PREPARATION OF AMMC's WITH NANO SIZED REINFORCEMENT BY STIR CASTING PROCESS WITH VARIOUS TECHNIQUES

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Abstract : **Now a days researches are carried out on different Al alloys reinforced with bottom ash and flyash by using stir casting method. and everyone got unexpected results one or another way mainly uneven distribution of reinforcement material in alluminium alloy.In order to know the reason we go through different papers with different wt% and we enlighted that different wt% ,size of the reinforcement and also method of addition of reinforcement material matters in uniform distribution of reinforcement in alluminium alloy. so we conducted 4 different methods of addition with nano-sized reinforcement material in stir casting casting process. we attended better results in 3rd method than 2nd method and failed in 4th method due to temperature sharing.**
We concluded this by performing various tests like hardness and tensile and also performed micro-structural analysis like Scanning Electron Microscopy (SEM).

***Keywords: Al alloy, Bottom ash , stir casting, mechanical properties and microstructure*.**

I. INTRODUCTION

Now a days the particulate reinforced aluminium matrix composite are gaining importance because of their low cost with advantages like isotropic properties and the possibility of secondary processing facilitating fabrication of secondary components. Cast aluminium matrix particle reinforced composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys.

These are the most abundantly used matrix material. Generally the mechanical properties of polymers are inadequate for many structural purposes, particularly their low strength and stiffness as compared to metals and ceramics. Among various discontinuous dispersoids used, bottom ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with bottom ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications.

MMC'S (Metal matrix composites) are metals reinforced with other metal, ceramic or organic compounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements are usually done to improve the properties of the base metal like strength, stiffness, conductivity, etc. [2]. Today aluminum based composite reinforced with ceramic particles is on huge demand, due to its superior mechanical characteristics, for example; specific stiffness, wear resistance, high modulus and fatigue. These metal matrix composites have been considered as excellent candidates, applied as structural materials to the automobile industry and aerospace. There are different manufacturing techniques for reinforcing alloy such as spray decomposition, liquid metal infiltration, powder metallurgy, squeeze casting, mechanical alloying and compo-casting.

The matrix should bond strongly with the reinforcement but should not be chemically affected by adverse reactions. The mechanical properties are completely dependent on the micro-structural parameters [4]. The adhesive strength between the matrix and reinforcement plays an important role in the determination of mechanical properties for MMCs. Reinforcement is usually composed of non-metal components and generally conventional ceramic materials, such as SiC, Al2O3, fly ash and so on. Many important automotive components, such as pistons, cylinders, engine blocks, brakes, drive shafts and snow tire studs, have used aluminum matrix composites in their production. [5]. Higher strength is required to replace heavier metals with this alloy in some applications at ambient and elevated temperatures Powder metallurgy provides better bonding of matrix and nano-particles. MgO due its high melting point (Tm = 28000C), compressive strength, hardness and excellent thermodynamic stability is a better choice for reinforcement. The mechanical properties have been improved by the addition of MgO particles [7] another reinforcement is added along with the MgO i.e. fly ash because there are many advantages of Hybrid Composites over monolithic, alloys and composite Materials were high strength to weight ratio, good corrosion/wear resistance, strength/stiffness, low Thermal conductivity/coefficient of thermal expansion, light weight, Better impact and flexural Properties Reduced overall cost of the composite.

Manufacturing of alluminum alloy based casting composite materials via stir casting is one of the prominent and economical route for development and processing of metal matrix composites materials. Properties of these materials depend upon many processing parameters and selection of matrix and reinforcements

Example: Aircraft as well as automobile applications, where the fuel economy plays the key role. Hybrid composites consisting of one matrix phase and other phase is two or more reinforcements. These are bonded due to heterogeneous mixing of one or more particles reinforcement, which has been homogeneous phases at macro level and fabricated through various techniques such as powder metallurgy route, stir casting, two step stir casting, squeeze casting [9]. As fly ash is a by-product of coal combustion, available in very large quantities with minimal cost, therefore, the material costs of composites can be reducing significantly by incorporating fly ash into the matrices of metallic alloys [10].The chemical composition of this ash consists of Al2O3, SiO2 and Fe2O3 as major constituents and MgO, CaO, K_2O and Na_2O as minor constituents. The utilization of aluminum matrix composites with fly ash particles as reinforcement are likely to overcome the cost barrier for widespread applications, such as engineering, automotive and other applications.

2. METHODOLOGY

Fabrication of selected composite is prepared by using stir casting method. The matrix material is selecting according to the application i.e automotive application The preparation of required powder by using ball milling process. in ball milling process.

powder mixture placed in ball mill is subjected to high energy collision from the balls (nano-particles) and the required powdered size is obtained. Now the prepared matrix powder material and reinforcement powder material is heated in crucible up to 700℃.The heated matrix and reinforcement material is thoroughly mixed using stir casting process .as it is a economical and easy way to get uniform distribution of reinforcement on liquid matrix material. The obtained liquid metal is poured into the mould. Now the required dimension specimen is obtained and the tests are carried out and the results are evaluated.

Ball milling Aluminium billets Bottom ash

Figure 2.1: Preparation of Reinforcement and Matrix

2.1 Preparation Of Matrix phase

We brought the Al2024 from FENFE casting Bangalore in required quantity as per the the following composition.

Table 1: Chemical Composition of Aluminium alloy

Element	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti	Al	Others:each	Others:total
Percentage	1.4%	3%	13%	1%	0.4%	1.4%	0.1%	0.1%	0.1%	0.2%	78.8%	0.04%	0.14%

2.2 Preparation of Reinforcement phase

We brought bottom ash from JSW plant. we sieved it for 42 microns size and other particles were removed. We did it in seiver machine. then we have gone to PES college for the ball milling to reduce the size of the bottom ash particle to nano size particle. Then we have gone for SEM testing in the BMS college. We got the nano size . for casting we made filling on billet to get the powder material of 2kg. hence we started fabrication process.

2.3 Preparation Of composite

1. Heating matrix material in crucible without adding reinforcement.
2. Reinforcement addition after melting matrix material in the crucible.
3. Reinforcement addition before melting matrix material in the crucible.
4. Reinforcement is mixed with matrix material before introducing in to the crucible.

METHOD 1 (0% addition of bottom ash)

First we weighed 1.5kg and placed the Aluminium billets in the crucible. Now the electric heated crucible is switched on. The Aluminium metal starts melting as the time goes on. The specimen is heated up to 830 ˚C. After 2 1/2 hours the specimen completely melts. now hexachloroethane tablet is placed in the molten metal to remove the slag and gasses formed during the process. before that the die is preheated. After that the molten Aluminium is poured into the die and cooled in the air for an hour.

METHOD 2 (4% of bottom ash the reinforcement is mixed after the billet melts)

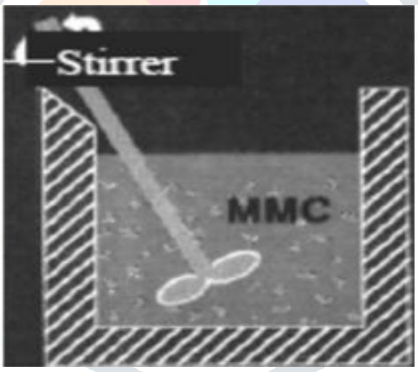
The preheated Aluminium billets are now placed in the crucible and the 2 kg of billets are weighed and placed around the crucible for preheating. Now the bottom ash is weighed by mass percentage of 4% and placed around the crucible for preheating. The billets are heated up to 830 ˚C for 2hours. As the billets melts and become molten metal. Now hexachloroethane tablet is placed in the molten metal to remove the slag and gasses formed during the process. Now the bottom ash is added by spoon in small amount continuously. In this adding process stirrer is used for uniform distribution of the reinforcement.the stirrer speed is increased continuously as the formation of the slag increases. After the stirring the slag is removed from the molten metal and the molten metal is poured into the die and the die is air cooled for an hour.

METHOD 3 (4% of bottom ash the reinforcement is added before melting of the billets)

The preheated aluminum billet of 2kg is placed in the crucible and the reinforcement is placed below the billets and heated up to 830 ˚C for 2 hours. As the billets melts the mixing of the matrix and reinforcement takes place. now hexachloroethane tablet is placed in the molten metal to remove the slag and gasses formed during the process .And there will be formation of slag. Hence the stirrer is once again used and the slag will come up. The slag is removed from the crucible and the molten metal is poured into the die.

METHOD 4 (4% of bottom ash Pre-mixed Aluminium powder and the reinforcement)

The Aluminum powder is formed by hand forging and it is mixed with reinforcement. the Aluminium powder of 2kg is with Aluminum powder of 4% by mass. The mixed Aluminum powder is placed in the crucible and it is heated to 830 ˚C. And we heated it for 3 ½ hours. After that also the powder didn't melts. It is just forming like lumps like charcoal. After that we come to know the reason behind the not melting of the powder is not melting of al powder is sharing of temperature. Hence we need to increase the temperature when there is powder form of matrix material.



Die Stirring action Pouring process

Pre-heating Stirrer Composite-bar

Figure 2.2: Casting Process

PRAPRATION OF SPECIMEN ACCORDING ASTM STANDARDS

3.1 Specimen Preparation for Mechanical Testing.

3.1.1 TENSILE TEST SPECIMEN DIMENSIONS

- Gauge length- 50mm
- Outer diameter- 12.55mm

3.1.2 HARDNESS TEST SPECIMEN DIMENSIONS

- Length- 10mm
- Outer diameter-20mm

3.2 Specimen Preparation For SEM Analysis.,DIMENSIONS

- Length- 10mm
- Outer diameter-10mm

Figure 2.3: Tested specimen as per ASTM standard

4 RESULTS AND DISCUSSION

As we conducted 3 methods with different addition methods and different wt% i.e 0% ,4%, 4% with and without addition of reinforcement material. We performed test on mechanical properties like tensile, hardness .we found that hardness of the material with addition of reinforcement material is increased then without reinforcement material. There is increase in ultimate tensile strength & hardness due to addition of reinforcement material (bottom ash) which gives strength to the matrix alloy by enhancing resistance to tensile stresses.

4.1 Tensile Test

The tensile test provides information on Yield stress, Tensile strength, peak load, Percentage elongation in reduction in area. The graphs are drawn by using results obtained in 3 different methods and graphs are plotted load v/s cross head travel (Displacement).The plotted graphs for 3 methods are shown above.

Table 2: Property of materials during tensile test

Aluminium With (Reinforcement)	Peak Load KN	Yield Stress Mpa	Tensile Strength Mpa	% Of Elongation
METHOD 1 (0%)	9.76	68.66	79.39	1.10
METHOD 2 (4%)	7.56	54.64	61.11	1.14
METHOD 3 (4%)	10.44	73.12	85.20	0.72

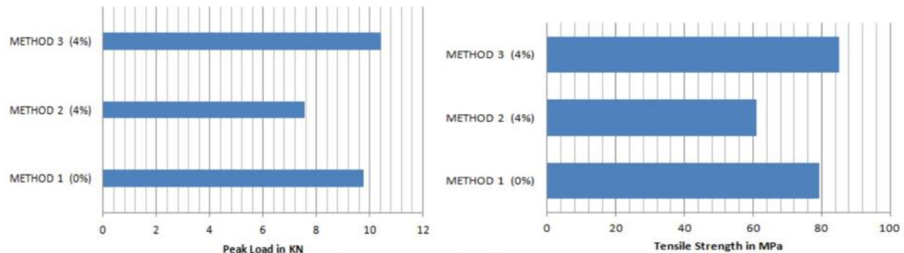


Figure 4.1: Graph of tensile test of different method

4.2 Hardness Test

The hardness have been evaluated for Al2024/bottom ash composites with Vickers hardness test and hardness values of base alloy & composite are listed in Table 1.In Vickers hardness tester diamond indentor is used here readings are taken in terms distance & diagonals.

Diameter of the specimen=20mm Length of the specimen=10mm Applied load=1 kg

D=Distance DLX=Diagonal X DLY=Diagonal Y VHN=Vickers harness number

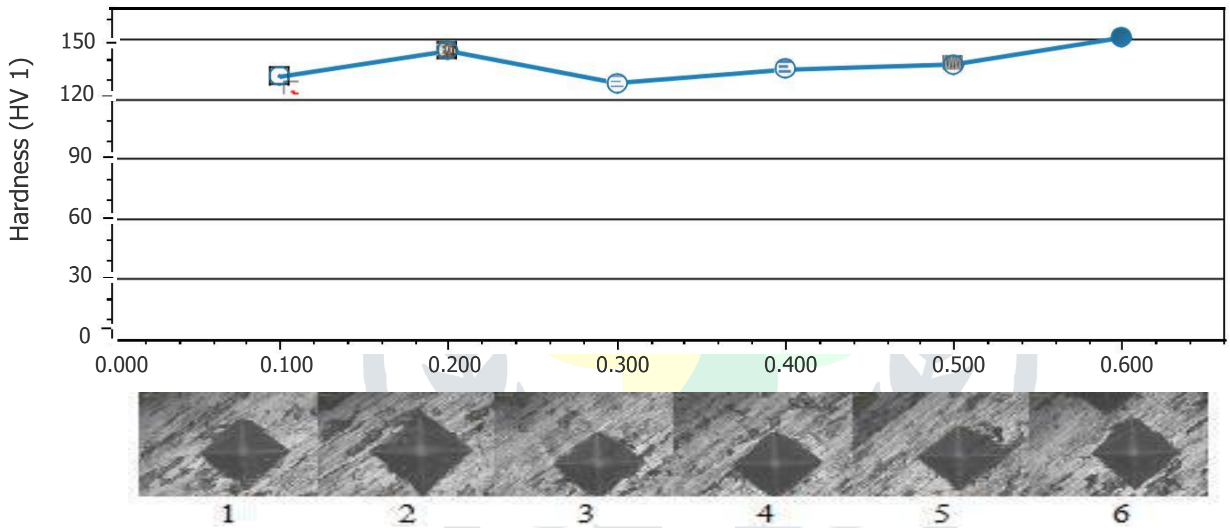
Table 4.1: Hardness test performances

SL.NO	METHOD 1 (0%)				METHOD 2 (4%)				METHOD 3 (4%)			
	D mm	DLX mm	DLY mm	VHN	D Mm	DLX mm	DLY mm	VHN	D mm	DLX Mm	DLY mm	VHN mm
1	0.1	0.115	0.122	131.6	0.1	0.113	0.111	147.6	0.1	0.127	0.131	111.8
2	0.2	0.110	0.116	144.3	0.2	0.126	0.134	109.3	0.2	0.111	0.115	145.2
3	0.3	0.120	0.120	128.5	0.3	0.109	0.100	170.3	0.3	0.121	0.126	121.3
4	0.4	0.117	0.117	135.0	0.4	0.104	0.105	169.3	0.4	0.114	0.108	150.6
5	0.5	0.119	0.113	137.6	0.5	0.112	0.102	160.9	0.5	0.112	0.118	140.3
6	0.6	0.108	0.114	150.8	0.6	0.111	0.113	148.6	0.6	0.124	0.128	116.5

The table shows the Vickers hardness measurements of 6 distinct position of the case specimen of 0%, 4%, 4% of reinforcement.

Method 1:

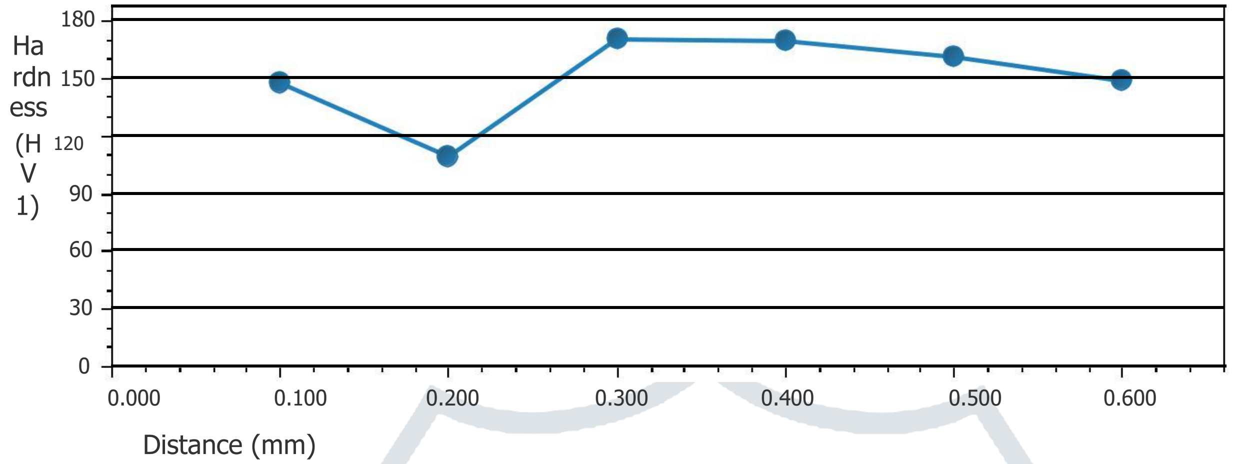
Mean	Minimum	Maximum	Range	Std. deviation
138.0	128.5	150.8	22.3	8.3



Point	Distance	Hardness	Diagonal X	Diagonal Y
1	0.100mm	131.6HV 1	0.115mm	0.122mm
2	0.200mm	144.3HV 1	0.110mm	0.116mm
3	0.300mm	128.5HV 1	0.120mm	0.120mm
4	0.400mm	135.0HV 1	0.117mm	0.117mm
5	0.500mm	137.6HV 1	0.119mm	0.113mm
6	0.600mm	150.8HV 1	0.108mm	0.114mm

Method 2:

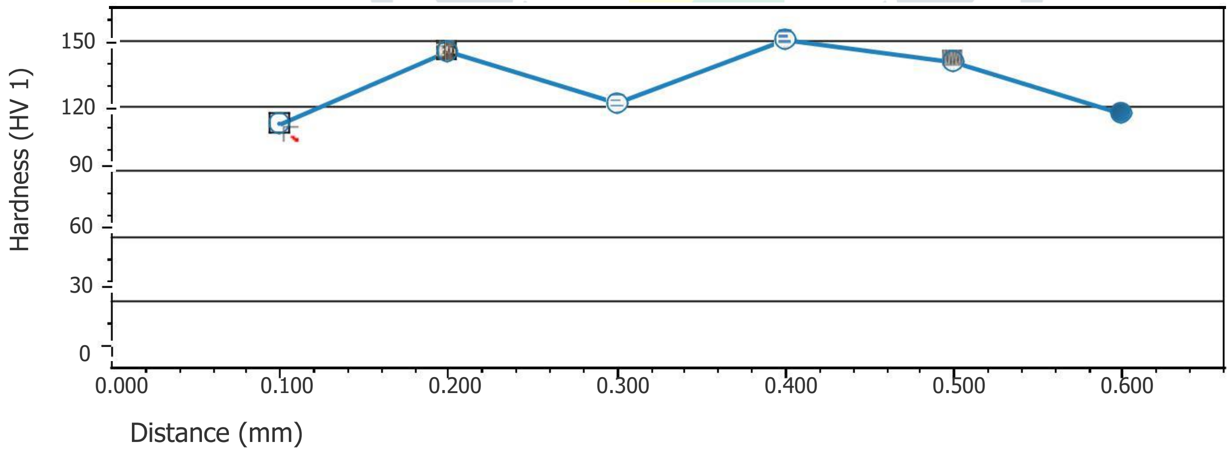
Mean	Minimum	Maximum	Range	Std. deviation
151.0	109.3	170.3	60.9	22.6



Point	Distance	Hardness	Diagonal X	Diagonal Y
1	0.100mm	147.6HV 1	0.113mm	0.111mm
2	0.200mm	109.3HV 1	0.126mm	0.134mm
3	0.300mm	170.3HV 1	0.109mm	0.100mm
4	0.400mm	169.3HV 1	0.104mm	0.105mm
5	0.500mm	160.9HV 1	0.112mm	0.102mm
6	0.600mm	148.6HV 1	0.111mm	0.113mm

Method 3:

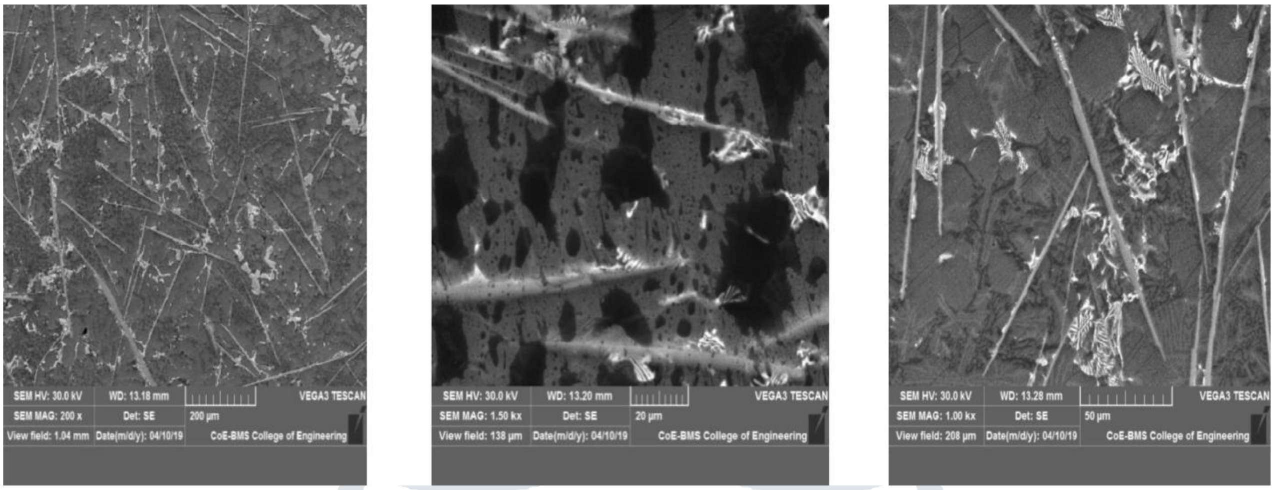
Mean	Minimum	Maximum	Range	Std. deviation
131.0	111.8	150.6	38.7	16.4



1 2 3 4 5 6

Point	Distance	Hardness	Diagonal X	Diagonal Y
1	0.100mm	111.8HV 1	0.127mm	0.131mm
2	0.200mm	145.2HV 1	0.111mm	0.115mm
3	0.300mm	121.3HV 1	0.121mm	0.126mm
4	0.400mm	150.6HV 1	0.114mm	0.108mm
5	0.500mm	140.3HV 1	0.112mm	0.118mm
6	0.600mm	116.5HV 1	0.124mm	0.128mm

4.3 Micro-Structural Analysis



Method 1 Method 2 Method 3

Figure 4.2: SEM of Different methods

Scanning Electronic microscope is one of the techniques to view the structure of AMMC's. SEM gives the microstructure of the specimen through which we can come to know about porosities, grain structure, and dispersion of reinforcement in matrix phase.

In method-1 there is only pure alluminium which doesn't have any porosities and it is a defect less one as shown in Fig 4.2

In method-2, 4% reinforcement added, we observed un-even distribution of reinforcement in matrix phase & large porosities were observed indicated by the dark black regions, bottom ash is indicated by white color as shown in Fig 4.2.

In method-3, 4% reinforcement added, we observed uniform distribution of reinforcement in matrix phase and no porosities were observed, bottom ash is indicated by white colour region, As shown in Fig 4.2.

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CONCLUSION

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