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Processing and Evaluation of Strength Properties of Granite Powder Reinforced Al7075 Metal Matrix Composite

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Abstract: ***Aluminum, due to strength to its weight ratio, has more demand in aerospace and automobile sector. Our work focuses on processing and studies of mechanical properties of Al7075-granite powder composite. Stir casting technique is employed for processing. Combination of granite powder (2 wt%, 4wt% and 6wt%) and aluminium has been evaluated for hardness, tensile strength and wear for different loads along with SEM photographs. Ultimate tensile strength, Hardness and wear resistance have appreciably enhanced as compared to the base alloy for a reinforcement of 2%. Whereas for higher percentage it suffers because of agglomeration and porosity.***

Index terms: AL7075, Granite, Composite, Stir casting, Wear.

I. INTRODUCTION

Metal matrix composite have seen a vast research for improving their properties. Aluminium composites poses more benefits over conventional materials due to its strength to weight ration, availability, corrosion resistance. Since the granite dust is a waste industrial by product incorporating it in composite is economical and help in handling industrial waste. Being a ceramic material and hard material it impacts its own effect on composite. Anand pai et al. [1] have studied the influence of graphite and granite dust on al6061 matrix, wear and hardness tests were performed. The study indicated that the composite offers better properties compared to the alloy. Bharath et al. [2] investigated wear and mechanical properties of al6061 alloy reinforced with alumina. The addition of reinforcements resulted in increase of hardness and tensile properties compared to unreinforced al6061. Rajesh studied the effect of boron carbide reinforcement on al6061 alloy and reported an increase in wear resistance of the composite compared to al6061 alone. Srinivasa reddy et al. [3] incorporated flyash and E-glass into al7075 alloy and revealed that the properties get enhanced with the addition of reinforcement. Alaneme et al. [4] studied the impact of alumina and rice husk ash over al-mg-si alloy matrix. The tensile strength and hardness found to increase with the addition of alumina. Since the granite powder mainly composed of SiO_2 and Al_2O_3 [5], has the potential of a ceramic additive and impacts the hardness and wear resistance of the composite.

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II. MATERIALS AND METHOD

Al7075 ingots with composition tabulated in table 1, was used as matrix alloy. And Granite powder from granite industry is used as reinforcement with an interval of 2% up to 6%. Granite powder obtained from the industry is washed twice with water and sunlight dried, the composition is shown in table2. The obtained powder is sieved and particles less than 150µm are selected for further process.

Table 1. Composition of Al7075 in wt%

Elements	Cu	Mg	Zn	Cr	Fe	Mn	Ti	Si	Al
Wt.%	1.6	2.3	5.5	0.23	0.20	0.20	0.12	0.10	Rest

Table 1. Composition of Granite powder in wt%

Elements	$Si o_2$	$Al_2 O_3$	$Fe_2 O_3$	CaO	MgO	$K_2 O$	TiO2	Residue
Wt.%	63.1	18.3	5.53	4.2	2.12	2.9	1.51	Balance

The composition of composites prepared on weight basis is as shown in table 3.

Table 3. Composition of prepared composites

Composition code	Composition
A	Al7075
B	98% Al7075 + 2% Granite powder
C	96% Al7075 + 4% Granite powder
D	94% Al7075 + 6% Granite powder

Stir casting is made use for the preparations of composite. Setup employed for casting is shown in figure 1. Required quantity of material is weighed and placed inside the crucible, melted in a electric arc furnace at 750°C. After absolute melting, solid hexacholorethene (C_2Cl_6) is used as degassing agent. The coverall flux is used to reduce oxidation. Prior to addition of reinforcement, Magnesium of 1% and K_2TiF_6 filler is added to melt to improve wettability [6].

Upon stirring at 300RPM the reinforcement are added to the melt at a slower rate, the stirring is continued further for 10 minutes, the stirrer is immersed to a depth of 2/3 of molten metal [6,8]. And then the melt was poured to preheated mould (450^0C) and allowed to solidify for 5hours.

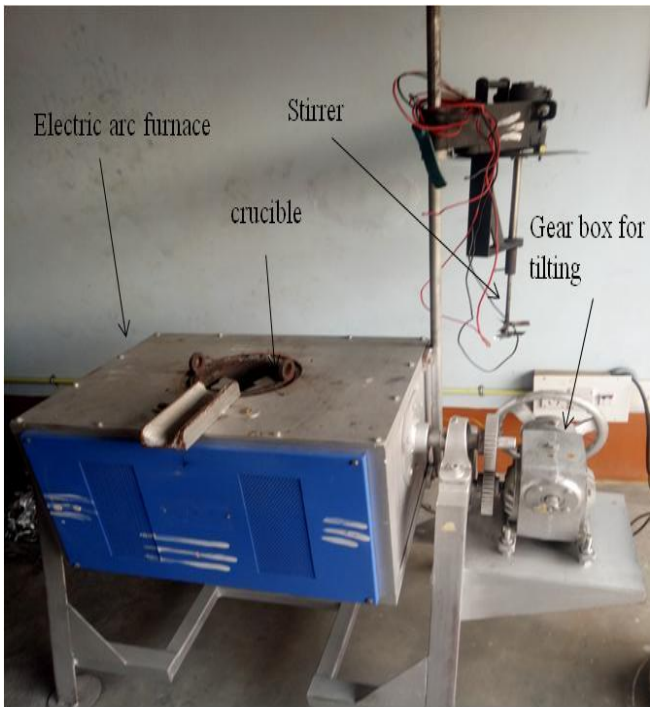

Fig. 1: Stir casting setup

The specimens are prepared according to ASTM standards by machining. For tensile ASTM E8M (figure 2) standards are used where as for wear (ASTM G99) pins of diameter 8mm and length 10mm were prepared from the casting. For studying the micro structure the specimens were polished using different grit sized emery paper and buffed, later etched with Keller's reagent.

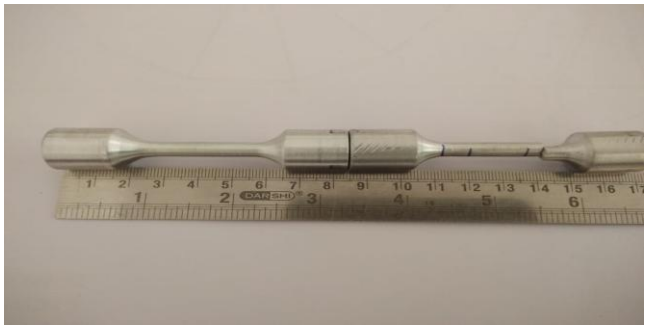

Fig. 2: Tensile test sample

III. Results and Discussion

The variation of hardness, tensile strength are as shown in table 3.

Table 3. Strength properties of prepared samples

Mechanical properties	Al7075	Al7075+ 2% Granite powder	Al7075+ 4% Granite powder	Al7075+ 6% Granite powder
Tensile Strength (MPa)	137±10	152±8	123±9	78±8
Hardness (BHN)	55±2	66.3±2	51.1±1	46.6±4

By the addition of granite particles the material becomes more brittle, which results in reduction of elongation [7]. The addition of 2% granite powder increases the tensile strength (figure 3) and hardness (figure 4).

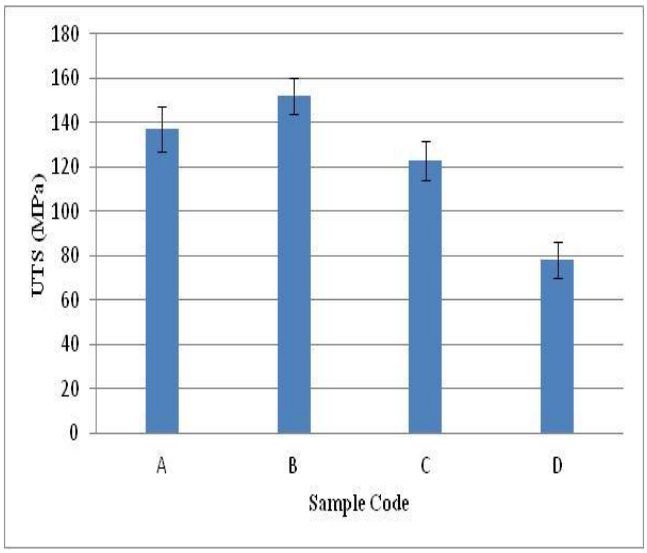

Fig. 3: Tensile Strength v/s Composition

But for higher percentage it decreases due to agglomeration and increase in porosity. Improvement in strength may be reasoned to the thermal mismatch between Al7075 and Granite dust [8] and also due to grain refinement [9].

Due to granite particles hard nature, its resists plastic deformation [10] and improves the hardness of the prepared composite than its alloy.

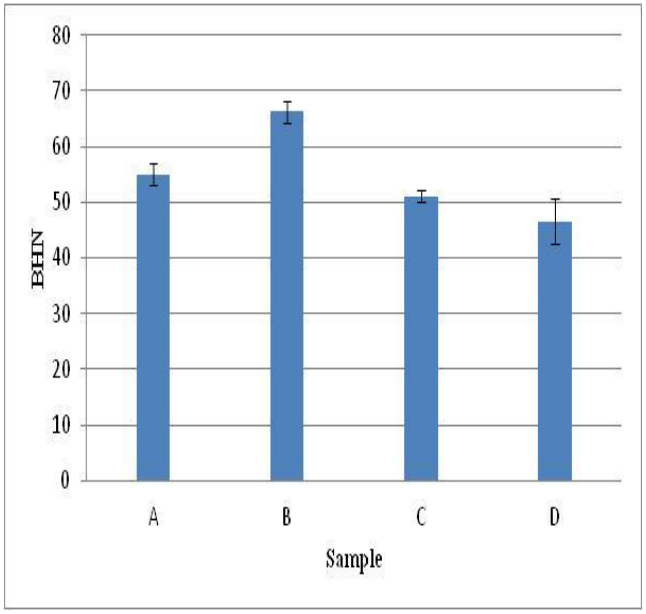

Fig. 4: BHN v/s composition

The variation of wear rates for different loads at a constant speed of 1.5m/s and a distance of 500m are as shown in table 4.

Table 4. Wear rate of different composition

Load (N)	Wear rate (x 10^{-3} mm^3/Nm)			
	Al7075	Al7075+2% Granite powder	Al7075+4% Granite powder	Al7075+6% Granite powder
10	0.3635	0.3231	0.3666	0.3723
20	0.3983	0.3249	0.3988	0.4100
30	0.3891	0.3334	0.3990	0.4112

The wear rate are decreasing with reinforcement addition of 2% later increases for 4% and 6% but found to rise with increase in load. The enhancement in resistance to wear is due to the existence of hard reinforced material. And also due to improvement in hardness of the prepared sample.

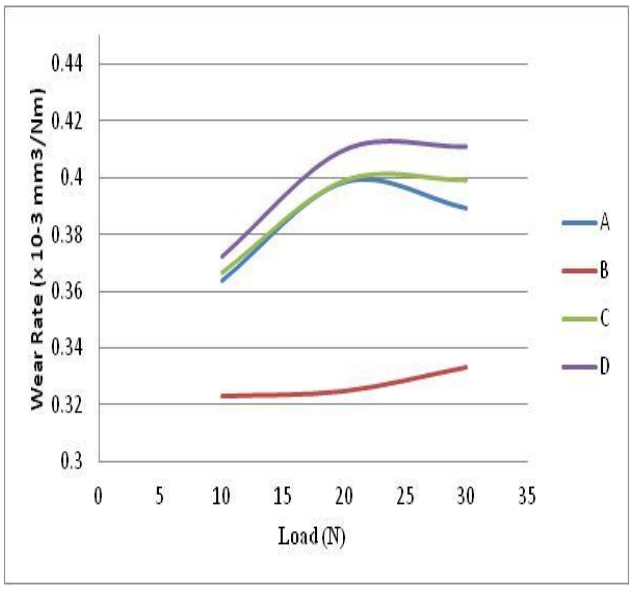

Fig. 5: Variation of Wear Rate with reinforcement percentage

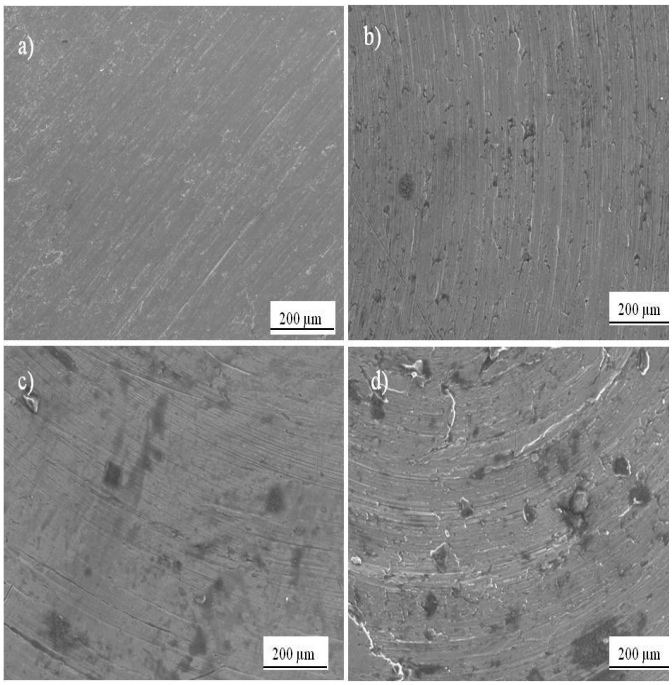

Fig. 6: SEM micrographs (a) Al7075 (b) 2% Granite, (c) 4% Granite, (d) 6% Granite

The above graphs give a clear insight for the wear property of the prepared material, from A and B its clear that the distribution of particle is even and it imparts the reduction of wear rate whereas in from C we can say due to agglomeration of particle the wear rate increases, as the delamination of the paticles at the surface will be more.

IV. CONCLUSION

The present work intended to study the wear rate and mechanical properties of the granite powder reinforced composite has led to following conclusions

- Granite powder based composite can be effectively fabricated using stircasting method.
- Hardness and tensile strength of the composite is higher at 2% granite powder reinforcement.
- Wear rate can be minimized with addition of granite powder, which is lower at 2% of reinforcement.

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