Vol. 5 No. 1 page 38-42
DOI : 10.14456/randk.2019.8

*RESEARCH & KNOWLEDGE*

**Research Article**

# Effect of T6 heat treatment on Mechanical Properties of Aluminium Alloy; ADC10

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**Abstract:** This research aims to study of effect T6 heat treatment on microstructure and mechanical property of aluminum alloy; ADC 10 and using master alloy as 5Ti-1B. Master alloys were added as 0, 0.02, 0.04, 0.06 and 0.08 %wt. Aluminum alloy was melted at 750 ± 10 ºC by induction furnace and then pouring molten metal into a permanent mold where the temperature is 240 ± 10 ºC. And then, solution treatment at 548 ºC for 1 hr; quenching in water. Aging temperature at 204 ºC for 1 hr.

The results showed that adding 5Ti-1B as 0.08% after T6 process with the highest hardness and tensile strength were 41.13 HRB and 254.79 MPa, respectively. Impact energy was 3.1 J. The microstructure results showed that the refinement by adding 5Ti-1B 0.02-0.80%wt affect the grain size. Moreover, the addition of 5Ti-1B 0.08 %wt results in fine grain and uniform distribution. XRD results confirmed the formation of $Al_2Cu$ from precipitation in aging process have indicated the presence of $Al_2Cu$ peaks distribution in matrix. As a result, aluminum alloy; ADC 10 has higher mechanical properties.

**Keywords:** ADC 10; T6 heat treatment; precipitation; mechanical properties

## 1. Introduction

Aluminum-silicon alloys are popular for the foundry industry in Thailand and around the world because of good casting properties and resistance to corrosion. Not easily cracked if mixed with other metals such as magnesium, copper and etc., which can be used to improve mechanical properties by thermal processes as well.

ADC10 is hypoeutectic aluminium alloy. The microstructure consists of Al-rich phase as matrix and eutectic structure which consists of Al-rich phase and Si-rich phase. The shape of eutectic structure was rods and uneven distribution. This results in poor mechanical properties. So, there is one method for improving mechanical properties for aluminium alloys was modification. Modification is the addition of alloying element in molten metal with degassing. Then, the alloying elements are combined with oxygen to form metal oxides which will hinder growth of Si-rich phase. This result is fine Si-rich phase, uniform distribution and good mechanical properties (Sahin, 2005; Sahin, 2003).

ADC10 aluminum alloy are a popular aluminum-silicon group for the foundry industry because this aluminum group has a large amount of silicon mixed which helps in the fluidity in casting. The ADC10 alloy also has a copper content of 2.0-4.0%wt, which can be developed to increase strength by thermal processing in precipitation hardening or age hardening. In age hardening step, the hardness increases due to lattice distortion caused by the coherency precipitation of CuAl2 which is small and widely distributed in matrix resulted in both hardness and strength increasing.

Therefore, this research aims to study the mechanical properties of ADC10 alloy by grain refinement process from Al-5Ti-1B master alloy and T6 thermal process.

## 2. Experimental procedure

### 2.1 Casting process

2.1.1Calculate chemical composition and raw materials for melting.

2.1.2 Melting at 720 ºC with induction furnace and then the mold were heated at 240±10 ºC in heat treatment furnace. as shown in Fig. 1.

2.1.3 Clean the molten metal using Flux KK 436 and sweep the slag out.

2.1.4 Check chemical composition with a spectrometer.

2.1.5 Reducing the amount of gas in molten metal using argon gas.

2.1.6 Check chemical composition again and when getting the desired chemical composition, Pouring molten metal into mold according to JIS Z 2245: 2016 No. 4 as shown in Fig. 2.

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**Fig.1** melting at 720 °C with induction furnace.

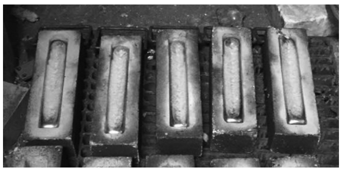


**Fig.2** mold according to JIS Z 2245: 2016 No. 4.

**2.2 T6 process**

2.2.1 Prepare the samples for annealing. Clean the samples and check the heat treatment furnace as shown in Fig.3 a).

2.2.2 Solution heat treatment step; set the heat treatment furnace temperature at 548 °C for 1 hour.

2.2.3 Remove the samples from the heat treatment furnace to quench and cool in air as shown in Fig.3 b-c) and Fig.4.

a) b) c)

**Fig.3** T6 thermal process.

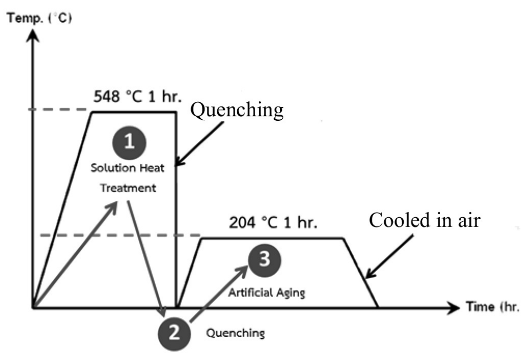



**Fig. 4** T6 heat treatment process.

**2.3 Microstructure examination**

2.3.1 Cut the sample to the size of 1.5 x 1.5 cm.

2.3.2 Polishing the samples without scratches. Polished with SiC paper no. 180, 320, 600, 800, 1000, 1200 and 1500 respectively.

2.3.3 Wash the samples with water before polishing with alumina powder size 0.02 micron. Then wash with water; wipe with alcohol and blow dry immediately.

2.3.4 The samples were etched by etchant (distilled water 75% + HCl 10% + $NHO_3$ 10% + HF 5%).

2.3.5 Bring the samples to analyze microstructure with optical microscope.

**2.4 Mechanical properties test**

**2.4.1 Hardness test**

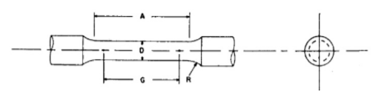
2.4.1.1 Prepare samples by polishing with SiC paper no. 180, 320, 600 and 800 respectively, by polishing the samples on both sides to make smooth surface.

2.4.1.2 Hardness measurement using Rockwell hardness scale B using 1/16-in. (1.588-mm) steel ball, 100 kfg load.

**2.4.2 Tensile test**

2.4.2.1 Prepare specimen for tensile test according to ASTM E8M as shown in Fig.5.

2.4.2.2 Bring specimen to the test machine using universal testing machine(Hounsfield model H 10 KM) with the tension speed of 1 mm/s. .



| Standard Specimen Dimensions, mm [in.] | |
|---|---|
| G—Gage length | 62.5 ± 0.1 |
| D—Diameter | 12.5 ± 0.2 |
| R—Radius of fillet, min | 10 [0.375] |
| A—Length of reduced section, min | 75 [3.0] |

**Fig.5** Dimension of the specimen according to ASTM E8M.

**2.4.3 Impact test**

2.4.3.1 Prepare samples for impact testing according to ASTM E23 as shown in Fig.6.

2.4.3.2 Impact testing with charpy test.

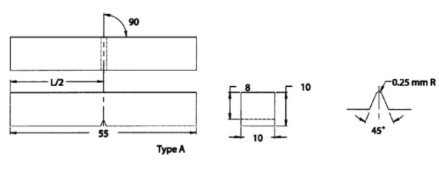


**Fig. 6** Dimension of the specimen according to ASTM E23.

**3. Results and discussion**

**3.1 Chemical composition results**

From the melting of ADC10 and adding master alloys Al-5Ti-1B, the amount of 0.00, 0.02, 0.04, 0.06 and 0.08%wt. when the samples were analyzed to chemical composition get results as shown in Table. 1.

**Table.1** chemical analysis results with a spectrometer.

| Al-5Ti-1B (% wt of molten metal) | Element, %wt. | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Cu** | **Si** | **Mg** | **Fe** | **Mn** | **Ti** | **B** |
| 0.00 | 3.08391 | 8.08451 | 0.15051 | 0.84589 | 0.20971 | 0.01503 | 0.00049 |
| 0.02 | 3.07203 | 8.10501 | 0.14595 | 0.84346 | 0.20906 | 0.01619 | 0.00070 |
| 0.04 | 3.25623 | 8.12146 | 0.13984 | 0.91830 | 0.19165 | 0.01780 | 0.00100 |
| 0.06 | 3.26516 | 8.13414 | 0.13814 | 0.92366 | 0.19239 | 0.01962 | 0.00134 |
| 0.08 | 3.26068 | 8.18558 | 0.13471 | 0.92381 | 0.19166 | 0.02181 | 0.00166 |

### 3.2 Microstructure results

Based on the microstructure examination of the aluminum alloy according to JIS standard, ADC10 grade that has been fine-grained by mixing the Al-5Ti-1B mother metal at the amount of 0.00, 0.02, 0.04, 0.06 and 0.08% wt. of molten metal. It found that the samples after passing T6 process results in $Al_2Cu$ (β phase) being degraded into matrix as α phase. While the copper is in the form of a solid solution, when the samples were rapidly cooled, microstructure at room temperature was solid solution beyond super saturated solid solution. When samples were heated again, Al2Cu phase will occur in α phase. The newly formed $Al_2Cu$ phase sediment will strong bond with α phase.

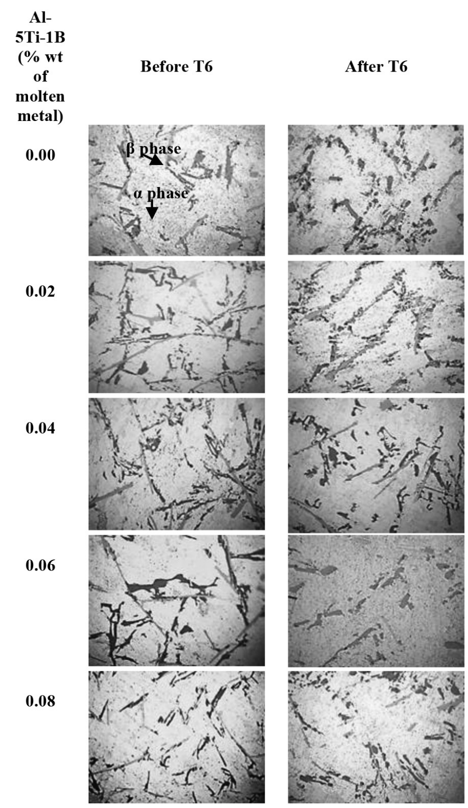



**Fig. 7** Microstructure examination results by optical microscope.

### 3.3 Mechanical properties results

Fig. 8 Show mechanical properties of ADC10, The specimen was fine grained by mixing Al-5Ti-1B master alloy at the amount of 0.00, 0.02, 0.04, 0.06 and 0.08% wt. of molten metal. Mechanical properties of the samples after T6 thermal process showed that ADC10-T6 thermal process has a hardness of 35.98, 36.54, 37.11, 39.95 and 41.13 HRB, respectively. It can be seen that at 0.08%wt., the highest hardness is 41.13 HRB.

The result of the tensile test of ADC10 that has been fine grained by mixing the Al-5Ti-1B master alloy at the amount of 0.00, 002, 0.04, 0.06 and 0.08% wt. of molten metal after T6 thermal process showed tensile strength equal to 214.97, 230.47, 237.48, 236.42 and 254.79 MPa respectively, yield strength were 116.67, 165.67, 185.67, 172.33 and 187.00 MPa respectively, and elongation were 2.08, 1.49, 1.23, 0.96 and 0.69%, respectively. It can be seen that 0.08%% wt., the highest strength of 254.79 MPa, the yield strength of 187.00 MPa and the elongation of 0.69%. But the impact strength is slightly different.

Therefore, the mechanical properties of the samples after T6 thermal process with higher mechanical properties resulting from a very small $Al_2Cu$ as coherency precipitation and distributed in matrix.

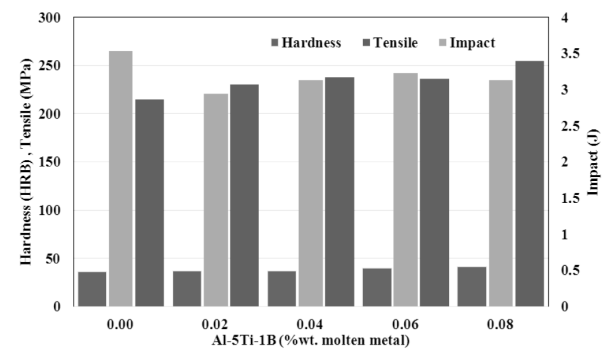



**Fig. 8** Comparison of mechanical properties of ADC10 alloy through T6 thermal process.

## 4. Conclusion

1. The addition of Al-5Ti-1B master alloy results in significant improvement in grain size, grain size decrease with increasing Al-5Ti-1B master alloy content.

2. T6 thermal processes provide the highest yield strength and ultimate tensile strength are obtained with Al-5Ti-1B master alloy of 0.08% wt. of molten metal. But the impact strength is slightly different.

## 5. Acknowledgement

The authors gratefully acknowledge the support from Faculty of Engineering, rajamangala University of technology Isan, KhonKaen Campus for The financial supported. The authors would like to thank Institute of Research and Development Rajamangala University of Technology Isan for instrument

And finally, thank you to students; Miss. Kamonwan Kraion, Miss. Sumalai Dapee and Mr. Wayu Prakhothanang that helped this research.

**6. References**

John E. Gruzleski and Bernard M. Closses, 1990. The Treatment of Liquid Aluminum-Silicon Alloys, USA

LimCYH,LimSC,GuptaM.Wear behavior of SiCp-reinforced magnesium matrix composites.Wear 2003;255:629-37.

Sahin Y. Optimization of testing parameters on the wear behaviour of metal matrix composites based on the Taguchi method. Mater Sci Eng 2005; A408:1–8.

Sahin Y. Wear behaviour of aluminium alloy and its composites reinforced by SiC particles using statistical analysis. Mater Des 2003;24:95-103.