Fly Ash and Bagasse Ash Al-MMCs Izod Test Analysis

Mohd. Zafaruddin Khan[1] Mohd.Anas[2] Ather Hussain[3] Saman Khan[4] Mohd.Sibghatullah[5]
[1,2,3,5]Department of Mechanical Engineering [4]Department of Civil Engineering
[1,2,3,4,5]Integral University, Lucknow, Uttar Pradesh, India

Abstract— Metal matrix composites (MMCs), in recent decade have found worldwide applications, constitutes an important class of design and weight efficient structural materials that are encouraging every sphere of engineering applications. Ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste byproduct. Hence, composites with ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications. To produce Al matrix cast particle composites, wettability of the ceramic particles by liquid Al is essential. In the present investigation, to improve wettability, elements such as Mg and Si are added into Al melt to incorporate the ceramic particles. The focus is on finding of the toughness using izod impact test, abundant available industrial waste such as fly ash and bagasse ash are used in useful manner by dispersing it into Eutectic Al-Si alloy LM6 Containing 10.58% Si to produced composites by liquid casting route. The izod impact strength test is investigated. The result of the mechanical property test showed that the toughness varies from 44 joule to 60 joule with maximum value at 10wt % fly ash +10wt % bagasse ash as reinforcement in the matrix metal. It was concluded that 10wt% fly ash +10wt% bagasse ash can be used as reinforcement in aluminium composites.

Key words: Aluminium Metal Matrix Composite, Fly Ash, Bagasse Ash , Impact Test

I. INTRODUCTION AND LITERATURE SURVEY

The growth of Indian population and its dependence on agricultural products for cooking purpose and the ease of having high living standard due to technological developments have increased the waste materials generated through industrial, mining and agriculture activities etc. As the waste materials are hard to dispose and thus a prime concern to environmental pollution [1]. Utilization of waste materials to reduce contamination not only meets spaces for disposal but at the same time leads to manufacturing of new engineering materials. One such composite is Aluminium alloy matrix, using different %age of various types of ashes [2]. Thus, recycling the waste material by converting it into green material for application in automobile and construction industries is a prime concern among the current researchers. A composite such as Aluminium metal matrix (Al-MMCs) was produced mainly for reducing material usage since metal is quite expensive due to its limited availability in future and also the fabrication cost which is lower than conventional cost. Composites material is have already proven their worth as weight-saving materials. The efforts to produce economically attractive composite from easily available raw materials to enhance innovative manufacturing techniques for industries. Metal Matrix composites (MMCs) generally, represent a new class of engineering materials, which has been incorporated with ceramic reinforcement for having improved properties such as specific strength, specific stiffness, wear resistance, excellent corrosion resistance and high elastic modulus [3, 4].

Aluminium is widely used as a structural material in the aerospace industry because of its light weight inherent property. However, the low strength and low melting point is always a problem. The stir casting method is widely used among the different processing techniques available. Stir casting usually involves prolonged liquid reinforcement contact, which can cause substantial interface reaction [5]. The most conventional method of production of composites by casting route is vortex method, where the liquid aluminum containing 2-5% Mg is stirred with an impeller and ceramic particles are incorporated into vortex formed by stirring of the liquid metals [6]. Addition of Mg into the liquid metal reduces the surface tension and there by avoids the rejection of the particles from the melts. Without addition of Mg recovery of the particles into the melt is quite low. Hence 2-5% Mg is generally added into the Al melts before incorporation of the particles. However, the chemistry of the particles of an Al alloy is changed with addition Mg that can be deleterious to the mechanical properties of the composites. The addition of hard or stiff ceramic has been established to improve the modulus behavior and strength properties in the metallic matrices [7, 8].

However this improvement varies from one ceramic material to another depending on the physical and chemical properties of the ceramic material. These properties include hardness, stiffness, and their interaction between each other and to the matrix material. Hence different ceramic material give different improvement properties of matrix material and the selection of reinforcing material depends on the basic requirements of the components during usage [9]. Reinforcing aluminium metal with rice husk or bagasse ashes as a source of silica particulate yields a material which has combination of physical and mechanical properties of both the metal matrix and the silica and alumina from the ashes. In our previous work Usman et al. [10] the silica and alumina potentials of rice husk ash and bagasse ash were determined while in other works [11], the density and some mechanical properties of composites produced by reinforcing aluminium alloy with rice husk ash and bagasse ash, respectively were determined.

Bagasse is a by-product from the sugar industry and it is usually burnt at the mill to provide process power or steam that provides energy for process machineries. The use of sugar cane bagasse as a source of energy, because of its appreciable calorific value, leads to production of ash as waste which has no specific economic application. A new reuse process of these wastes has to be established because these wastes, their ashes and gases are environmental burdens. Reinforcing aluminium metal with bagasse ash as a source of silica and alumina particulate will yield a material that displays combination of physical and mechanical properties of both the metal matrix and the silica [12].

Fly ash is one of the residues generated in the combustion of coal. It is an industrial by-product recovered from the flue gas of coal burning in electric power plants. All fly ash in general includes substantial amounts of silica (silicon dioxide, SiO2) (both30 amorphous and crystalline) and lime (calcium oxide, CaO) [13]. In general, fly ash consists of SiO2, Al2O3, Fe2O3 as major constituents and oxides of Mg, Ca, Na, K etc. as minor constituent. The largest application of fly ash is in the cement and concrete industry, though, creative new uses for fly ash are being actively sought like use of fly ash for the fabrication of MMCs. Aluminum–fly ash composites have potential applications as covers, pans, shrouds, casings, pulleys, manifolds, valve covers, brake rotors, and engine blocks in automotive, small engine and the electromechanical industry sectors [14, 15]. The fly ash reinforced AMCs are also termed as "Ash alloys".

The aim of present study is to utilize the abundant agro-industrial waste (fly ash and bagasse ash) from Indian agricultural dominating areas, where major waste is ashes, for its reinforcement in aluminium matrix composites, determining and comparing the properties of these composites. The economic utilization of these agro-residue and scraps can only enhance the energy problem of the country and provide alternative engineering material for composites and ceramics applications, providing source of income to farmers and masses thereby escalating rural developments and reducing environmental pollution. Most of the previous work carried out on processing and manufacturing of aluminium–fly ash composites have utilized different size of reinforcement, different amount of reinforcement, different types of fly ash [1, 2, 14]. Almost no work found on mixing different weight percentages of fly ash and bagasse ash to examine the effect on the characteristics of AMCs. An attempt is made to mix different weight percentage of fly ash and bagasse ash as reinforcement to fabricate the AMCs and a comparative analysis is presented in terms of their mechanical property. The details of experimentation and results are discussed in subsequent sections below.

In earlier study [16] mechanical properties such as hardness and tensile strength were studied.

II. SELECTION OF MATERIALS

Processing techniques using for the production of the composite materials are broadly classified into solid state and liquid state processing. The selection of the processing technique mainly depends on the application and state of the matrix and reinforcement materials. In this work, liquid state processing is preferred for the manufacturing of the desired composite material. The Eutectic Al– Si alloy LM6 which has a composition of 10.58% Si is used as a matrix and it is further designated as base alloy in this paper. Fly ash was brought from Panki Thermal Power Plant, Kanpur, Uttar Pradesh and Bagasse ash was collected from Kisan Sahkari Chini Mills Limited, Oudh, Mahmudabad, Sitapur, ttar Pradesh. The chemical compositions of the base alloy is given in Table I. The chemical compositions of different samples after reinforcement are as Base alloy+ 20wt% Fly Ash, Base alloy+10wt%Bagasse Ash and Base alloy + 10wt%Fly Ash+10wt%Bagasse Ash are listed in Table II , Table III and Table IV respectively.

	Compound	%wt	Compound	%wt
Elements in major quantities	Si	10.58	Al	86.8
Elements in small quantities	Fe	0.73	Mn	0.327
	Cu	0.247	Mg	0.368
	Pb	0.168	Cr	0.060
	Ni	0.021	Sb	0.015
	Ga	0.013	P	0.010
	Zn	0.02	Ti	0.016
Elements in minute quantities i.e. less than 0.1%- Ag, Sn, B, Sr, In, Li, Na, Ba, V, Be, Zr, Bi, Hg, Ca, Ce, Cd.				

Table - 1 Chemical Composition of Al-Si Alloy [Wt. %] Designated as Base Alloy

	Compound	%wt	Compound	%wt
Elements in major quantities	Si	12.0023	Al	85.98937
Elements in small quantities	Fe	0.81	Mg	0.343
	Cu	0.177	Ga	0.011
	Mn	0.092	P	0.0099
	Pb	0.085	Zn	0.319
	Cr	0.068	Ni	0.039
	Ti	0.015	Sb	0.0099
Elements in minute quantities i.e. less than 0.1%- Ba, Be, Sr, Na, Li, In, Zr, B, Cd, Ce, Co, Bi, Ag, Hg, Sn, Ca.				

Table: 2: Chemical Composition of Base Alloy+20%by weight Fly Ash

	Compound	Wt%	Compound	Wt%
Elements in major quantities	Si	12.678	Al	84.7838
Elements in small quantities	Fe	1.12	Ca	0.011
	Cu	0.151	Ga	0.012
	Mn	0.118	Cd	0.011
	Mg	0.364	V	0.0093
	Cr	0.141	Sn	0.0077
	Ni	0.062	P	0.012
	Zn	0.363	Pb	0.106
	Ti	0.017	Sb	0.017
Elements in minute quantities i.e. less than 0.1%- Li, In, Ba, Be, Ag, Co, Bi, Ce, Zr, Sr, Hg, B, Na.				

Table: 3: Chemical Composition of Base Alloy+10% by weight Bagasse Ash

	Compound	Wt%	Compound	Wt%
Elements in major quantities	Si	13.895	Al	85.2161
Elements in small quantities	Fe	0.303	V	0.0028
	Cu	0.020	Ga	0.016
	Mg	0.353	Mn	0.060
	Ni	0.0090	P	0.012
	Zn	0.024	Pb	0.038
	Ti	0.0063	Sb	0.0079
	Cr	0.022	Hg	0.0039
	Ca	0.0027	Ce	0.0015
Elements in minute quantities i.e. less than 0.1%- Cd, Zr, Sr, Na, Li, In, Co, Ba, Be, Sn, B, Ag, Bi				

Table: 4: Chemical Composition of Base Alloy+10% by weight Fly Ash+10% By weight Bagasse Ash

Several samples are prepared for the test. Sample 1 is the base alloy. Sample 2 is Base alloy with 10% Fly Ash by weight. Similarly Sample 3 has Base alloy with 20% Fly Ash by weight and so on. For each sample 3 specimens are prepared (Table V)

The above samples of aluminium ash metal matrix are prepared by Stir casting method i.e. 500gm of base metal is taken with required amount of bagasse ash and fly ash particles. The ash particles are preheated to remove moisture content. The base alloy converted to molten form at 660 0C in the open hearth furnace and stirred with the help of mild steel stirrer for 5-7 minutes at 200rpm. The dispersion of fly ash particles is achieved by the vortex method. The melt with reinforced particulates is poured into the sand mould at 620 0C. Ceramic particulate are incorporated to solidify. For increasing wettability, Mg is added to decreases the surface tension of the ash.

Sample	Composition	No. of specimens
S1	Base Alloy	03
S2	Base Alloy with 10% Fly Ash by weight	03
S3	Base Alloy with 20% Fly Ash by weight	03
S4	Base Alloy with 30% Fly Ash by weight	03
S5	Base Alloy with 10% Bagasse Ash by weight	03
S6	Base Alloy with 20% Bagasse Ash by weight	03
S7	Base Alloy with 30% Bagasse Ash by weight	03
S8	Base Alloy with 10% Fly Ash by weight and 10% Bagasse Ash by weight	03
S9	Base Alloy with 15% Fly Ash by weight and 15% Bagasse ash by weight	03
S10	Base Alloy with 20% Fly Ash by weight and 20% Bagasse Ash by weight	03

Table: 5: Preparation of Samples

III. METHODOLOGY

A. Impact Strength Test:

The impact toughness of a material can be determined with a Charpy or Izod test. Impact properties are not directly used in mechanics calculations, but the economical impact tests continued to be used a quality controlled method notch sensitivity and for comparing the relative toughness of emerging materials. For both test, the specimen is broken by a single overload event due to the impact of the pendulum. A stop pointer is used to record how far the pendulum swims back up after the fracturing the specimen. The impact toughness of a metal is determined by measuring the energy absorbed in the fracture of the specimen.This is simply obtained by noting the height at which the pendulum is released and the height to which the pendulum swings after its has struck the specimen. The height of the pendulum times the weight of the pendulum produces the potential energy and the difference in potential energy of the pendulum at the start and the end of the test equal to the absorbed energy.

IV. RESULTS AND DISCUSSION

Sample	Impact strength in Joule			Mean
	Test-1	Test-2	Test-3	
S1	46	44	42	44
S2	48	50	48	48.67
S3	54	52	54	53.33
S4	50	48	52	50
S5	58	60	60	59.33
S6	54	56	54	54.67
S7	52	52	54	52.67
S8	62	64	60	62
S9	62	62	60	61.33
S10	60	62	58	60

Table: 6: Impact Strength Test

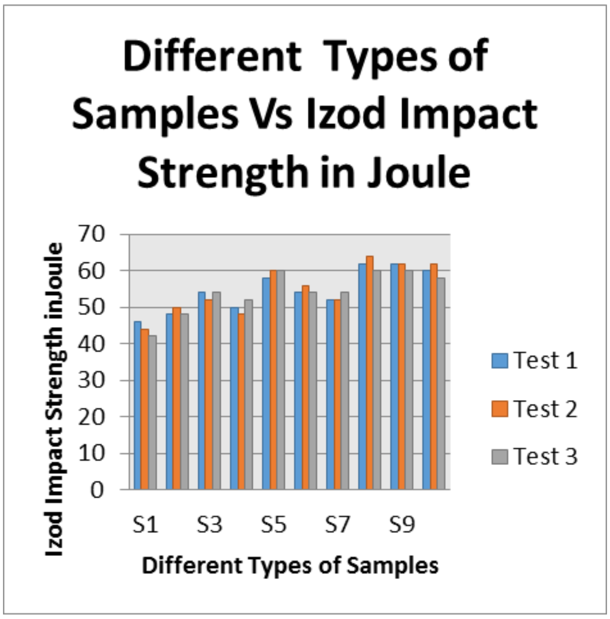

Fig. 1: Showing the Graph for Different Samples and Izod Impact Strength in Joule

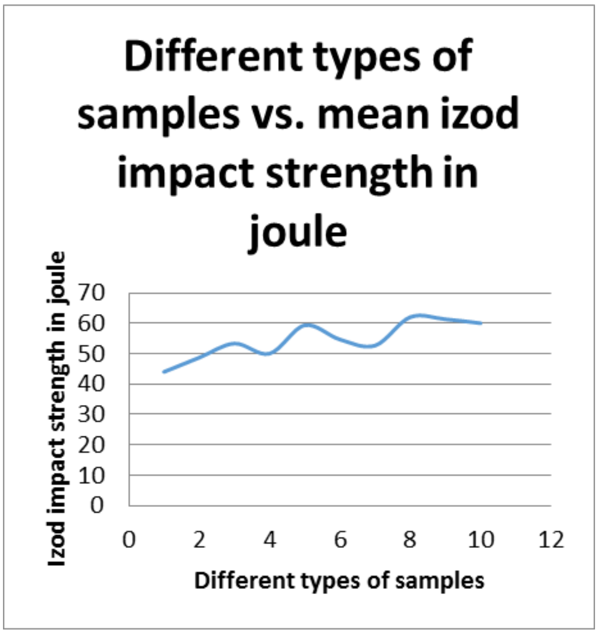

Fig. 2: Showing the Graph for Different Samples and Mean Izod Impact Strength in Joule

The figure 1 shows Different types of Samples Vs Izod Impact Strength in Joule . It is observed that Sample 8 has relatively high value of Izod Impact Strength. Similarly as in earlier case we have prepared 3 Samples for each configuration we obtain 3 readings for each Sample. The Mean Izod Impact Strength of Sample 8 is given in fig.2 i.e. 62 Joule is relatively high than all the other Samples. It can be therefore concluded that by adding 10% Fly Ash by weight and 10% Bagasse Ash by weight we can obtain best results for the Izod Impact Strength .It is also observed that as the percentage of both the ashes is further increased we obtain a relatively low Impact Strength.

For the fig. 2 obtained, it represents the Mean value of the Izod Impact Strength for each sample. Various plots are plotted to observe the toughness profiles in figure 1 and figure 2. The highest value of strength is 62 joule when 10% Bagasse Ash and 10% Fly ash were added. However as the bagasse Ash's %wt is increased, strength decreases.

V. Conclusion

The continuous stir casting method used to prepare the composites could produce uniform distribution of the reinforced fly ash particles. In the present investigation, it was anticipated that all the composites will have the same wt% of the dispersed phases. The experimental data reveals that selection of reinforcement is one of the important aspects in production of metal matrix composites especially when the enhanced mechanical properties are desired. The following conclusions may be drawn from the present work:

- From the study it is concluded that we can use fly ash and bagasse ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage and disposal of ash.
- 10% by weight Fly Ash +10% by weight Bagasse Ash can be successfully added to Al-Si alloy LM6 by stir casting route to produce composites.
- Addition of magnesium improves the wettability of ash with aluminium melt and thus increases the retention of the ash in the composite.
- Izod Impact Strength also improved by adding Fly Ash and Bagasse Ash with each other 10% by weight.

VI. Scope for Future Work

1) The similar studies can be made by varying the percentages of Fly Ash and Bagasse Ash between 10% to 15% may we can get better results. As in the present study we have incorporated 10% Fly Ash by weight and 10% Bagasse Ash by weight in the Sample 8 and also we have mix 15% Fly Ash by weight and 15% Bagasse Ash by weight in the sample 9 , So as per the results obtained we can say that there is a possibility of getting better results by varying the percentages of Fly Ash and Bagasse Ash between 10% to 15%.
2) The similar studies can be performed by incorporating different percentages of Fly Ash and Coconut Ash . Also Bagasse Ash and Coconut Ash can be used as reinforcement material.
3) There is more possibility of getting fascinating results by mixing different types of Ash and different percentages of Ash. Rice Husk Ash can also be used in this respect.
4) Various other casting methods may give better results.

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