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EFFECT OF WEIGHT PERCENTAGE ON MECHANICAL PROPERTIES OF FRIT PARTICULATE REINFORCED Al6061 COMPOSITE

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ABSTRACT

Frit-Al6061 alloy composites having 2 wt%, 4 wt%, 6 wt%, 8 wt% and10 wt% of frit particles were fabricated by liquid metallurgy (stir cast) method. The casted ingots were subjected to T6 heat treatment to optimize the properties. The composite specimens were machined as per test standards. The specimens were tested to know the common casting defects using ultra-sonic flaw detector testing system. Some of the mechanical properties have been evaluated and compared with Al6061 alloy. Significant improvement in tensile properties, compressive strength and hardness are noticeable as the wt % of the frit particles increases. The microstructures of the composites were studied to know the dispersion of the frit particles in matrix. It has been observed that addition of frit particles significantly improves ultimate tensile strength along with compressive strength and hardness properties as compared with that of unreinforced matrix.

Keywords: frit particles, Al6061 alloy-matrix composite, ultra-sonic flaw detector, mechanical properties.

INTRODUCTION

The reinforcement of aluminium alloys with ceramic particle leads to new generation of engineering materials with improved mechanical properties to weight ratio [1-3]. Aluminium alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These alloys have started to replace cast iron and bronze, to manufacture wear resistance parts [4]. Previous studies have shown that mechanical properties of Al-matrix composites would be enhanced with particle reinforcement [5-7]. Development of composite materials can bring combined advantages of the constituent materials [8-10]. MMC`s reinforced with particles tend to offer enhancement of properties processed by conventional routes [11, 12]. SiC is most common particle used as reinforcement in aluminium alloy composites [13, 14]. By adding ceramic particles as reinforcement to aluminium matrix, the properties are enhanced and lead to the development of materials for many lightweight applications [15]. For production of aluminium particle reinforced composites stir casting method appears to be promising method among various conventional processing methods [16]. Heat treatment process to modify the microstructure of aluminium alloy composites with aluminum alloy matrix is the final production stage of composites [17, 18]. Most of the researchers have investigated aluminium composites using SiC, Al_2O_3, MgO, Zircon etc,[19] and these composites are commercially available in different structural forms.Al6061 alloy have numerous benefits like formability, weldability, corrosion resistance and low cost. In this light an attempt as been made to develop frit-Al6061 alloy composites. An effort has been made in this paper to study the mechanical properties of frit-Al6061 alloy composite by varying the wt% of frit.

MATERIALS AND METHODS

Materials preparation

Al6061 alloy as matrix material and frit is used as reinforcement material in the preparation of composites. The chemical composition of matrix material and frit are as shown in Tables 1 and 2.

Table-1. Chemical composition of Al6061 alloy (wt %).

Si	**Cu**	**Fe**	**Mn**	**Mg**	**Zn**	**Pb**	**Ti**	**Sn**	**Al**
0.809	0.355	0.155	0.027	0.8	0.008	0.023	0.010	0.010	97.390

Table-2. Chemical composition of frit (wt %).

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	B_2O_3
68.90	9.41	0.40	15.22	4.30	0.75	0.42	<0.05

A stir casting setup was used consisting of resistance furnace with a mechanical stirrer unit. Approximately 1900 grams of Al6061 alloy ingots were cut in to pieces to accommodate into the graphite crucible. The temperature of the furnace was raised slowly above liquideous temperature of the melt and then slowly reduced below the liquideous temperature of the matrix material. Preheating of frit particles at 450^0 C was done in a muffle furnace, placed near the casting set up, in order to remove the moisture and gases from the surface of frit particles [20]. The stirrer was raised, positioned and then lowered into crucible. The speed range was 300-350 rpm. The preheated frit particles in weighed quantities were added slowly into the melt. After adding frit particles, stirring was continued for 10 minutes for better wetting dispersion. The pouring temperature was maintained at 710^{0}C. Then melt was poured into a preheated metal molds (dies).

Cast and composite ingots were T6 heat treated in a muffle furnace to an accuracy of $\pm$ 1^{0}C for 2 hours at 529^{0}C, followed by ice quenching and then aged at 199^{0}C for 6 hours.

Testing

As cast and composite T6 heat-treated ingots were machined using CNC lathe according to IS1608-2005 standards to prepare the specimen, as shown in Figure-1.

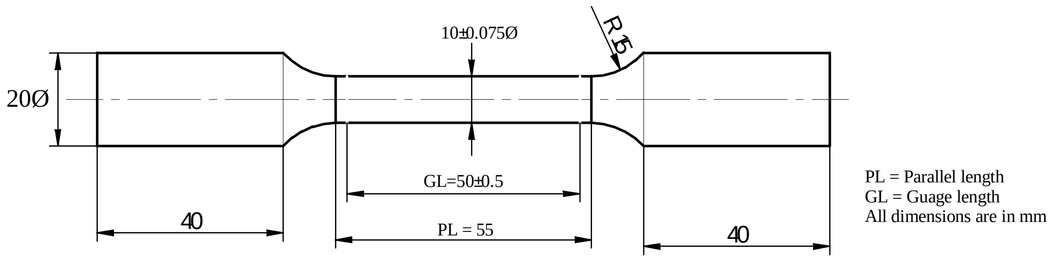

Figure-1. Tensile test specimen dimensions.

The specimens were subjected to non-destructive test to know the common casting defects using ultra-sonic flaw detector testing system.

The tensile and compression tests were conducted at ambient temperature using computerized uni-axial tensile testing machine at a strain rate of 0.51 mm/min. Each test was repeated twice and average response value was considered. The compression test was conducted on specimens.

Hardness tests were performed on as cast and composites to know the effect of frit particles in matrix material. The polished specimens were tested using Vickers micro hardness testing system. A load of 1N for a period of 10 seconds was applied on specimens. The hardness was determined by recording the diagonal lengths of indentation produced. The test was carried out at three different locations and the average value was taken as the hardness of the as cast and composite specimens.

RESULTS AND DISCUSSIONS

Micrograph studies

Figure-2 shows the microstructure of as cast Al6061 alloy in the as received samples. Precipitations were evident both in the grains and along grains.

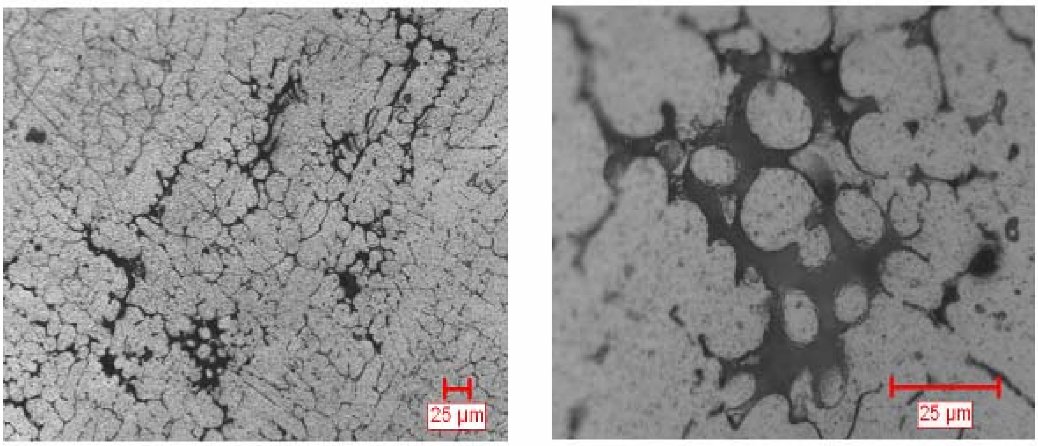

Figure-2. Microstructure of as cast Al6061 alloy.

Figure-3 shows the microstructure of Al6061 alloy reinforced with 6 % frit after heat treatment. Micrograph clearly reveals minimal micro porosities in the casting. No clustering of frit particles was observed in the matrix, and the dispersion of frit particles was seen to be uniform. It is evident from the micrograph that the coursing occurs after T6 heat treatment. This enhances the properties of the composites.

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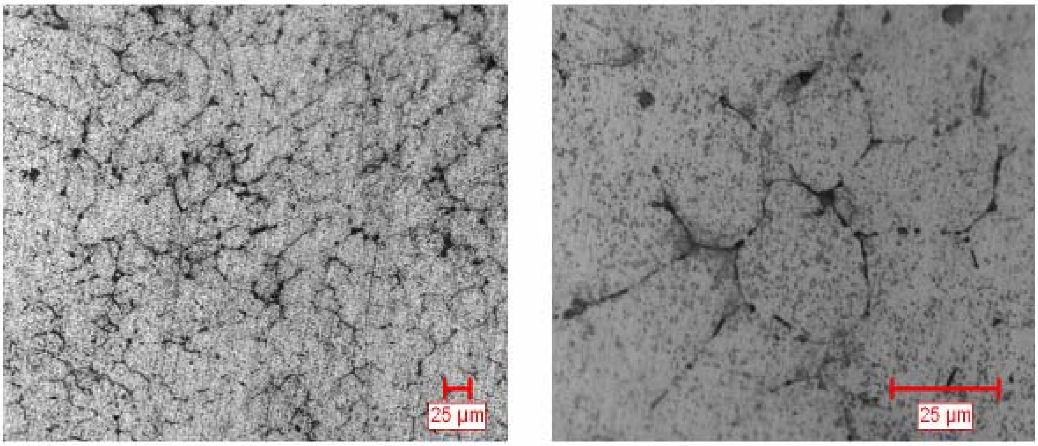

Figure-3. Microstructure of 6 wt % of Frit-Al6061 composite.

Micro Hardness results

Figure-4 shows the micro hardness of Al6061 alloy and the composite containing varying weight percentage of frit particles. The Figure shows that the addition of frit particles into Al6061 alloy matrix enhances the hardness of the composites compared with as cast Al6061 alloy. The dispersion of frit particles enhances the hardness, as particles are harder than Al6061 alloy, and render their inherent property of hardness to soft matrix [21].

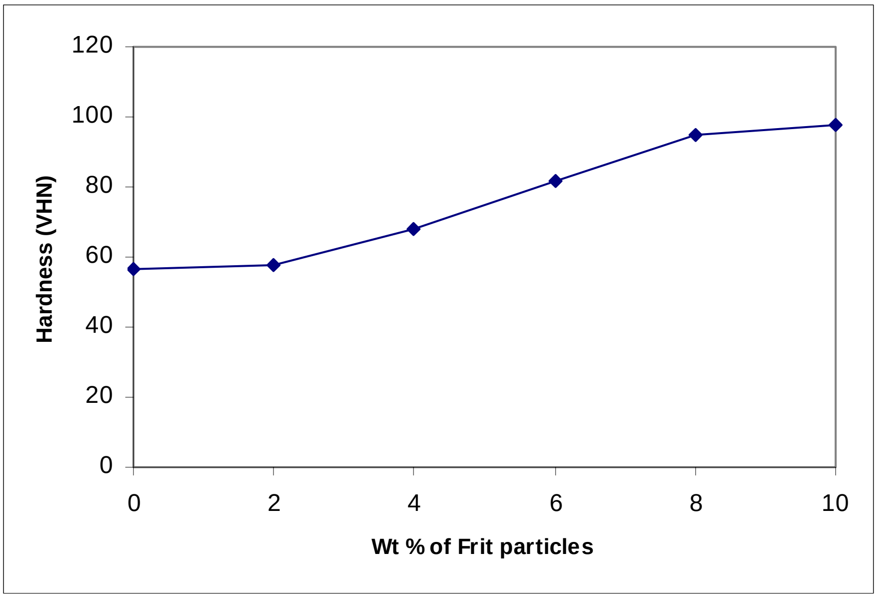

Figure-4. Effect of frit wt % on hardness of composites.

Tensile strength results

Figure-5 shows the ultimate tensile strength results of Frit-Al6061 alloy composites of varying weight percentage of frit particles. It can be observed from the Figure, that addition of frit particles enhances the ultimate tensile strength of composites. Dispersion of hard ceramic particles in a soft ductile matrix results in improvement in strength [22]. This may be attributed to large residual stress developed during solidification and due to mismatch of thermal expansion between ceramic particles and soft aluminium matrix as corroborated also in [23-26]. The increase in strength may also be result of closer packing of reinforcement with soft aluminium matrix. Wettability is one of the dominating factors to ensure good bonding between the matrix and reinforcement [27]. A good bonding between reinforcement and soft aluminium matrix favors an enhancement of the ultimate tensile strength of the composite [28].

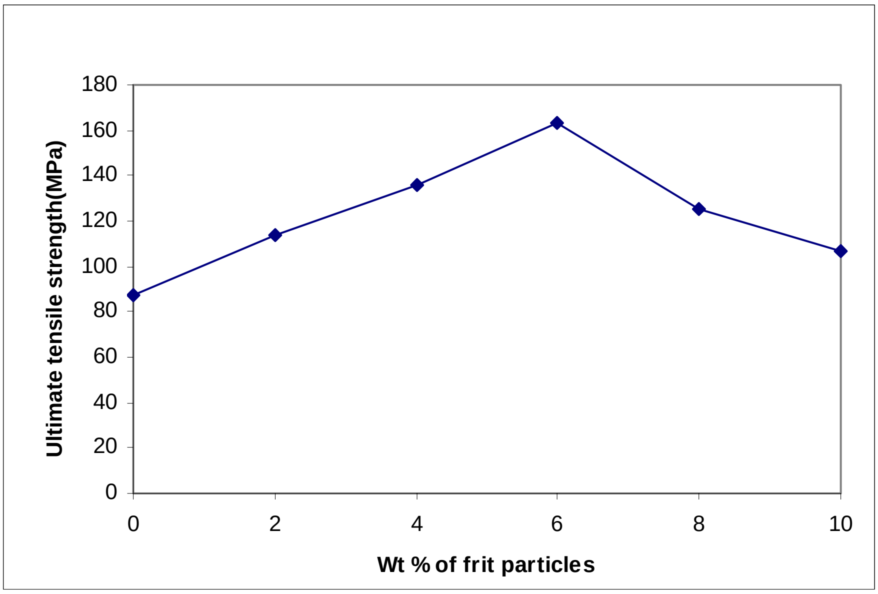

Figure-5. Effect of Frit wt % on tensile property of composites.

Compression strength results

Figure-6 shows the results obtained from uniaxial compression, as a function of frit content of the matrix. Addition of frit up to 8 wt% caused an enhancement in compression strength. Beyond 8 wt% of frit, the compression strength decreased. Similar result can be observed by Hayrettin Ahlaci [29] who attributed the decrease of strength of Al-Si alloys and their composites to the fact that the composite is subjected to compressive stress, the matrix around SiC particle flows away from the particle in a direction perpendicular to the compressive stress. Then a cavity is formed at the interface of SiC particles and matrix that experiences tensile loading. This cavity formation decreases the composite strength because of the decrease in load transfer from matrix to particles [30].

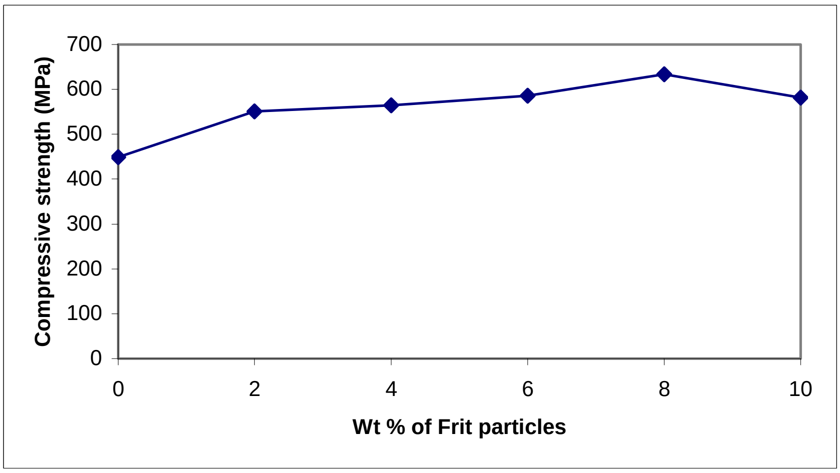

Figure-6. Effect of Frit wt % on compressive strength of composites.

CONCLUSIONS

Based on the experimental observations made in the present research, the following conclusions have been drawn. Al6061 alloy matrix composites have been successfully developed with fairly uniform dispersion of frit particles. The hardness of Frit-Al6061 composite increases as the addition of frit particles weight percentage is increased. This is due to hard frit particles dispersion in soft aluminium alloy matrix.

Addition of frit particles significantly improves ultimate tensile strength of Al6061, when compared with that of unreinforced matrix, the ultimate tensile strength of Frit-Al6061 composite is increased by 46.51%. However, the ultimate tensile strength begins to decrease above 6 wt % of frit particles.

Addition of frit particles to Al6061 alloy matrix clearly improves the compressive strength. Above 8 wt % of frit, however the compressive strength begins to decrease. The compressive strength of Frit-Al6061 composite is increased by 29.17%.

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