SANMAN S
PRASHANTH K P
ANIL K C
VENKATESHA B K
GOPAL KRISHNA U B
and
YUVARAJ L

# Effect of percentage of reinforcement particulates on the corrosion behaviour of aluminium boron carbide composites

*Aluminum based composites are generally used to build marine structures and liquid cargo containers because of its high strength and low weight. In the present investigation, the corrosion behaviour of $B_4C$ particle reinforced Al-6061 alloy has been studied. The aluminum-boron carbide composite were prepared using stir casting method by varying percentage of reinforcement from 6 to 12% in steps of 2%. Salt spray method was adopted to investigate the corrosion behaviour of the composite. The test was conducted for a period of 240 hours and for every 48 hours the weight loss of the specimens was measured. The extent of corrosion was measured by using weight loss method. The results showed that the corrosion resistance of the composite decreases with the increase in the percentage of boron carbide particulates. The optical microscope was used to analyze the corroded surfaces and corrosion mechanism. The pit initiation side tends to the possibility of the accuracy corrosion on the interface between the hard reinforced particles and matrix alloy.*

***Keywords:*** Corrosive, stir casting, aluminum alloy, boron carbide, metal matrix composites.

## 1.0 Introduction

The new generation of MMCs like aluminum composite has the latent energy of satisfying the demands of advanced engineering applications. This can be achieved by reducing the cost of the aluminum composites and also by applying improved mechanical properties [1-2]. Due to the development limits of conventional metals and alloys, the advanced metal matrix composites are getting popular. The properties of the MMCs can be improved by proper processing of reinforcement [3-6]. Muna et al studied the corrosion resistance of aluminum alloy 6061/SiC composites in 3.5% NaCl solution. The composite was prepared by stir casting using vortex technique by varying the percentage of reinforcement by 10% and 20% of reinforcement. Potentio statically polarization measurement was used to study the corrosion behaviour of the aluminum alloy. The results revealed that the corrosion rate tends to increase by the addition of the SiC particles [7]. Kenneth Kanayo Alaneme et al studied the corrosion and wear behaviour of Al-Mg-Si alloy matrix hybrid composites with the use of rice husk and SiC as reinforcement. The results revealed that the effect of weight ratio of SiC/RHA on the corrosion behaviour of the composites in NaCl solution was not consistent. It is also revealed that there is improvement in corrosion resistance of the composite in 3.5% NaCl solution by using reinforcement of RHA and SiC [8]. H C Anand Murthy et al has done the investigation on the corrosion behaviour of Al-6061-tin composite. It is revealed that there is an increase in the corrosion resistance in the composite compared to the matrix alloy. Further study revealed that the resistance of polarization increases with the increase in tin content [9]. H.M Zakari gives the brief concept of micro structural and corrosion behaviour of Al/SiC metal matrix composites. The results reveal that the Al/SiC composite has more corrosion resistance than pure Al at ambient temperature. The corrosion resistance of Al/SiC is reduced by reducing the particle size of SiC and by increasing the percentage volume [10]. The aim of the present work is to study the corrosion behaviour of aluminium metal matrix composites reinforced with boron carbide by varying the percentage of reinforcement.

Messrs. Sanman S, Department of Mechanical Engineering, Acharya Institute of Technology, Bengaluru, Prashanth K P and Anil K C, Department of Automobile Engineering, Acharya Institute of Technology, Bengaluru, Department of Industrial Engineering and Management, Siddaganga Institute of Technology, Tumakuru, Venkatesha B K and Gopal Krishna U B, Department of Mechanical Engineering, Alva's Institute of Engineering and Technology, Moodabidire, REVA University, Bangalore and Yuvaraj L, Department of Automobile Engineering, Acharya Institute of Technology, Bengaluru, India. E-mail: sanman2289@gmail.com / venkatesha.bk@reva.edu.in

## 2.0 Experimental details

### 2.1 Preparation of composites

Melt stirring technique was used to fabricate the Al-$B_4C$ composite. Al6061 alloy and boron carbide of size 105 microns were used as the matrix and the reinforcement material respectively. The percentage of reinforcement was varied from 6 to 12% in steps of 2%. Initially, aluminum was melted at 750°C in a crucible made of graphite inside electrical resistance furnace. Before adding into the melt to ensure the wettability, the $B_4C$ is preheated at 250°C for 30 minutes and then addition takes place with continuous stirring. The entrapped gasses were removed by degassing technique by adding solid hexachloro ethane and the atmospheric contamination is reduced by adding cover flux into the melt. The hot melt was then poured into the mold and allowed to solidify.

### 2.2 Salt spray test

The developed Al-$B_4C$ composites were evaluated for salt spray test according to ASTM B117-2007 standards. The test specimens of size 10×10×8 mm were cut from as-cast and polished using standard metallographically procedure. Acetone was used to degrease the specimens and the initial weight of the specimen was noted using precision electronic balance with ±0.1 mg accuracy. Fig.1 shows the photograph and the specimen dimensions of the salt spray test specimens. The test specimens were kept in a closed salt chamber where it is exposed to continuous spraying of 5% NaCl solution (AR Grade) of pH-7.08 and compressed air at constant temperature and pressure. The testing temperature was maintained at 35°±2°C. The test was conducted for a period of 240 hours and for every 48 hours the weight loss of the specimens was measured. After the tests, the corroded specimens were dried and degreased with acetone and the final weight was measured. The extent of corrosion was measured by using weight loss method.

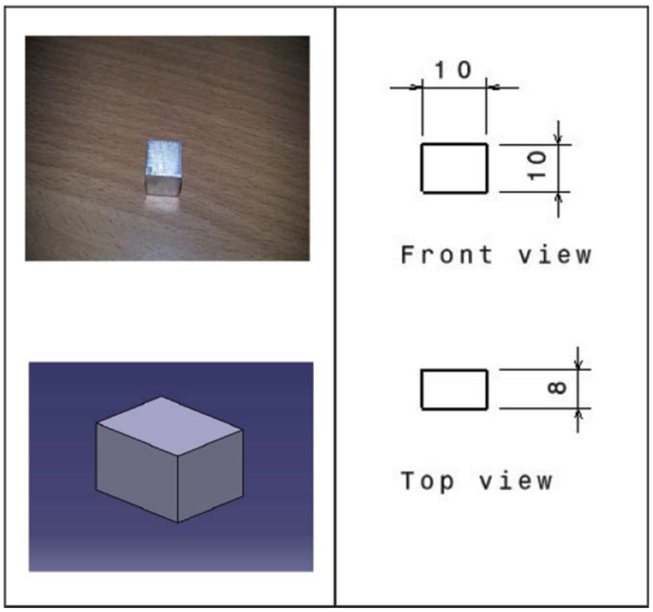


Fig.1: Specimen dimension of corrosion test specimen

## 3.0 Result and discussions

### 3.1 Microstructural examination before salt spray test

The microstructure characterization of the developed Al-$B_4C$ metal matrix composites were carried out using optical microscope. The optical image shows the uniform distribution of reinforcement particles and interfacial cohesion between the reinforcement and the matrix which is the outcome of effective stirring and use of suitable process parameters. The presence of $B_4C$ in the matrix material is confirmed through XRD analysis [7].

### 3.2 Effect of weight fraction of $B_4C$ on corrosion

Fig.2 shows the plot of weight loss of composite due to corrosion versus time for which the composite is exposed to 5% NaCl during salt spray test.

The corrosion behaviour of aluminum is sensitive to the small amount of impurities in the metal. From the graph we can see that the corrosion of aluminum composite increases with the increase in time of exposure to the NaCl which is indicated by the weight loss. We can also notice that the corrosion rate of aluminum boron carbide composite increases with increase in the percentage reinforcement. This is due to the sensitiveness of aluminum towards corrosion. The difference in thermal and mechanical properties of the matrix and reinforcement particles are the reason for arising of the residual stress which are considered as the sites for corrosion in the material. It is also seen that the corrosion rate in the base alloy is lesser than the composite. This shows that the presence of $B_4C$ particles is the reason for increase in the corrosion rate of the composite. This is because of the presence of the large amount of the reinforcement particle at the surface of the composite, which accelerate the pit growing into the metal. The pit initiation side tends to the possibility of the accuracy corrosion on the interface between the hard reinforced particles and matrix alloy.

## 4.0 Conclusions

In the present investigation, the corrosion behaviour of $B_4C$ particle reinforced Al-6061 alloy has been studied and the following conclusions are derived.

- Aluminum-boron carbide composite was successfully fabricated using stir casting method. Keeping the reinforcement particle size constant of size 105 microns and varying percentage of reinforcement from 6 to 12% in steps of 2%.
- The presence and uniform dispersion of $B_4C$ reinforcement particles in the matrix material was

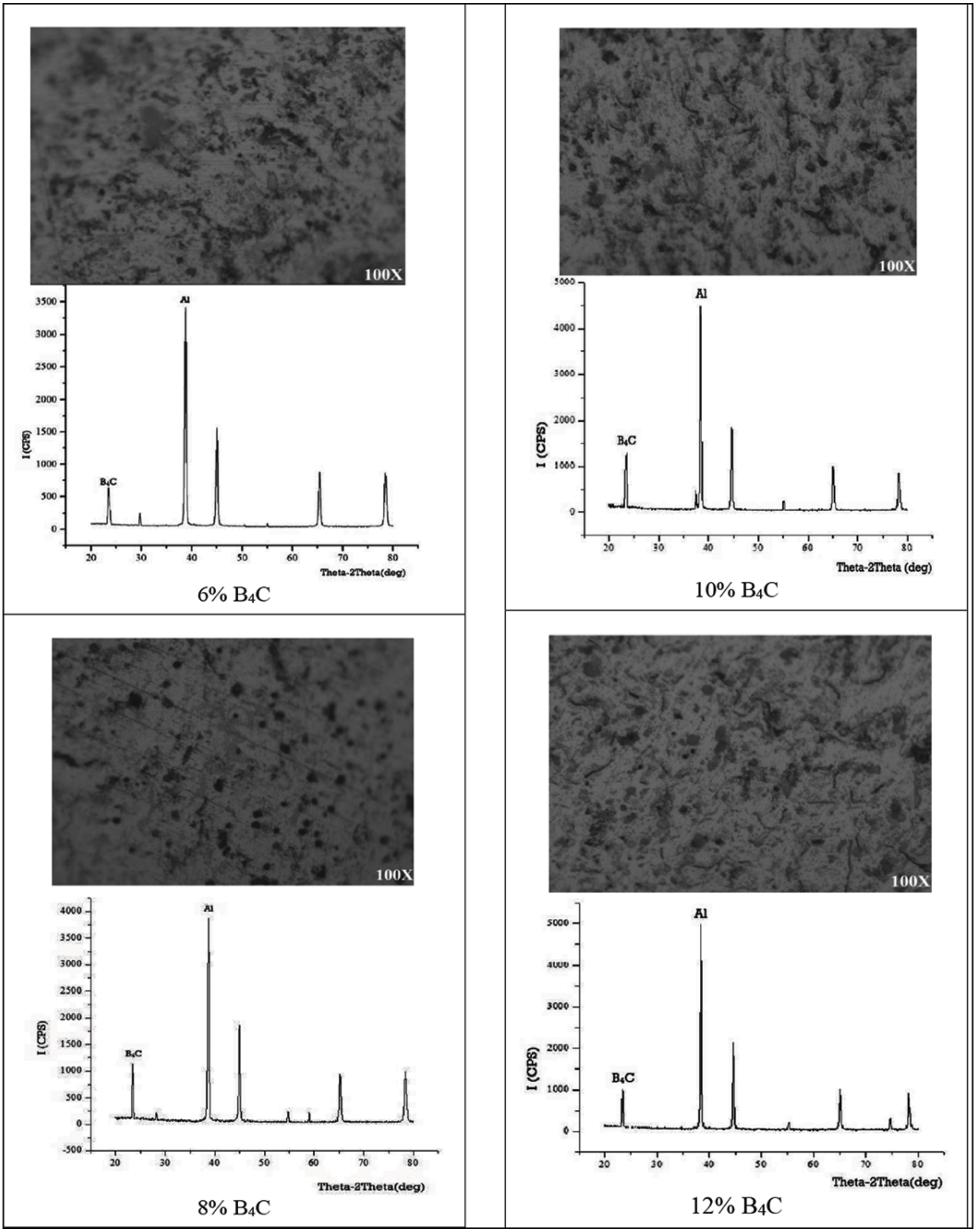


Fig.2: Optical micrographs of surface of Al6061-$B_4C$ composites before corrosion [7]

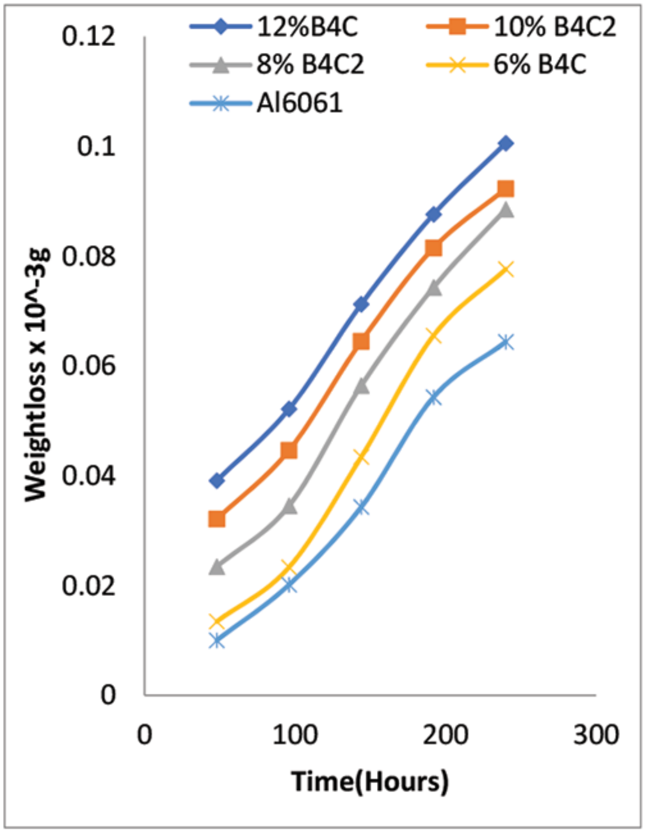


Fig.3: Effect of weight fraction of $B_4C$ on corrosion

analysed by optical micrographs and XRD.

- Corrosion of aluminum composite increases with the increase in time of exposure to the NaCl which is indicated by the weight loss.
- We can also notice that the corrosion rate of aluminum boron carbide composite increases with increase in the percentage reinforcement.
- It is also seen that the corrosion rate in the base alloy is lesser than the developed composite.
- The pit initiation side tends to the possibility of the accuracy corrosion on the interface between the hard reinforced particles and matrix alloy.

## References


1. Sreenivas Rao, K. V., and S. (2015): Sanman. In Advanced Materials Research, vol. 1101, Trans Tech Publications, pp. 32-35.
2. Rao, K V Sreenivas, and S. Sanman (2017): Materials Today: Proceedings 4, no.9, pp.9607-9611.
3. Sanman, S., and KV Sreenivas Rao. (2018): Materials Today: Proceedings 5, no.1, pp. 2951-2954.
4. Sreenivas Rao, K. V., (2017): et al. Materials Science Forum, vol. 895, Trans Tech Publications, Ltd., Mar., pp.85–88.


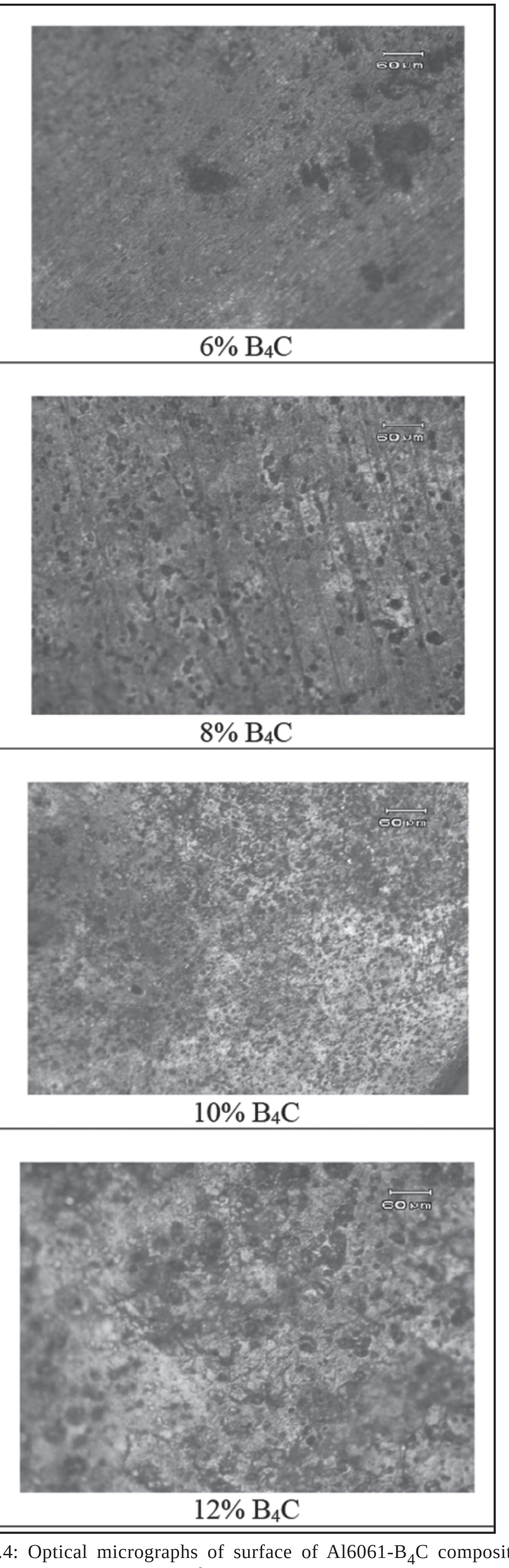


Fig.4: Optical micrographs of surface of Al6061-$B_4C$ composites after corrosion

5. Rao, K.V., S, Sanman, Sanjeevamurthy and Bharathesh.T.P, (2016): 11. 235-239.
6. Lokesh GN, Prasad GP, Raghavendra S, Prashanth KP. (2020): AMR; 1159:100–11.
7. Abbass, Muna, Hassan, Kharia and Alwan, Abbas. (2015): *International Journal of Materials, Mechanics and Manufacturing*. 3. 31-35.
8. Alaneme, Kenneth, Adewale Oke, Tolulope and Olubambi, Peter. (2014): *Journal of Materials Research and Technology*. 3. 9–16.
9. Murthy H C, Ananda, Raju, V and Shivakumara, C. (2013): Bulletin of Materials Science. 36.
10. H.M. Zakaria, (2014): *Ain Shams Engineering Journal*, Volume 5, Issue 3, Pages 831-838.
11. Gopal Krishna U B, Sreenivas Rao K V, and Vasudeva B, (2012): *International Journal of Mechanical Engineering and Robotics Research*, Vol.1, No.3, pp. 290-295, October.