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Research Article

Analysis on Mechanical behaviour of Hybrid Aluminium metal matrix composite material using Rice husk ash and Iron ore tailing

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Abstract

Aluminium metal matrix composites are mostly consume in technological and innovative field .In this research work , Hybrid Aluminium metal matrix composite were developed by using Rice husk ash (RHA) with Iron Ore tailing (IOT) as reinforced element through stir casting process. RHA and IOT used as reinforcement by varying weight percentage of 5 to 15 wt% and its mechanical behaviour like density , porosity , harness , tensile and compressive properties was examined. From the mechanical test result, it is found tensile strength, hardness and compressive strength value increased and tensile strain and density value decreases with increasing amount of reinforcement. Tensile strength value increased by minimum 50 % to maximum 100% and hardness value also increased by up to 43% compare with unreinforced aluminium composite. porosity of composite material vary from 1.92 % to 4% which is acceptable to develop dense composite material. Therefore combination of bio waste (RHA) and industrial waste (IOT) serve great promise to replace conventional ceramic materials as reinforcement for improvement of cost effective metal composite material by utilizing waste material as wealth.

***Keywords*:** Metal matrix composite, Rice husk ash, Iron ore tailing, Mechanical behaviour

1.0 **Introduction**

Aluminium metal matrix composite(Al MMC) material are broadly consume in vehicle area , aviation application ,building materials since its superior strength , great wear and consumption obstruction , high stiffness and other properties . Ceramic material like SiC , Al_2O_3, boron carbine are widely utilized as reinforcement in Al MMC .these ceramic materials can be replaced by using low cost agro and industrial waste material like Rice husk ash ,wheat husk ash baggase ash , bamboo leaf , iron ore tailing, fly ash , red mud etc . Out of this Rice husk ash and iron ore tailing were chosen for this study.

Rice husk ash contents much amount of SiO2 which contributes for better tensile strength and improved wear properties likewise some of specialists utilized it for different sector like making mortars[1], replacement of Portland cement[2], development of low cost eco friendly concrete [3,4],used as a new sensing material[5], preparation of nano composite material [6,31],used as coating material for improvement of flexural strength of geo polymer composite[7],developing hybrid Al Metal matrix composite[8,9,10,11].

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Iron ore tailing is by waste during iron ore production. Billions tons of iron ore tailing produced annually. it creates hazardous problem because of its alkaline nature(pH 10-13.5) and removal problem[12] also these contend so much industrial compound such as Fe203, Al203, CaO[13] etc, there are many researcher utilized iron ore tailing for environmental design of cementitious composite material[14], stone preparation [15], brick manufacturing[16] , utilized as adsorbent material for elimination of weighty metals [17,18,19] and for reinforcement of hard iron ore tailing boost mechanical properties and wear properties of Al MMC[20] .present work emphasis on development of cost effective Al Metal matrix composite to take benefit of both industrial and bio waste by stir casting process . Mechanical properties such as density, porosity, ultimate tensile strength and hardness value tabulated.

2.0 Material and Methods

2.1 Material:

Al 6061 was used in the form of sheet as base material. Rice husk ash (RHA) was procured from baloda bazaar district, Chhattisgarh state and iron ore tailing (IOT) were procured from bailadila mines, Chhattisgarh state. RHA and IOT were used as reinforcement particulates element. Some amount of Mg (0.5wt %) were used for proper dispersion of element.

2.2 Methods:

2.2.1 Material preparation:

Metallic drum was used as burner for combustion of Rice husk. solid charcoal used as fuel for combustion. Ash particle were collected 24 hr after combustion.ash particle and iron ore tailing(IOT) was soaked in open sun for removal of moisture content. both iron ore tailing and Rice husk ash than sieved in 150 micron size for proper and uniform mixing. composition of RHA and IOT are tabulated in following table

Table 1: composition of Rice husk ash (RHA) and Iron ore tailing (IOT)

Constituents (wt %)	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	K_2O	LOI
RHA [4]	90.89	0.06	0.09	1.02	0.42	0.08	1.70	5.74
IOT[32]	9.02	9.56	67.67	1.96	2.12	0.43	0.46	8.9

Where, RHA = Rice husk Ash and IOT= Iron ore tailing

2.2.2 Composite preparation:

Hybrid metal matrix composite are prepared through stir casting . four types of sample were prepared by varying 5 wt % to 15 wt % of base metal Al .both RHA and IOT were preheated to 150 ˚C for removal of moisture content. Cupola furnace was used for combustion and heated at 800 ˚C for melting of Al metal . RHA and IOT as reinforcement element were slowly added with 0.1 Mg at this temperature and stirring of this combination done manually by mechanical stirrer for 15 minute at a speed of 150 rpm for proper uniform distribution of reinforced element . Than molten metal poured into cylindrical cast moulds.

2.2.3 Density measurement:

Density of hybrid composite were to check the effect of reinforcement on MMC .theoretical density were checked by ration of mass of composite to volume of composite . Experimental density used to check porosity percentage of developed composite material. This was checked by archmidies principle, where each sample submerged into pure water and ratio of mass measurement to water level volume provides density value. Porosity of each composite measured by following formula:

Porosity = $\{(\rho T - \rho\ exp)/ \rho T\}\times 100\%$

Where ρT = theoretical density (kg/m3) and $\rho\ exp$= experimental density (kg/m3).

2.2.4 Mechanical test sample preparation:

Tensile test performed on round and slender length having gauge length 50 mm and thickness 10 mm as per the ASTM EO8 standards. Tensile test was execute by instron testing machine under strain 1mm/s. ultimate tensile strength and 0.2% yield stress was calculated by load deflection curve. Rockwell hardness was calculated under the load of 100 kgf , 4 to 5 reading was perform on each specimen to get optimized hardness value . Round flat polished specimen was used for hardness testing under dwell time of 5 sec.

3.0 Result and discussion

3.1 Composite density and porosity:

Density and porosity are tabulated in following table and it has seen that actual or experimental density of composite material decline with the increasing amount reinforcement and vary from 2.67 kg/m3 to 2.55 kg/m3 . Density increases With RHA and decreases with IOT because low density of RHA 1.50 kg/m3 easily associated with matrix. also heavier IOT (density 5.15 kg /m) with Al density 2.67kg/m3 lead to improper involvement of density behavior which increasing the porosity . Here porosity varies from 1.51 % to 4.09% which is acceptable for development of Al composite [23]. The SiO_2 present in RHA and oxide of Fe, Al and Ca present in Iron ore tailing weaken the atomic bonding among matrix and reinforcement leads to decrement of density [24].

Table 2 : density and porosity of developed composite

Designation	Al 6061 wt%	IOT wt%	RHA wt%	Theoretical density (kg/m3)	Experimental density (kg/m3)	Porosity %
C 1	100	0	0	2.61	2.67	1.51
C2	90	5	5	2.55	2.60	1.92
C3	80	5	15	2.62	2.70	2.99
C4	80	15	5	2.48	2.58	3.89
C3	77	11.5	11.5	2.40	2.55	4.07

Where RHA= Rice husk Ash IOT= Iron ore tailing

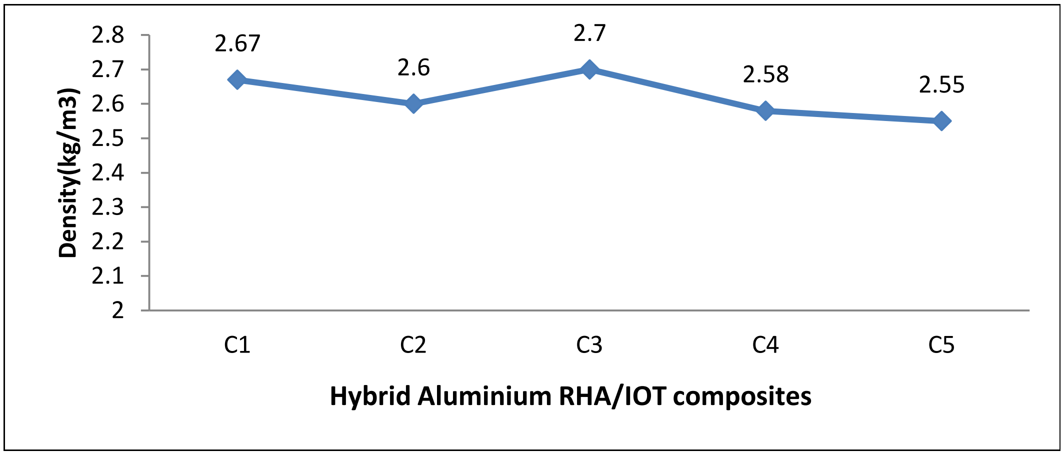

**Fig 1: variation of experimental density for unreinforced Al with hybrid Al composites **

3.2 Mechanical Behaviour:

Rockwell hardness of composites under the load of 100kgf are shown in fig . it is noted that hardness increases with increasing amount of reinforcement and hardness varies from 123 HRB to 177 HRB and there is improvement of 57.1% than unreinforced pure aluminium this is due to many reason ,initially proper distribution of reinforcement particle with lower porosity. Secondly presence of harder particles in reinforcement leads to inclusion of dislocation density which overall improve hardness at the time of indentation [25]. Oxide of iron and aluminium leads to enhance toughness and hardness of metal matrix composite [26].

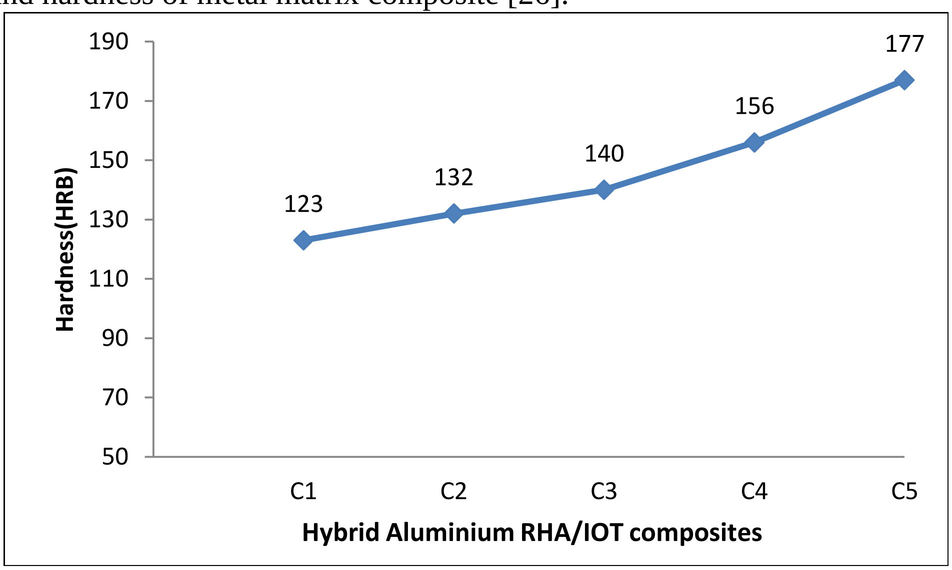

Fig 2: variation of hardness for unreinforced Al with hybrid Al composites

Figure 3 and 4 shows compressive strength and ultimate tensile strength of pure unreinforced Al and reinforced composite materials. It is noticed that improvement of tensile strength value up to 20% reinforcement than it value decreased. Compressive strength value enhances is maximum having Al/5wt%RHA /5wt%IOT than its value decline and increasing amount of Iron ore leads to decrease in compressive strength value. SiO2 present in RHA promotes compressive strength , when RHA associated with IOT its creates some void in matrix region which is suitable for tensile property than compressive property[21] so which up to 10wt% RHA with 10% IOT have best compressive strength .

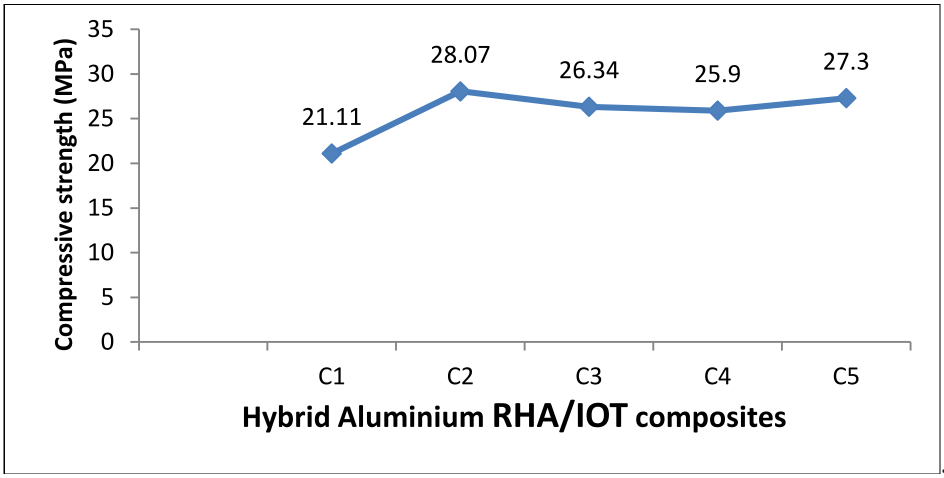

Fig 3: variation of compressive strength for unreinforced Al with hybrid Al composites

There are significant increment of tensile strength value by 99.23% by using 15 wt % IOT and 5 wt% RHA compare with unreinforced Al. previous research result shows that hard particle i.e SiO2, Fe203 and Al2O3 etc present in RHA and IOT promotes strengthen mechanism and also creates strain field during sintering process[27]. This strain field obstruct the dislocation when application of load which leads to enhance the tensile and compressive strength [28]. It is examined that thermal mismatch between high density ceramic particle and lesser thermal expanded Al matrix creates dislocation which enhances the strength of particulates composites material [29]

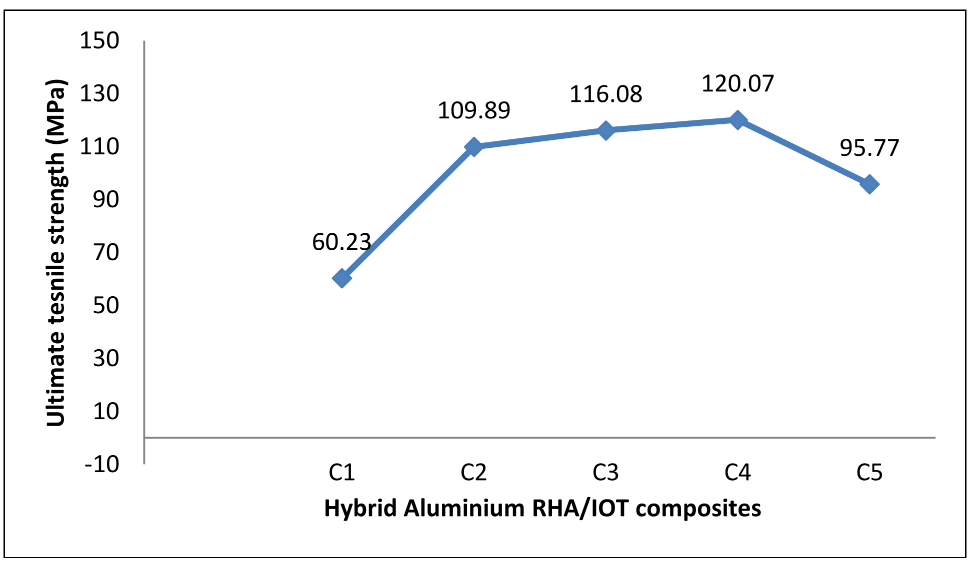

Fig 4: variation of ultimate tensile strength for unreinforced Al with hybrid Al composites

figure 5 shows the variation of tensile strain on composites materials and noted that higher ductility achieved by low reinforcement material .brittleness property improved with the amount of reinforcement because hard and stiff particles present in reinforcement lead towards formation of ductile brittle fracture at void and dislocation areas[30].

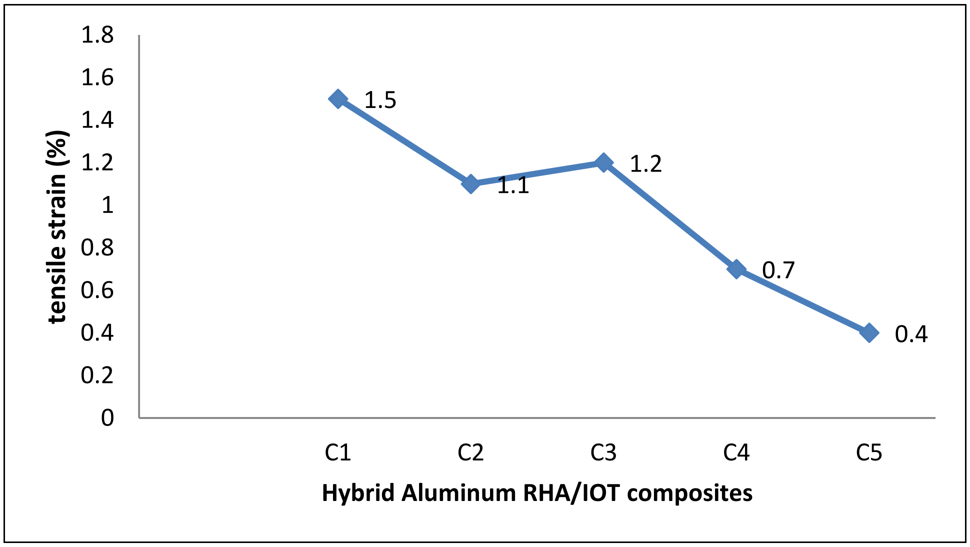

Fig 5: variation of tensile strain of Hybrid Al metal matrix composites

.4.0 Conclusions:

Al 6061 / RHA /IOT with varying percentage was developed by stir casting process. Following conclusion are to drawn by its mechanical behaviour:

1. Successfully developed low cost hybrid Al composite by using industrial waste (iron ore tailing) and bio waste(rice husk ash) up to 15 wt% independently.
2. Experimental density and tensile strain of composites materials decline with incremental proportion of reinforcement .the composite material shows optimum amount of porosity maximum 4% .density increases with increase amount of RHA and also decrease with increase amount of IOT.
3. Hardness of composites increases with increasing amount of reinforcement. Al /11.5wt% RHA / 11.5wt% IOT show highest hardness value and it is increased by 43% compare with unreinforced Al 6061 composite.
4. Compressive strength value varies from 21.11 MPA to 28.07 Mpa. Compressive strength value of reinforced composites are almost same and minimum and maximum compressive strength is 21.11% and 36% are more than unreinforced composite.
5. Ultimate tensile strength value increased by addition of reinforcement material. Tensile strength value increased by almost 100% for Al composite having 15wt% IOT/5wt% RHA.

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