EXPERIMENTAL INVESTIGATIONS ON MECHANICAL CHARACTERISTICS OF FLY ASH REINFORCED AA2011 MATRIX NANO-COMPOSITES

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ABSTRACT - *Now-a-days we are widely using aluminum based metal matrix composites. To overcome the problems faced in conventional materials, lots of studies are going on replace them with composites/alloys. In these metal matrix composites are heavily used in structural, aerospace, weapons, machinery parts, marine and automobile applications for its light weight, high strength and low production cost. As developments of light weight materials has provided numerous possibilities for weight reduction. In this project we are casting aluminum based (AA2011) composites with magnesium and fly ash as reinforcements, fly ash is one of the inexpensive and low density material and it is easily available as the product during coal combustion and then casted components are machined specimen dimension and different materials testing had been conducted to the obtain material properties, characteristics and micro structures. We are varying mass fraction of fly ash (0%, 5%, 10%, 15%, and 20%) and keeping 4% of magnesium as constant. We had got well advancements in mechanical properties like tensile, hardness and impact strength with increase in wt% of reinforcement.*

Key Words: (Metal matrix composites, Mg - Fly Ash, Stir Casting, and Mechanical Properties)

1. INTRODUCTION

Traditional solid materials have confinements in accomplishing great mix of solidarity, solidness, sturdiness and thickness. To beat these deficiencies and to fulfill the consistently expanding need of advanced innovation, composites are most encouraging materials of ongoing interest. Metal lattice composites (MMCs) have essentially improved properties including high explicit quality; explicit modulus, damping limit and great wear obstruction contrasted with unreinforced compounds. There has been an expanding enthusiasm for composites containing low thickness and minimal effort fortifications. At the plainly visible level at least two materials join to give helpful material which is named as composite. An inhomogeneous material made by the engineered get together of at least two materials at the naturally visible level, to get explicit attributes and properties, is named as composites.

The greater parts of the composite materials are made out of two stages one is named as lattice, which is ceaseless and encompasses the other stage, frequently called the scattered stage. Composites are partitioned into the accompanying classes based on the type of the basic constituents:

1) Fibrous: In this class of composite the scattered stage comprises of filaments.

2) Flake: In this, the scattered stage comprises of level drops.

3) Laminar: It is made out of layer or laminar constituents.

4) Particulate: For this situation scattered stage comprises of little particles

In view of the utilization of the material the necessities of properties of composite are:

Strength, Stiffness, Corrosion Resistance, Wear Resistance, Attractive segments Weight (for use in vehicle/airplane businesses) Temperature subordinate property, Thermal conductivity Insulation.

1.1 Metal Matrix Composites (MMCs)

MMCs are of enthusiasm for nowadays since they offer the chance to tailor a material with a mix of properties inaccessible in any single material. For instance, consolidating the high rigidity and modulus of versatility of different sorts of strands with low thickness of a metal, for example, Aluminum, Titanium (Ti) or Magnesium (Mg) to acquire a composite material with a higher solidarity to-thickness or modulus-to-thickness proportion than any single amalgam.

Earthenware support might be silicon carbide, boron, alumina, silicon nitride, boron carbide, boron nitride and so on while Metallic Reinforcement might be tungsten, beryllium and so forth. MMCs are utilized for Space Shuttle, business carriers, electronic substrates, bikes, vehicles, golf clubs and an assortment of utilizations. From a material perspective, when contrasted with polymer grid composites, the benefits of MMCs lie in their maintenance of solidarity and firmness at raised temperature, great scraped spot and creep obstruction properties. Most MMCs are still in the improvement stage or the beginning phases of creation and are not all that generally settled as polymer lattice composites.

The greatest disservices of MMCs are their significant expenses of manufacture, which has put impediments on their real applications. There are additionally points of interest in a portion of the Fly Ash al characteristics of MMCs, for example, no critical dampness assimilation properties, non-inflammability, low electrical and warm conductivities and protection from most radiations. MMCs have existed for as long as 30 years and a wide scope of MMCs have been contemplated. Because of the helpless wet capacity between the metal lattice and the fired particles, the particulates will in general agglomerate in the network. Outside field powers are expected to separate the bunches and help scatter the particles into the metal.

Contrasted with solid metals, MMCs have:

- Higher solidarity to-thickness proportions
- Higher firmness to-thickness proportions
- Better exhaustion opposition
- Better raised temperature properties
- Higher quality
- Lower creep rate
- Lower coefficients of warm development
- Better wear opposition

MMCs can be partitioned into three classifications:

a) Particle fortified MMCs

b) Short fiber fortified MMCs

c) Continuous fiber fortified MMCs

Among the three classifications, the manufacture cost of particulate fortified MMCs is low which make it appealing and financially suitable to consider for modern application. Particulate MMCs contain second stage particles extending from 10nano meters up to 500micro meters. MMCs with a uniform scattering of particles in the scope of 10 nano-meters to 1micro meter are named as METAL MATRIX NANO COMPOSITES (MMNCs). With the size of fortification downsizing to nano-scale; MMNCs display progressively remarkable properties over MMCs and are accepted to beat the deficiencies of MMCs, for example, helpless malleability, low crack durability and machinability. It has been accounted for that with a little portion of nano-sized fortifications; MMNCs could acquire tantamount or even far predominant mechanical properties than MMCs.

Prof.N.RDamere, atal [1] proposed the utilization of nano particles created by base up approach for the manufacture of the nano composites considering malleability maintenance with uniform increment in pliable properties. Top down is additionally passable to use in creation of MMNC. In their work they has accepted network material as A356 and fortification material as nano silicon carbide particles at 0.1 to 5 weight rate by ultrasonic cavitation , and the outcomes are contrasted and A356 lattice composite strengthened with small scale particles at 5wt% by mix throwing additionally arranged. They demonstrated that 1kw force ultrasonic transducer and 6 min as sonication time 0.1wt% of fortification is adequate to scatter nano materials in 500gmsof AL metal. In this work he reasoned that with the expansion in the fortification proportion, rigidity, hardness of nano-Fly Ash critical change in flexibility. While for small scale composite, slight increment in quality, hardness and abatement in malleability were watched.

J.David Raja Selvam, D.S.Robinson Smart [2]; has taken AA6061 as network material and they took fortification material fly debris. This examination demonstrates that 1kw force ultrasonic transducer with 30min sonication time for 12wt% support is adequate to scatter nano materials in 500gms of Al metal. They contrasted the outcomes and the unadulterated A356 composite and they reasoned that utilization of nano materials indicated improvement in elastic properties and hardness with decline in malleability. 12wt% of the CNTs displays the best return and elasticity and great maintenance of pliability, and among Fly Ash and B4c the fly debris shows preferable ductile properties over the other.

Dr.RavindraKommineni ;atal [4], has accepted lattice material as AA2024 combination and support material as B4c and contrasted the outcomes and the base amalgam they has taken another and cheap strategy for the creation of light weight MMNC by utilization of ultrasonic nonlinear impacts to be specific transient cavitation and acoustic gushing. They has reasoned that the 1.5wt% of B4c in the base metal has improved the mechanical properties including the elasticity and the yield quality fundamentally and furthermore by watching the SEM pictures great scattering of the fortification I the lattice material.

2. FABRICATION OF THE METAL MATRIX COMPOSITE:

Despite the fact that there are a few strategies for the arrangement of the composite, giving developed a role as the one of the best techniques to deliver items with the unpredictable shapes. Anyway it is very hard to acquire uniform scattering of nano-sized particles in fluid metals because of high consistency, helpless wet capacity, and enormous surface to volume proportion in the metal grid. So to beat this difficult we utilize high force ultrasonic waves to have uniform scattering in the fluid stage as they produce the fundamental non - straight impacts required.

2.1 Equipment and Consumables Used:

Matrix Alloy	AA2011.
Reinforcement	Fly ash Of Size 5μm-300 μm
Wetting agent	Magnesium (Mg)
Crucible	Graphite Material With 1.5 Kg Capacity
Dies	Mild Steel
Inert Gas	Argon.
Ultrasonic Transducer	20Khz, 2000W
Electrical Resistance Furnace	1200°C
Chamber Size	12×12×18

Table 1: Equipment and Consumables Used

2.2 Composition Of Aa2011:

Table 2: Composition of AA2011

Component	**Wt%**
Cu	6.00%max
Fe	0.7%max
Si	0.40%max
Zn	0.30%max
Bi	0.60%max
Pb	0.40%max
Al	Balance

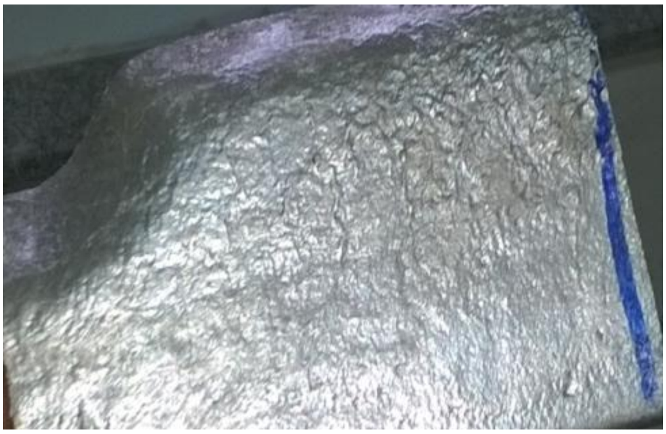


Fig 1: Aluminum Block

2.3 Aluminum Aa2011 Properties

2011 aluminium amalgam is an al based composite frequently utilized in the avionic business and general use. It is effortlessly machined in specific tempers and among the most grounded accessible al combination, just as having high hardness. Notwithstanding, it is hard to work, as it is liable to breaking. Al 2011 is the second generally well known of the 2000 arrangement aluminum composites, after 2011 aluminum amalgam. It is normally acceptable expelled, formability, manufactured. The erosion opposition of these combinations is especially poor. To battle this, it is regularly clad with unadulterated aluminum. In the event that unclad 2011 aluminum is to be presented to the components, it ought to be painted as consumption insurance measures. The liquefying purpose of AA2011 is 540°C.

Characteristics:

- High hardness and quality
- Good formability and work capacity
- Excellent machining
- Poor destructive obstruction
- It is heat treatable amalgam

2.4 Fly Ash:

Fly debris otherwise called "pummeled fuel debris" within the UK could be a coal burning item made out of fine particles that are driven out of the heater with the vent gases. Debris that falls within the base of the kettle is named base debris. Before, fly debris was by and huge discharged into the air, however air contamination control measures currently necessitate that it's caught preceding discharge by fitting contamination control hardware. Two classes of fly debris are characterized by ASTM C618: Class F fly ash and sophistication C fly debris.

The most contrast between these classes is that the measure of calcium, silica, alumina, and iron substance within the debris. The compound properties of the fly debris are to an excellent extent laid low with the synthetic substance of the coal consumed (i.e., anthracite, bituminous, and lignite).Not every fly ash meet ASTM C618 prerequisites, despite the very fact that relying upon the appliance, this could not be important. Debris utilized as a concrete substitution must fulfill exacting development guidelines, however no standard ecological guidelines are built up within the u. s.. 75% of the debris must have a fineness of 45 µm or less, and have carbon content, estimated by the misfortune on start (LOI), of under 4%. In the U.S., LOI must be under 6%. The molecule size circulation of crude fly debris will normally vary continually, due to changing execution of the coal factories and therefore the evaporator execution.

2.5 Synthetic Composition of Fly Ash:

Elements	Fly Ash
SiO2	38-63
Al2 O3	27-44
TiO2	0.4-1.8
Fe2 O3	3.3-6.4
MnO	0.02-0.5
MgO	0.01-0.5
CaO	0.2-8
K2 O	0.04-0.9
Na2 O	0.07-0.43
LOI	0.2-5.0
pH	6-8

Table 3: Composition Of Fly Ash

2.6 Magnesium:

Mix throwing in addition to cooling plate procedure has been utilized for the manufacture of Al network composites dependent on compound 356. Improvement of the wettability of Fly Ash particles was done, utilizing the oxidization of Fly Ash particles, the utilization of wetting operators by including Magnesium (Mg) into the grid and the covering of Fly Ash particles utilizing a sol–gel procedure. The presentation of Fly Ash particles into incompletely cemented amalgam with high thickness keeps the particles from skimming and agglomerating.

Un-Oxidized Fly Ash particles are for the most part isolates from the Al lattice during the crushing recommending helpless grip and helpless wettability between the framework and the particles. Oxidized Fly Ash particles and sol–gel silica covered Fly Ash particles demonstrate great authoritative among composite and network. The utilization of magnesium advanced wettability of Fly Ash with A356 compound. The eutectic silicon stage framed on the outside of Fly Ash particles during hardening might be because of nucleation impacts gave by the particles.

Fig 2: Magnesium Turnings

3. STIR CASTING:

Among the assortment of assembling forms accessible for intermittent metal network composites, mix throwing is commonly acknowledged, and as of now rehearsed monetarily Its preferences he in its straightforwardness, adaptability and pertinence to huge scope creation and, on the grounds that on a basic level it permits a traditional metal handling course to be utilized, and its ease This fluid metallurgy method is the most conservative of all the accessible courses for metal lattice composite creation, permits huge measured parts to be manufactured, and can support high profitability rates. As a rule mix throwing of MMCs includes creating a soften of the chose network material, trailed by the presentation of a fortifying material into the liquefy, getting a reasonable scattering through blending in composites delivered by this strategy, molecule dissemination will change altogether relying upon process boundaries during both the dissolve and cementing phases of the procedure The expansion of particles to the soften radically changes the consistency of the liquefy, and this has suggestions for throwing forms. It is significant that hardening happen before obvious settling has been permitted to occur. Scattering by mixing with the assistance of a mechanical stirrer has gotten broadly utilized. This outside power is utilized to blend a non-wetable artistic stage into a soften, and furthermore to make a homogeneous suspension in the liquefy.

3.1 Experimental Setup:

An electrical opposition warming unit was acclimated soften the AA2011 inside the graphite pot. A titanium waveguide which was just as a 20 kHz, 2000w ultrasonic converter was plunged into the soften for ultra sonic handling. The nano-sized debris particles were included into softens during the strategy from the most elevated of the pot. The aluminum soften pool was very much ensured by the argon gas. The ultrasonic handling temperature was controlled to 100°C over the compound the point of solidification (610°C). A ultrasonic intensity of 1880 watts from the converter was acclimated create satisfactory preparing capacity inside the cauldron. Absolutely four kinds of nano composites were set up during which the heap percent of the fortification was considered at 5%, 10%, 15% and 20% for the picked Nano size of 0.5 μm-300 μm debris particles. As saw during the technique the thickness of the melts fundamentally expanded with the nano-sized debris particles inside the melts.

Along these lines after productive ultrasonic handling the following throwing temperature of 760°C was wont to ensure the stream capacity inside the graphite form. In this way we get 4 nano composites with various debris rates in each and one crude AA2011 is moreover arranged to coordinate and watch the qualities.

Fig 3 : Stir Casting Process

Fig: 4 Experimental Setup

4. MICROSTRUCTURES:

The figures underneath shows the miniaturized scale auxiliary investigation for the cast aluminum combination without fly debris particles and ultrasonic preparing. It o.k. is also watched unmistakably that the dendrite grains are obviously uncovered.

4.1 MICRO STRUCTURES OF AA2011 HYBRID MMC

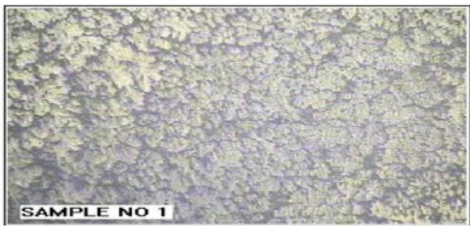


Fig 5:Microstructure of Raw AA2011

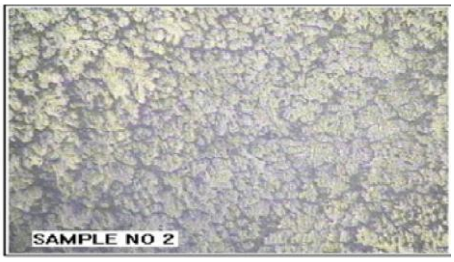


Fig 6 : Microstructure of AA2011 with 5%Wt of fly ash

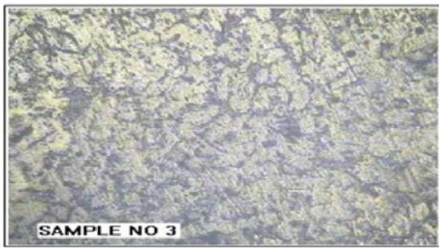


Fig 7: Microstructure of AA2011 with 10%Wt of Flyash

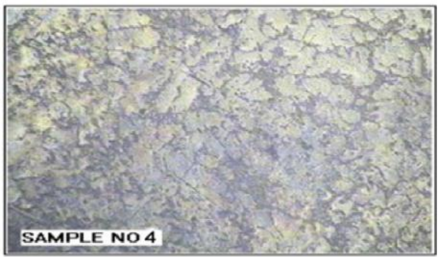


Fig 8; Microstructure of AA2011 with 15%Wt. of FlyAsh

4.2 SCANNING ELECTRON MICROSCOPE IMAGES

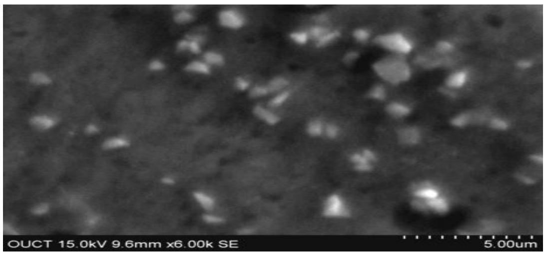


Fig 10: SEM Image OF AA2011 with 5% Wt. of Fly Ash

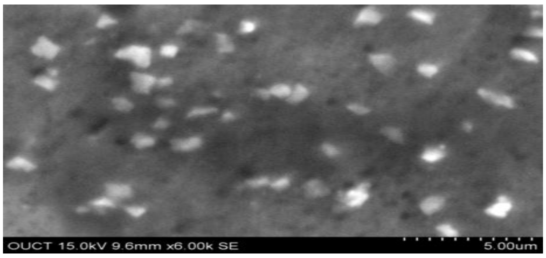


Fig 11: SEM Image of AA2011 with 10% Wt. of Fly Ash

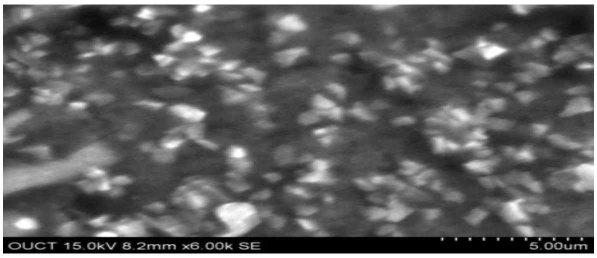


Fig 12:.SEM Image of AA2011 with 15% Wt. of Fly Ash

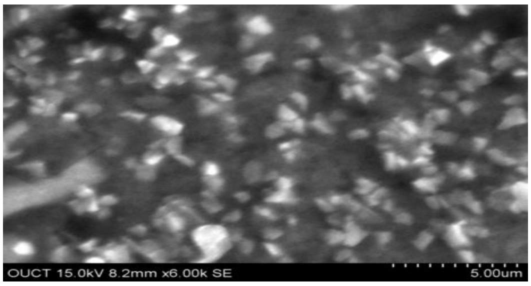


Fig 13: SEM Image of AA2011 with 20% Wt. of Fly Ash

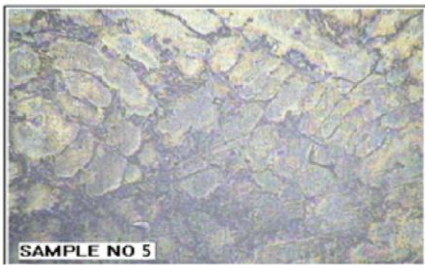


Fig 9: Microstructure of AA2011 with 20%Wt of Flyash

5. MECHANICAL PROPERTIES:

5.1 Tensile strength:

To conduct tensile strength the casted specimens are machined to standard ASTM dimensions. And tested on universal testing machine.
The general length be 210mm

Gauge length 90mm

Width 15mm

Width of held territory 25mm.

The mass Al cast composite was cut predictable with the above standards in Wire EDM process.

Fig 14: Al Cast Alloy in sync with ASTME8 Standards

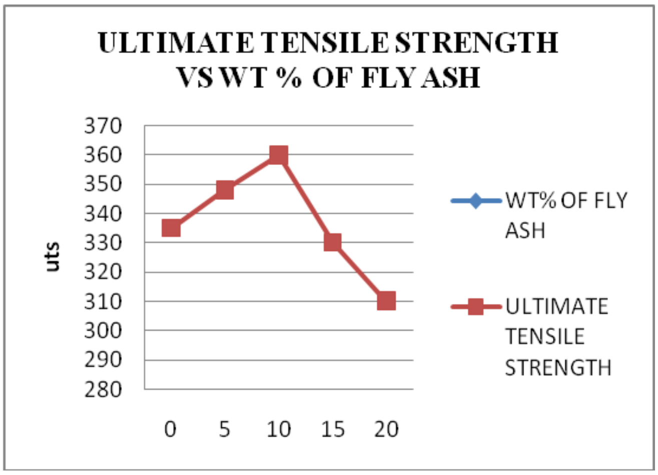
Fig 15: Piece before breaking in UTM

Fig 16: Piece after breaking in UTM

By taking the debris molecule weight rate on the X pivot and in this manner a definitive sturdiness on the Y hub the resulting perceptions were watched.

Wt (%)	UTS
0	335 MPa
5	348 MPa
10	360 MPa
15	330 MPa
20	310 MPa

Table 4: Showing Values of Ultimate tensile strength

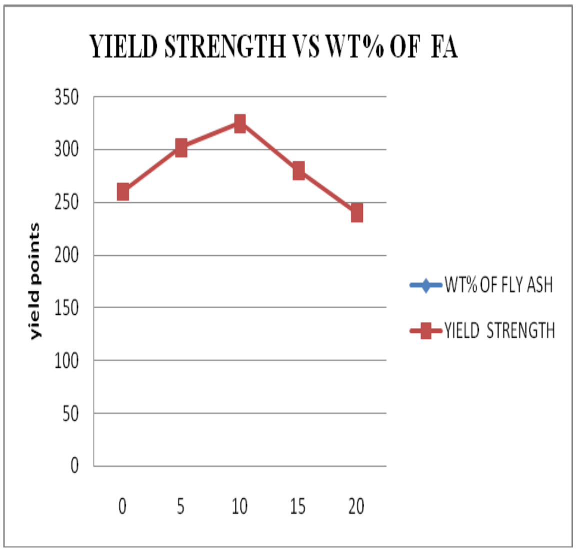


Graph 1: Showing UTS Vs Wt. (%)

5.2 Yield strength:

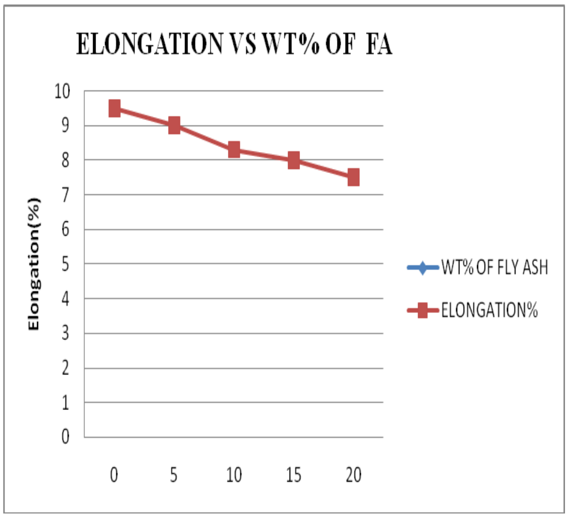
Wt. (%)	Y.S
0	260 MPa
5	302 MPa
10	325 MPa
15	280 MPa
20	240 MPa

Table 5: Showing Values of Yield Points



Graph 2: Showing Yield Strength Vs Wt%

5.3 Elongation:



Graph 3: Showing Values of % Elongation

Wt. (%)	5(nm)
0	9.5%
5	9.0%
10	8.3%
15	8.0%
20	7.5%

Table 6: Graph Showing Elongation% Vs Wt%

5.4 HARDNESS

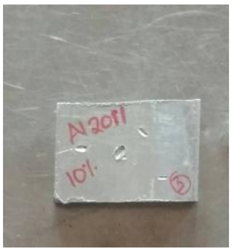
Hardness is that the property of a texture that engages it to restrict plastic deformation, generally speaking by invasion. Be that since it might, the term hardness may similarly insinuate assurance from winding, scratching, scratched region or cutting. Hardness isn't an understudy debris material property coordinated by accurate definitions to the extent vital units of mass, length and time.

5.4.1 Brinell Hardness:

The Brinell hardness test methodology involves indenting the test material with a ten mm separation across cemented steel or carbide ball presented to a load of 3000 kg. For gentler materials the store will be diminished to 1500 kg or 500 kg to stay faraway from over the most noteworthy space. the all out weight is normally applied for 10 to fifteen seconds by virtue of iron and steel and for at any rate 30 seconds because of different metals. the hole across of the space left inside the test material is evaluated with an espresso controlled amplifying instrument. The Brinell outfit number is set by isolating the load applied by the surface zone of the space.

Wt. (%)	5 (nm)
0	60 BHN
€5	74 BHN
10	80 BHN
15	70 BHN
20	56 BHN

Table 7: The Hardness Values Obtained



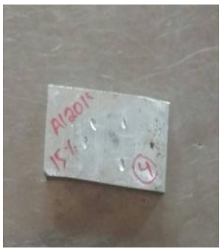
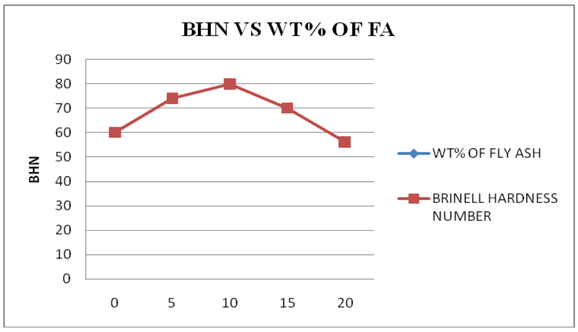


Fig 17: Drinell Hardness Tested Peaces



Graph 4 : Graph Showing Hardness Vs Wt (%)

5.5 Izod Impact Testing:

The Izod sway test was named for English designer Edwin Gilbert Izod, who initially portrayed the test technique in 1903. The pendulum at that point impacts the example at a predefined zone over the score. A test example having a V-formed score is fixed vertically, and the example is broken by striking it from a similar side as that of the indent by the utilization of the mallet. The crack vitality is resolved from the swing-up point of the sledge and its swing-down edge. The Izod sway esteem (J/m, kJ/m2) is determined by isolating the crack vitality by the width of the example.Effect test was done at room temperature utilizing Impact analyzer to compute the durability. The example is bolstered toward one side like a cantilever shaft in the test and perusing was taken by breaking the example because of the effect of the pendulum. It tends to be noticed that the strength expanded with an expansion in the weight level of magnesium and fly-debris. This is because of appropriate scattering of magnesium and fly-debris into the grid or solid Interfacial holding between aluminum composite 2011 and magnesium and fly-debris interfaces. As appeared by the diagram the durability of test 1 is 4.2 and it increment with increment percent of fly-debris and consistent pace of magnesium spans to a most extreme estimation of 6.8 for test 3 which has greatest estimation of Fly-Ash (15%) and magnesium (4%).To expanding the fly debris content at 20% then the material sturdiness is decreased.

Fig 18: Fixing the specimen

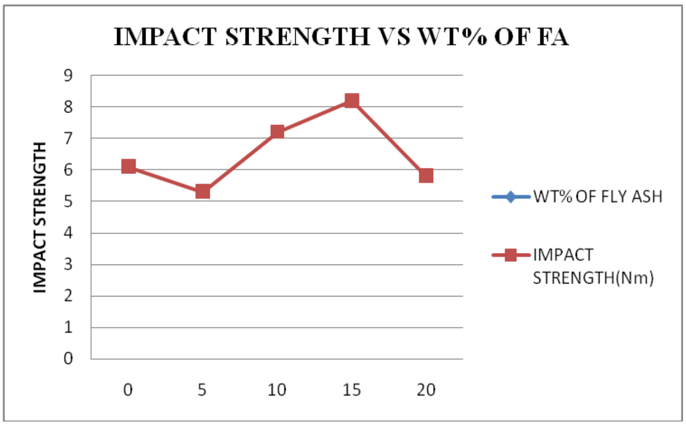
Fig 19: Breaking the specimen

Fig 20: Before testing specimen

Fig 21; After testing specimen

Composition of AA2011	**Impact Load (Nm)**
AA2011 base alloy and 4% of magnesium	6.1Nm
AA2011+5%fly ash and 4% of magnesium	5.3Nm
AA2011+10%fly ash and 4% of magnesium	7.2Nm
AA2011+15%fly ash and 4% of magnesium	8.2Nm
AA2011+20%fly ash and 4% of magnesium	5.8Nm

Table 8; experimental values of toughness



Graph 5: Showing Impact strength Vs Wt (%)

CONCLUSIONS:

The conclusions drawn from the present investigation are as per the following:

- The result affirmed that mix framed AA2011 with Magnesium/Fly-Ash strengthened composites is plainly better than base AA2011 in the correlation of elasticity, hardness and effect quality.
- It is discovered that prolongation will in general decline with expanding particles wt% which affirms that 4% magnesium and variety of Fly-Ash expansion builds weakness.
- It appears from this investigation that UTS and Yield Strength tend beginnings to increments with increment in weight level of magnesium and variety of fly debris.
- Impact quality is expanded when 15% fly debris was included and same way sway quality is diminishes when fly debris is expanded by over 15%.
- Hardness of aluminium (AA2011) is expanded from 60BHN to 80BHN with expansion of fly debris and magnesium.
- It can be seen from the SEM pictures and EDS examination that the particles are all around dispersed in the base amalgam and agglomeration of the particles are extraordinarily diminished, and the dissolve pool is all around shielded from the barometrical conditions.

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