



STUDY OF INFLUENCE OF TITANIUM CARBIDE IN ALUMINIUM 7075 METAL MATRIX COMPOSITES REINFORCED WITH TITANIUM CARBIDE, GRAPHITE AND EGG SHELL PARTICULATES

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Abstract: In the present study an effort has been made to study the microstructure, hardness and tensile properties of aluminium 7075 Metal Matrix composites reinforced with Graphite (Gr), Egg Shell Particulates (ESP) and Titanium carbide (TiC). Fabrication of hybrid Al7075 was carried out by stir casting technique. Percentage of TiC particles were varied from 2 wt. % to 6 wt. % in steps of two by keeping constant 1 wt. % of graphite and Egg Shell particulate. The prepared samples were subjected to mechanical testing like tensile and hardness as per ASTM standards. It was observed that as the wt. % of TiC increases there is a great improvement in the mechanical properties of Hybrid Al7075 MMC. Also Microstructural study was carried out by using inverted metallurgical microscope to study the dispersion of reinforcement particles in the Al7075 matrix phase.

Keywords: Al7075, Metal Matrix Composites, Egg Shell Particulates, Graphite Titanium Carbide

I. INTRODUCTION

Composite materials have gained great importance in the last years due to their enhanced mechanical properties, which are obtained by combining different materials. Metal matrix composite (MMC) is engineered combination of metal matrix and hard reinforcement particles to get tailored properties. Aluminum alloys are of special interest to be used as matrix in composites due to their low specific weight, due to which they are very widely used in the aeronautic and aerospace industry, especially the 2XXX, 6XXX, and 7XXX series, that can be heat treated in order to improve their strength. Among all the mentioned alloys, the 7XXX series exhibit the greatest response to the precipitation hardening because of presence of Zn and Mg. Therefore the Aluminium 7075 is considered a high strength alloy because its yield strength is above 500 MPa in the optimal aging conditions.

In recent times several authors have focused their attention on fabrication of hybrid MMCs reinforced with nano, micro and macro sized reinforcement particles as they are gaining wide acceptance in different applications. Incorporation of graphite powder in Al 7075 with different concentrations (0.0 to 1.5 wt. %) using milling process enhances the Yield strength, maximum strength and Vickers micro hardness [1]. By mixing 5, 10 and 15 wt.% egg shell particles in aluminium 6061 metal matrix, increases the hardness by 14 % [2]. Yixiong Liu et al. [3] studied the effects of Ti particles on the mechanical properties and ageing behaviour of (SiCp+Ti) / 7075Al hybrid composites. Because of precipitation of η phases and ageing condition, tensile strength of both composites improved.

Metal matrix composites can be fabricated by both solid state as well as liquid state processing technique. One important fabrication method of composites is the stir casting techniques, a liquid state processing technique, which is generally accepted as a promising route currently practiced commercially. The objective of this work is to fabricate hybrid metal matrix composites by incorporating Titanium carbide, graphite and Egg shell particulates in aluminium 7075 matrix in different weight percentage and to study the tensile and hardness properties of hybrid MMC.

2. Materials and Experimental Procedure:

2.1 Material Selection:

In the present study aluminium 7075 is used as matrix material. Aluminium 7075 is an alloy with zinc as the primary alloying element. Among several series of aluminum alloys, Aluminum alloy 7075 possesses very high strength, higher toughness, wear resistance and temperature resistance. Al7075 is used in the form of ingots in the fabrication process by stir casting. The chemical composition of Al7075 is as shown in the table below.

Table 1. Chemical composition of Al7075

Component	Zn	Mg	Cu	Cr	Fe	Si	Mn	Ti	Al
Wt. %	5.5	2.5	1.6	0.15	0.5	0.4	0.3	0.2	Balance

Titanium carbide, graphite and Egg shell particles are selected as reinforcement material. Titanium carbide is an extremely hard, refractory ceramic material, similar to tungsten carbide. Because of its good mechanical properties and corrosion resistance property, it is chosen as reinforcement particles. Percentage by weight of Titanium carbide in Al7075 matrix is varied from 2 to 6 in steps of 2. Titanium carbide in the form of powder of 40 micron size is used to fabricate the Al7075 hybrid MMC.

Graphite is one more reinforcement material used in the fabrication of Al7075 MMC. The graphite is selected in the form of powder of 100 micron size. 1 % by weight of graphite is kept constant in this study. Another reinforcement material used in this study is Egg Shell Particulates. Egg shell mainly comprises of calcium, a very hard material which can withstand very high compressive load. White egg shells, collected from the hotels, washed thoroughly with water and dried under the sunlight for 32 hours. Then the dried egg shells are ball milled at 250 rpm and converted into fine powder. These powdered egg shells are sieved by placing on a set in a sieve shaker, vibrated for about 20 minutes and 106 μm size uniform egg shell powder is obtained. The weight percentage of egg shell particulates is again kept constant as 1%. Figure 2.1 below shows the reinforcement particles used in the study.



Fig.2.1 (a) Titanium carbide Powder, (b) Graphite powder, (c) Egg shell Powder

2.2 Fabrication:

Stir casting is a relatively simple, low cost and best liquid phase fabrication method to fabricate metal matrix composites commercially. Measured quantities of aluminium 7075 ingots in a graphite crucible are placed inside the furnace. Furnace temperature is elevated above the melting point of aluminium 7075 and maintained until the aluminum ingots melt completely. Now the temperature of the molten metal is reduced just below the melting point of aluminum 7075 to form a semi-solid state. At this stage the pre heated reinforcement materials i.e., Graphite, Egg Shell Particles and Titanium carbide in powder form are added in a specified weight percentage to the melt one after the other and thoroughly mixed by manual stirring. Then the temperature of the molten metal mixture is raised to fully liquid state and stirred using a mechanical stirrer to obtain a uniform mixture of matrix and reinforcement materials. This molten composite mixture is slowly poured to a cylindrical shape metallic mold cavity 300 mm long and 26 mm diameter as shown in figure and let to solidify. After solidification the casting is removed from the mold.



Fig. 2 (a) Mold used for casting, (b) Melting of Al7075

Castings are prepared with different weight percentage of reinforcement material as given below

1. Al7075 alloy as cast
2. Al7075 + 1 % Gr + 1 % ESP+ 2 % TiC
3. Al7075 + 1 % Gr + 1 % ESP+ 4 % TiC
4. Al7075 + 1 % Gr + 3 % ESP+ 6 % TiC

3. Result and Discussion:

3.1 Microstructure:

To ensure the distribution of the reinforcement in the matrix, microstructure characterization was investigated experimentally by using inverted metallurgical microscope. The specimens were cut from the central portion of the composites, and then polished on the belt grinding machine and next polished with different grades of emery papers. The specimen is then etched with acetone to remove the burrs and foreign particles. The specimen was placed on the viewing stage of the inverted metallurgical microscope and then examined the microstructure with the monochromatic light source and photographs of microstructure was captured at magnification of 100 X. Figure 3.1 shows the microstructural images of hybrid metal matrix composites for different weight percentage of reinforcement materials. From figure it clear that the reinforcement particles are uniformly distributed throughout the matrix phase without any clustering.

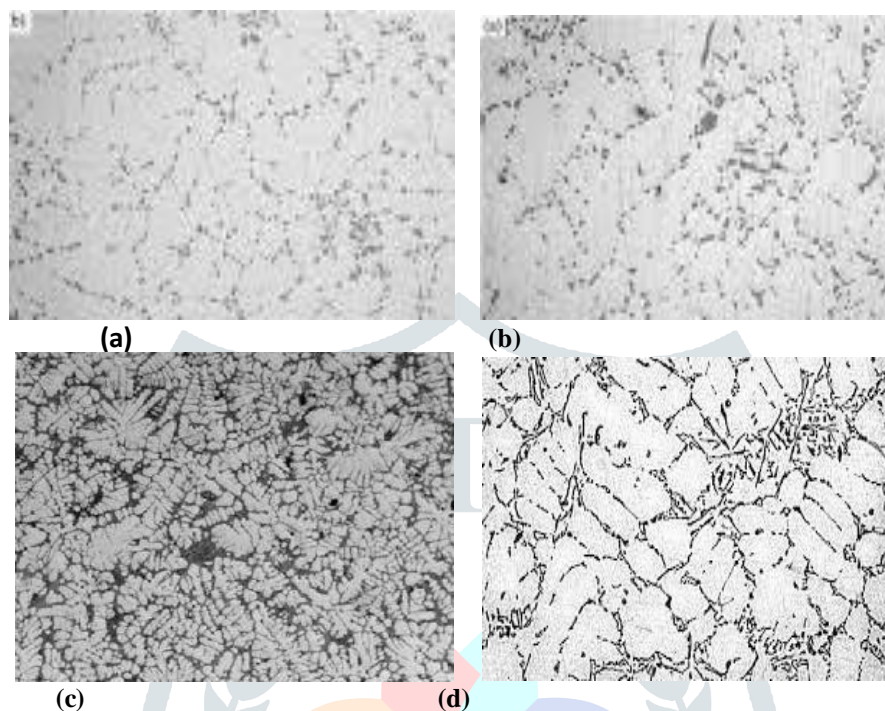


Fig 3.1 (a). Microstructural images of (a) As cast Al7075; (b) Al7075 with 1 wt.% Gr, 1 wt.% ESP and 2 wt.% TiC; (c) Al7075 with 1 wt.% Gr, 1 wt.% ESP and 4 wt.% TiC; (d) Al7075 with 1 wt.% Gr, 1 wt.% ESP and 6 wt.% TiC

3.2 Tensile Strength:

To study the tensile behavior and to determine the yield strength and the ultimate tensile strength, tensile tests were conducted for all the prepared samples as per ASTM E8M-15a standards. The variation of tensile strength with the increase in reinforcement particle is as shown in figure 3.2. From the graph it is seen that the ultimate tensile strength increases with increase in weight percentage of reinforcement particle. The improvement in tensile strength is mainly because of hard TiC particle in the matrix and also because of good bonding between the matrix and reinforcement phase.

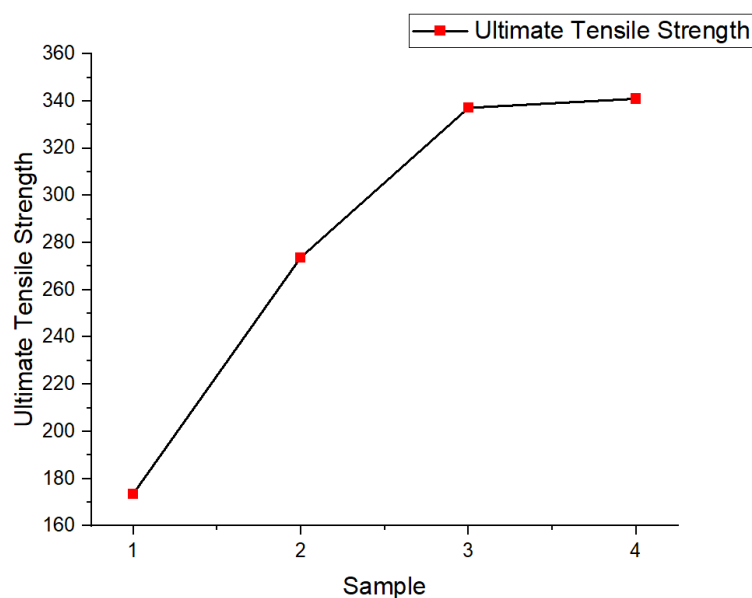


Fig.3.2 Variation of Ultimate tensile strength with increase in wt % of Reinforcement materials

3.3 Hardness:

The hardness test was carried out by using 5 mm diameter ball indenter and applying a constant load of 500 kg for about 30 second. Three readings were taken on every individual specimen and the result is averaged to overcome the error. The variation of hardness

value with variation in reinforcement weight percentage is shown in figure 3.3. The hardness value increases with increased weight percentage of reinforcement particle. It is evident that presence of TiC particles highly influences on the hardness of Al7075 MMC.

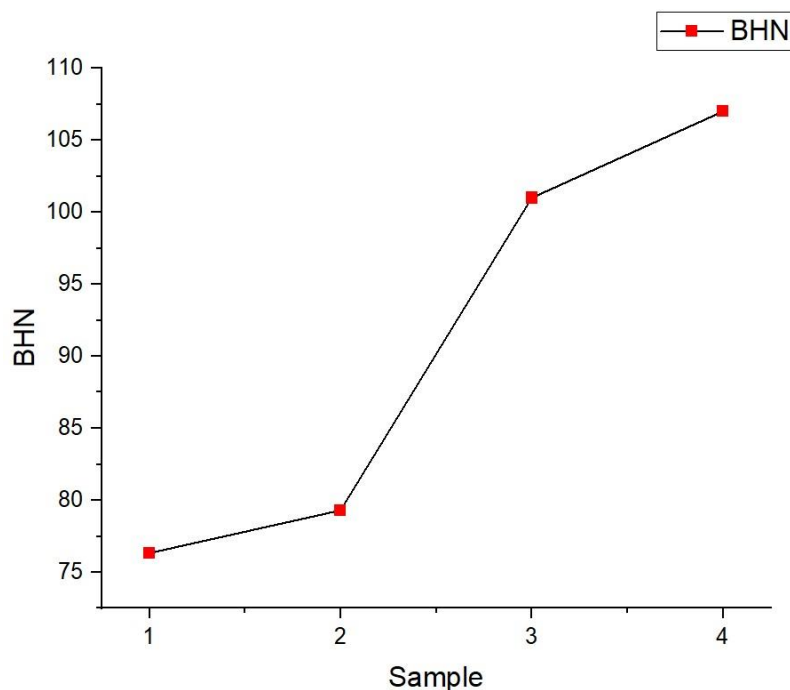


Fig.3.2 Variation of Brinell hardness number with increase in wt % of Reinforcement materials

4. Conclusion:

In the present study incorporation of Gr, ESP and TiC reinforcement particle in the Aluminium 7075 Matrix phase was successfully carried out by stir casting process and the following conclusion is derived.

1. Microstructural analysis of the Al7075 MMC with different weight percentage of reinforcement particle revealed that the reinforcement particles are uniformly distributed in the matrix phase.
2. The addition of reinforcement particle in the Al7075 matrix phase resulted in increase in the ultimate tensile strength when compared with Aluminium 7075 alloy.
3. Hardness of the hybrid MMC increases with the increased weight percentage of reinforcement particles.

References:

- [1] R. Deaquino-Lara, I. Estrada-Guel, G. Hinojosa-Ruiz, R. Flores-Campos, J.M. Herrera-Ramírez, R. Martínez-Sanchez, Synthesis of aluminum alloy 7075-graphite composites by milling processes and hot extrusion, *Journal of Alloys and Compounds* 509S (2011) S284–S289
- [2] Amba Chaithanyasai, Pragnya Rani Vakchore, V Umasankar, The micro structural and mechanical property study of effects of Egg Shell particles on the Aluminum 6061, *Procedia Engineering* 97 (2014) 961 – 967
- [3] Yixiong Liu, WeipingChen, ChaoYang, DezhiZhu, YuanyuanLi, Effects of metallic Ti particles on the aging behavior and the influenced mechanical properties of squeeze-cast (SiCpTi)/7075Al hybrid composites, *Materials Science&EngineeringA620(2014)190–197*
- [4] I. Estrada-Guel, C. Carreno-Gallardo, D.C. Mendoza-Ruiz, M. Miki-Yoshida, E. Rocha-Rangel, R. Martinez-Sanchez, Graphite nanoparticle dispersion in 7075 aluminum alloy by means of mechanical alloying, *Journal of Alloys and Compounds* 483 (2009) 173–177
- [5] J. Jebeen Moses, I. Dinaharan, S. Joseph Sekhar, Prediction of influence of process parameters on tensile strength of AA6061/TiC aluminum matrix composites produced using stir casting, *Trans. Nonferrous Met. Soc. China* 26(2016) 1498–1511
- [6] Mohammed Imran, A.R. Anwar Khan, Sadananda Megeri, Shoaib Sadik, Study of hardness and tensile strength of Aluminium-7075 percentage varying reinforced with graphite and bagasse-ash composites, *Resource-Efficient Technologies* (2016)
- [7] Kannan, C., Ramanujam, R., Comparative study on the mechanical and microstructural characterization of AA 7075 nano and hybrid nanocomposites produced by stir and squeeze casting, *Journal of Advanced Research* (2017)
- [8] Mr. Vikas Verma, Mr. Nishant, Mr. Mandeep Gill, Effects of waste eggshells and silicon carbide addition in the synthesis of aluminium alloy 6061 hybrid green metal matrix composite, *International Research Journal of Engineering and Technology (IRJET)*, Volume: 05 Issue: 06 | June-2018
- [9] S.Divagar, M.Vigneshwar, S.T.Selvamani, Impacts of Nano Particles on Fatigue Strength of Aluminum Based Metal Matrix Composites for Aerospace, *Materials Today: Proceedings* 3 (2016) 3734–3739
- [10] M Nagendra Naik, K Dharma Reddy, P Venkata Ramaiah, B Venkata Narayana, G Bhanodaya Reddy, Exploration of Mechanical behaviour and Wear Behaviour of Al4C3 Reinforced Aluminium Metal Matrix Composites, *Materials Today: Proceedings* 4 (2017) 2989–2998