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Experimental Evaluation of Specific Heat Carrying Capacity of Fly-ash Reinforced Aluminium 6061 Composite

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***Abstract* -The present work concentrates on utilization of fly ash in useful manner by mixing it with Al6061 alloy with different weight fractions and particle size. Initially two sets of specimen are prepared using stir casting route technique. First set contains fly ash particle size below 50µm and second set consists fly ash particle size between 53-100µm. Mainly two sets of composite samples with the reinforcement weight percentages of 4, 8, 12 and 16% were used. One of the important thermal properties of the material, specific heat carrying capacity has been determined.**

***Key words**: Alluminium, fly ash, specific heat, Temperature, composites.*

1.0 INTRODUCTION

The Metal matrix composites are dominantly in leading phase in the midst of different classes of composites. In last two to three decades this metal matrix composites (MMCs) has converted into a scientific topic. Also it gives intellectual awareness about material of extensive technological and commercial significance. MMCs deal with distinctive balance of mechanical and physical properties. Aluminium based MMCs has found increasing attention in last few decades as engineering material.

In this work fly ash is taken as reinforcement material for Al6061. We know that fly ash is a waste product which is formed after burning the coal in thermal power plant. The disposal of this fly ash is difficult because in open atmosphere if we dispose then minute particles may enter our respiration system. [1] Hence it creates problem to living beings. Now days we know many other methods are there to utilize this waste product. Like use of fly ash in brick industries, cement industries etc. [4]. It is of non-engineering applications so here a small attempt is made to use it in same engineering passion. It is true that only up to 20% of weight fraction of fly ash particles can be successfully added [5]. Further increase in fly ash weight percentage is not recommended.

From the literature review, it is concluded that in order to study and analyse the influence of the particle size of fly ash as reinforcement on the aluminium alloy (Al6061) composite is taken. To study its effect on thermal properties different sizes of fly ash have also been taken in this study. Some of the earlier investigations showed that the mechanical properties are enhanced with increase in fly ash percentage. It is true that with mechanical property thermal properties are also varying. Hence some consideration is given to study this thermal properties are given. It is known that the influence of these parameters on the various properties is maximum because due to the mixing of reinforcement its micro structural state changes which leads to increase in properties. In order to explore an interesting and useful engineering material this study is carried out.

1.1 Specific Heat Capacity (Cp):

Heat carrying capacity per unit mass can be termed as Specific heat capacity. Its unit is J/kg-K or Cal/kg-K (1-4). Upon increase in heat energy, a dimensional change occurs. Hence two different heat capacities are defined. They are specific heat at constant pressure and specific heat at constant volume. Specific heat at unceasing pressure is denoted as Cp whereas Cv is notation for specific heat at constant volume. Cp is always higher than Cv (5).

From the literature survey it is found that specific heat capacity of Al6061 alloy was found to be 0.896 J/g-°C and for fly-ash it is 0.9497 J/g-°C.

2.0 EXPERIMENTAL SETUP

Setup used for the measurement of specific heat capacity is shown in below figure. It consists of voltmeter (0-200v), ammeter (0-2A), dimmer stat (4A load),thermocouples (0-250°C), temperature indicator (up to 1200°C), heater, insulated container etc. Electric flow diagram is also shown below. Before starting the experiment all the connections are properly checked. After this 200ml of water is filled in the insulated container and its temperature is noted down, with this the specimen weight is also noted down (6). Now specimen whose specific heat is to be measured is heated with the help of mica heater by supplying heat with dimmer stat, up to a temperature of 100°C. The dimmer stat is a device which is used to control temperature by supplying constant heat. Once the specimen reaches the desired temperature it is dipped inside the insulated container. The heat transfer will takes place from metal piece to surrounding water. After some time interval both metal temperature and water temperature becomes equal. That temperature is used as the final temperature of water as well as metal. Now by usual proceeding i.e. by using the formula (Q= m Cp Δt) (By balancing the this equation) specific heat capacity of metal piece is calculated (7).

Figure -2: Experimental setup were used for the measurement of specific heat.

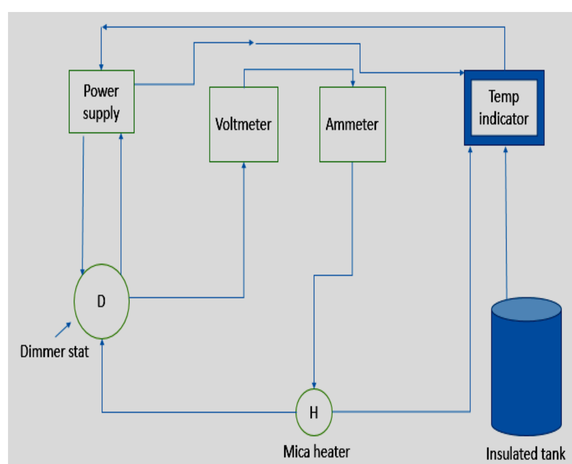

Figure –1: Electrical Flow diagram of the experimental setup.

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2.1 Measurement of Specific Heat Capacity of composite solid (Cp):

Specimen no. 1: Pure Al6061 without fly ash

Mass of water = 200ml

Mass of specimen = 14.1g

Initial temperature of water = 31°C

Cp of water = 4.187 J/g °C

We know that,

$$Q = mCp\Delta t$$

Voltage (V)	Current (A)	T_1 Initial water temp. (˚C)	T_2 Final water temp. (°C)	T_3 Initial specimen temp(°C)	T_1 Final specimen temp. (°C)
205	0.35	31	32	100	32

$$(mCp\Delta t)_{water} = (mCp\Delta t)_{Specimen}$$

$$200 \times 4.187 \times (32-31) = 14.1 \times Cp \times (100-32)$$

$$837.4 = 958.8 \text{ Cp specimen}$$

Cp of Specimen= **0.8733** J/g°C

Table -1: shows the specific heat capacity values for different compositions of fly ash.

Fly ash weigh fraction in%	Cp value in J/g °C	Cp value in J/g °C
0	0.8733	0.8733
-	**For I – Set(flyash particle size below 50µm)**	**For II – Set flyash particle size between (53µm-100µm)**
4	1.0811	0.9835
8	1.1968	1.0681
12	1.4589	1.3343
16	1.6937	1.5545

From literature survey the specific heat carrying capacity of Al 6061 is 0.896 J/g-°C. In this experimental work specific heat capacity is found as 0.8733 J/g-°C. The difference is very small and it is mainly due to some tiny experimental errors. Even though the result obtained from the experimental work is accepted. From the above table it can be observed that specific heat carrying capacity of composite is gradually increasing with increase in fly ash percentage(7). It is mainly due to the fact that fly ash particle exhibit higher specific heat capacity. As a result of this specific heat capacity of composite also increased. Enhanced specific heat capacity is most widely accepted in automobile and aerospace industries (8). Now if we see the variation of specific heat with respect to fly ash particle size then it is higher for small sized particles. It is because fine powdered particles exhibit lower thermal expansion, as a result of this specific heat carrying capacity increases. In this present work up to 16% fly ash particles were added and result obtained are within acceptable range. But from literature survey it is observed that only up to 20% weight fraction of fly ash particles can be successfully added. Further increase in fly ash particles leads disadvantages rather than advantages.

3.0 RESULTS AND DISCUSSION:

Heat carrying capacity is the measure of the ability of the material to absorb thermal energy. Specific heat carrying capacity is another important thermal property that needs to be considered for a newly defined material[9]. This is because higher the specific heat, more heat it must absorb before it raising its temperature.

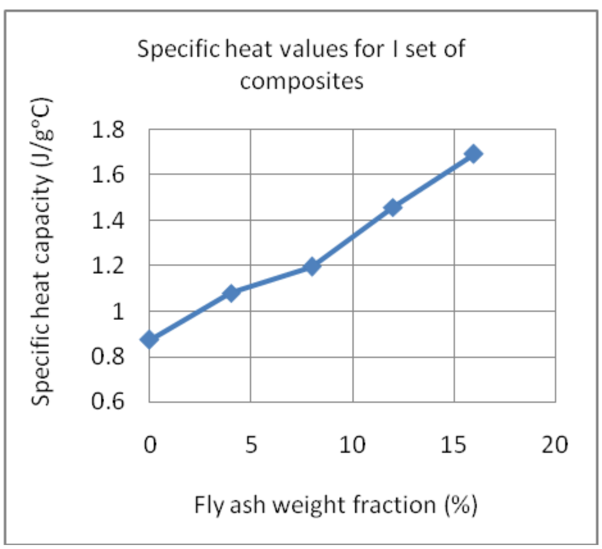

Figure 3 shows different values of Cp for different weight fractions of fly ash particles sized below 50µm.

Table -1: give values of specific heat carrying capacity over various weight fractions of fly ash particles

Fly ash weigh fraction in%	Specific heat value in J/g °C		Specific heat value in J/g °C	
	For I – Set (flyash particle size<50µm)	% change	For Set II (50µm-100µm)	% change
0	0.8733	19.22	0.8733	11.20
4	1.0811	9.66	0.9835	7.92
8	1.1968	17.96	1.0681	19.95
12	1.4589	13.86	1.3343	14.16
16	1.6937	-	1.5545	-

Fig 3 and 4 indicates the variation of specific heat carrying capacity of composite material with different weight fractions of fly ash particles. It is observed from the graph that specific heat carrying capacity is increasing with increase in fly ash percentage. This is due to higher specific heat carrying capacity fly ash particles compared to Al6061[10].

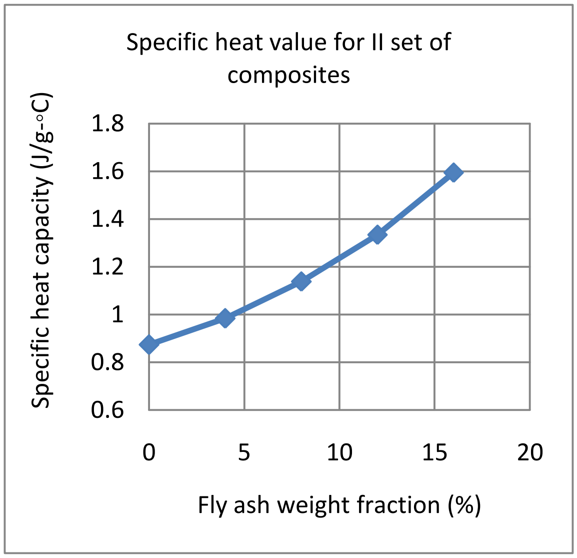

Figure -4: shows different values of Cp for different weight fractions of fly ash particles sized above 50µm

Table 2 shows different values of specific heat capacities for two different sets of composite materials. It is observed from the above table that specific heat carrying capacity is increased with addition of fly ash. It also observed that for first two compositions, percentage change in values of specific heat capacities are more for composite with fly ash particles sized below 50µm. For last two compositions, percentage change in values of specific heat capacities are more for composites with fly ash particles sized above 50µm[11]. This may be due to higher thermal expansion of fly ash. This leads to decrease in values of thermal conductivity. Finally the result will be increase in values of specific heat capacity.

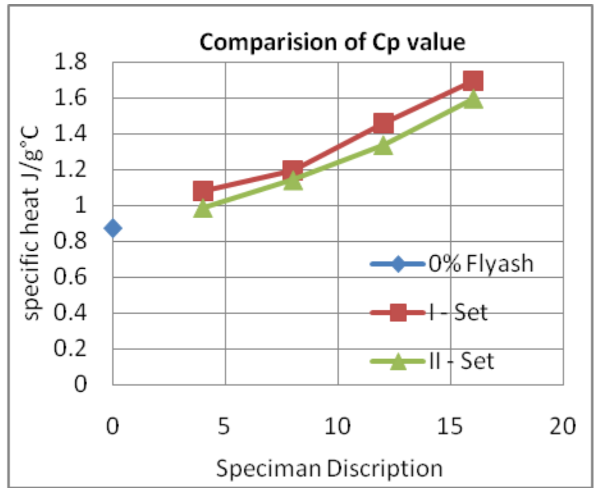

Figure -5: show comparison of specific heat capacity of composite for different weight fractions of fly ash.

Fig 5 shows comparison of specific heat capacity of composite with different weight fractions of fly ash. It is known that specific heat capacity of Al6061 is 0.896 J/g-°C. In this experimental work it is observed that specific heat capacity of Al6061 is 0.8733 J/g-°C. From the above graph it is observed that specific heat carrying capacity of composite is gradually increasing with increase in fly ash percentage. It is mainly due to the fact that fly ash particle exhibit higher specific heat capacity[12]. As a result of this specific heat capacity of composite also increases. This enhanced specific heat capacity is most widely accepted in automobile and aerospace industries. If we observe the variation of specific heat with respect to fly ash particle size, then it is higher for small sized particles. This is due to fact that fine powdered particles exhibit lower thermal expansion as a result of this specific heat carrying capacity increases. In this work up to 16% fly ash particles were added and results are obtained within acceptable range. From literature survey it is observed that only up to 20% weight fraction of fly ash particles can be successfully incorporated. Further increase in fly ash particles leads disadvantages rather than advantages.

4.0 CONCLUSION

Specific heat carrying capacity is one of the important thermal property that needs to be studied. This property is of prime concern because it gives ability of material to carry heat inside the material. This property is mainly related to inter atomic structure. In this work it is observed that composite with fly ash particles sized below 50µm exhibit higher specific heat carrying capacity than composite with fly ash particles sized above 50µm. This may be due to proper mixing of fly ash particles in composite and also due to fact that smaller fly ash particles exhibit higher specific heat carrying capacity. It is observed that for pure Al6061 specific heat carrying capacity is 0.8733 J/g° C. For Al6061+fly ash composite with 4% weight fraction specific heat carrying capacity is observed as 1.0811 J/g° C and 0.9835 J/g °C for fly ash sized below 50µm and above 50µm respectively. The percentage change occurred in specific heat of composite for case-I is 19.22%, for case II (Fly ash with particles sized above 50µm) is 11.20%. The difference is mainly due to size of fly ash particles. Higher the size of fly ash particle, lower will be the percentage change in specific heat capacity.

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