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Evaluation of Mechanical Properties of Al 7075 reinforced with WC Metal Matrix Composites

Arun Babu Nallabelli[1], Balu Naik Banoth[2], B.Ravi[3] and G.Raja kumar[4]

[1]Associate Professor, Dept of mechanical engg, KITS, Khammam, Telangana, India
[2]professor, Dept of mechanical engg JNTUH, Hyderabad, Telangana, India
[3,4]Associate Professor, Dept of mechanical engg, SBIT, Khammam, Telangana, India

* Corresponding author. Tel: 09393007431, E-mail: nallabelli.arunbabu@gmail.com

Abstract— Metal matrix composites are mostly used in components of various parts of industrial equipment because of their excellent properties like high strength to weight ratio and high impact value and fracture toughness while compared to the conventional material. Due to the concepts of high strength to low weight ratio, the aluminum primarily based composites are gradually being applied as a part of the transport, aerospace, marine, automobile industries. The usually applied reinforcing materials for those composites are silicon carbide, tungsten carbide, aluminum oxide and graphite as particles. The Evaluation of mechanical properties of Al7075 reinforced with WC Metal Matrix Composites was explored. Al 7075 was extensively applied in aircraft engine and wings. Because of their higher hardness, higher strength, excellent wear resistance, and high-temperature corrosion protection, it is in need of further enhancement of properties for increasing its applicability. Tungsten carbide is attractive as reinforcement because it has high hardness, high modulus of elasticity and excellent thermal stability. In the present work, the metal matrix composite are prepared by using stir casting technique. The development of Al7075 alloy based metal matrix reinforced with varying steps of tungsten carbide by 1.5wt%, 3wt%, 4.5 wt%, 6 wt% and also experimental study was carried out to investigate the mechanical properties such as hardness, tensile strength, impact strength. As a result hardness, tensile strength increases with the increase in the wt% of WC, and impact strength decreases with the increase in WC particulates.

Keywords— Metal Matrix Composite (MMC), stir casting, Al7075, Reinforcement, Hardness, Tensile strength, Impact strength.

I. INTRODUCTION

Metal matrix composites (MMCs), like most composite substances, offer stronger properties over monolithic substances, inclusive of higher electricity, stiffness, hardness and weight savings. Aluminum based metal matrix composites are concentrating more for engineering applications since it is the class of light weight and high performance aluminum centric materials system. Now a day's AMMCs gain a worldwide focus in the field of research for aerospace and automotive industries because of their enhanced properties like high strength, lightweight, low thermal conductivity, excellent wear resistance and high operating temperature [1]. Heat treatable aluminum alloys such as Al2021, Al6061, and Al7075 were widely used due to its higher strength to weight ratio and MMC's prepared with these alloys exhibit superior elevated temperature properties [2-3].

Particulate composites are widely used in composites development because they are cheap and easy to manufacture. Particulate reinforced MMCs have recently found special interest because of their specific strength and specific stiffness at room or elevated temperatures. Ceramic particles or fibers are commonly used as reinforcement. The simple reason of metals strengthened with hard ceramic particles or fibers are progressed residences than its authentic fabric like strength, stiffness, put on resistance and many others. It can also improve strength to weight ratio of the composites. Fabrication of composites is commonly done by the stir casting among the different processing techniques available, because it is simplest and cheapest form[4-6].In recent days, considerable work has been done on tungsten carbide reinforced metal matrix composites Tungsten carbide, well known for its

Exceptional hardness, refractory metal with specific density of 15.8g/cc finds application in cutting tool, extrusion dies and drilling of components at elevated temperatures the tungsten carbide is used as reinforcement in Al7075 matrix composites with different weight percentages, The fabrication is done by stir casting process. It become observed that increasing the WC content in the matrix fabric, ended in widespread improvement in mechanical residences like hardness, tensile strength in references [7-9] Hence, the present work focuses on processing of Al7075-WC based composite using conventional stir casting technique. Work mainly focuses on studying the Mechanical properties of the prepared composites.

2. MATERIALS

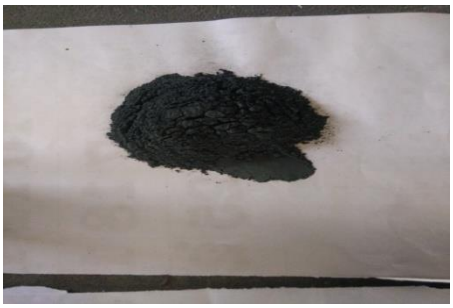
2.1 Aluminum 7075:

The material used in the present study is Al 7075 whose chemical composition is listed in Table 1. It consequently has a low melting point 660°C. The molten metallic has excessive fluidity and solidifies at regular temperature. It possess excellent mechanical properties, such as good corrosion resistance, good deformation behavior, high specific modulus, tensile strength, hardness, good wear resistance and low coefficient of thermal expansion.

2.2 Tungsten carbide:

Tungsten carbide (WC) is commonly known as carbide. It is an inorganic compound having Tungsten and carbon atoms in equal amount Fig. 1 which is colloquially called carbide. In its most basic form it is a fine gray power. In the present investigation WC of 5 microns size is used as reinforcement in preparing the MMCs. The wt% of WC was varied from 1.5 to 6 wt% in steps of 1.5 wt%. Tungsten Carbide (WC) is having very high hardness, density, tensile strength and modulus of 1630 Mohr's scale, 14.9 g/cc, 5000 MPa and 629 GPa respectively. It is widely used in industrial machinery, tools, abrasive and also in high hardness. It is basically used in the manufacture of friction pads and liner tubes in furnace etc. The Tungsten carbide is approximately three times stiffer than steel, and much denser than steel

Fig 1: Tungsten carbide (WC) particulates



2.3 Preparation of Al7075-WC composites

In the present study, stir casting method is used for the preparation of metal matrix composite. In this process Al 7075 bars are cut into small ingots. These ingots are placed in Graphite crucible in which it is kept in induction furnace. The ingots are melted at a temperature of 800^0C, after effective degassing predetermined mass of preheated WC of 1.5wt%, 3wt%, 4.5wt%, 6 wt% at suitable intervals of 1.5wt% in steps of 4 is added into the alloy and stirred continuously in order to achieve uniform distribution of particles in the matrix. After the mixing of the reinforcements (WC) with the base matrix, the crucible is taken out from the furnace and the molten metal is poured into the mould die and allowed to solidify. After the solidification, the casted specimen is removed from the mould and machined as per ASTM standards for testing.

Fig 2: Stir Casting Set-up used for fabrication of Composite Plates (Al 7075/WC)

Table 1: Chemical composition of Al7075 matrix used in the present study

Chemical composition	Cu	Mg	Si	Fe	Mn	Zn	Cr	A1
Al7075	1.16	1.92	0.119	0.132	0.003	4.57	0.005	Bal

Table-2: Weight percentage of Al 7075/WC Aluminum Metal Matrix Composites (AMMCs)

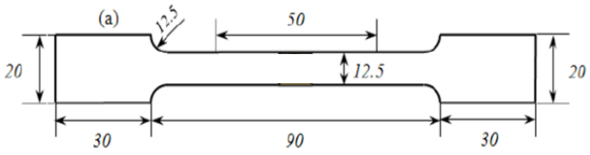
S.No	A	B	C	D	E
composition	Al 7075	Al7075+1.5%WC	Al7075+3%WC	Al7075+4.5%WC	Al7075+6%WC

3. Preparation of specimen for testing:

3.1 Tensile Test

The tensile tests were conducted on UTM at room temperature. The samples had been prepared in step with ASTM E8M. The tensile test of the alloys were decided by means of performing the anxiety take a look at on Regular flat tensile specimens. The machining involves facing and turning. Before to testing, the surface of the specimens turned into finished by means of using 400 grid emery sheets. a normal tensile specimen as in step with ASTM well known is shown in

Fig 3. **Tensile test specimen dimension**



Before Tensile specimens

After tensile specimens

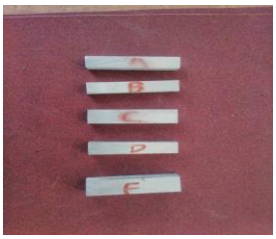
3.2. Micro hardness

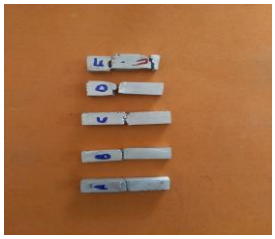
The Vickers micro hardness of solid Al7075 base matrix and their composites containing 1.5-6 wt% of WC are evaluated using diamond indenter at an implemented load of 100N.

3.3 Impact Test:

In an impact test a notched of material, arranged either as a cantilever or as a simply supported beam, is broken by a single blow in such a way that the total energy required to fracture it may be determined. The power required to fracture a material is of importance in cases of -shock loading when a component or structure may be required to absorb the K.E of a moving object. Energy absorbed is the energy which is absorbed by the material. The energy is

calculated in joules. The energy absorbed is calculated the energy available at the end. The energy absorbed can be found with the help of Charpy impact tests.





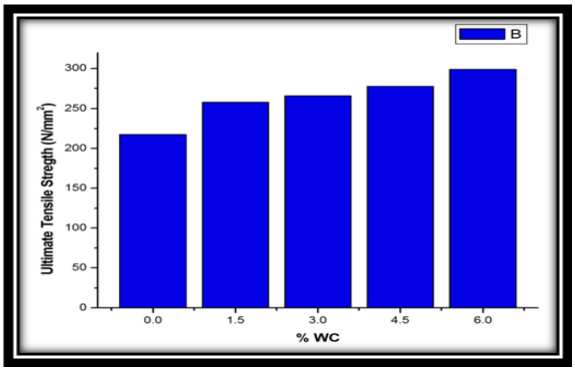
Before Impact **After Impact**

4. Result and discussion

4.1: Ultimate tensile strength:

The tensile strength outcomes of the Al 7075/WC composites are proven in Figure 4.it is observed that final tensile Strength is elevated by means of growing the percentage of the WC particles inside the composite. that is because of higher interfacial bonding among the matrix and the reinforcement which transfers and distributes the load from the matrix to the reinforcement. Therefore the reinforcement particle has a tendency to bear the whole load that has been acted upon the matrix. The addition of WC particles within the matrix induces a great deal strength to matrix alloy via offering extra resistance to tensile stresses. The thermal mismatch among matrix and the reinforcement causes better dislocation density in the matrix and load bearing potential of the tough debris which subsequently increases the composites electricity [10.]

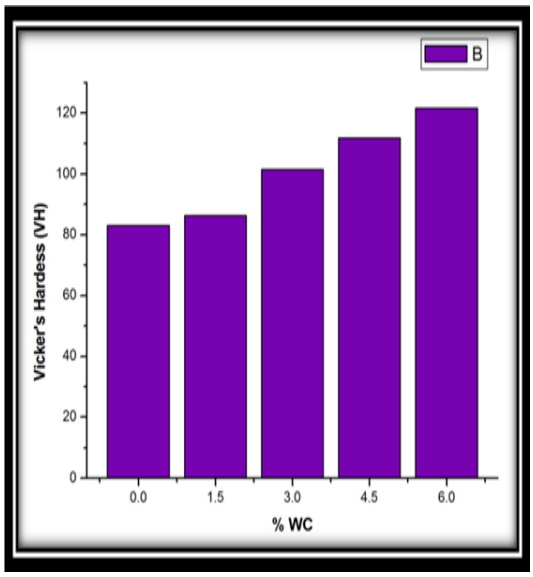
Fig 4: the effects of percentage of WC particles on the Ultimate Tensile Strength of MMCs



4.2. Micro hardness

The hardness consequences of the Al 7075/WC composites are proven in figure.5 .The hardness cost is elevated by way of growing the wt% of WC reinforcement debris in the composites, as the presence of hard reinforcement debris on the floor resists the plastic deformation of the material. The energy of the grain obstacles increases to most degree and dislocation of atoms is decreased by means of increasing the wt% of reinforcement, which offers power to the matrix and thereby hardness of the composite gets improved. The same phenomenon is determined [11]

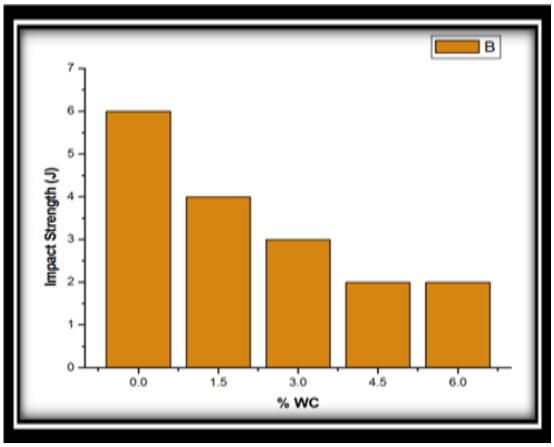
Fig 5: the effects of percentage of WC particles on the hardness of MMCs



4.3: Impact Strength:

The impact strength of the Al 7075/WC composites are shown in Fig 6. It is observed that the toughness is decreased by increasing the weight percentage of the WC particles in the composite. This is due to the addition of WC in various percentages with aluminum, the brittleness of the material also increased. Because of high brittleness, the impact strength of the material is decreased.

Fig 6: The effects of percentage of WC particulates on the toughness of MMCs



Conclusions:

The Al 7075/WC composites were produced by stir cast route with different weight percentage of mechanical properties was evaluated. From this study, the following conclusions are derived

- In this Al 7075 with WC Metal matrix composite successfully completed
- The micro hardness of the composites was Enhancing from 83 HV to 121 HV with increasing weight percentage of WC particles.
- The WC reinforcement has enhanced the tensile strength of Aluminum Matrix Composites (AMCs) from 217 MPa to 298 MPa.
- The Wt% Of WC reinforcement has Incraesed the impact strength of Aluminum Matrix Composites (AMCs) Reduced from 6 J to 2 J.

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