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Studies on Non Destructive test of friction stir welding of AA 7075-wc metal matrix composites welds

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ABSTRACT

Friction stir welding (FSW) is a relatively new solid-state joining process. This joining technique is energy efficient, environment friendly, and versatile. In particular, it can be used to join high-strength aerospace aluminum alloys and other metallic alloys that are hard to weld by conventional fusion welding. In this work, similar friction stir welding between 7075-WC aluminum metal matrix welds alloy was investigated. The Friction stir welding between these two similar metals were produced at different tool rotational speeds with constant feed rate. The tool rotational speed was varied between 700 and 1500 rpm. The visual inspection and the x-ray radiographic testing techniques were conducted on the welds to ascertain the joint integrity before characterization to have an idea of the quality of the welds. Chemical analysis was carried out to attain the chemical composition at the weld nugget.

Keywords: Metal Matrix Composite (MMC), stir casting, Al7075, Reinforcement, Visual inspection, Radio graphy test

I.INTRODUCTION

Fairly modern technique of welding materials together has established itself as an increasingly popular procedure in the manufacturing industry. This method of welding is formally known as Friction Stir Welding (FSW).FSW has shown great results for joining metals together without significantly altering the original properties of the parent metals. FSW is a solid-state joining process which is applicable to all metals and plastics. The popularity of this welding procedure is due to the fact that unlike conventional welding, it does not create brittle bonds caused by the localized heating of metal and also has narrow Heat Affected Zone (HAZ). The localized heating present in conventional welding techniques effectively alters the chemical composition within that heated section. This severely alters the mechanical properties of the metal and further heat treatment is required to resolve this inadequacy. The advantage of FSW is that the heat is generated internally via a mechanical method and therefore localized heating Major aspects affecting the quality of the welds are the combinations of the rotational speed and feed rate parameters. These are responsible for generating the heat and the stirring mechanism used to effectively join the materials. These welding parameters employed in FSW process have vast effect on the quality of the welds produced and are known to be the two most important welding parameters which strongly affect the joint integrity [3]. The rotation of the tool results in the stirring and mixing of the material around the rotating pin, while the translation of the tool moves the stirred material

IJARSE
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from the front to the back of the pin and finishes the welding process. A major weld quality aspect in question is how to be able to detect the internal defect formed in the weld and a Non-Destructive Testing (NDT) technique is most appropriate in this regard. Non-Destructive Testing rose from the necessity to detect flaws within components to avoid detrimental and repetitive failures. NDT is a wide group of analysis techniques used in science and industry to evaluate the characteristics of a material or component without causing Damage. A. K. M. Patel et al.,[5] have studied the influence of Friction Stir Welding Parameters on Tensile Strength of AA8011 Aluminum. S. M. Bayazida et al.,[6] have investigated the friction stir welding parameters of 6063-7075 Aluminum alloys by Taguchi method s. R.I. Rodriguez et al.,[2]have studied the microstructure and mechanical properties of friction stir welded dissimilar butt joints of6061-to-7050 aluminum alloys were evaluated.Sadeesh P et al.,[3] have studied the joining of dissimilar AA2024 and AA6061 aluminum plates of 5mm thicness was carried out by friction stir welding (FSW) technique.M. Ilangovan et al.,[4] have studied the microstructure and tensile properties of friction stir welded dissimilarAA606 and AA5086 aluminium alloy joints.

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.

IJARSE
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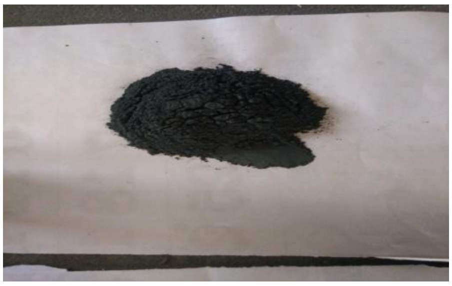

Fig 1: Tungsten carbide (WC) particulates

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.

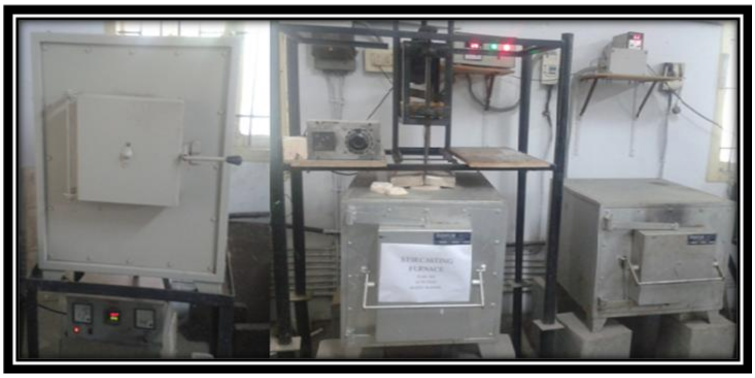

Fig 2: Stir Casting Set-up used for fabrication of Composite Plates (Al 7075/WC)

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

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.

IJARSE
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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

Weld Plates

III. RESULT AND DISCUSSION

3.1: Visual inspection

Fig 4: Photographs and Visual inspection of welds 1120 rpm and feed rates of 50, mm/min 2^0 tool tilt angle and tool pin profile

Due to the nature of the surface appearances of friction stir welded samples, it was difficult to observe any surface defects. No significant cracks, wormhole or other surface deformities were observed in any of the samples produced.

3.2 Radiographic testing

The results of the radiographic tests conducted on all the welds produced at 600 rpm and feed rates of 50, 150 and 300 mm/min are hereby presented in Table II. This includes the xray radiographs and the comments on each sample examined

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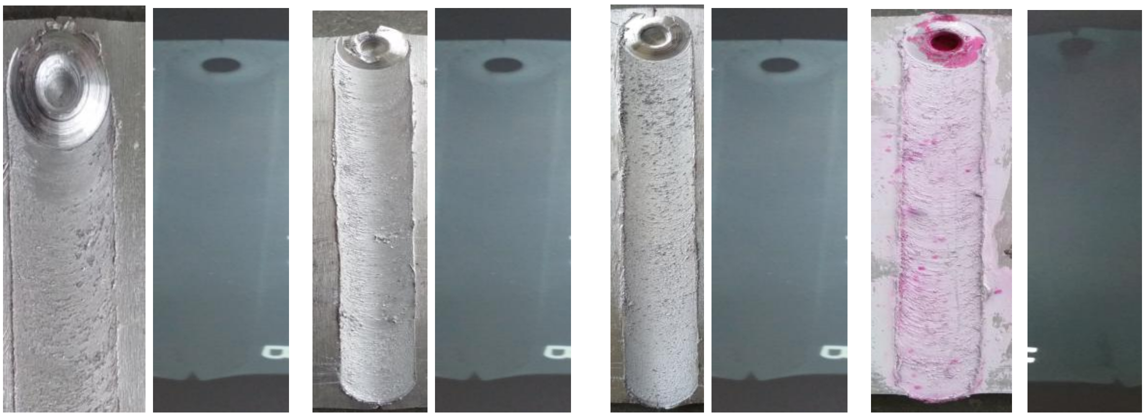

Fig5: Photographs and Radiographs of welds 1120 rpm and feed rates of 50, mm/min 2^0 tool tilt angle and tool pin profile

Although no defect was found on the surface of the welds through visual inspection, from the x-ray radiographs presented in Table I, it was observed that these welds are characterized with incomplete fusion of both materials joined and wormhole defect was also noticed.

IV. CONCLUSION

Non-Destructive testing techniques are visual inspection and x-ray radiography were successfully conducted on welds produced at various parameter combinations. It can be concluded that the visual inspection of the welds is not the best technique as it was found that although all the welds passed this test and appeared as defect-free welds, the x-ray radiographic testing technique successfully detected the defects present in the welds and can be said to be appropriate in this regard. Only about 44% of the welds were defect-free. Good mixing and metallurgical bonding were achieved in the defect-free welds as revealed in the microstructure of the interfacial regions. An optimum rotational speed for producing defect-free welds of aluminum and copper was found to be 1120 rpm.

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