

# Experimental Investigation of Thermal behaviour on Rice Husk Ash-Alumina Reinforced with Al6063 Alloy Matrix

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**Abstract:** The present work concentrates on utilization of rice husk ash in useful manner by mixing it with Al6063 alloy. In this work Alumina particles will be added with 0, 2, 4, 6, 8 wt% Rice husk ash (RHA) to prepare 10 wt % of the reinforcing phase with Al6063 alloy as matrix using two step stir casting method. Thermal properties like Linear coefficient of thermal expansion ( $\beta$ ), Specific heat capacity (C), Thermal conductivity (K) and Thermal diffusivity ( $\alpha$ ) are evaluated. The results show that increase of Rice husk ash percentage in composite increases the thermal properties, which enhances thermal insulation capability of reinforced Al6063 alloy. Further SEM analysis is carried out to examine the proper dispersion of Rice husk Ash and Alumina particles in composite material for suitable industrial applications.

**Keywords:** Aluminium alloy, Rice husk ash, Alumina, Thermal conductivity, Specific heat capacity, Thermal diffusivity, Thermal expansion, Dilatometer.

## I. INTRODUCTION

The Metal matrix composites are dominantly in leading phase in the midst of different classes of composites. In recent days 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. Aluminum based MMCs have found increasing attention in last few decades as engineering material. It importantly possesses the benefits of great strength, rigidity and wears resistance. The conventional aluminum alloys do not exhibit required properties under all facility conditions. This draw backs are overcome by reinforcing these alloys with ceramic particles. This kind of reinforced aluminum alloys are universally known as aluminum matrix composites (AMCs) [1].

Cost of fabrication is high; because of this it limits the application of Aluminum metal matrix (AMCs). This can be overcome by using inexpensive reinforcements like Rice husk ash and natural minerals. RHA is a surplus by-product of Rice husk burning in thermal power plants cogeneration plants which exist in large quantities in the Indian subcontinent and all over the world. Compared to all other reinforcements such as SiC, Al<sub>2</sub>O<sub>3</sub>, B<sub>4</sub>C and TiC this rice husk ash is most inexpensive and easily available [1].

Quantity of addition of reinforcement materials should be appropriate so that in the present work we have used Al6063 Aluminum alloy as parent material and combination or mixture of Alumina (Al<sub>2</sub>O<sub>3</sub>) and Rice husk ash is used as filler materials. We have prepared six specimens in which one is pure Al6063 Aluminum alloy and other five specimens are of 90% Al6063, 10% Rice husk ash and Alumina (Al<sub>2</sub>O<sub>3</sub>) together in the ratio 0:10, 8:2, 6:4, 4:6 and 2:8. Composites are produced using two step stir casting. Various experiments would conduct on all specimens to evaluate various thermal properties like Thermal conductivity (K), Coefficient of thermal expansion ( $\beta$ ), Diffusivity ( $\alpha$ ) & Specific heat capacity (C).

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## II. MATERIALS AND METHODS

### Aluminium alloy

There are total 9 series are there of Aluminum alloy from 1xXX to 9xXX with different compositions. Aluminum alloys are combinations of aluminum with other metals, frequently with copper, zinc, manganese, silicon or magnesium. Uncovered aluminum combination surfaces will keep their obvious sparkle in dry environment because of the development of clear, defensive oxide layer. Galvanic erosion can be fast when aluminum compound is set in electrical contact with stainless steel, or different metals with a more negative consumption potential than aluminum amalgam, in a wet domain. Aluminum alloy and stainless steel parts should only be used together in water comprising systems or outdoor fittings if provision is made for either electrical or electrolytic separation between the two metals [5].

### Chemical composition of Al6063

<u>Chemical</u>	<u>% by weight</u>	<u>Chemical</u>	<u>% by weight</u>
Silicon	0.2 - 0.6	Chromium	< 0.10
Iron	< 0.35	Zinc	< 0.10
Copper	< 0.10	Titanium	< 0.10
Manganese	< 0.10	Magnesium	0.45 - 0.9
Other elements	< 0.05 each, 0.15 total	Remainder	Aluminum

Table 1 Physical properties of Aluminium

Al6063	
Density	2700 kg/m <sup>3</sup>
Melting point	655°C
Modulus of Elasticity	70 GPa
Ultimate tensile strength	140 to 230 MP
Tensile yield strength	214 MP
Poisson's ratio	0.33

### Rice husk ash

Rice husk Ash is the residue or waste generated abundantly by the combustion of rice husk in brick solidification process and in thermal power plants. Due to the environmental concerns and disposal difficulties, the utilization of Rice husk ash has become of great importance, although the beneficial use of rice husk ash in concrete, brick making, soil stabilization treatment and other applications have been recognized, only a small quantity of the total rice husk ash is being utilized in our country currently in such applications. In this work we used rice husk ash burnt in brick solidification for the preparation of the composites.

The demand for the lightweight materials such as for surfaces of ships had led to the development of rice husk ash based thermosetting resins. The fineness of individual rice husk ash particle ranges from 1 micron to 100 µm size. The fineness of rice husk ash particles has a significant influence on its performance.

### Alumina

The chemical formula of aluminum oxide is Al<sub>2</sub>O<sub>3</sub>. It is commonly referred to as alumina, or corundum in its crystalline form, as well as many other names, reflecting its wide spread occurrence in nature and industry. Alumina (Al<sub>2</sub>O<sub>3</sub>) is the most cost effective and widely used material in the family of engineering ceramics [3]. The raw materials from which this high performance technical grade ceramic is made are readily available and reasonably priced, resulting in good value for the cost in fabricated alumina shapes. With an excellent combination of properties and an attractive price, it is no surprise that fine grain technical grade alumina has a very wide range of applications. Its most significant use is in the production of Aluminum metal, although it is also used as an abrasive due to its hardness and as a refractory material due to its high melting point [4].

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Table 2. Alumina Properties

Alumina (Al <sub>2</sub> O <sub>3</sub> )	
Density	2700 – 3950 kg/m <sup>3</sup>
Melting point	2072 °C
Boiling point	2977 °C
Thermal conductivity	30 W/mK
Specific heat capacity	775 J/kg-K
Coefficient of thermal expansion	7.6 μm/m-K

### Composite fabrication

Casting has been done by pouring reinforcement material added molten metal in cavities created by patterns with some allowance. The testing techniques for composite required that four sets of pattern (Thermal conductivity, Coefficient of heat transfer, Specific heat capacity) should produce. The pattern should make according to the required dimensions of test samples [5].

Table 3. Composition of different composites

Specimen	% by wt. of Reinforcement materials		% by wt. of Al6063
	Alumina (Al <sub>2</sub> O <sub>3</sub> )	Rice husk ash	
S1	0	0	100
S2	10	0	90
S3	8	2	90
S4	7	3	90
S5	6	4	90
S6	4	6	90

### A) Thermal conductivity

Thermal conductivity measurements are carried out under steady state condition. According to ASTM E1530 guarded heat flow meter method, disc shaped specimens with diameter of 100mm and thickness of 6 mm are used for thermal conductivity measurements. The constant heat is applied from one side of the specimen. When the thermal equilibrium is attained and the system approaches to steady state situation, the temperature of top and bottom surfaces were recorded by using thermocouples installed on top and bottom surfaces of the specimen. Knowing the values of heat supplied, temperatures and thickness the thermal conductivity was determined by employing one-dimensional Fourier's law of conduction [7].

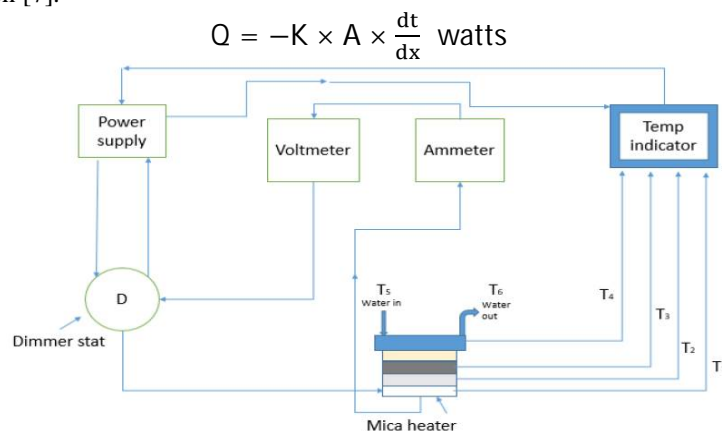


Fig 1. Electrical flow diagram of the thermal conductivity test setup

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## B) Specific heat

Specimen whose specific heat is to be measured is heated with the help of mica heater by supplying heat with dimmer stat, up to certain temperature. Once the specimen reaches the desired temperature it is dipped inside the insulated container that contains certain amount of water. The heat transfer will take place from composite to surrounding water. Initial temperatures of water and specimen are noted down before heating the specimen. After some time interval both metal temperature and water temperature become equal. That temperature is used as the final temperature of water as well as composite [7].

By using following formula specific heat capacity of the composite can be calculated

$$Q = mC\Delta t$$

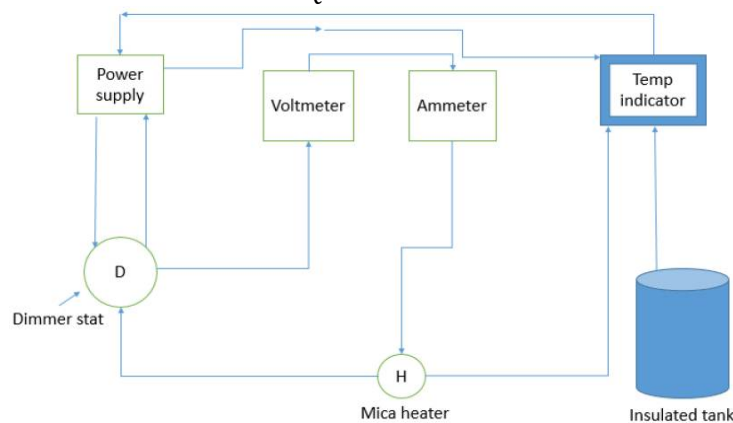


Fig 2. Electrical flow diagram of the specific heat test setup

## C) Thermal diffusivity

It measures the capability of a material to transfer thermal energy relative to its ability to withhold thermal energy. In heat transfer analysis, thermal diffusivity is the thermal conductivity divided by density and specific heat capacity at constant pressure.

$$\alpha = \frac{k}{\rho C_p}$$

## D) Co-efficient of Thermal expansion

In simple terms it can be defined as the ratio of change in length to product of temperature change and original length. Dilatometer test setup is used to measure the linear coefficient of thermal expansion of composites.

$$CTE(\beta) = \frac{\Delta L}{L \times \Delta T}$$

## III. EXPERIMENTAL RESULTS

### Thermal conductivity

The thermal conductivity of the composite material is influenced by its compositions. As the filler material Rice husk ash and Alumina are added to the composite the thermal conductivity of the compositions reduces as compared to that of the pure Al6063. It is observed from the figure that the composition S6 shows maximum decrease of about 10.1% compared to pure Al6063 this is due to increasing percentage of Rice husk ash.

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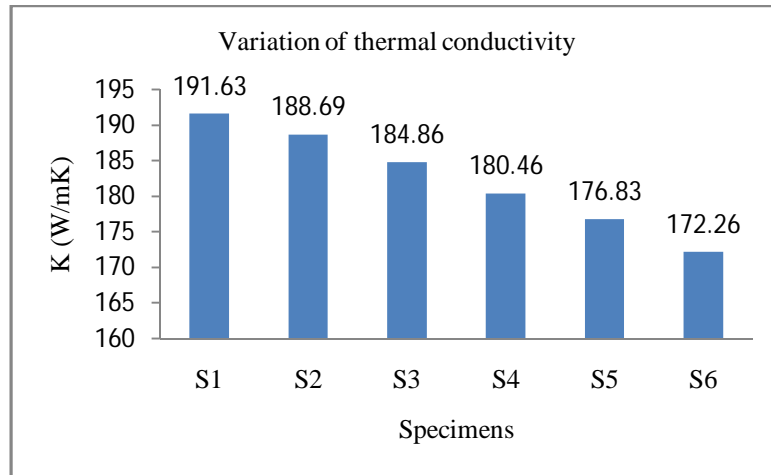


Fig 3. Variation of thermal conductivity for different composition of Rice husk ash and Alumina

### Specific heat

Figure illustrates the variation of specific heat carrying capacity of composite material with different percentage of rice husk ash and Alumina. It is observed from the graph that specific heat carrying capacity is suddenly decreases because of Alumina and then gradually increasing with increase in rice husk ash percentage. This is due to lower specific heat carrying capacity of Alumina higher specific heat carrying capacity rice husk ash particles compared to Al6063.

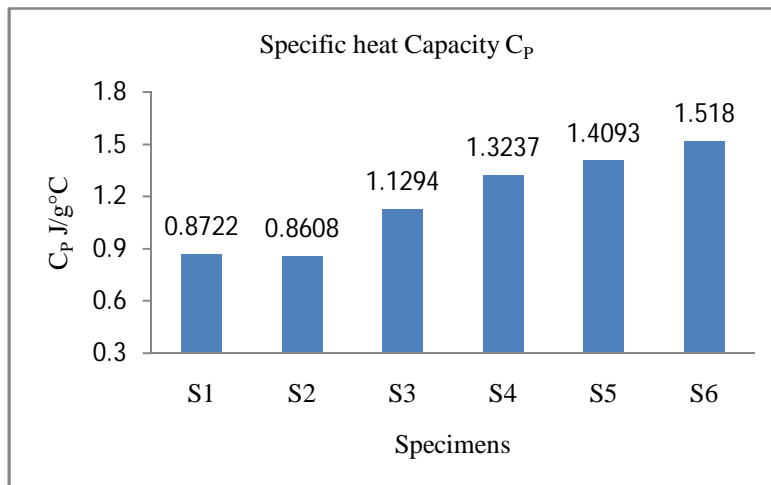


Fig 4. Shows the specific heat of different composition of rice husk ash

### Thermal diffusivity

The effect of various percentages of RHA particles on thermal diffusivity of Al6063/RHA AMCs is presented in Figure. It is evident from the figure that the incorporation of rice husk ash particles significantly reduces thermal diffusivity. This is may be due to low thermal conductivity, low thermal expansion and high specific heat capacity of composites. The uniform distribution of rice husk ash particles provides good strength hence thermal diffusivity.

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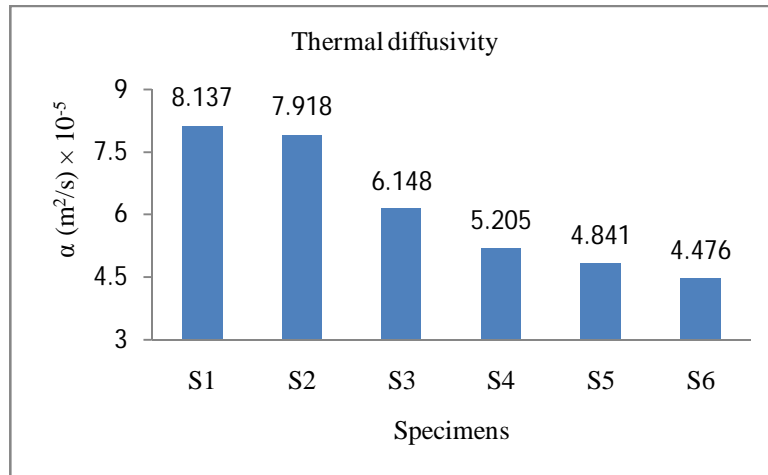


Fig 5. Variation of thermal diffusivity of different composition of rice husk ash

## Co-efficient of Thermal expansion

The above figure shows that the variation of coefficient of thermal expansion of different composite materials. From literature study it is found Thermal expansion of the Al6063 alloy is  $23.4 \mu m/m^{\circ}C$ . In this experimental work thermal expansion coefficient of Al6063 is  $23.11 \mu m/m^{\circ}C$ . The difference is because of minute errors occurred while conducting experiment. CTE is high for composites which contains small amount of RHA and gradually decreases with increase in percentage of RHA. Percentage of decrease in elongation of the length of composite material with 2%  $Al_2O_3$  and 8% RHA is 34.40%.

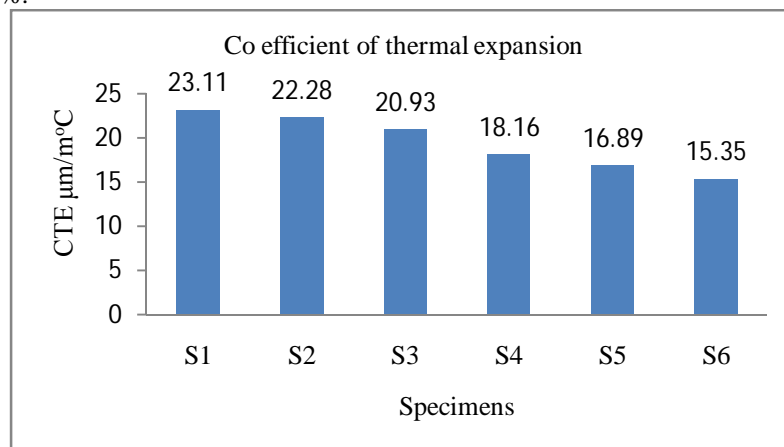


Fig 6. Shows the specific thermal expansion of different composition of rice husk ash

## IV. CONCLUSION

The thermal properties of the composite such as thermal conductivity, specific heat and thermal diffusivity of the composites are measured with and without the addition of Alumina and rice husk ash.

- It is observed that the increase in incorporation of Rice husk ash particles results in decrease in the thermal conductivity compared to that of pure Al6063 alloy thereby improves its thermal insulation capability. This decrease in the thermal conductivity is widely accepted for industrial applications..

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- It is observed that composite with higher percentage of rice husk ash particles exhibit higher specific heat carrying capacity than composites with lower percentage of rice husk ash because of high specific heat capacity of rice husk ash.
- It shows that with increasing the rice husk ash percentage in Al6063 reduces the Thermal expansion. However it will not respond quickly to thermal loads or deform faster since it can be used in high temperature regions.
- Thermal diffusivity is decreased with addition of rice husk ash. This is because the composite has higher specific heat. It requires more heat to heat up.

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