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EFFECT OF TIB_{2P} PARTICULATE ADDITION IN ALUMINIUM 6061 THROUGH STIR CASTING TECHNIQUE

Rama Durai K, Chanakyan C, Janet A & Bharathikanna R
Assistant Professor, Department of Mechanical Engineering,
Parisutham Institute of technology and science, Thanjavur, Tamilnadu

Abstract:

Metal matrix composite (MMC) focuses primarily on improved strength, hardness and tensile properties. The AMMC are widely used in Hi-TECH Engineering application as it has superior properties than any other MMC. Properties of this material depend upon the manufacturing techniques and its processing parameters, selection of matrix and reinforcements. Aluminium matrix reinforced with titanium di-boride give superior properties than the Aluminium alloy reinforced with other particulates such as Al_2O_3, SiC, and TiC. The main challenge is to produce the composite cost effective way to meet the above requirements. The research of Al 6061 alloy to have been manufactured by the Stir casting technique, with varying particulate addition (such as volume fraction of 3%, 6%, and 12%) included the characterization such as SEM analysis and mechanical properties(Tensile, Hardness) as well.

Keywords: MMC, TiB_{2p}, Tensile Test & Hardness

Introduction:

Conventional monolithic materials have limitation in achieving good combination of Tensile strength, Hardness. Aluminium and its alloys play an important role in the production of MMC. AMMC materials have greater advantages in a wide number of specific fields due to their high specific strength, stiffness, yield strength and dimensional stability. AMMC can be fabricated in several ways based on its end use. Among Aluminium alloys AA6061 is quite a popular choice as matrix material. It is primarily due to its better formability characteristics and option of modifying strength of the composite by employing optimal heat treatment. Al–TiB_{2p} composite is not readily available in the market and it is costly. This is due to the difficulty in producing this composite. Few attempts were made to produce it by in-situ process.

Stir casting technique is the conventional and economical way of producing AMC. But, with the conventional stir casting technique, it is difficult to produce a particulate reinforced composite. In this present method suitable modifications were carried out on conventional stir casting method to take care of the reaction of molten Aluminium with atmosphere, segregation of reinforcing particles and wettability. Controlled bottom pouring arrangement helps to regulate the molten metal flow. But, when compared to the present method, particle infiltration is relatively a difficult process.

Experimental Setup Material:

Composition test (Table-1) was taken from Omega Inspection and Analytical lab, Chennai, supplied by Coimbatore metal mart ltd. TiB_{2p} supplied for Alfa Aesar (India) was used as reinforcement.

Table 1 - Composition of Aluminium Alloy 6061

Material	Si	Fe	Cu	Mn	Mg	Zn	Cr	Ti	Al
Composition	0.713	0.154	0.27	0.391	0.773	0.01	0.005	0.022	97.550

Table 2 - Size and material composition of TiB2p

Material	Oxygen	Carbon	-325 mesh	Particle size, D50
Composition (%)	0.266	0.476	99.80%	14.7µm

Stir Cast Process:

It is liquid metallurgy route. 1kg of Aluminium was melted in a graphite crucible. For this the melt temperature was raised to 900K. Then the TiB_2p (3%, 6%, 12%) weight of TiB_2p were added to the Aluminium melt for production of three different composites. The TiB_2 particles were preheated to 573K for to remove the moisture. Commercially pure Aluminium was melted by raising the temperature to 950K. Then it is stirred well using a mild steel stirrer.

TiB_2p particle were added to the melt at the time of formation of in the melt due to stirring. The melt temperature was maintained 950k during the addition of the particles. Then the melt was casted in a graphite crucible. The particle size analysis for TiB_2p and Chemical composition analysis was done for Aluminium 6061. The micro hardness measurement was carried out Al (3%, 6%, 12%) hardness testing machine with 0.5kg load and diamond ball intender. The detention time for the micro hardness measurement was 10 seconds. The tensile properties of Aluminium- TiB_2p composites were evaluated using Universal Testing Machine. The SEM was done for all the samples SEM is use to find homogeneous distribution of particle.

Literature References

The processing of microstructure-mechanical properties of aluminium base metal matrix composites materials synthesized using stir casting route were investigated by Vivekanandan and Arunachalam[2] et al. they had used fly ash reinforced in aluminium matrix and reported the improvements in mechanical properties up to 20% of fly ash. A similar effect Titanium Carbide particle reinforced with aluminium 6061 matrix composites was observed by S.Gopalakrishnan and N.Murugan [1] et al. they had investigate specific strength of the material improved appreciably with more addition of TiC.

Muhammad Hayat Jokhio, Muhammad Ibrahim Panwar and Mukhtiar Ali Unar [7] et al, has reported information regarding Al_2O_3 particles up to 10% increase in tensile strength. Pardeep sharma, Gulshan chauhan and Neeraj Sharma[3] et al has resulted processing variables such as holding temperature , stirring speed, size of the impeller and the position of the impeller in the melt are among important factors to be considered in the production of cast metal matrix composites as these have an impact on mechanical properties.

Results and Discussion Microstructures:

Samples of as cast MMCs for metallographic examination were prepared by grinding through different size of grit papers. Then the samples were etched with the etchant i.e. Keller's reagent (2.5 ml Nitric acid, 1.5 ml HCl , 1.0 ml HF,95.0 ml Water)

The etched samples were dried by using electric drier. The microstructure observed by using scanning electron microscope (SEM-Care Institute of Technology, Tiruchirapalli). The microstructure of the as cast MMCs are shown in Fig.1&2 at different percentage TiB_2p of the casting. The micrograph of MMC castings at different section shows that the distributions of TiB_2p particles are not uniform throughout the casting and segregation of particles are more in the eutectic region.

Porosity generally found in stir casting of Aluminium composites increases with increase in "TiB_{2p}" particles contents in Aluminium matrix especially containing high percentage of alloy addition.

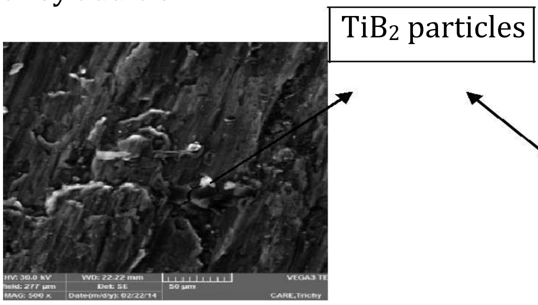

Fig. 1 - SEM image for 3% composites

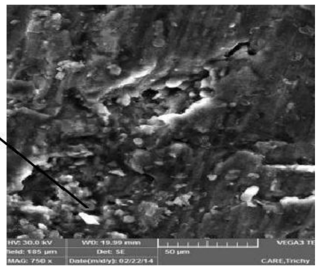

Fig. 2 - SEM image for 12% composites

Tensile Test:

Tensile tests were used to assess the mechanical behavior of the composites and matrix alloy. The composite and matrix alloy plot were machined to tensile specimens with a Width 6mm, Length 9mm, Gauge length 25mm. As the reinforcement weight percentage increases, Ultimate Tensile Strength are also increases.

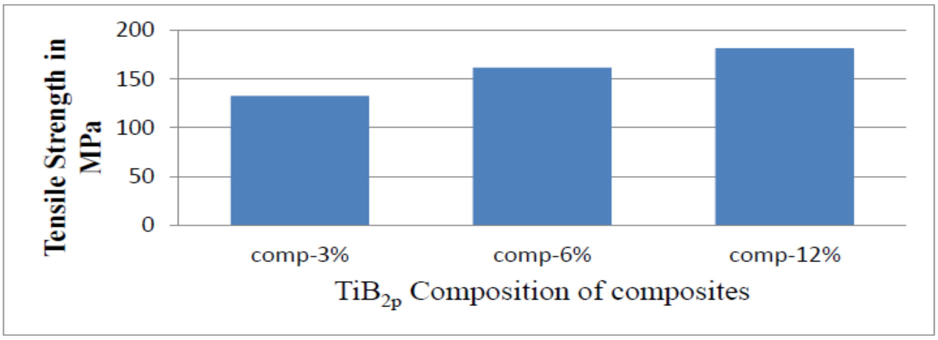

Figure 3 - Graph for tensile strength

This happens may be due to dispersion of which TiB_2p creates hindrance to dislocation motion. This may results increase in tensile strength of reinforced Al 6061 alloy. All these mechanical tests are done properly as per the standards given in various material testing books. Use ASTM557B. For these tests we observed (Figure-3 & Table-3) improved in mechanical properties of newly manufactured AMMC material using stir casting as compared to Aluminium alloy 6061 and TiB_{2p}.

Micro Hardness:

Hardness is often a function of the particle size, porosity, and binder material. Hardness is very important to the success of machining operations. The hardness of the samples was measured using Vickers micro hardness (Anusudhan Kendra Block, Sastra University) measuring machine by applying a load of 0.5Kg and this load was applied for 10 seconds.

In order to eliminate the possibility of error a minimum of four hardness readings were taken for each sample. According to the table (Table: 4) Micro Hardness is gradually increase with increase addition of TiB_{2p} in Aluminium Alloy 6061. The graph (Figure-5) shown optimum level is obtained in 12% composites.

Table 3 - Tensile strength for all composites

Sample	Tensile strength	Yield stress	Elongation	Rank
Composites 3%	132.76	117.06	2.40%	3
Composites 6%	161.9	141.53	5.60%	2
Composites 12%	181.58	171.91	7.20%	1

Table 4 - Vickers Micro Hardness for all composites

Sample	Trial 1	Trial 2	Trial 3	Trial 4	Average
Composite 3%	67.7	68	68.7	66.7	67.77
Composites 6%	73.6	74.7	72.7	73.5	73.62
Composites 12%	75.4	78.9	77.6	76.8	77.17

Figure 4 - Tensile tested specimen (T_1-3%, T_2-6%, T_3-12%)

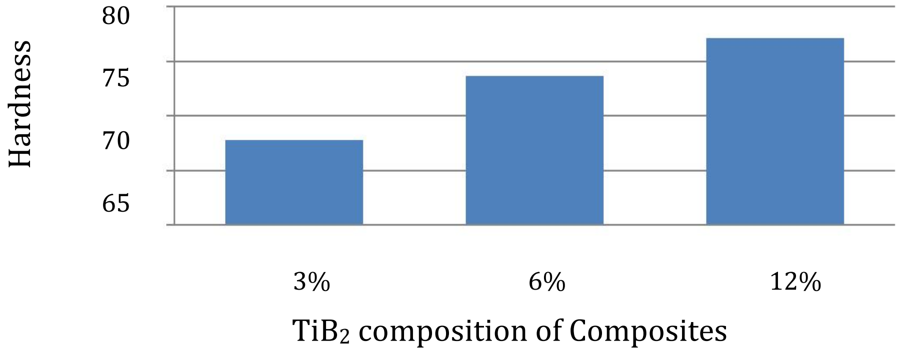

Figure 5 - Graph for Micro Hardness

Conclusion:

Based on the earlier discussion, the following conclusions are drawn:

- Al-TiB_2p composite (3% and 6% TiB_2p) shows good improvement in hardness as compared to pure Aluminium
- TiB_2p particles are moderately distributed in Aluminium matrix and are clearly visible in SEM micrographs. The size of TiB_2p particles is about 14µm
- The hardness of the MMCs is higher than the unreinforced matrix metal and the hardness of the cast composites increases linearly with increasing the weight fraction of TiB_2p.
- The tensile strength of the as cast composites increases on increasing the volume fraction of TiB_2p.

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