International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.11 No.07, pp 78-83, 2018

Heat Treatment of Al/TiB_2 MMC with Different Moulds

C.Rajaravi*, M.Sivabalan, M.Shivathanu, M.Thirumaran

Department of Mechanical Engineering, Veltech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, Chennai-68, Tamilnadu, India

Abstract : In this work, A356 cast aluminium alloy with 6% TiB_2 in-situ formed MMCs have been fabricated using stir casting route and poured at sand and permanent moulds. The composite was synthesized using stir casting technique. The A356 cast aluminium alloy and all synthesized composites are subjected to solutionizing treatment at a temperature of 540˚C for one hour, followed by quenching in hot water at 43˚C. The quenched samples are then subjected to artificial aging at 171˚C for 8 hours. Morphology of the cast composites was studied in detail by the optical microstructure. The Mechanical properties have been carried over on both sand and permanent of Al/TiB_2 MMC composites before and after heat treatment. Under heat treated condition, Al/TiB2 composites showed better tensile strength and hardness when contrasted with base Al matrix alloy. And different moulds were investigated and its comparison shows that the tensile and hardness value of Al/TiB_2 MMC is higher than permanent mould.

1. Introduction

Aluminium based MMCs reinforced with ceramic particulates have been the subject of numerous research works. Owing to the low density, low melting point, high specific strength and thermal conductivity of aluminum, a wide variety of ceramic particulates such as SiC, B_4C, Al_2O_3, TiC and graphite have been reinforced into it. Among these particulates, TiB_2 has emerged as an outstanding reinforcement (1-3). In situ synthesizing of MMCs involves the production of reinforcement within the matrix during composite fabrication. This technique exhibit the presence of a uniform distribution of reinforcement that tends to be fine and associated with a clean interface with the metallic matrix, which assists in the formation of a stronger bond between the reinforcement and the matrix (4). An attempt was made to synthesize the in-situ composite withA356 as matrix material and TiB_2 as the reinforcement eliminating the inherent associated defects with ex-situ process like agglomeration, poor wettability and nonuniformity of distribution. The as-cast aluminium based reinforced composites requires to be heat treated for enhancing its mechanical properties (5).Nevertheless, the synergic impact of heat treatment and the kind of reinforcement plays a huge part in dictating the final mechanical properties of composites (6). The microstructure was used to confirm the size and uniformity of TiB_2 particles. Whereas, X-ray diffractometer (XRD) was used to confirm the presence of TiB_2 particles in the composites (7).

C.Rajaravi *et al* /International Journal of ChemTech Research, 2018,11(07): 78-83.

DOI= http://dx.doi.org/10.20902/IJCTR.2018.110710

2. Experimental Procedure

A stir casting method has been adopted to fabricate the cast composites. Cast A356 Aluminium, the chemical composition of matrix material is shown in Table I. Potassium HexaFulroTitanate (K2TiF6) and Potassium Tetra Fluro Borate (KBF4) salts with stoichiometric composition to obtain 6 weight percentages of TiB2 particles were used. The two halide salts are preheated at 250˚C for about 30 min. and thoroughly mixed and introduced into the Al6061 molten matrix maintained at 820 ˚C temperature and hand stirred for about 30 min. Argon gas was supplied through a fine copper tube to avoid atmospheric contamination. The dross was skimmed off twice the surface of the melt, once before adding salts and the other just before the pouring.

The composite melt was cast in a permanent mould and sand mould. Cast Al6061 alloy and all synthesized composites are subjected to heat treatment process. The sequence of heat treatment process involved were solutionizing, hot bath quenching, aging and furnace cooling. Solutionizing was done at a temperature of 540 ˚C over a time period of one hour and then quenched in a hot water bath at 43 ˚C to prevent the warping of specimens. Immediately after that artificial aging was carried out in a muffle furnace at a temperature of 171 ˚C over a time period of 8 hours. Both solutionizing and aging temperatures were maintained accurate to within ±2 ˚C and quench delays in all cases were within 10 sec.

Table 1 Chemical composition of cast Al alloy used in this investigation

Elements	Si	Mg	Mn	Fe	Cu	Ni	Ti	Al
Cast Al alloy	7	0.33	0.3	0.5	0.1	0.1	0.2	Bal

All the synthesized as-cast and heat treated composites were tested for tensile strength as per ASTM standard E8-M16. The specimens for micro structural observations and X-ray diffraction analysis samples were cut with the overall dimensions less than 10 mm x 10 mm x 10 mm and XRD analysis was carried out were cut from the composite samples and prepared using conventional cutting and polishing as shown in Figures 2. The microstructures of in situ Al/TiB_2 composites were examined with optical microscope. Tensile tests were carried out with Instron machine in accordance with ASTM E8M. MicroVickers hardness tester was employed to find the hardness of the MMCs produced. Prepared tensile and hardness samples are shown in the Figures 2 and 3. Tensile and harness properties were obtained by averaging the results of two replications.


Fig. 2.Tensile test specimen, Fig.3.Hardness specimen

3. Results and Discussion

3.1. Micro structure

The Optical micrograph as shown in Figure 4. It Show the Al/TiB_2 MMC cast in permanent mould and sand mould condition at a pouring temperature of 820˚C. The Al/TiB_2 MMC cast in sand mould has bigger particles of TiB_2 than permanent mould. This is because at higher pouring temperature TiB_2 particles formed grow in size (8).The Al/TiB_2 MMC as shown in Figure 4.1 and that shown in Figure.4.2 appear to have almost same sized TiB_2 particles as both of them were cast in sand mould and the Al/TiB_2 MMC, before solidification, remain in molten condition longer as the sand moulds insulate .

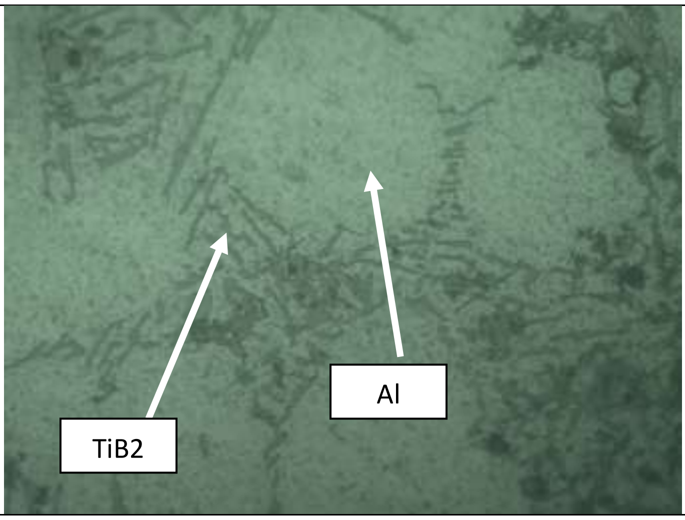

Fig 4.1 Al/TiB_2 MMCs cast in permanent mould

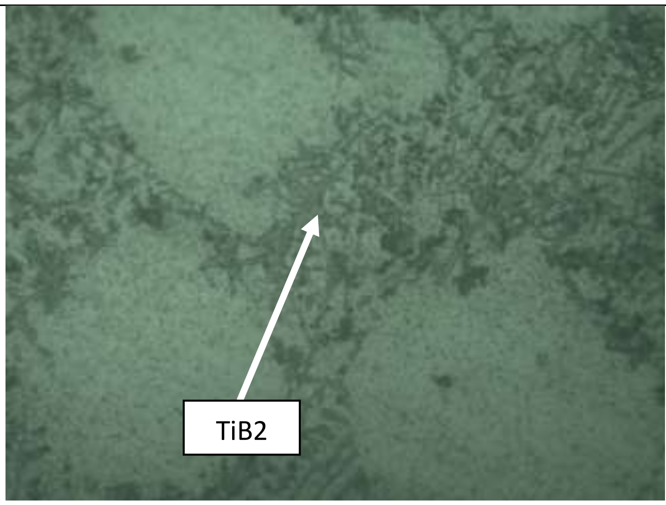

Fig .4.2 Al/TiB_2 MMCs cast in sand mould

The presences of TiB_2 peaks in all of the cases confirm the formation of TiB_2. The relative fractions of three phases viz TiB_2, Al_3Ti and Aluminium are calculated based on the intensity of diffraction peaks as shown in Figure.5.

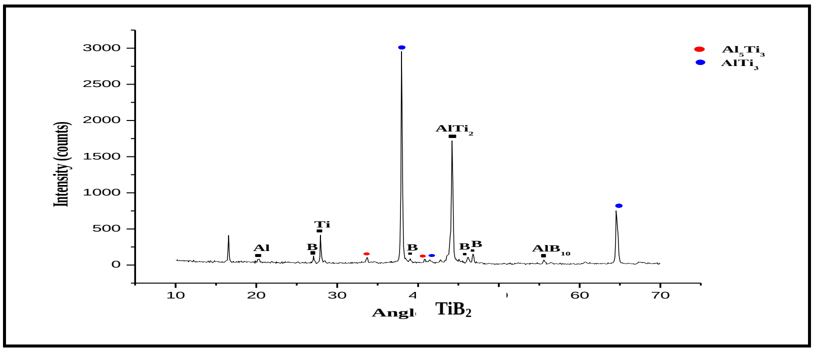

Fig.5. XRD Patterns of Al-TiB_2 Composites

3.2. Tensile strengths

The experimental found values of tensile strength for Al/TiB_2MMC cast in sand and permanent moulds are given in Table 2. For Al/TiB_2 MMCs cast in permanent mould the tensile strength increase from 152 MPa and 175 MPa as pouring temperature at 820˚C. For Al/TiB_2 MMCs cast in sand mould the tensile strength increase from 180 MPa and 171 MPa at same pouring temperature. The tensile strength of Al/TiB_2 MMC cast in sand mould is found to be higher than that cast in permanent mould. This is because; the casting made in the sand mould of Al/TiB_2 MMC has fine grained structure as the cooling rate is higher as compared to that in permanent mould as shown in Figure.6 .

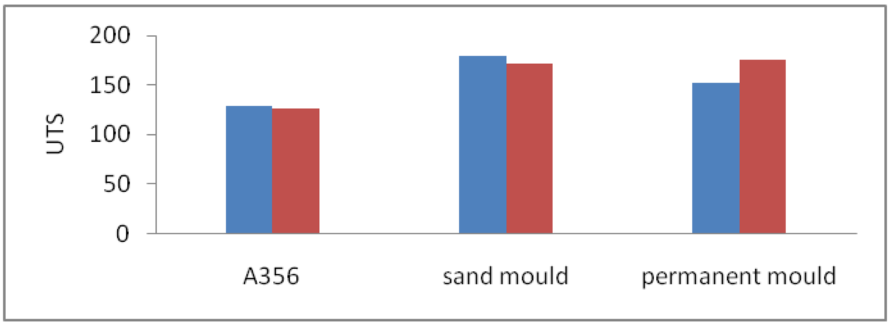

Fig.6. Graph of ultimate tensile strength between different moulds

Table 2: Tensile strength of Al/TiB_2 MMCs cast in different mould

S.No	Temperature ˚C	Tensile Strength	
		Before Heat Treatment UTS (MPa)	After Heat Treatment UTS (MPa)
Cast A356	750˚C	129	136
		126	132
Sand mould	820˚C	180	189
		171	180
Permanent mould	820˚C	152	167
		175	185

Figure.7 it shows, During the heat treatment, intermetallic particles are precipitated which resist the movement of dislocations in a crystal lattice (9-10).TiB2 particles and precipitation of intermetallic increasetensile strength. As the amount of TiB2 particles and intermetallics put together increase, the tensile strength increase less proportionately. Thealuminium based particulate reinforced composite, the dislocations are generated during solutionizing due to thermal mismatch between the matrix and the ceramic reinforcement particles. Most of the matrix during aging favour nucleation of semi-coherentprecipitates (11).Therefore, need arises for a longer solutionizing time and accelerated aging at elevated temperature for aluminium based particulate reinforced composite, when compared to unreinforced alloys.

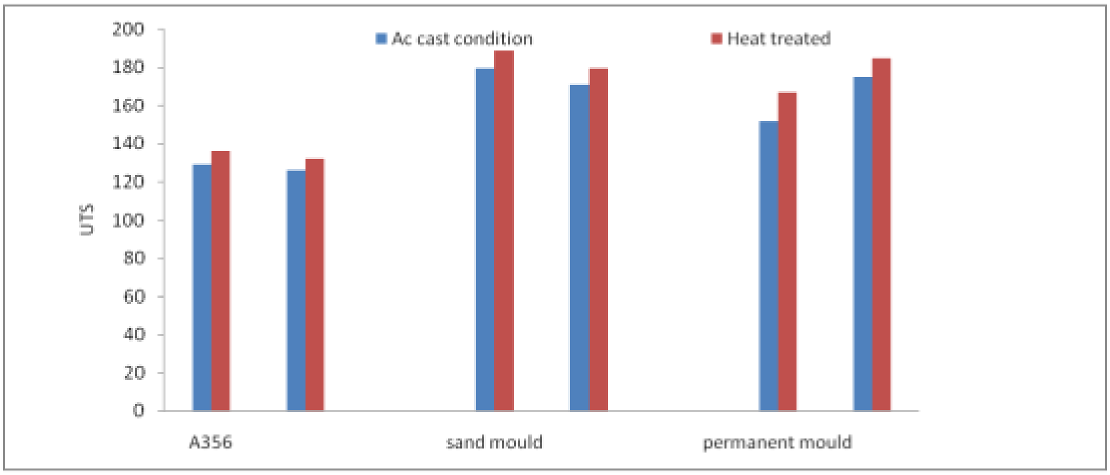

Fig.7. Graph of ultimate tensile strength between as-cast and heat treated conditions

3.3. Hardness

Micro Vickers Hardness test results are shown in table.2 and the hardness values are compared for sand mould and permanent mould conditions. For both mould conditions, it shows significant improvements of hardness corresponding to heat treatment than as cast conditions. The Al/ TiB_2 MMCs cast in the Hardness values are found to be sand mould more than that with permanent mould condition. This is because in the case of sand mould the cast MMC has grain growth increased structure as compared to the permanent mould. It is concluded that the sand mould castings are more suitable for Al/TiB_2 composite fabrication as compared with permanent mould as shown in Figure.8

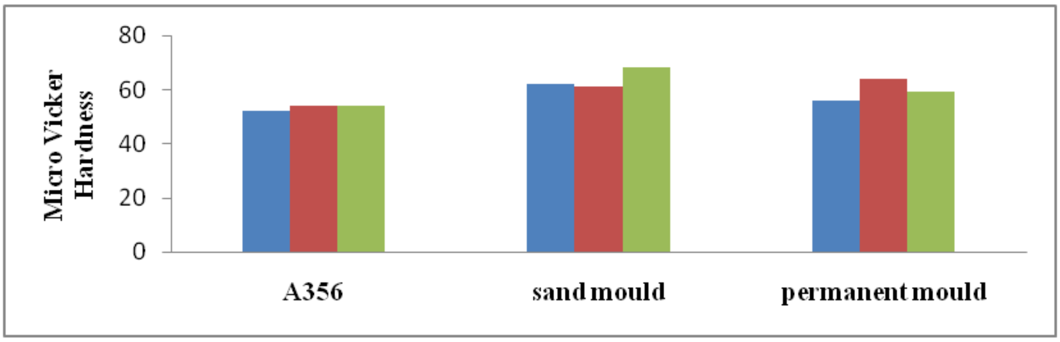

Fig. 8. Graph of hardness between different mould

The variation of hardness under heat treatment condition are shown in Figure 9. Heat treatment has a profound effect on the hardness of the matrix alloy as well as the composite. It is due to precipitation hardening of aluminium based particulate reinforced composite in the solutionizing stage, and these precipitates impede dislocation movement(12). In addition the intermetallics that form due to heat treatment settle in between the TiB2 particles and thus effect of intermetallics formed from precipitation is to increase the properties less proportionate.

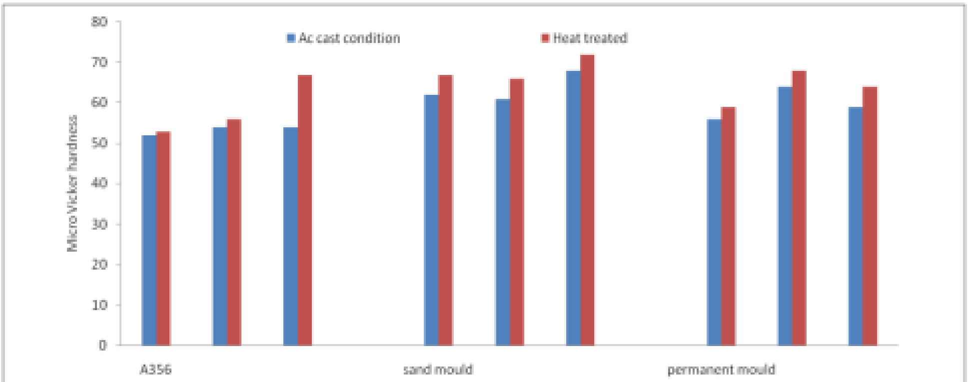

Fig. 9. Graph of hardness between as-cast and heat treated conditions

Table 2. Micro Vickers Hardness of Al/TiB_2 MMCs cast in different mould

S.No	Temperature °C	Micro Vickers Hardness	
		Before Heat Treatment	After Heat Treatment
Cast A356	750°C	52	53
		54	56
Sand mould	820°C	62	67
		61	66
		68	72
Permanent mould	820°C	56	59
		64	68
		59	64

4. Conclusions

Al-TiB_2 composites have been successfully manufactured by in-situ salt metal reaction technique in sand mould and permanent mould.Micro Structural analysis shows the presence TiB_2 and its distribution in the metal matrix.The mechanical properties are achieved for Al/TiB_2 MMCs poured in perment mould at the fabricating conditions of pouring Temperature = 820°C, Reaction Time = 30 minutes and % of TiB_2 is 6 and the values are UTS = 175 MPa and heat treated conditions UTS = 185 MPaand Hardness =64VH and heat treated conditions VH=68VH.The mechanical properties are achieved for Al/TiB_2 MMCs poured in sand mould at the fabricating conditions of pouring Temperature = 820˚C, Reaction Time = 30 minutes and % of TiB_2 is 6 and the values are UTS = 180 MPa and heat treated conditions UTS = 189 MPa , and Hardness =68VH and heat treated conditions VH=72VH. During heat treatment the smaller precipitations club to form larger particles of intermetallics that impede the dislocation movement.

References

1. Srivatsa, T.S, etall. Processing techniques for particulate reinforced metal aluminium matrix composites. Journal of Materials Science, 1991, Vol .26, pp .5965-5978.
2. Veereshkumar, G.B., et all. Mechanical and tribological behaviour of particulate reinforced Al metal matrix composites-a review, J. Min. mater. Cha.eng, 2011,Vol 8, pp .59-91
3. Emamy, M., Mahta, M., Rasizadeh, J. (2000), "Formation ofTiB2 particles during dissolution of TiAl3 in Al-TiB2 metal matrix composite using an in-situ technique", Composite science and Technology, Vol.66, pp.1063-1066.
4. S.C. Tjong, Z.Y. Ma1, (2000), "Microstructural and mechanical characteristics of in situ metal matrix composites", Materials Science and Engineering, Reports, Vol.29, pp. 49-113.
5. T.V. Christy, N. Murugan and S. Kumar, "A Comparative Study on the Microstructures and Mechanical Properties of Al 6061 Alloy and the MMC Al 6061/TiB2/12p", Minerals & Materials Characterization& Engineering, Vol.9, No.1, (2010) pp. 57-65.
6. C. Rajaravi, K. Niranjan, and P. R. Lakshminarayanan, (2015), "Comparative Analysis of Al/TiB2 Metal Matrix Composites in Different Mould Conditions", Journal of Advanced Microscopy Research, Vol. 10, pp. 1–5.
7. Niranjan, K., Lakshminarayanan, P.R.Optimization of process parameters for in situ casting of Al/TiB2 composites through response surface methodology, Trans. Nonferrous Met. Soc, 2013, Vol 23, pp. 1269−1274.
8. Mingliang Wang., et all. Mechanical properties of in-situ TiB2/A356 composites, Mater. Sci. Eng A, 2104, Vol 590, pp .246–254.
9. Nimbalkar, V.M.,et all. Development reaction synthesis process of novel Al-alloys -TiB2 metal matrix composites by in-situ, J. Met. Mater. Sci, 2011, Vol 53, pp .197-203.
10. U. AthulAtturan., etall.Processing and characterization of in-situ TiB_2 stabilized closed cell aluminium alloy composite foams, Mater. Des, 2016, Vol101, pp .245–253.
11. B. Gobalakrishnan∗, P. R. Lakshminarayanan, and R. Varahamoorthi. (2017), Combined Effect of TiB2 Particle Addition andHeat Treatment on Mechanical Properties ofAl6061/TiB2 In-Situ Formed MMCs, Journal of Advanced Microscopy Research, Vol. 12, pp. 230-235.
12. Rajaravi, C., Niranjan, K. and Lakshminarayanan, P. R. (2015), Comparative Analysis of Al/TiB2 Metal Matrix Composites in Different Mould Conditions, Journal of Advanced Microscopy Research, Vol. 10, pp. 1–5.

*****