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Compared Production Behavior of Borax and Unborax Premixed SiC Reinforcement Al7Si-Mg-TiB Alloys Composites with Semi-Solid Stir Casting Method

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Abstract. The present study was aimed to investigate the effect of borax additive on physical and mechanical properties of Al7Si-Mg-TiB with the reinforcement of silicon carbide. In this case, the different weight percentage from the reinforcement of SiC (10, 15, and 20% wt), and the borax additive (ratio 1:4) were homogenously added into the matrix by employing the semi-solid stir casting method at the temperature of 590°C. Al7Si-Mg-TiB melted in an electric resistance furnace at 800°C for 25 minutes and the holding time of 5 minutes; SiC was stirred with borax inside the chamber and heated at the temperature of 250°C for 25 minutes. Then, it melted by lowing the temperature into 590°C. The SiC-borax mixture was added into the electric resistance furnace, and automatically stirred by the stirrer at a constant speed (500 rpm for 3 minutes) in the composite A17Si-Mg-TiB. It melted when heated at 750°C for 17minutes,then, casting was performed on the prepared mould. The characterizations of Al7Si-Mg-TiB-SiC/borax were porosity, hardness, and microstructure on the Al7Si-Mg-TiB-SiC/ borax. The porosity of AMC tended to increase along with the increaseof the wt% SiC (1.4%-3.6%); however, borax additive underwent a decrease in porosity (0.14%-1.3%). Further, hardness tended to improve along with the increase of wt% SiC. The unboraxmixture had 79,6 HRB up to 94 HRB. Whereas, the borax additive mixture had 105,8 HRB up to 121 HRB.

INTRODUCTION

AMC is made by mixing particlesreinforcement in a molten alloy. The composites tend to be stronger, more rigid, harder, and durable better than pure aluminum or alloys. In general, aluminum may decrease the electrical and thermal conductivity, and the coefficient of thermal expansion in which the silicon carbide may enhance the thermal conductivity as well as decreasing the electrical conductivity and the thermal expansivity [1-2].

Another study employed an alternative stirring process, and indicated the level of porosity could be between the range of 2-4% in which it was called as an acceptable level of the porosity in the cast composite. In this case, the use of borax additive in the combination of two-step stirring was to improve the wettability without pre-heating the SiC particulates and decrease level of porosity until 1,6% [3-6].

In the semi-solid stir casting process, particles reinforcement were added into a semi-solid alloy and stirring, then,it was poured into the mould for solidification. The mechanical properties of the SiCp/Al composite was strongly related to the particledistribution as well as the interfacial bond strength between particles and matrix. This could be achieved by optimizing stirring parameters [7-12].

The other case, the volume percentage of SiC reinforcement in the Al composite produced, the theoretical and experimental densities tended to be very close as reflected by the maximum of 1.6 % porosity obtained. Moreover, they observed that the porosity in the monolithic cast alloy without stirring have higher level of porosity in comparison with the composites produced with the two-step stirring and used the Borax [3].

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In the present study, we were to investigate the effects of borax and unborax premixed SiC composite through a semi-solid stir casting method, focusing on the physical andmechanical properties of the Al7Si-Mg-TiB-SiC alloy composite. Further, we compared the microstructure, porosity, and hardness of the stir casting of the composite.

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MATERIAL AND METHOD

Materials

The base material to investigate was aluminum alloy (A356). Silicon carbide (carborandum) with particleswhich size was 400 mess was used as the reinforcement, along with borax (ratio 1:4 of SiC), TiB and Mg, to improve the wettability of molten aluminum (A356) and SiC particles during the melting process. In this research used 10, 15 and 20 wt% of SiC reinforcement to produced composite.

TABLE 1. Composition of A356

Si	Mg	Ti	Al	Others
6,71 - 7,54	0,005	0,125 – 0,150	92,922	0,617

METHOD

Al7Si-Mg-TiB melted in the electrical resistance furnace (fig 1.a) at 800°C for 25 minute and holding time for 5 minute.In this case, SiC was manually stirred with borax in the chamber and heated in an oven at the temperature 250°C for 25 minute. When it melted, the temperature was lowered into 590°C. The SiC-borax mixture was added into the electrical resistance furnace and automatically stirredat constant speed (500rpm for 3 minute) in the Al7Si-Mg-TiB alloy. Then, it meltedwhen it was heated at 750°C for 17minute. Whereas, the mould was heated at 250°C for 17 minute. Casting was then performed on prepared mould.

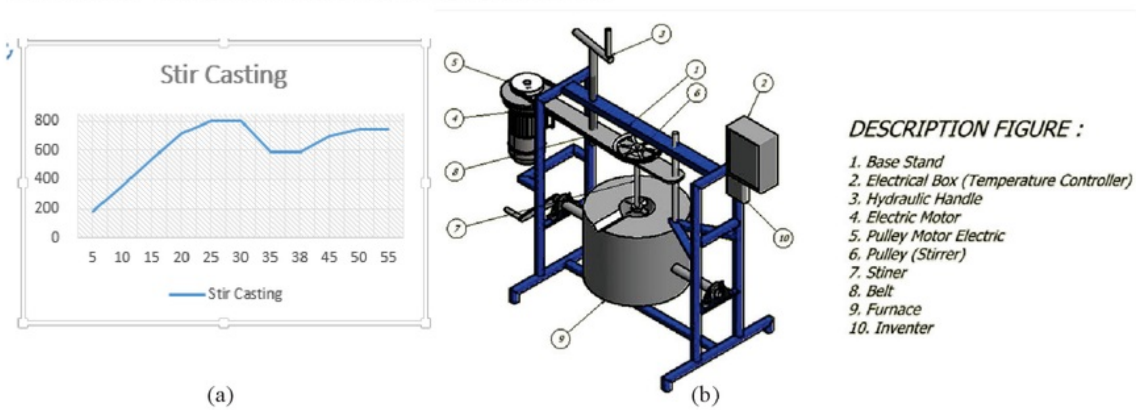


FIGURE 1. (a) Semi-solid stir casting process and (b) Electrical Resistance Furnace.

EXPERIMETAL

Density Measurement

The density measurements were carried out to determine the porosity level of samples. It was achieved by comparing the experimental and theoretical densities of eachpercentage volume in which SiC was reinforced with composite.

Hardness Measurement

Hardness test was performed using Rockwell Hardness Tester (HR-150A). A direct load of 100kgf was applied on flat smooth specimenthat were polished from the composite for 45 seconds. The hardness reading evaluated by following standard procedures.

Microstructure Investigation

The microstructure investigation was conducted by employing OPTILAB Software-Driven Metallurgical Microscope. The specimens for the optical microscope was polished by using a series of emery papers of grit sizes ranging from 800µm-2,500µm. The specimens were etched with 1ml HF, 2,5ml HNO3, 1,5ml HCl solution by swabbing for 9 second, followed by rinsing them on hot water and drying before observation in the optical microscope was conducted

RESULTS AND DISCUSSION

Porosity Investigation

In the present study, the SiC-Borax mixture tended to have a low levelporosity (0,14%, 1,3% and 0,26%) in comparison with the unborax mixture that tended to havea high porosity level within the range of 1,4 up to 3,6% porosity. The percentage of porosity may affect the composite quality.

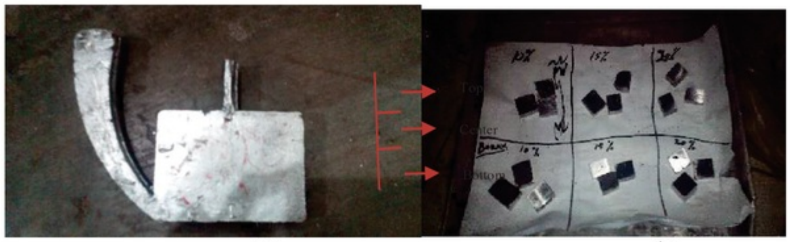
TABLE 2. Percent Porosity

Material	Density (g/cc)	Reinforcement (wt%)			
		0	10	15	20
Unborax	Theorical Density	2.66	2.69	2.74	2.77
	Experimental Density	2.64	2.65	2.64	2.68
	Percent Porsity	0.7	1.4	3.6	3.2
Borax	Theorical Density	2.66	2.684	2.696	2.707
	Experimental Density	2.64	2.68	2.66	2.7
	Percent Porsity	0.7	0.14	1.3	0.26

The previous studies which indicated that porosity within the range of 2 % and 4 % tended to be acceptable in the cast metal matrix composites. The use of borax additive in the combination with the two-step stirring to aim improve the wettability SiC particulates on interfacial Al matrix [4, 13]. It was observed that the porosity in the monolithic alloy cast without stirring havehigher levelporosity compared to the composites produced by the two-step stirring and addition the Borax [3].The adoption of the two-step stirring and the addition of borax tended to be decreased the porosity levels and the minimal defectscasting in the composites produced [3,6].

Hardness Investigation

The hardness value was evaluated on composite interfacial. The specimen used in the hardness test was the top,center, and under parts of the specimen. The specimen wascut into the size of 2cmx2cmx2cm size (fig. 2).



(a) (b)

FIGURE 2. (a), Base specimen casting (b), Specimen of hardness investigated

FIGURE 3. ComparedHardness level of SiC and SiC-borax mixture

As shown in Fig. 3, weindicated thatthe increase of wt% of SiC may affect the composite hardness properties. Al7Si-Mg-TiB had hardness value 68,2HRB. The use of SiC on the composite tended to increase the hardness properties. The 20 wt% SiC had a highhardness properties. Then, the hardness properties on unborax and borax mixtureshad been compared, the unborax mixture had hardness value 97HRB compared with the borax mixture that had 121 HRB. The hardness may increase along with the increase of SiC content [14, 17].The composite which use borax may affect the hardness properties in which as indicated in fig. 3, we discovered that borax composites tended to havea highhardness value compared to the unborax composites.

Microstructure and SEM Investigation

Microstructure indicatedthe composite quality and the effectiveness of the stir casting method. In particular, the present study was aimed to investigate the distribution of SiC on the interfacial Al-Matrix.

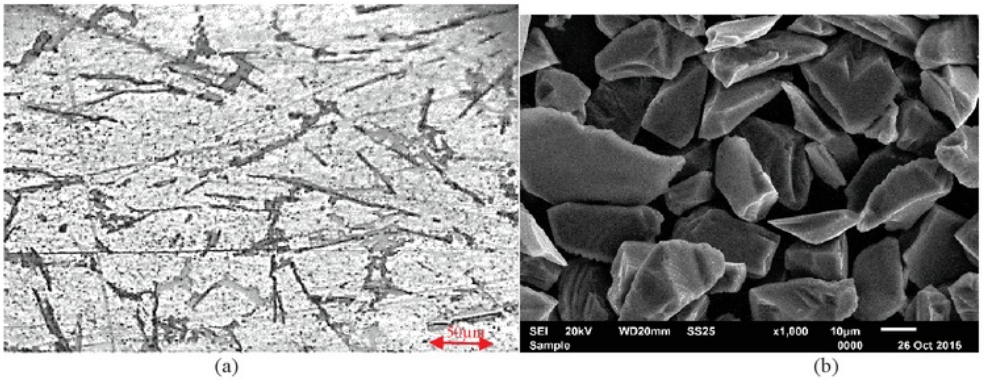


FIGURE 4. (a) Microstructure on Al7Si-Mg-TiB, (b) SEM morphology of SiC

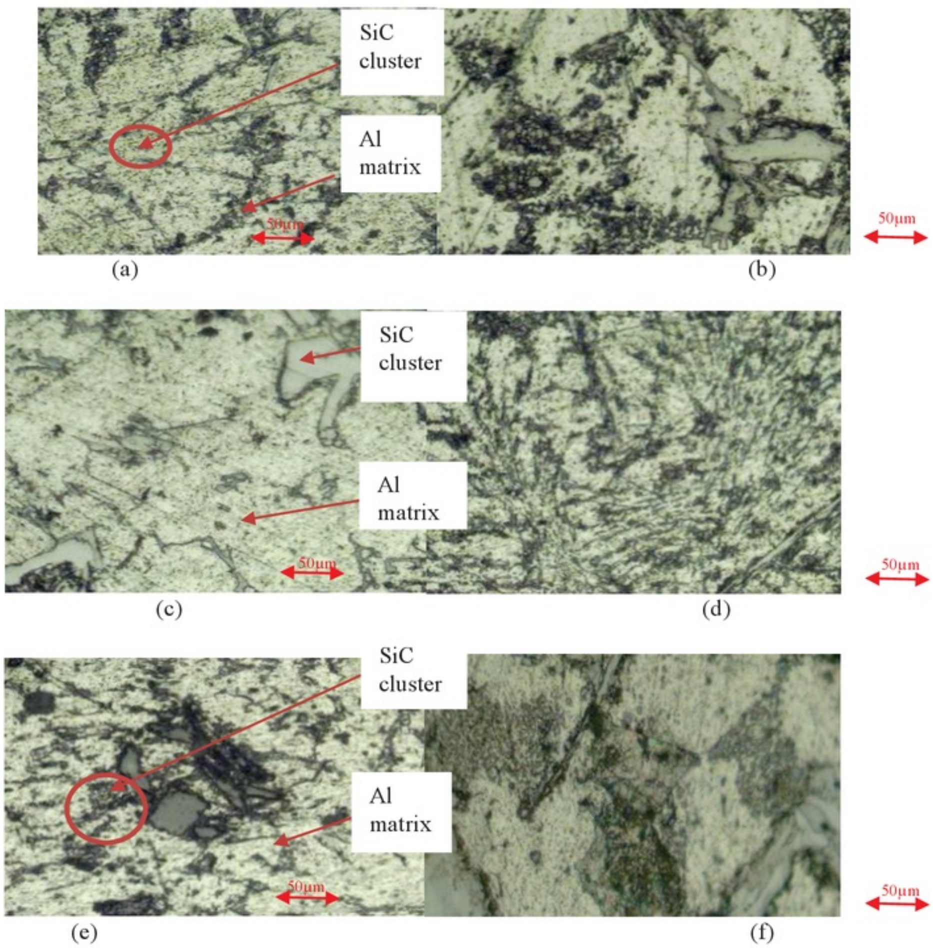
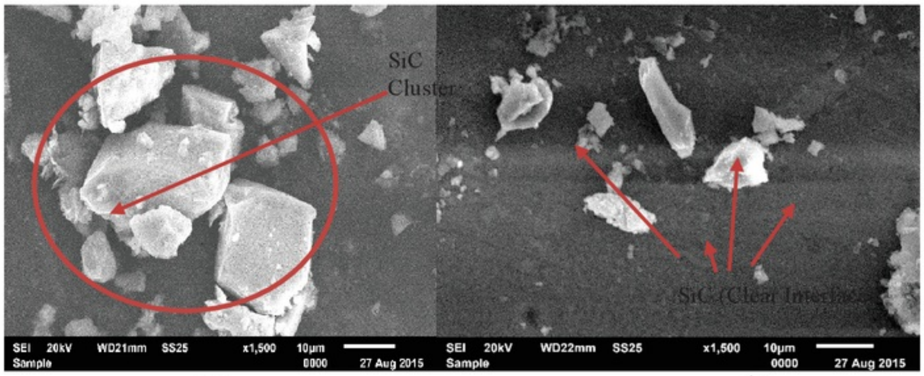


FIGURE 5. Microstructure on AMC, (a) Al7Si-Mg-TiB-SiC with variation 10%wt SiC, (b) Al7Si-Mg-TiB-SiC-Borax with variation 10%wt SiC, (c) Al7Si-Mg-TiB-SiC with variation 10%wt SiC, (d) Al7Si-Mg-TiB-SiC-Borax with variation 15%wt SiC, (e) Al7Si-Mg-TiB-SiC with variation 20%wt SiC, (f) Al7Si-Mg-TiB-SiC-Borax with variation 20%wt SiC



(a) (b)

FIGURE 6. SEM on AMC, (a) Al7Si-Mg-TiB-SiC with variation 20wt% SiC, (b) Al7Si-Mg-TiB-SiC-Borax with 20 wt% SiC

The SiC particles were added in the melt during the casting process; then, it caused gas trapped in the liquid among the particles. Consequently, it increase the wt % of SiC particles produce the gas trapped in which it may result in the higher porosity [15]. Agglomeration the SiC tended to improvedin a lower speed and time[5]. The first stirring of borax / SiC particles then heated and the molten Al slurry were performed in the semi-solid state to prevent the relatively denser SiC particles from floating on the surface of the melt due to the high surface tension and the poor wetting between the particles and the melt [3,6]. A uniform dispersion product of SiC particles in the microstructure of Al based-matrix-composites had been used as a composite quality-level measurement [16]. We indicated that the distribution of the SiC with the borax particulates in the Al matrix tended to be fairly uniform with minimal particle agglomerations. Further, based on the previous result we may indicate that the technique utilized for the composite production seemed to be efficient [3]. Figure 5 indicated the non-homogeneity and agglomerations on the interfacialof Al7Si-Mg-TiB-SiC; in this point, Borax may affect the uniform distribution of SiC-borax.The increase of the temperature tended to create a strong bond of SiC-Borax mixture. Besides, SEM as shown in Fig. 6investigated the non-homogeneous SiC on the Al-matrix interface and the difficult distribution of SiC through the semi-solid stir casting method. The Al7Si-Mg-TiB-SiC composite (fig. 6a) showedagglomerationson the interface materials; nevertheless, the use of borax tended to reduce agglomerations on the composite interface. The minimal agglomerations on Al7Si-Mg-TiB-Borax-SiC appeared to decrease the porosity level (Table 2). Consequently, the uniformityof Al7Si-Mg-TiB-SiC -Borax may improve the hardness value.

CONCLUSION

In the present study, the effect of SiC on the microstructure and mechanical properties indicated that:

a. Porosity tended to increase along with the increase of wt% of SiC; nevertheless, borax could reduce the porosity on the composite.
b. The hardness value tended to increase along withthe increase of wt% of SiC in which the 20 % of the wt% of SiC appeared to have a high hardness value. The composite which used borax tended to havea high hardness compared to SiC with the unborax mixture.
c. In particular, borax tended to reducethe particle clustering on the composite interface; nonetheless, increasethe wt. % of SiC particles in which it may increase the trapped gas in higher amount of porosity.

In this study successfully to made homogenization on composite interface, homogenization on composite tended to decrease porosity level and increase hardness level. The futheremore study, my suggestion is increase on speed and time of stirring process to better distribution SiC particulate on Al-Matrix. The other suggestion was increase borax ratio to homogenization SiC particulate on Al-Matrix.

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