IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 5 Ver. IV (Sep. - Oct. 2015), PP 108-122
www.iosrjournals.org

Evaluation of Mechanical Properties of AL 2024 Based Hybrid Metal Composites

Preetam Kulkarni
Department of Mechanical Engineering, University Visvesvaraya College of Engineering, India

Abstract: *The use of hybrid composite materials is very attractive because they have outstanding stiffness, strength and light-weight. An additional advantage of using hybrid composites is that their stiffness and strength can be tailored to specific design loads. Metal Matrix Composites are a broad family of materials aimed at achieving an enhanced combination of properties. While the matrix can be of any metal or alloy, most interest has been shown in the lighter structural metal cases. Improvement in the mechanical properties has been the primary objective. Much of the progress in the field of MMCs is closely linked to developments in reinforcements for incorporation in MMCs. However, the orientation of this research is towards the fabrication and testing of Aluminium-E-Glass-Flyash Composites. Aluminium alloy (2024) is the matrix metal used in the present investigation. The Test specimen are prepared as per ASTM standards size by turning and facing operations to conduct Tensile and Compression test. The specimens are tested for tensile and compression strength as per ASTM standard E8-82 and E9 respectively using Universal Testing Machine. It is observed that the MMC obtained has got better tensile and compression strength when compared to AL 2024 alone.*
Keywords: *AL 2024, Flyash, E-Glass, Hybrid Metal Matrix Composite, Mechanical Properties.*

I. Introduction

Many of the engineering applications in today's world require materials with unusual combination of properties that cannot be met by the conventional metal alloys, ceramics or polymers. This is especially true for the materials that are needed in Aerospace and Transportation Industries.

Often, materials having high strength have relatively high density, also increasing the strength or stiffness results in a decrease in impact strength. Engineers around the world have always been in search of better combination of properties in materials.

A new class of materials, called "composite materials" has answered to this search to great extent. Composite materials are those which are created artificially by combining two or more materials which usually have dissimilar characteristics.

The constituents of a composite material can be generally identified macroscopically. This is in contrast to usual metallic alloys, whose phases can be identified only under higher magnification microscopic examination.

In the present study mechanical tests such as Tensile and Compression are conducted as per ASTM (American Society for Testing and Materials) Standards.

1.1) Composite Materials

Composite materials (also called **composition materials** or shortened to **composites**) are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure.

Typical engineered composite materials include:

1. Composite building materials such as cements, concrete
2. Reinforced plastics such as fiber-reinforced polymer
3. Metal Composites
4. Ceramic Composites (composite ceramic and metal matrices)

Composite materials are generally used for buildings, bridges and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, and storage tanks, imitation granite and cultured marble sinks and countertops. The most advanced examples perform routinely on spacecraft in demanding environments.

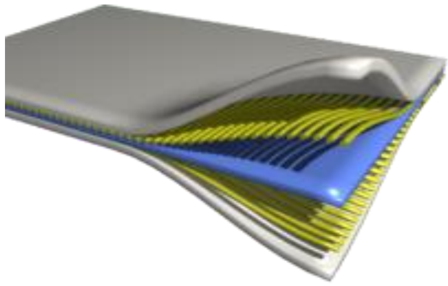


Fig 1.1 Fiber-reinforced polymer

1.2) Metal Matrix Composites

A **metal matrix composite** (**MMC**) is composite material with at least two constituent parts, one being a metal. The other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a **hybrid composite**. An MMC is complementary to a cement.

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminum matrix to synthesize composites showing low density and high strength. However, carbon reacts with aluminum to generate a brittle and water-soluble compound Al_4C_3 on the surface of the fiber. To prevent this reaction, the carbon fibers are coated with nickel or titanium boride.

1.3) Stir Casting Methods of Fabrication of MMCs

Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed Phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of Mechanical stirring. The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.

Stir Casting is characterized by the following features:

1. Content of dispersed phase is limited (usually not more than 30 vol. %).
2. Distribution of dispersed phase throughout the matrix is not perfectly homogeneous:
   a) There are local clouds (clusters) of the dispersed particles (fibers)
   b) There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase.
3. The technology is relatively simple and low cost.

Distribution of dispersed phase may be improved if the matrix is in semi-solid condition. The method of stirring metal composite materials in semi-solid state is called Rheocasting. High viscosity of the semi-solid matrix material enables better mixing of the dispersed phase.

Fig. 1.2 Stir Casting

1.4) Aluminium Alloy 2024

Aluminium alloy 2024 is an aluminium alloy, with copper as the primary alloying element. It is used in applications requiring high strength to weight ratio, as well as good fatigue resistance. It is weldable only through friction welding, and has average machinability. Due to poor corrosion resistance, it is often clad with aluminium or Al-1Zn for protection, although this may reduce the fatigue strength.

1.4.1) Basic properties

Density (×1000 kg/m3)---2.77
Elastic Modulus (GPa)---70-80
Tensile Strength (Mpa) ---185
Yield Strength (Mpa) ---76
Elongation (%) --- 20
Hardness (HB500) --- 47

1.4.2) Composition

Al 2024 composition roughly includes

Table 1.2

Copper	4.3-4.5%
Manganese	0.5-0.6%
Magnesium	1.3-1.5%
Zinc, Nickel, Chromium, Lead, Bismuth	<0.5%

1.4.3) Mechanical properties

The mechanical properties of 2024 depend greatly on the temper of the material.

1. 2024-O

2024-O temper aluminium has no heat treating. It has a maximum tensile strength of 30-32 ksi (207-220 MPa), and maximum yield strength of no more than 14,000 psi (96 MPa). The material has elongation (stretch before ultimate failure) of 10-25%, this is the allowable range per applicable AMS specifications.

2. 2024-T3

T3 temper 2024 sheet has an ultimate tensile strength of 58-62 ksi (400-427 MPa) and yield strength of at least 39-40 ksi (269-276 MPa). It has an elongation of 10-15%.

3. 2024-T351

T351 temper 2024 plate has an ultimate tensile strength of 68 ksi (470 MPa) and yield strength of 41 ksi (280 MPa). It has an elongation of 19%.

1.4.4) Uses

Due to its high strength and fatigue resistance, 2024 is widely used in aircraft structures, especially wing and fuselage structures under tension. Additionally, since the material is susceptible to thermal shock, 2024 is used in qualification of liquid penetrant tests outside of normal temperature ranges.

1.5) E-Glass Fiber

E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiberglass.

Glass fibers are generally produced using melt spinning techniques. These involve melting the glass composition into a platinum crown which has small holes for the molten glass to flow . Continuous fibers can be drawn out through the holes and wound onto spindles, while short fibers may be produced by spinning the crown, which forces molten glass out through the holes centrifugally. Fibers are cut to length using mechanical means or air jets.

Fig 1.3 E-Glass Fiber Particles

E-Glass is a low alkali glass with a typical nominal composition of SiO 54wt%, Al2O3 14wt%, CaO+MgO 22wt%, B2O3 10wt% and Na2O+K2O less than 2wt%. Some other materials may also be present at impurity levels.

The use of E-Glass as the reinforcement material in polymer matrix composites is extremely common. Optimal strength properties are gained when straight, continuous fibers are aligned parallel in a single direction. To promote strength in other directions, laminate structure scan be constructed, with continuous fibers aligned in other directions. Such structures are used in storage tanks and the like. It possesses poor corrosion resistance.

1.6) Fly Ash

Fly ash is one of the residues generated in the combustion of coal. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide(CaO), both being endemic ingredients in many coal bearing rock strata.

Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to100 µm.

Fig 1.4 Fly Ash powder

The chemical composition of fly ash is shown in table:

Table 1.3 Composition of Flyash

Component	Bituminous	Sub Bituminous	Lignite
Si02 (%)	20-60	40-60	15-45
Al2O3 (%)	5-35	20-30	20-25
Fe2O3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

II. Literature Survey

Energy distribution in Glare and 2024-T3 Aluminium during low-velocity impact (International Congress of the Aeronautical Sciences)

F.D.Moriniere et.al. [1] This paper presents a theoretical and experimental comparative study on the low velocity impact behavior of GLARE Fibre Metal Laminate (FML). Using the Classical Laminate Theory and the First-order Shear Deformation Theory, an analytical model was developed to predict the impact behavior of FMLs. Delamination onset and contact increase during perforation were taken into account. New generic expressions were derived for strain energy and contact force. Absorbed energy, impact force, maximum deflection and impact velocity were predicted within 5% of test results. GLARE 5-2/1-0.4 is 72% more resistant than its monolithic 2024-T3 aluminium counterpart of the same thickness. Because GLARE is made of thin high strength layers that can undergo large deformation, this hybrid material is an ideal candidate for impact prone structures. This general understanding will support the development of high-energy absorbing FML concepts

.

Crack Detection in Aluminium 2024-T3 Plates and in an Airbus A320 Slat-Track using Electrical Crack Gauges

Thomas Gesang et.al. [2] Structural health monitoring (SHM) is a valuable tool for the investigation and detection of cracks in various engineering structures. Due to the rapid growth of the aviation industry, SHM might have an important place in the field of aeronautics. Appropriate SHM sensors on critical structural components could help to reduce costs by avoiding unnecessary scheduled inspections and will increase the safety of the monitored structures. In this paper, tests on crack gauges made from conductive material are reported. The gauges were mounted on aluminium 2024-T3 plates and on an Airbus A320 slat-track. The aluminium plates along with the A320 slat-track are consecutively painted with layers of primer and coating according to the manufacturer standards. The basic concept of crack detection by the gauges is the interruption of the electrical conductivity by fatigue cracks. The gauges are embedded between the layers of primer and coating in order to be protected and insulated. Results obtained from resistance measurements showed that these crack gauges could detect cracks at a relatively early stage.

J.W. Kaczmar et.al.[3] Purpose: Wear improvement of Aluminum matrix composite materials reinforced with alumina fibres, was investigated. The effects of the applied pressure and T6 heat treatment on wear resistance were determined.

Design/methodology/approach: Wear tests were carried out on pin-on disc device at constant sliding velocity and under three pressures, which in relation to diameter of specimens corresponds to pressures of 0.8 MPa, 1.2 MPa and 1.5 MPa. To produce composite materials porous performs were prepared. They are characterized by the suitable permeability and good strength required to resist stresses arising during squeeze casting process. Performs exhibited semi-oriented arrangement of fibres and open porosity enabled producing of composite materials 10% (in vol%) of Al2O3fibres (Saffil).

Findings: In comparison with T6 heat treated monolithic 2024 aluminium alloy composites revealed slightly better resistance under lower pressure. Probably, during wear process produced hard debris containing fragments of alumina fibres are transferred between surfaces and strongly abrade specimens. Under smaller pressures wear process proceeded slowly and mechanically mixed layer MML was formed.

Research limitations/implications: Reinforcing of 2024 aluminium alloy could be inefficient for wear purposes. Re-melting and casting of wrought alloy could deteriorate its properties. Interdendrite porosities and coarsening of grains even after squeeze casting process were observed.

Practical implications: Aluminum casting alloys can be locally reinforced to improve hardness and wear resistance under small pressures.

Originality/value: Investigations are valuable for persons, what are interested in aluminum cast composite materials reinforced with ceramic fibre perform.

Corrosion Protection of Aluminum Alloy 2024-T3 by Vanadate Conversion Coatings

H. Guan and R.G. Buchheit et.al. [4] In this paper, the formation, chemistry, morphology, and corrosion protection of a new type of inorganic conversion coating is described. This coating, referred to as a vanadate conversion coating (VCC), forms on aluminum alloy substrates in a matter of minutes during simple immersion in aqueous vanadate-based solutions at ambient temperatures. VCCs are yellow in colour and conformal across the surface of aluminum alloy 2024-T3 (AA2024-T3 [UNS A92024]) substrates. Auger electron sputter depth profiles and x-ray absorption near-edge spectroscopy show that VCCs formed by a 3-min immersion are 300 nm to 500 nm thick and consist of a mixture of vanadium oxides and other components in the coating bath. In anodic polarization experiments conducted in aerated chloride solutions, VCCs increase the pitting potential and decrease the rate of oxygen reduction. When characterized by electrochemical impedance spectroscopy, VCCs demonstrate a low-frequency impedance between 1 MΩ-cm2 and 2 MΩ-cm2 after 24 h exposure to aerated 0.5 M sodium chloride (NaCl) solutions. In salt spray testing conducted according to ASTM B117, VCCs suppress formation of large pits for more than 168 h. VCCs also appear to be self-healing. Analysis of solution in contact with VCCs by inductively coupled plasma emission spectroscopy indicates that vanadate is released into solution upon exposure. Vanadium deposits were identified by x-ray micro chemical analysis on a bare alloy substrate held in close proximity to a vanadateconversion-coated surface, and corrosion resistance of this bare surface was observed to increase during exposure. An important component of VCC formation appears to involve inorganic polymerization of V5+, which leads to the build-up of a film that passivates the surface and inhibits corrosion.

Electrochemical Noise Studies of Aircraft Coatings over Al 2024 T-3 in Accelerated Exposure Testing (2000 NACE International)

Gordon P. Bierwagen et.al.[5] Electrochemical Noise Methods (ENM) have been employed to evaluate corrosion resistance of aircraft coatings in accelerated testing environments, such as alternating QUV/Prohesion exposure, flow electrolyte immersion, and constant immersion with various concentration electrolytes. ENM measurements were performed on aluminum 2024 T-3 substrates coated with epoxy and urethane aircraft coatings against exposure time. First order exponential decay function was employed to fit the noise resistance time series data. Results have shown the usefulness of ENM in investigating corrosion protection and lifetime prediction of aircraft coatings.

Ductile Fracture characterization of Aluminium alloy 2024-T351 using damageplasticity theory (Dept. of Mechanical Engineering, Massachusetts Institute of Technology)

Liang Xue et.al. [6] This paper presents the calibration procedure for Aluminum alloy 2024-T351 using a recently developed damage plasticity theory. The damage plasticity theory consists of a full three dimensional damage evolution law where the pressure sensitivity and the Lode angle dependence are included in a fracture envelope and the equivalent plastic strain is used as a time-like variable to determine the damage rate.

Because of the coupled nature of the plastic strain and the damage, material parameters are calibrated from a parallel study of numerical simulations and experimental measurements. A set of 10 tests that cover a wide range stress states for both the hydrostatic pressure and the Lode angle are conducted in order to capture the fracture envelope in the interested stress range. The experimental setups include un-notched and notched round bars with three diff erent notch radii, a doubly grooved flat plate and compressed cylinders of three diff erent heights at two friction conditions. The detailed numerical and experimental procedure of calibration is demonstrated by using four of these tests. The accuracy of the calibrated material parameters is further assessed by the remainder of tests. Notch sensitivity in tensile round bars and the friction conditions in upsetting tests are discussed in detail. Good agreement in the tested load conditions is achieved for both the fracture patterns and the load-displacement curves.

III. Experimental Procedure

3.1) Materials procurement

1. **Al 2024 alloy**

   ALUMINIUM 2024 was collected at FENFE METALLURGICALS located at Uttarahalli, Bangalore

2. **E-glass fiber**

   1 Kg E-Glass Fiber was being collected at SUNTECH FIBER PVT. LTD, Vasanth Nagar, Bangalore.

3. **Flyash**

   1 Kg Flyash was collected at KPCL, Kudithini located near to Bellary

3.2) Fabrication of Test Specimens

The microstructure of any material is a complex function of the casting process, subsequent cooling rates. Therefore composites fabrication is one the most challenging and difficult task. Stir casting technique of liquid metallurgy is used to prepare Al 2024 Hybrid composites.

3.2.1) Al based MMC preparation by Stir Casting

A stir casting setup as shown in Figure, Consisted of an Electrical Resistance Furnace and a stirrer assembly. This was used to synthesize the composite.

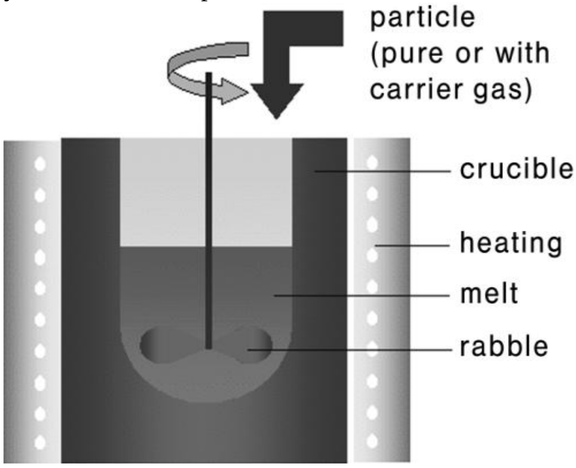


Fig 3.1 Graphical representation of stir casting

3.2.2) Composite Preparation Furnace

Three-phase electrical resistance type 10 KW capacity furnace is shown in the figure is used. The temperature range of the furnace is 1000^0 C with a controlled accuracy of $\pm\ 10^0$ C fitted with digital temperature controller. The shooting capacity of the furnace is 500^0C per hour.

3.2.3) Preheating of reinforcement

Muffle furnace was used to preheat the particulate to a temperature of 500^0C. It was maintained at that temperature till it was introduced into the Al 2024 alloy melt. The preheating of reinforcement is necessary in order to reduce the temperature gradient and to improve wetting between the molten metal and the particulate reinforcement.

3.2.4) Melting of Matrix alloy

The melting range of Al 2024 alloy is of 700 – 800^{0}C. A known quantity of Al 2024 ingots were pickled in 10% NaOH solution at room temperature for 10 min. Pickling was done to remove the surface impurities. The smut formed was removed by immersing the ingots for 1min in mixture of 1 part nitric acid and one part water followed by washing in Methanol. The cleaned ingots after drying in air were loaded into the Graphite crucible of the furnace for melting. The melt was super heated to a temperature of 800^{0}C and maintained at that temperature. The molten metal was then degassed using Hexo chloro ethane tablets for about 8min.

3.2.5) Mixing and Stirring

Alumina coated stainless steel impeller was used to stir the molten metal to create a vertex. The impeller was of centrifugal type with 3 blades welded at 45^0 inclination and 120^0 apart. The stirrer was rotated at a speed of 300 – 400 rpm and a vertex was created in the melt. The depth of immersion of the impeller was approximately one third of the height of the molten metal. From the bottom of the crucible. The preheated particulates of flyash and short E-Glass fibre were introduced into the vertex at the rate of 120gm/min.

Stirring was continued until interface interactions between the particles and the matrix promoted wetting. The melt was degassed using Hexo chloro ethane tablets and after reheating to superheated temperature (800^{0}C) it was poured into the preheated die.

3.2.6) Pouring of molten metal into dies

Then after few minutes of stirring, the liquid metals with reinforcements are poured into the dies to get the required castings. The pouring into the dies is as shown in the Fig. The dies were pre heated and coated additives to ease the process of removing the castings. The dies were coated with a mixture of china clay, water and sodium silicate to prevent iron contamination.

3.2.6a) Melting Of the Aluminium Alloy

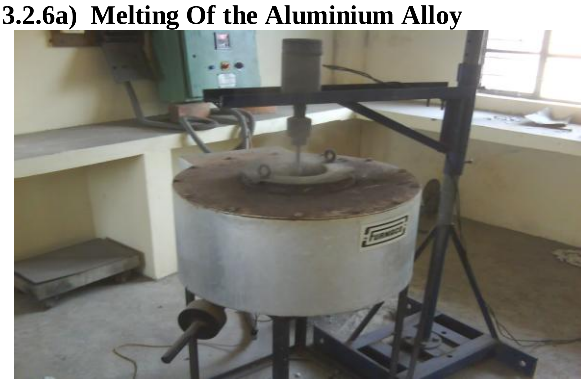


Fig 3.2 External View of Electrical Resistance Furnace

Fig 3.3 Crucibles

Fig 3.4 Al 2024 Ingots

Fig 3.5 Loading Al 2024 in to Furnaces with Crucible

Fig 3.6 Molten Metal

3.2.6b) Adding Degasifier

Fig 3.7 Degasifier

3.2.6c) Adding Flyash And Chopped E Glass Fiber

Fig 3.8 Adding reinforcent material Chopped E-Glass Fibre

Fig 3.9 Adding reinforcent material Chopped Flyash Powder

3.2.7) Stir casting method for MMC Production:

Fig 3.10 Stirring after Adding Reinforcements

3.2.8) Pouring:

Fig 3.11 ASTM Mould Box

Fig 3.12 Pouring Molten Metal

Fig 3.13 Removing Casted Component Fron Dies

Fig 3.14 Final Casted Product

3.2.9) Specimen Preparation

The casted specimens obtained were machined on a CNC Lathe according to ASTM E 8-82 and E 9 standards for Tension, Compression tests respectively.

3.2.10) Composition of Specimens Prepared

Table 4.8 Different casting composition For Al-2024 Hybrid Composites

Specifications	Flyash %	E fibre %	AL 2024 %
A2F1E	1	2	97
A2F3E	1	4	95
A2F5E	1	6	93
A4F1E	3	2	95
A4F3E	3	4	93
A4F5E	3	6	91
A6F1E	5	2	93
A6F3E	5	4	91
A6F5E	5	6	89
A8F1E	7	2	91
A8F3E	7	4	89
A8F5E	7	6	87

3.3) Tension Test

While subjecting a prepared specimen of specified shape and size to a gradually increasing uni-axial load (force) until failure occurs, simultaneous observations are made on the elongation of the specimen. The operation is accomplished by gripping opposite ends of the work piece and pulling it, which results in elongation of test specimen in a direction parallel to the applied load. The ultimate tensile strength tests were done in accordance with ASTM E8-82 standards. The tensile specimens of diameter 10mm and gauge length 60mm were machined from the cast specimens with the gauge length of the specimens parallel to the longitudinal axis of the casting. Yield strength of the specimens was evaluated in terms of MPa. Five specimens were tested and average values of the ultimate tensile strength and yield strength were reported. It was found that in all cases there was a little scatter in the results and each value did not deviate more than 2% from the average value. The test was carried out at room temperature. The tensile specimens prepared in accordance with ASTM E8-82 were subjected to homogenous and uniaxial tensile stresses in a Universal Testing Machine. The ultimate tensile strength of the hybrid composites specimens and of the base alloy, plotted against the flyash content and E-glass. It follows from the graph that the specimens show an increase in UTS as the content of flyash in the composite is increased in ascast conditions.

Fig 3.15 Universal Testing Machine

Fig 3.16 Tensile Specimens Before Test

Fig 3.17 Tensile Specimens After Test

3.2) Compression Test

Specimens were machined according to ASTM [E9] standards Viz., diameter=20mm and length=20mm and test was conducted on the computerized UTM. Ductility of the specimen is evaluated in terms of Mpa. The three specimens of each composites of ascast composites were tested and average results were noted down. It can be seen that the compressive strength of the hybrid composites increases monotonically as the reinforcement contents are increased. Earlier researchers observed similar results, when they conducted tests on whiskers reinforced composites.

Fig 3.18 Compression Specimens Before Test

Fig 3.19 Compression Specimens After Test

IV. Results And Discussions

Mechanical properties like Tensile strength and Compressive strength are found for the developed composites of different weight percentage of Flyash and E-Glass in Al 2024. The present work attempts to understand the influence of reinforcement on the matrix alloy.

Figures and tables show the effect of flyash and E-Glass fibre on the various mechanical properties of all alloy composites. Each value represented is an average of five measurements. Each value is repeatable in the sense that the individual values did not vary by more than 5% from the mean value.

4.1) Ultimate Tensile strength

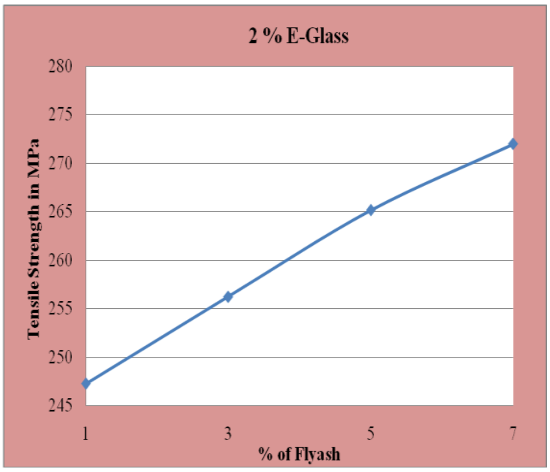
The tensile specimens prepared in accordance with ASTM E8-82 were subjected to homogenous and uniaxial tensile stresses in a Universal Testing Machine. The tensile specimens of diameter 10mm and gauge length 60mm were machined from the cast specimens with the gauge length of the specimens parallel to the longitudinal axis of the casting.

The ultimate tensile strength of the hybrid composites specimens and of the base alloy, plotted against the flyash content and E-glass. It follows from the graph that the specimens show an increase in UTS as the content of flyash in the composite is increased in ascast conditions. The 5% of Flyash yields best results in its properties.

Tensile test results for AL2024 Hybrid Metal Matrix Composite

Table 4.1: Tensile test results for Al 2024+2% E-Glass + Varying % of Flyash

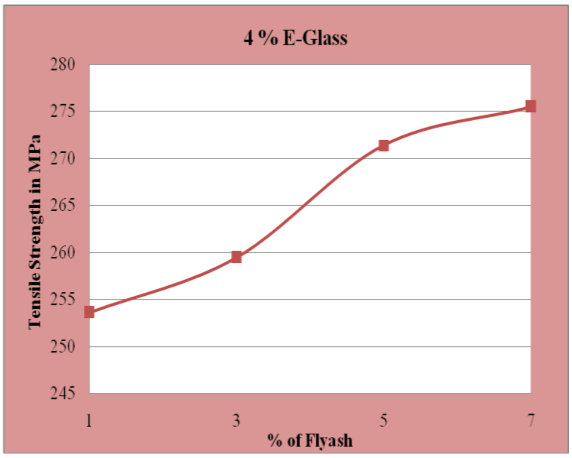
Tensile Strength (N/mm^2)	Percentage of Flyash (%)
247.24	1
256.21	3
265.12	5
271.98	7



Graph 4.1: Tensile test results for Al 2024+2% E-Glass + Varying % of Flyash

Table 4.2: Tensile test results for Al 2024+4% E-Glass + Varying % of Flyash

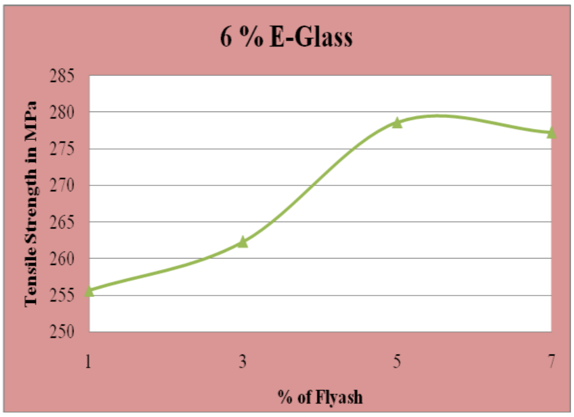
Tensile Strength (N/mm^2)	Percentage of Flyash (%)
253.56	1
259.45	3
271.38	5
275.48	7



Graph 4.2: Tensile test results for Al 2024 +4% E-Glass + Varying % of Flyash

Table 4.3: Tensile test results for Al 2024+6% E-Glass + Varying % of Flyash

Tensile Strength (N/mm^2)	Percentage of Flyash (%)
255.67	1
262.37	3
278.65	5
277.28	7

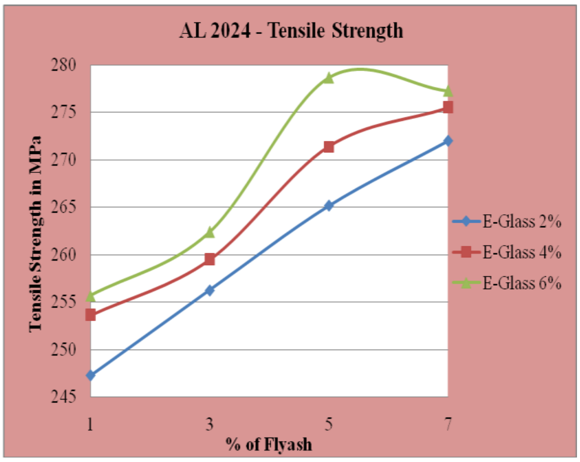


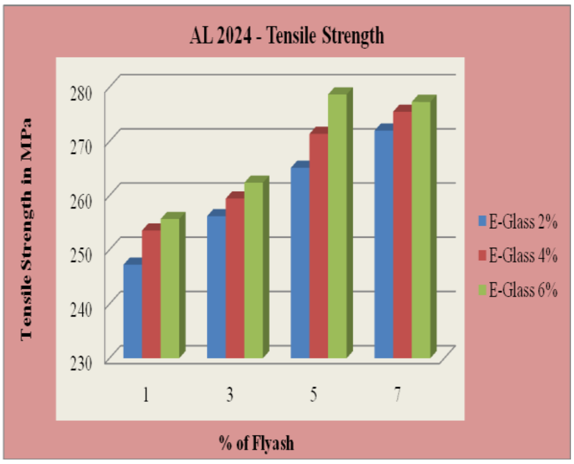
Graph 4.3: Tensile test results for Al 2024+6% E- Glass + Varying % of Flyash

Comparison of Tensile Test (MPa) Results for Al 2024 Hybrid Metal Matrix Composites

Table 4.4: Comparison of Tensile Test Results for Al 2024 Hybrid Composites

E-Glass 2%	E-Glass 4%	E-Glass 6%	% Flyash
247.24	253.56	255.67	1
256.21	259.45	262.37	3
265.12	271.38	**278.65**	5
271.98	275.48	277.28	7





Graph 4.4: Comparative charts of Tensile test results for Al 2024 Hybrid Composites

The ultimate tensile strength of the hybrid composites specimens and of the base alloy, plotted against the flyash content and E-glass. It follows from the graph that the specimens show an increase in UTS as the content of flyash in the composite is increased in ascast conditions. The 5% of Flyash yields best results in its properties.

The factors that influence the UTS are complex and interrelated. Several variables, such as distribution of the particles/ fibre in the matrix, the mechanical properties of the matrix and reinforcing particles/ fibre and the bonding between the matrix and reinforcement, are reported to influence the strength of discontinuously reinforcing composites strongly. Also, various strengthening mechanisms have been proposed to explain the improvement in strength in the case of discontinuously reinforced MMCs.

4.2) Compression Strength

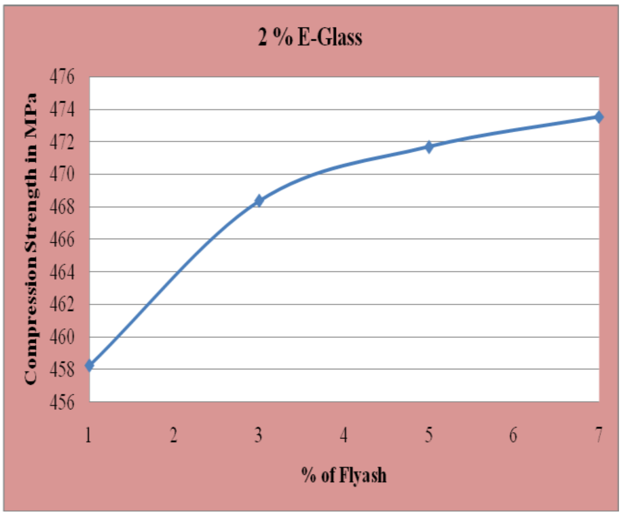
The table shows the effect of Flyash and E-Glass on compression strength of aluminium hybrid composites.

Graphs and tables showing the effect of E-Glass and Flyash content on the compressive strength of the composites. It can be seen that the compressive strength of the hybrid composites increases monotonically as the reinforcement contents are increased. The increase in compression strength is mainly due to the decrease in the inter-particle spacing between the particles. Since E-Glass fibres are much harder than 2024 aluminium alloys, the presence of E-Glass fibre and Flyash resist deforming stresses which enhances the compressive strength of the composite material.

Compression test results for AL2024 Hybrid Metal Matrix Composite

Table 4.5: Compression strength results for Al 2024 +2% E-Glass+ Varying % of Flyash

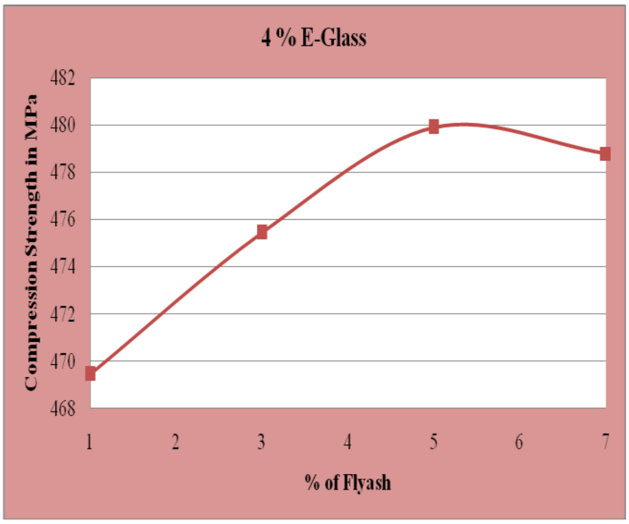
Compression Strength (N/mm^2)	Percentage of Flyash (%)
458.25	1
468.35	3
471.67	5
473.53	7



Graph 4.5: Compression strength results for Al 2024+2% E-Glass+ Varying % of Flyash

Table 4.6: Compression strength results for Al 2024 +4% E-Glass+ Varying % of Flyash

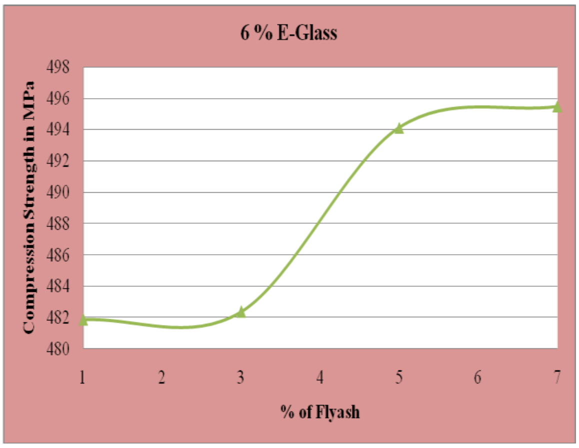
Compression Strength (N/mm^2)	Percentage of Flyash (%)
469.46	1
475.43	3
479.89	5
478.78	7



Graph 4.6: Compression strength results for Al 2024+4% E-Glass+ Varying % of Flyash

Table 4.7: Compression strength results for Al 2024 +6% E-Glass+ Varying % of Flyashs

Compression Strength (N/mm^2)	Percentage of Flyash (%)
481.87	1
482.37	3
494.12	5
495.48	7

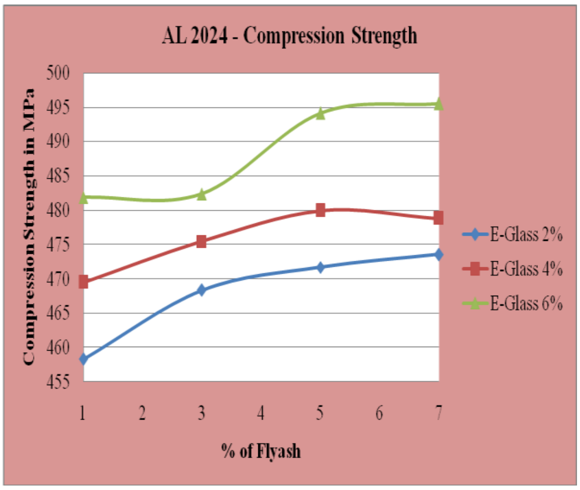


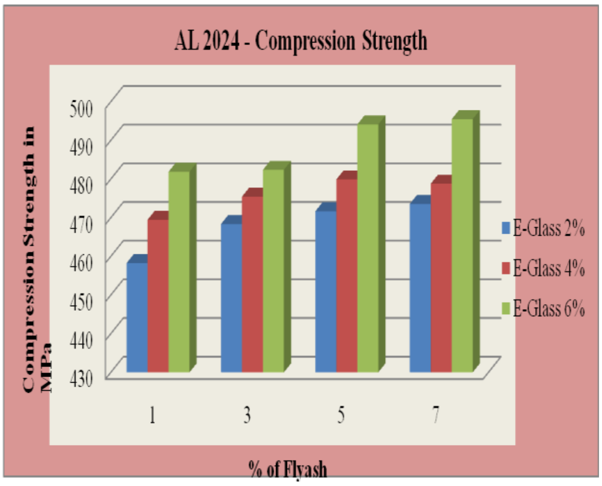
Graph 4.7: Compression strength results for Al 2024+6% E-Glass+ Varying % of Flyash

Comparison of Compression Strength (MPa) Results for Al 2024 Hybrid Composites

Table 4.8: Comparison of Compression Strength Results for Al 2024 Hybrid Composites

E-Glass 2%	E-Glass 4%	E-Glass 6%	%Flyash
458.25	469.46	481.87	1
468.35	475.43	482.37	3
471.67	479.89	494.12	5
473.53	478.78	**495.48**	7





Graph 4.8: Comparative charts of Compression strength results for Al 2024 Hybrid Composites

V. Conclusion

The summary of the effect of E-glass and Flyash on the Mechanical Properties of Aluminium 2024 Hybrid composite like Tensile strength & Compression strength are as follows:

1. It is clear that ultimate tensile strength increases with increase in percentage composition of constituent material with Aluminium 2024.
2. The increase in ultimate tensile strength is due to the addition of E-glass fibre which gives strength to the matrix alloy by enhancing resistance to tensile stresses. There is a reduction in the inter-spatial distance between the particles which leads to restriction of plastic flow due to the random distribution of the particulate in the matrix.
3. It is seen that the compressive strength of the hybrid composites also increases monotonically as reinforcement contents are increased. The presence of E-glass fibre and flyash resists deforming stresses and thus enhances the compressive strength of the composite material.

4. **Tensile strength:** Al 2024 with 5% Flyash and 6% E-Glass possesses maximum Tensile Strength of 278.65 Mpa
5. **Compression strength:** Al 2024 with 7% Flyash and 6% E-Glass possesses maximum Compression Strength of 495.48 Mpa

References

[1] Energy distribution in Glare and 2024-T3 Aluminium during low-velocity impact (International Congress of the Aeronautical Sciences) F.D. Moriniere, R.C. Alderliesten, R. Benedictus Structural Integrity Group, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherlands

[2] Crack Detection in Aluminium 2024-T3 Plates and in an Airbus A320 Slat-Track using Electrical Crack Gauges Ioannis Pitropakis, Helge Pfeiffer, Thomas Gesang, Stein Janssens and Martine Wevers

[3] Wear behavior of composite materials based on 2024 Al-alloy reinforced with $^{\delta}$ alumina fibers J.W. Kaczmar, K. Naplocha, a Institute of Production Engineering and Automation, Wroclaw University of Technology, Poland

[4] Corrosion protection of Aluminium Alloy 2024-T3 by Vanadate Conversion Coatings H. Guan and R.G. Buchheit, Fontana Corrosion Center, Department of materials Science and Engineering, The Ohio State University, Columbus, OH 43210

[5] Electrochemical Noise Studies of Aircraft Coatings over Al 2024 T-3 in Accelarated Exposure Testing (2000 NACE International) Gordon P. Bierwagen (North Dakota State University) | Dennis E. Tallman(North Dakota State University) | J. Li | M. Zidoune (North Dakota State University) | S. Balbyshev (Air Force Research Lab)

[6] Ductile Fracture characterization of Aluminium alloy 2024-T351 using damageplasticity theory (Dept. of Mechanical Engineering, Massachusetts Institute of Technology) LIANG XUE, Department of Mechanical Engineering, Northwestern University, 2145 Sheridan Road, Evanston, IL 60208, USA