 62–66, 2012.

[7] S. Syahputra, “Pengaruh Penambahan Cu Dan Solution Treatment Terhadap Sifat Mekanis Dan Struktur Mikro Pada Aluminium Paduan A356,” J. Din., vol. 2, no. 14, pp. 39–45, 2014.

[8] S. Das Raj Kumar Singh, Amit Telang, “Microstructure and Mechanical Properties of Al-Si Alloy in As-cast and Heat Treated Condition,” Am. J. Eng. Res., vol. 5, no. 8, pp. 133–137, 2016.

[9] S. Moh. Indra P, Mahros Darsin, “Sifat Mekanik Dan Struktur Mikro Aluminium Aa1100 Hasil Pengelasan Friction Stir Welding Dengan Variasi Feed Rate,” Tekno, vol. 16, pp. 15–22, 2011.