Production of hybrid aluminium matrix composite with welding slag and flux by using stir casting technique

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Abstract: The objective of this work is to emphasize different compositions of weight percentages such as 5.0%, 7.0% and 9.0 % of welding slag electrode E6013 and 4% of MIG welding flux (MgO) with Aluminium alloy Al6061 by using stir casting technique. The cast samples were subjected to Rockwell hardness test following the standard. The experimental results revealed significant changes in each composition.

Keywords: Aluminium alloy Al6061, welding electrode E6013, MIG welding flux (MgO), Rockwell hardness test.

1. Introduction

Nowadays Metal matrix composites (MMC) have immensely expanding demand because of its great mechanical and material properties [1]. Aluminium based Metal Matrix Composites (MMC) are increasing critical enthusiasm inside the application field of aviation, car and sports hardware fabricating businesses, because of their fascinating mechanical and material properties viz. high quality, high solidness, damping limit, low weight, high warm conductivity, diminished thickness, enhanced scraped area, wear protection limit and low thermal expansion compared with unreinforced alloy [2]. Inexpensive debris is used as a reinforcing material to minimize the cost of fabrication. In modern years aluminium metal matrix composites have been used in variety of general and special applications owing to their superior specific strength, high temperature capability, specific stiffness, lower coefficient of thermal expansion, better wear resistance, enhanced dimensional stability and amenability to conventional metal forming techniques [3-4]. Machinability of aluminium MMCs has received significant attention because of high tool wear connected with machining [5-13]. Many researchers and practitioners worked in the field of producing Aluminium Matrix Composites (AMC) due to its vital need to the manufacturing sectors very few are listed below;

Anilkumar et al. [14] have detailed that the mechanical properties of fly-ash debris fortified aluminium combination (Al 6061) composites tests handled by stir-casting route. Three arrangements of composites with fly-ash debris molecule sizes of 4-25, 45-50 and 75-100 µm have been utilized. It has been discovered that the rigidity, compressive quality and hardness of the aluminium combination (Al 6061) composites diminished with the expansion in molecule size of strengthened fly-ash. Increment in the weight portions of the fly-ash remains particles expanded a definitive rigidity, compressive quality, hardness and lessened the malleability of the composite.

Kumar et al. [15] prepared aluminium based (Al 6061) composites through silicon carbide and in addition fly-ash as fortifications by changing mass division of Al 6061 and fly-ash debris (9, 12, and 15%) and keeping up 9% silicon carbide consistently. They acquired superb enhancements in mechanical properties, for example, hardness, compression and tensile through ascent in wt % of fortification.

Behera et al. [16] manufactured LM6 aluminium alloy-oriented composities toughened with diverse weight portions of particulate silicon carbide using stir-cast method and observed the outcome of toughened percentages on forgeability. They reported the growth in weight porsions of particulate reinforcement in the matrix metal to have enhanced the mechanical property such as hardness. It also caused poor forgeability.

Mahdavi and Akhlaghi [17] prepared Al6061/SiC/Gr hybrid composite having 20% volume of particulate silicon carbide and in addition 13% volume of uncoated particulate graphite utilizing in-situ process. It has been noticed that the amplified silicon carbide particulate size and also graphite substance yielded in upgraded compressibility of powder blends and also declined hardness of the hybrid composites.

Jayashree et al. [18] looked into the impact of silicon carbide on mechanical and wear behaviour of stir-cast aluminium MMCs. They detailed that mechanical and tribological properties of the composites enhanced with silicon carbide particles and prescribed the composites for a few applications like aviation, vehicle, space, submerged and transportation.

Admile et al. [19] have endeavoured to give a broad writing survey on the general execution of fly-ash debris strengthened composites manufactured by stir-casting. They have checked on writing in every class as indicated by the key factors and gave a reasonable diagram of the use of fly-ash as a fortifying specialist in various aluminium combination lattices alongside its unmistakable execution.

From the literature survey, it becomes clear that the preparations of Al6061 based composites were prepared by many researchers but still, there remain some research gaps. So in this research work welding slag and welding flux (MgO) is reinforced with Al6061 of various compositions and its mechanical property hardness is investigated.

2. Materials and methods

Aluminium alloy 6061 is widely used in manufacturing industries due to its superior advantages such as strength, good toughness, good surface finish, excellent corrosion resistance to atmospheric conditions, good corrosion resistance to sea water, can be anodized, good weldability and brazability, good workability, widely availability. The chemical composition of Al6061 is given in Table 1 and the physical property is given in Table 2.

Table 1: Typical composition of aluminium alloy 6061

Component	Composition (wt.%)
Magnesium	0.8-1.2
Silicon	0.4 – 0.8
Iron	Max. 0.7
Copper	0.15-0.40
Zinc	Max. 0.25
Titanium	Max. 0.15
Manganese	Max. 0.15
Chromium	0.04-0.35
Aluminium	Rest

Table 2: Physical Properties

Property	Value
Density	2.7 g/cm^3
Melting point	580^{0}C
Modulus of elasticity	70-80GPa
Poisons ratio	0.33

E6013 is a high titanic coated electrode. This electrode was primarily designed to provide good wetting and shallow penetration for thin sheet metal applications (using smaller diameter electrodes), but with sufficient penetration for welding medium gauge steel. As a result, E6013 is an all purpose electrode that provides a soft steady arc which is easily regenerated, easy slag control for vertical-down welding, low spatter and a beautiful bead appearance. E6013 electrodes may be used in any position with AC or DC (straight or reverse polarity). E6013 electrode is commonly used for automobile bodies, truck frames and bodies, ornamental iron, metal furniture, farm implementations, machinery guards, storage tanks, or wherever appearance is important or desirable.

The flux magnesium oxide (MgO), which are mainly used in MIG Welding are kept in powder form. The amount of MgO varies from 5-20% according to the type and use of the flux while for some specific products can go up to 40%. Its main role is the adjustment of the slag properties such as the viscosity and the refractoriness.

3. Processing of Composites:

The Aluminium Al6061 matrix composites were fabricated by mixing the accurately weighed quantities of welding slag electrode E6013 and MIG welding flux (MgO) The above mixture was slowly added, and stirred. Stirring was

carried at 650rpm about 50 seconds until interface between the particle and the matrix promoted wetting and the particles were uniformly dispersed. Melt formed was solidified in a permanent mould to obtain the flat plate samples. The different compositions were cast as mentioned above by stir casting method. The Stir casting setup is shown in the figure 1.

Figure 1: Aluminium stir casting setup

4. Results and Discussion

The cast composites samples were machined to specified dimensions as per test standards and the hardness test was done.

4.1. Rockwell Hardness Test

Rockwell hardness test was employed on the cast samples following the test standard ASTM. Four samples were tested for each composition and mean value was taken as the Rockwell hardness text result. The results for hardness test are as follows;

Table 3: Rockwell hardness number of the AMC

Sl. No.	Sample	**Rockwell Hardness (HRB)** at 100kgf load and 1/16" ball indenter
1	Al 6061	56
2	Al 6061 +5% of Welding Slag+4% of welding flux	56.3
3	Al 6061 +7% of Welding Slag+4% of welding flux	57.2
4	Al 6061 +9% of Welding Slag+4% of welding flux	57.9

Figure 2: Rockwell hardness testing apparatus

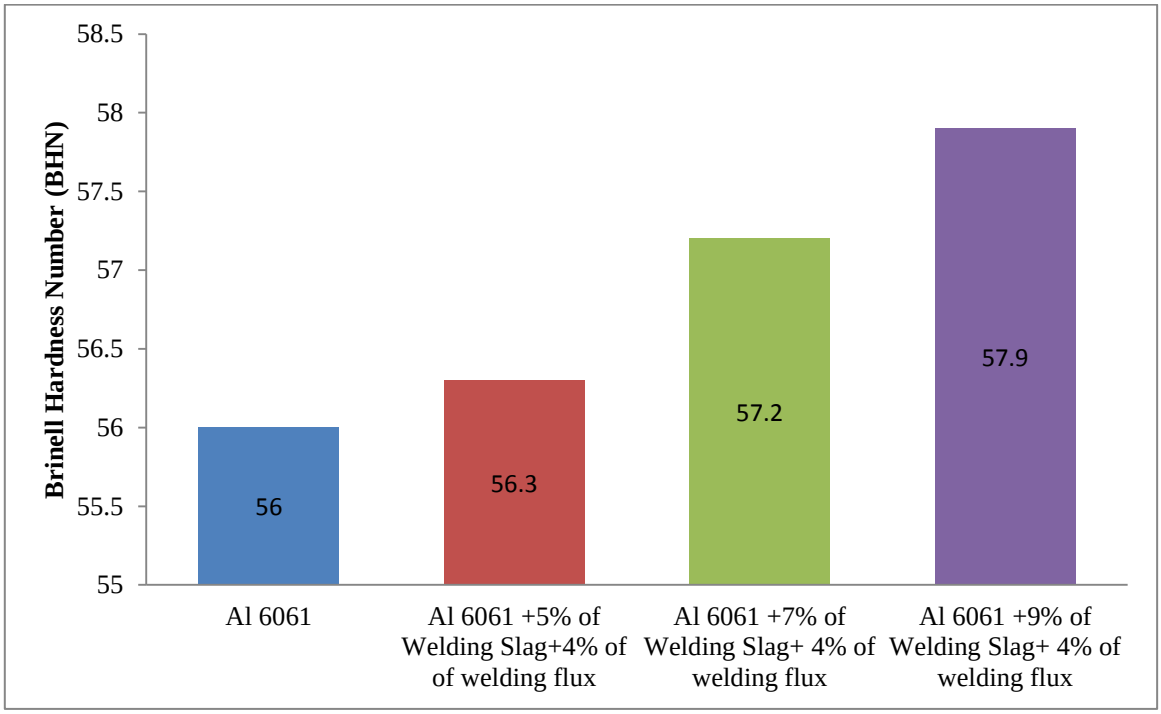

Figure 3: Variation of hardness results

5. Conclusion

This research work is concluded with the following key points:

i. The stir casting method used to prepare the composites could produce a uniform distribution of the reinforcement.

ii. The hardness increased with the increase in the weight fraction of reinforcement.

iii. Thus the fabricated reinforcement could be used in manufacturing sectors were more strength is required.

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