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Fabrication and Friction Stir Welding of Aluminum 7075/Wc Metal Matrix Composites

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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. This paper is exclusively focused on the preparation procedure of Al-wc metal matrix composite and fabricated by using friction stir welding process .testing the prepared weld plates with different weight percentage of tungsten carbide testing of various mechanical properties like tensile strength, hardness, impact strength along with the micro structure evaluation of the composite at the welded portion. The sample composites prepared is of different compositions from (1.5 to 6% wc) Also the properties are checked on a welded and non-welded samples of each type.

Keywords: Metal Matrix Composite (MMC), FSW Process, Al7075, Reinforcement, Hardness, Tensile strength, Impact strength.

I.INTRODUCTION

Friction stir welding is widely used in welding heat treatable aluminum alloys and it is a new technology in the high performance aerospace automotive industries and marine applications. The process is used for the joining of two similar and dissimilar metal pieces at molecular level without melting [1]. Joining of materials is one of the key aspects of production departments. Every material is different to one another and hence possess distinct features and characteristics. While arc welding is still widely preferred technique, many other type of welding techniques proved to be more effective considering the requirements in production sector. The need arises to develop new technique to join different metals together and to attain desired properties. Such a technique developed is Friction Stir Welding process by The Welding Institute (TWI). This technique is however not

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widely used because of the certain disadvantages it has. But it has proved to be most efficient and effective welding technique till date and aerospace has been benefitted by the invention of this Friction stir welding process. FSW tool is used to perform friction stir welding process and on simultaneous performance of rotating and sliding in the direction of laying weld [2]. They did the experiment on butt joining of AA6061 aluminum alloy and concluded that, the Square tool pin profile followed by Triangular pin profile gives better result compared to other tool profiles [3]. Many researchers are interested in many topics like variation of micro hardness, material flow, material location, temperature distribution, residual stresses, and so forth, across the interface of the abutting materials and their consequent effect on the mechanical properties [4–6]

II. MATERIALS:

2.1 Aluminum 7075:

The material used in the present study is Al 7075 whose chemical composition is listed in Table 1. It therefore has a low melting point 660°C. The molten metal has high fluidity and solidifies at constant 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.

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

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.

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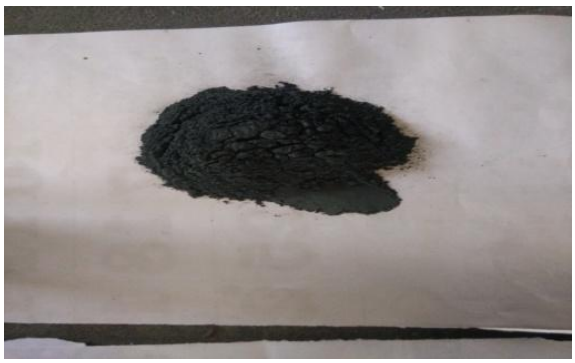

Fig 1: Tungsten carbide (WC) particulates

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.

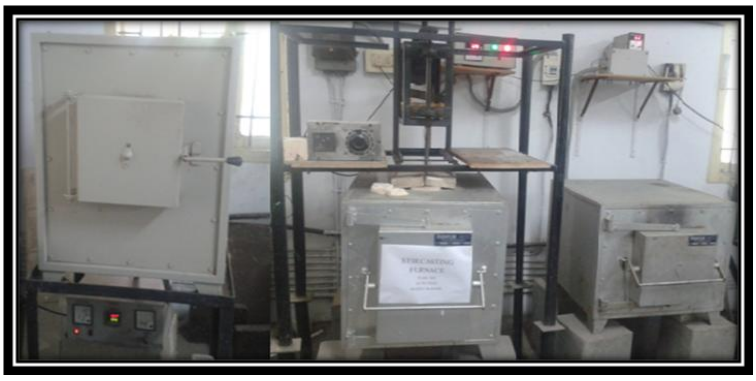

Fig 2: Stir Casting Set-up used for fabrication of Composite Plates (Al 7075/WC)

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

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

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Fig 3: Metal Matrix composite plates

2.4.: Preparation of welding plates:

2.4.1: Frictions stir welding:

The Friction Stir welds consisting of 7075 aluminum alloy and Tungstone carbide metal matrix composite welds were successfully produced at the Friction welding which is available at balanagar Hyderabad.. The dimension of the weld coupon was 175 x 120 x3 mm and butt joint configuration was considered in this research. The plates were cleaned with acetone to degrease before the welding procedure. The Friction Stir Welds were produced by constant the rotational speed, welding speed, tilt angle and tool profile. .the following table shows the designations of welds.

S.NO	Rotational speed (RPM)	Welding speed (Mm/min)	Tilt angle	Tool pin Profile
A	1120	50	2	Round
B	1120	50	2	Round
C	1120	50	2	Round
D	1120	50	2	Round
E	1120	50	2	Round

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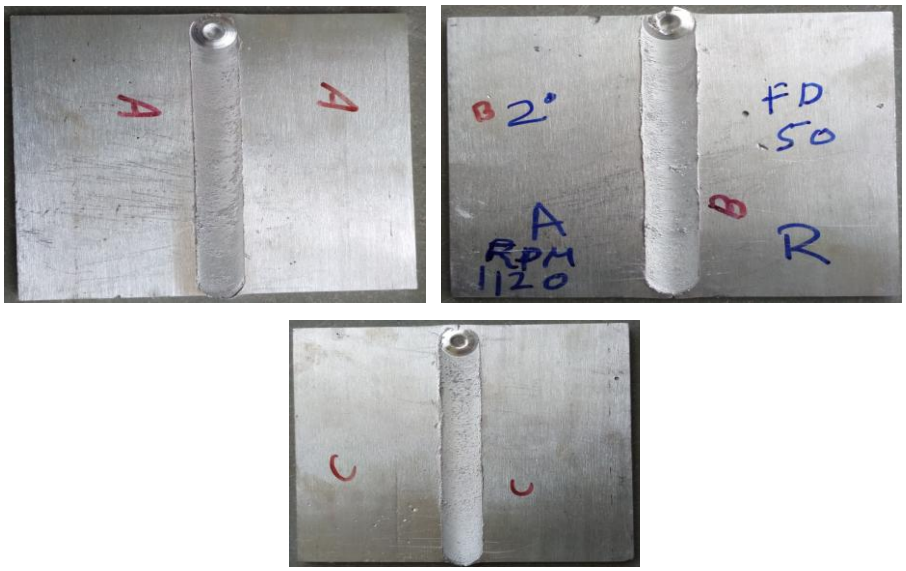

Frictions stir Weld Plates

IV. RESULT AND DISCUSSION

4.1: Microstructure

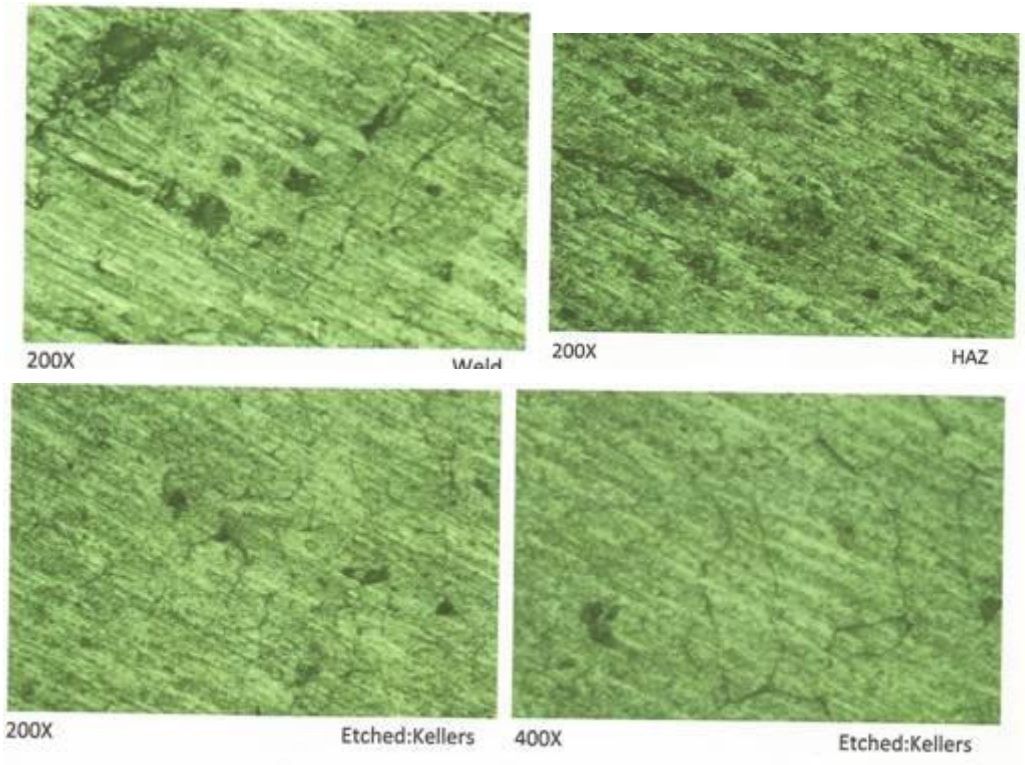

Fig 4: Photographs of Microstructure of welds 1120 rpm and feed rates of 50, mm/min 2^0 tool tilt angle and tool pin profile(1.5% wc,3% wc, 4.5%wc, 6%wc)

Heat affected zone shows fine intermetallic compounds and uniform distribute silicon carbides in weld to Al solid solution. No cracks and blow holes are observed Microstructure consists of non-uniform grains of silicon

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carbide with inter metallic compounds in aluminum matrix and free from eutectic melting. No micro porosity, stringers and segregations .

4.2: Mechanical properties

4.2.1: Ultimate tensile strength:

The tensile strength outcomes of the Al 7075/WC composites are proven in Figure 5.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.]

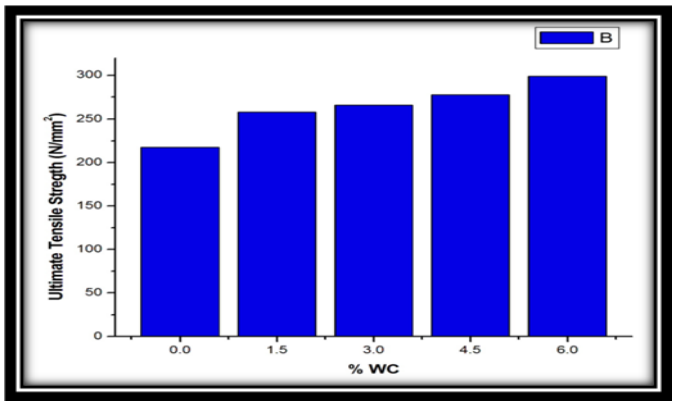

Figure 5: The effects of percentage of WC particles on the Ultimate Tensile Strength of MMC welds

4.2.2. Micro hardness:

The hardness consequences of the Al 7075/WC composites are proven in figure.6 .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

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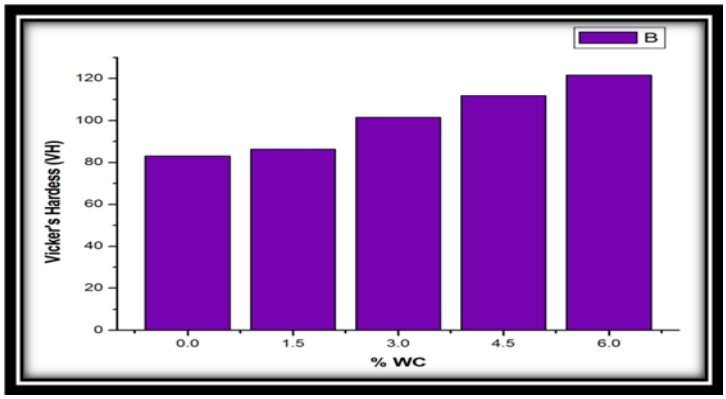

Figure 6: The effects of percentage of WC particles on microhardness of MMC welds

4.3: Impact Strength:

The impact strength of the Al 7075/WC composites are shown in Fig 7. 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.

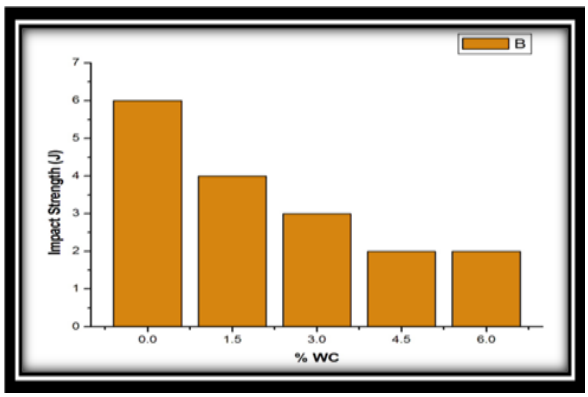

Figure 6: The effects of percentage of WC particles on Impact strength of MMC welds

V. CONCLUSIONS

The Al 7075/WC composites were produced by stir cast route with different weight percentage of microstructure and mechanical properties was evaluated. And also fabricated friction stir welding plates from this study, the following conclusions are derived.

1. In this Al 7075 with WC Metal matrix composite successfully completed
2. Different weight percentages of tungsten carbide fabricated friction stir welding plates successfully.

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3. The micro hardness of the composites welds was Enhancing from 83 HV to 121 HV with increasing weight percentage of WC particles.

4. The WC reinforcement has enhanced the tensile strength of Aluminum Matrix Composites (AMCs) welds from 217 MPa to 298 MPa.

5. The Wt% Of WC reinforcement has Incraesed the impact strength of Aluminum Matrix Composites (AMCs)welds Reduced from 6 J to 2 J.

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