Synthesis and Mechanical Property Evaluation of in-situ Prepared Al-TiC Composites

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Abstract In the present research work, synthesis and characterization of in-situ Al-TiC composites was carried out. In-situ Al-TiC with 3%, 6% and 8% composite was produced by introducing carbon bearing activated charcoal powder in to an Al-Ti melt, thereby forming TiC particles in the melt. Mechanical properties in terms of tensile strength and hardness of Al-TiC composites have been investigated. The degree of improvement of mechanical properties of composites strongly dependent on percentage of TiC formed. SEM test was performed on the prepared Al-TiC test specimen, micrograph shows the formation of TiC in the composite.

Keywords in-situ synthesis, Al-TiC composites, tensile strength, hardness

1. Introduction

Aluminium base particulate reinforced MMC's are becoming favourite choice in many applications such as aviation, space, automotive and chemical industries [1]. The superiority of aluminium matrix composite material over conventional ones is their high strength, high elastic modulus, excellent friction and wear resistance and low expansion co-efficient [2]. TiC is used as reinforcement phase because of its high hardness, elastic modulus, low density, good wettability with molten aluminium and its low chemical reactivity [3].

Aluminium matrix composites synthesized using ex-situ synthesis method such as, powder metallurgy, stir casting, pressure infiltration etc. but the size of reinforcement in the composites is large, which leads to a limited improvement and bad interface between aluminium matrix and reinforcements [4]. Compared to ex-situ synthesis techniques, in-situ synthesis method is a new technique to prepare composites owing to many advantages like fine reinforcements, clean interface between matrix and reinforcement and good mechanical characterization [5]. In-situ processing is able to produce reinforcements in the order of 0.5-5 μm [8].

Fabrication of in-situ composites involves synthesizing the reinforcing phases directly within the matrix. This approach is in contrast to ex-situ composites, where the reinforcements are synthesized separately and then introduced in to matrix during secondary process [9]. In-situ techniques involve a chemical reaction resulting in the formation of very fine and thermodynamically stable reinforcing ceramic phase within the matrix. This consequently provides thermodynamic compatibility at the metal reinforcement interface. Since reinforced surface are also likely to be free of contamination, a stronger matrix-reinforcement bond can be achieved[22].

In the present work Al-TiC composites have been developed via in-situ route. The microstructure and mechanical properties have been studied and the results are presented.

2. Experimental procedure

The in-situ process involves introducing carbon bearing activated charcoal in to an aluminium melt, there by forming TiC particles in the melt. In this procedure, a known quantity of Al-Ti master alloy is melted in the induction furnace to 1200 ^{0}C and carbon bearing activated charcoal powder was added in to the melt to meet the stoichiometry of TiC to complete the reaction for the formation of TiC particles inside the melt. The melt is allowed for the reaction time of 20 minutes. The degasser hexachloroethane was used to remove dissolved hydrogen gas from the melt. A small amount of potassium fluoride and sodium fluoride were added as a flux cover to remove the oxide film from the molten metal surface and to act as protective barrier to gas absorption and facilitating spontaneous incorporation of particles in to the melt. Afterwards the melt were cast in to rod form (20 mm in diameter and 250 mm length) in metallic moulds to complete the process. Al-TiC composites were prepared with varying weight percentages of reinforced particles Al-3TiC, Al-6TiC and Al-8TiC. The experimental setup for fabricating in-situ Al-TiC composites is shown schematically in figure1.

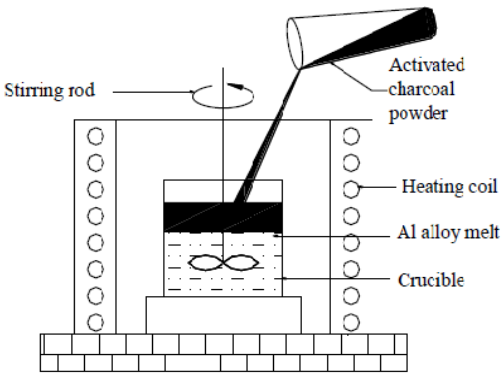

Fig. 1. Schematic diagram of the apparatus for fabricating in-situ Al-TiC composites

After the casting, a specimen of 5mm diameter and 5mm length is prepared for the microstructure analysis. The test specimen is well polished by using belt grinder and disc polisher. Microstructures of Al-TiC composites in the as cast condition were examined using scanning electron microscope (SEM)to ascertain the formation of TiC particles and its distribution. Specimens for the tensile property evaluation were prepared with gauge length of 50mm and diameter 10mm. and hardness specimen of diameter 20mm and length 20mm was prepared according to ASTM standard E8. And the tests are conducted under controlled atmosphere.

3. Results and discussion

3.1. Microstructure analysis

The SEM micrographs of the Al-TiC composites are as shown in figure 2 (a-c). it was observed that Al-TiC composites prepared at 1200^0C with 20minutes of holding time have both Al_3Ti and TiC particles. It is felt that the temperature or the reaction time was not sufficient to dissolve all the Al_3Ti particles inside the melt.

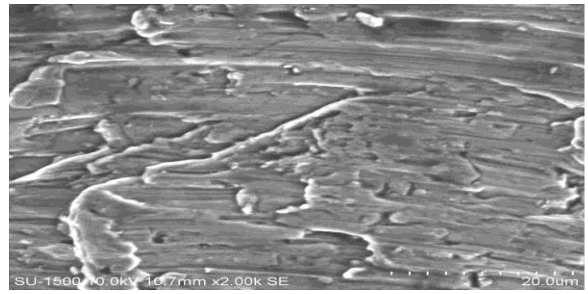

Fig. 2(a). SEM micrograph of Al-8TiC

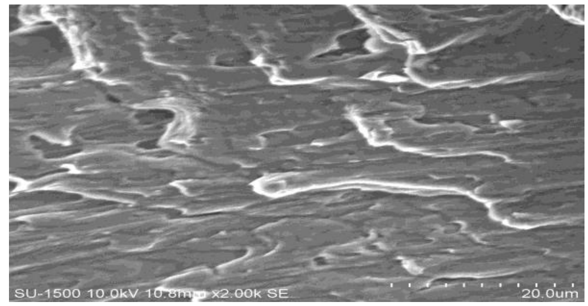

Fig. 2(b) SEM micrograph of Al-6TiC

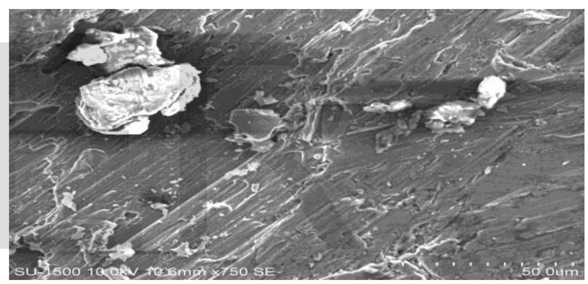

Fig. 2(c) SEM micrograph of Al-3TiC

3.2. Mechanical properties analysis

The results of the tensile and hardness test are presented in the table1. The effect of increase in percentage of TiC on tensile strength is shown in the table. It is observed that with the increase in percentage of TiC in Al-TiC composites the tensile strength increases where as ductility decreases.

Figure3 shows the variation of hardness and tensile strength with variation in percentage of TiC. Both Rockwell and Brinell hardness of the composites are increasing with he increase in percentage of TiC. Figure 4 and 5 shows the variation in the tensile properties, such as tensile strength and percentage elongation at break with the variation in percentage of TiC. The tensile strength increases and ductility decreases sharply as the percentage of TiC increases. This may be attributed to the incorporation of hard TiC particles resulting in improvement in the tensile properties of the composite.

Table1. Tensile strength and hardness test results of Al-TiC composites

%TiC	Tensile strength (MPa)	% Elongation at break	RHN	BHN
3	123	16	60	36
6	142	12	64	43.3
8	189	5	67	49.2

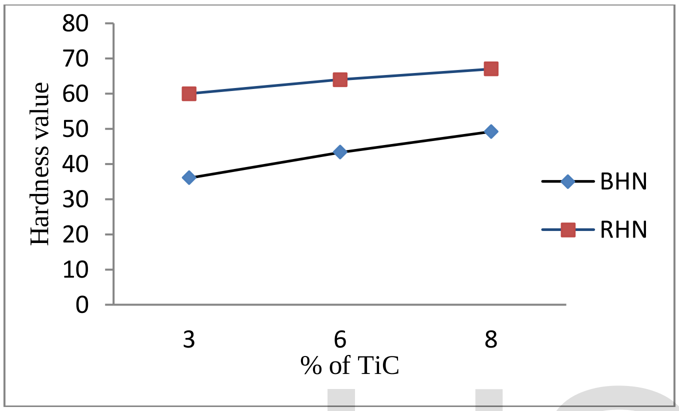

Fig. 3. variation of hardness with TiC volume fraction

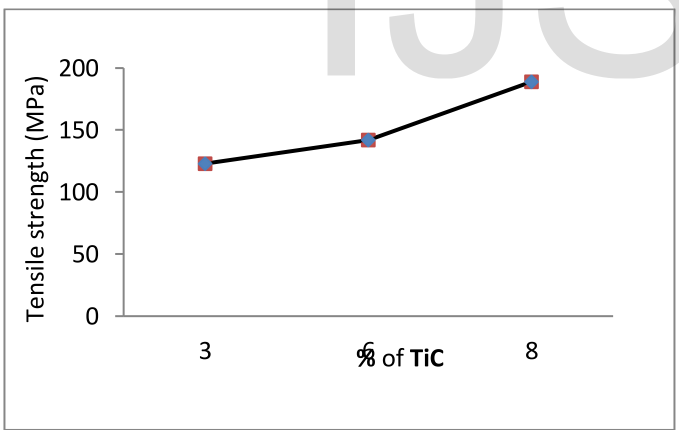

Fig. 4. variation of tensile strength with TiC volume fraction

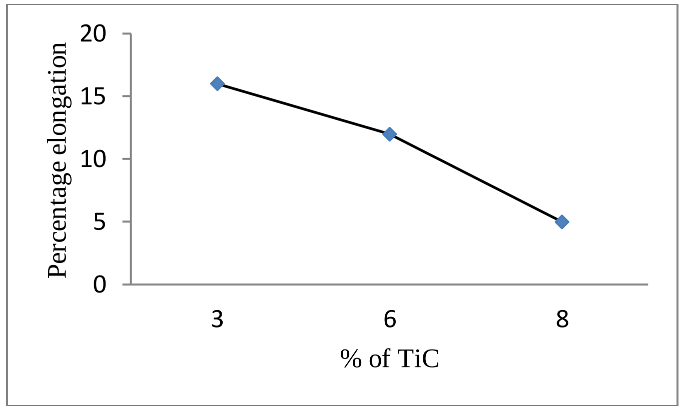

Fig. 5. variation of percentage elongation with TiC volume fraction

5. Conclusion

TiC reinforced aluminium matrix composites were produced by the addition of carbon bearing activated charcoal powder in to Al-Ti melt successfully with different percentage of TiC. The following findings are concluded;

1. In this method, TiC forms by the reaction between carbon and titanium In the solution.
2. SEM micrograph confirms the formation of TiC in the prepared composites.
3. The tensile strength increase sharply with the increase in percentage of TiC
4. Hardness of the composites increases with the increase in percentage of TiC

REFERENCES

[1] Rajnesh Thyagi, " Synthesis & Tribological characterization of in situ cast Al-TiC composites", Wear 259(2005), P569-576.

[2] X.W.Zeng,W.G.Zhang, "Preparation of In situ TiC_P /LY12 composite and its microstructure and mechanical properties", Material science and Engineering A (2006).

[3] B.Yang, F.Wang, J.S.Zhang, "Microstructural characterization of in situ TiC/Al composites prepared by spray deposition", Acta materilia, %1(20030, P4977-4889.

[4] Zhang Xiuqing, Liao Lihua, "New in situ synthesis method of magnesium matrix composites reinforced with TiC particulates", Material research ,9(2006), P357-360.

[5] In-Hyuck Song, Dokyung Kim, Yoo-Dong Hahn, " investigation of Ti_3AlC_2 in the insituTiC-Al composite

prepared by exothermic reaction process in liquid aluminium", materials letters, 58(2004), P593-597

[6] Ming Zhen MA, Riping Liu, Hongli zhao, "In situ TiC_P/Al composites prepared by TE/QP method", Journal of material science Technology, 21(2005), P652-656.

[7] P.Sahoo,M.J.Koczak, "Microstructure property relationships of in situ reacted TiC/Al-Cu Metal Matrix Composites " , Material science and Engineering A 131(1991), P69-76.

[8] K.L.Tee,Lilu, M.O.Lai, "Improvement in mechanical properties of in situ Al-TiB_2 composite by incorporation of carbon ", Material science and Engineering A, (2003)P227-231.

[9] R.F.Shyu, C.T.Ho, "in situ reacted titanium carbide reinforced alluminium alloys composites", Journal of materials processing technology, 171(2006), P411-416.

[10] Piejie Li, E.G.Kandalova, V.I.Nikitin, "In situ synthesis of Al-TiC in aluminium melt", Materials letters, 59(20050, P2545-2548.

[11] Piejie Li, E.G.Kandalova, V.I.Nikitin, A.G.Makarenko, " Preparation of Al-TiC composites by self propagating high temperature synthesis", Scripta Materilia, 49(2003), P699-703.

[12] A.R.Kennedy, D.P.Weston, M.I.Jones, "Reaction in Al-TiC metal matrix composites", Material science and Engineering A 316 (2001), P32-38.

[13] M.K.Premkumar, M.G.chu, " Al-TiC particulate composite prepared by a liquid state in situ process", Material science and Engineering A 202 (1995), P172-178.

[14] A.R.Kennedy, S.M.Wyat, " Characterizing particle matrix interfacial bonding in particulate Al-TiC MMCs produced by different methods', composites parta 32(20010, P555-559.

[15] Bin Yang chen, Zhang, " Effect of Ti/C additions on the formation of al3Ti of insitu TiC/Al composites", Materials and Design 22(2001), P645-650.

[16] Subhash khatri, Michael Koczak, "Formation of TiC in insitu processed composites via solid-gas, solid-liquid and liquid-gas reaction in molten Al-TiC", Material science and Engineering A, 162(1993), P152-162.

[17] Srinidhi sampath, Michael Koczak, " Processing and analysis of insitu composites", the minerals, metals and materials society, 1994, P37-60.