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RESEARCH ON MECHANICAL PROPERTIES OF COMPOSITE WITH THE INCLUSION OF ASH

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ABSTRACT
Due to self hardening properties of fly ash , they have wide spectrum of application, the fly ash particles ar classified as precipitator and cenosphere, the high electrical resistivity , low thermal conductivity is useful in making light weight insulating composites , fly ash as a filler in Al casting reduces cost, it also improves machining ability , damping capacity, coefficient of friction which are needed in various automotive components, the properties of MMC which got altered with changed percentage of fly ash , the experiments were conducted by preparing samples of composites with varied amount of fly ash 5,15,25,- wt % magnesium and silicon were added to increase the wet ability of fly ash particles , graphs have been obtained for variation of density with different composition , same is for different type of wear resistance , the fracture mode was observed to depend on reinforcement particle fabrication route adopted, extent of hot working , presence of any intermetallic precipitate and extent of coherency of second phase with the matrix The objective of experiment was to prepare cost effective MMC material by taking Al-si-Mg + fly ash alloy using stir casting technique , tensile test , hardness and impact strength of prepared MMC careful section of reinforcement type enables finished product characteristic to be tailored to any specific engineering requirement , whilst the use of composites will be clear choice in many instances , material selection in other will will depend on factors such as working life, complexity of product shape , possible saving in design in tapping the optimum potential of composites.

KEYWORDS : -Matrix , MMC , phases , reinforcement .

2.1 INTRODUCTION
The literature survey is carried out as a part of the thesis work to have an overview of the production processes, properties and wear behavior of metal matrix composites. Composite structures have shown universally a savings of at least 20% over metal counterparts and a lower operational and maintenance cost [1]. As the data on the service life of composite structures is becoming available, it can be safely said that they are durable, maintain dimensional integrity, resist fatigue loading and are easily maintainable and repairable. Composites will continue to find new applications, but the large scale growth in the marketplace for these materials will require less costly processing methods and the prospect of recycling [13] will have to be solved [44].

It has been reported that the energy consumed when aluminum is recycled is only about 5% of that required in the primary production of aluminum [45]. There are, however, certain disadvantages associated with the recycling of aluminum such as the presence of impurities, which to a large extent impair the mechanical properties of the recycled material. This problem can be overcome by a careful selection of the constituents and also the fabrication technique, as they can lead to the formation and piling up of intermediate phases that are detrimental [33].

There are many interdependent variables to consider in designing an effective MMC material.

Since the upper bound on MMC properties is established by the properties of the matrix and reinforcement material, careful selection of these components is necessary.

2.2 MATERIAL SELECTION

2.2.1 Matrix Material

Because it is much more than dispersing glue in MMC, the matrix alloy should be chosen only after giving careful consideration to its chemical compatibility with the reinforcement, to its ability to wet the reinforcement, and to its own characteristics properties and processing behavior [47]. One very crucial issue to consider in selection of the matrix alloy composition involves the natural dichotomy between wet ability of the reinforcement and excessive reactivity with it [36]. Good load transfer from the matrix to the reinforcement depends on the existence of a strongly adherent interface [41]. In turn, a strong interface requires adequate wetting of the reinforcement by the matrix.

2.2.2 Why Al Matrix Selection?

MMC materials have a combination of different, superior properties to reinforced matrix which are; increased strength, higher elastic modulus, higher service temperature, improved wear resistance, high electrical and thermal conductivity, low coefficient of thermal expansion and high vacuum environmental resistance. These properties can be attained with the proper choice of matrix and reinforcement.

Composite materials consist of matrix and reinforcement. Its main function is to transfer and distribute the load to the reinforcement or fibers. This transfer of load depends on the bonding which depends on the type of matrix and reinforcement and the fabrication technique. The matrix can be selected on the basis of oxidation and corrosion resistance or other properties [34]. Generally Al, Ti, Mg, Ni, Cu, Pb, Fe, Ag, Zn, Sn and Si are used as the matrix material, but Al, Ti, Mg are used widely.

2.2.3 Reinforcement

Reinforcement increases the strength, stiffness and the temperature resistance capacity and lowers the density of MMC. In order to achieve these properties the selection depends on the type of reinforcement, its method of production and chemical compatibility with the matrix and the following aspects must be considered while selecting the reinforcement material.

- Size – diameter and aspect ratio:
- Shape – Chopped fiber, whisker, spherical or irregular particulate, flake, etc.
- Surface morphology – smooth or corrugated and rough:
- Poly – or single crystal:
- Structural defects – voids, occluded material, second phases:
- Surface chemistry – e.g. SiO_2 or C on SiC or other residual films:
- Impurities – Si, Na and Ca in sapphire reinforcement.

2.2.3.1 Continuous fiber reinforcement

According to ASTM [12] the term fiber may be used for any material in an elongated form that has a minimum length to a maximum average transverse dimension of 10:1, a maximum cross sectional area of $5.1X10^{-4}$ cm^2 and a maximum transverse dimension of 0.0254 cm. Continuous fibers in composites are usually called filaments, the main continuous fibers includes boron, graphite, alumina and silicon carbide.

The fiber is unique for unidirectional load when it is oriented in the same direction as that of loading, but it has low strength in the direction perpendicular to the fiber orientation. As regards cost, continuous fibers are about 200 times higher than discontinuous fibers. Therefore for specific purposes only, that continuous fiber is used. The other advantage of discontinuous fibers is that they can be shaped by any standard metallurgical processes such as forging, rolling, extrusion etc.

2.2.3.2 Short fibers

Short fibers are long compared to the critical length (lc = d Sf / Sm where d is the fiber diameter, Sf is the reinforcement strength and Sm is the matrix strength) and hence show high strength in composites, considering aligned fibers. Nevertheless, disoriented short fibers have been used with some success as AMC (Aluminum Matrix Composite) reinforcement [13]. Short fibers are still used mainly for refractory insulation purposes due to their low strength compared with others, but they are cheaper than fiber and whisker.

2.2.3.3 Whiskers

Whiskers are characterized by their fibrous, single crystal structures, which have no crystalline defect. Numerous materials, including metals, oxides, carbides, halides and organic compounds have been prepared under controlled conditions in the form of whiskers. Generally, a whisker has a single dislocation, which runs along the central axis.

The relative freedom from discontinuous means that the yield strength of a whisker is close to the theoretical strength of the material [28] Silicon carbide, silicon nitride, carbon and potassium whiskers are available already. Among these, silicon carbide whiskers seem to offer the best opportunities for MMC reinforcement. Presently, silicon carbide whisker reinforcement is produced from rice husk, which is a low cost material. The physical characteristics of whiskers are responsible for different chemical reactivity with the matrix alloy [25] and also health hazard posed in their handling. Therefore the inherent interest shown by the researches in whiskers reinforcement has declined.

2.2.3.4 Particulates

Particulates are the most common and cheapest reinforcement materials. These produce the isotropic property of MMCs, which shows a promising application in structural fields. Initially, attempts were made to produce reinforced Aluminum alloys with graphite powder but only low volume fractions of reinforcement had been incorporated (<10%). Presently higher volume fractions of reinforcements have been achieved for various kinds of ceramic particles (oxide, carbide and nitride). The SiC particulate- reinforced aluminum matrix composites have a good potential for use as wear resistant materials. Actually, particulates lead to a favorable effect on properties such as hardness, wear resistance and compressive strength. The choice of reinforcement is not as arbitrary as this list of composites might suggest, but is dictated by several factors [36].

2.4 MECHANICAL PROPERTIES

The attractive physical and mechanical properties that can be obtained with metal matrix composites, such as high specific modulus, strength and thermal stability, have been documented extensively. The various factors controlling the properties of particulate MMCs [41] and the influence of the manufacturing route on the MMC properties has also been reviewed by several investigators. Improvement in modulus, strength, fatigue, creep and wear resistance has already been demonstrated for a variety of reinforcements [38]. Of these properties; the tensile strength is the most convenient and widely quoted measurement and is of central importance in many applications.

It is apparent from the literature that parameters controlling the mechanical properties of particulate reinforced composites are still not understood in any detail. However, some of the important factors are becoming apparent.

- The strength of particle-reinforced composites is observed to be most strongly Dependent on the volume fraction and particle size of the reinforcement.
- Dislocation strengthening will play a more significant role in the MMC than in the Unreinforced alloy due to the increased dislocation density.
- Of greatest concern appears to be the introduction of defects and in homogeneities In the various processing stages, which has been found to result in considerable Scatter in the mechanical properties [12]

2.5 EFFECT OF REINFORCEMENT VOLUME FRACTION

It was predicted by Friend [13] that there exists a critical reinforcement volume fraction above which the composite strength can be improved relative to that of the unreinforced material and below which the composite strength decreases, owing to the ineffective load transfer from matrix to reinforcement in MMCs. For low volume fraction of reinforcement, the composite strength was observed to be governed by the residual matrix strength, which decreases with increasing reinforcing volume fraction.

2.5.1 Effect of particle sizes

The deformation and fracture behavior of the composite revealed the importance of particle size. A reduction in particle size is observed to increase the proportional limit, yield stress and the ultimate tensile stress. It is well established that large particles are detrimental to fracture toughness due to their tendency towards fracture. It would be highly desirable to have a composite system where the reinforcing particles are relatively fine (4μm or less) so as to get the stiffness benefits of a composite without significantly lowering fracture toughness.

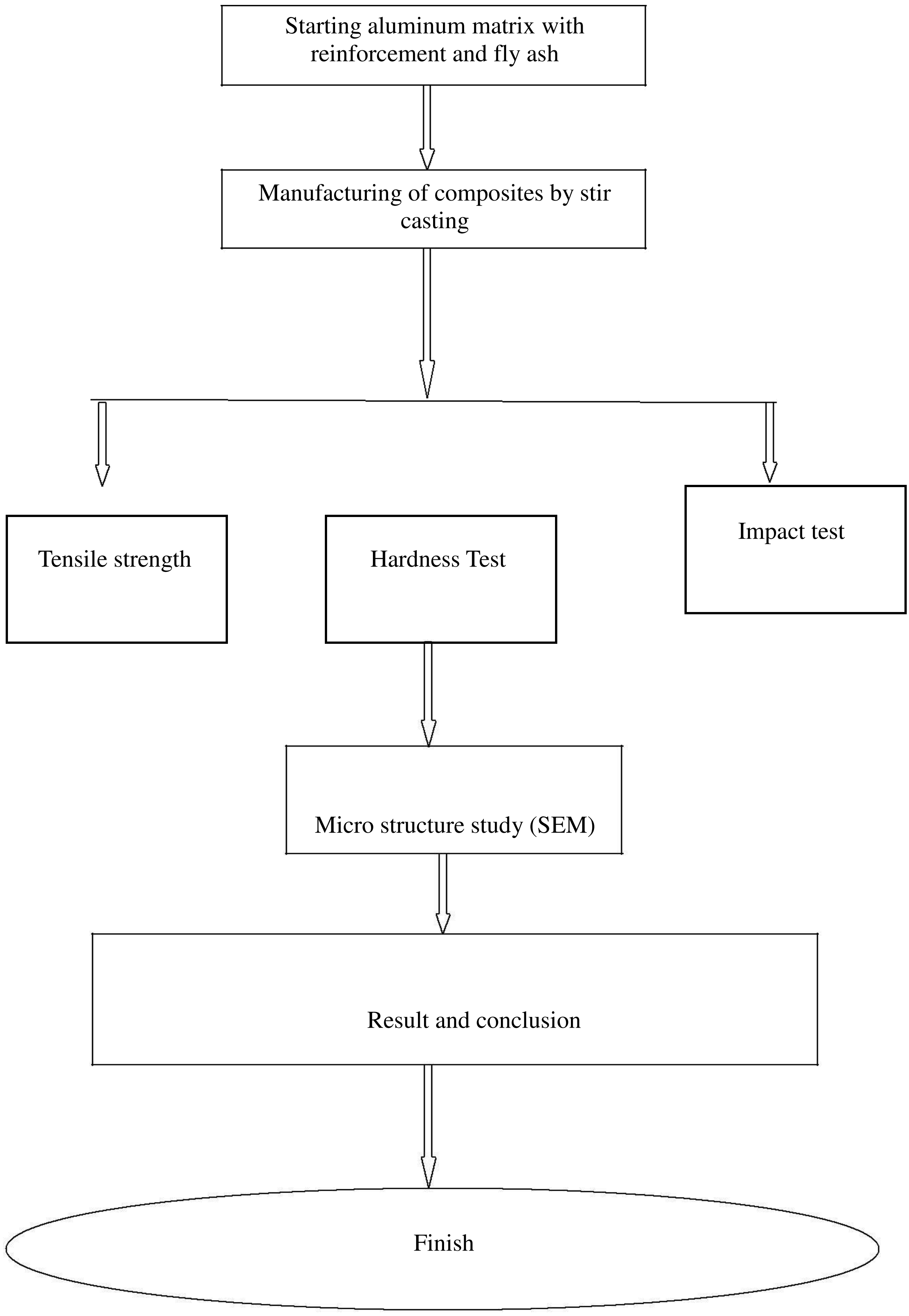
EXPERIMENTAL PROCEDURE

3.1 Problem Formulation

Objectives of Present Work

The problem is to study the tensile strength behavior of metal metric composite(MMC) of aluminum alloy with addition of varying percentage composition of fly ash, SiC particles and alumina by stir casting technique. The tensile strength and toughness, hardness properties will also take into consideration. The aim of the experiment is to study the effect of variation of percentage composition to predict the mechanical properties of the metal metric composites (MMC). The experiment was carried out by preparing the sample of different percentage composition by stir casting. The objective of present proposal is as follows:

1. To prepare cost-effective MMC material by taking Al-Si-Mg + fly ash alloy using stir casting technique.
2. Tensile strength, impact strength and hardness measurement of the prepared MMCs


Starting aluminum matrix with reinforcement and fly ash
Manufacturing of composites by stir casting
Tensile strength
Hardness Test
Impact test
Micro structure study (SEM)
Result and conclusion
Finish

Preparation of samples

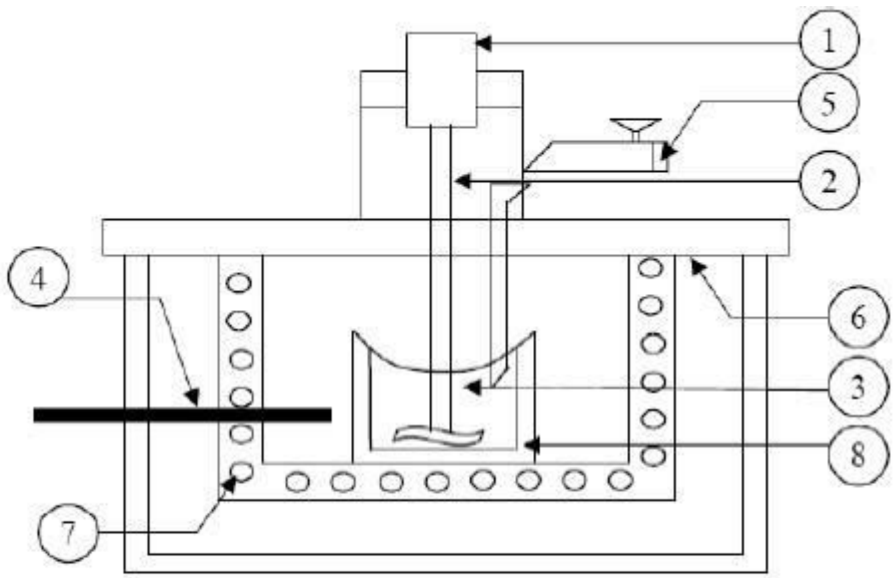


Fig. 3.1
Stir Casting Apparatus

1. **Motor**
2. **Shaft**
3. **Molten aluminum**
4. **Thermocouple**
5. **Particle injection chamber**
6. **Insulation heat chamber**
7. **Furnace**
8. **Graphite crucible**

3.1.1 Raw Material:

The matrix material used in the experiment investigation was commercially pure aluminum. The fly ash was collected from thermal plant. The particle size of the fly as received condition lies in the range from (0.1-100µm).

3.1.2 Melting and casting:

The aluminum fly ash metal matrix composite was prepared by stir casting route. For this we took 600gm of commercially pure aluminum and desired amount of fly ash particles. The fly ash particle was preheated to 300C for three hour to remove moisture. Commercially pure aluminum was melted in a resistance furnace. The melt temperature was raised up to 720C and it was degassed by purging hexachloro ethane tablets. Then the melt stirred with the help of a mild steel turbine stirrer. The stirring was maintained between 5 to 7 min at an impeller speed of 200rppm. The melt temperature was maintained 700C during addition of fly ash particles. The dispersion of fly ash particles were achieved by the vortex method. The melt with reinforced particulates were poured into the preheated permanent metallic mold.

The pouring temperature was maintained at 6800C. The melt was then allow to solidify the moulds. The composites were made a different amount of fly-ash(i.e. 5,15,25,wt %),Magnesium and silicon were added to increase the wet ability of fly ash particles.

Fig. 4.2
Component prepared by stir casting

3.2 Laboratory stir casting set up

1. Commercially pure Al was melted and casted.
2. Al-10% fly ash composites were fabricated by stir casting.
3. Chemical composition analysis was done for fly ash used.
4. Particle size analysis was done for fly ash used.
5. Density and hardness measurement was carried out for both commercially pure Al sample and Al-10% fly ash composite sample.
6. The wear characteristics of both commercially pure Al and Al-10% fly ash composite was evaluated and compared.
7. SEM analysis was done for both the samples.
8. EDS microanalysis was done for both the samples.

3.3 PROPERTIES OF ALUMINA:

Detailed properties of alumina are shown below:

99.5% Alumina oxide

Mechanical Properties	**Unit of Measurement**	**SI unit**
Density	g/cc	3.89
Porosity	%	0
Elastic	Gpa	375
Shear	Gpa	152

Bulk	Gpa	228
Hardness	Kg/mm^2	1440
Compressive	Mpa	2600

3.3.1 Micro structural characterization:

a. Scanning electron microscopy

Micro structural characterization studies were conducted on unreinforced samples. This is accomplished by using scanning electron microscope. The composite samples were firstly metallographic alloy polished prior to examination. Characterization is done in etched conditions. Etching was accomplished using keller's reagent. The SEM micrographs of composite and wear debris were obtained using the scanning electron microscope. According to requirement, the images were taken in both secondary electron (SE) and back scattered electron (BSE) mode. Microscopic studies to examine the morphology, particle size and micro structure were done by a JEOL 6480 LV scanning electron microscope (SEM) equipped with an energy dispersive X-ray (EDX) detector of oxford data reference system. Micrographs are taken at suitable accelerating voltages for the best possible resolution using the secondary electron imaging.

b. Optical microscopy:

The casting procedure was examined under the optical microscope to determine the case structure. A section was cut from the casting. It is first belt grinded followed by polishing with different grade of emery papers. Then they were washed and polished in clothes and then washed, dried and etched with keller's solution and then examined through optical microscope.

C. Particle size analysis:

Particle size of the milled powder was measured by Malvern particle size analyzer (Model micro-P, range 0.05-550 micron). Firstly, the liquid dispersant containing 500ml of distilled water was kept in the sample holder. Then the instrument was run keeping ultrasonic displacement at 10.00 micron and pump speed 1800 rpm.

6.1.5 Mechanical Properties Observation:

Observation:

Bulk hardness measurement were carried out on the base metal and composite samples by using standard Brinnel hardness test. Brinnel hardness measurements were carried out in .order to investigate the influence of particulate weight fraction on the matrix hardness.

Tensile Test:

The tensile testing of the composite was done on Instron testing machine. The samples rate was 9.103pts sec and cross-head speed 5.0 mm min. Standard specimen with 30mm guge length were used to evaluate ultimate tensile strength. The comparison of the properties of the composite material was made with the commercially pure Al.

Sliding wear behavior:

Wear has been defined as a displacement of material caused by hard properties where these hard particles are forced against and moving along a solid surface. Two body sliding. Wear tests were carried out on prepared composite specimen. A Ducom, Bangalore makes computerized piniondisc wear test machine was found for these tests. The principal objective of investigation was to study the coefficient of friction and wear.

particles used in the composites have a varying density. Density of the particles is one of the important factors determining the distribution of the particles in molten metal. Particles having higher density than molten metal can settle at the bottom of the bath slowly and particles of lower density can segregate at the top. During subsequent pouring of the composite melt, the particle content may vary from one casting to another or even it can vary in the same casting from one region to another. Therefore uniform distribution of the particles in the melt is a necessary condition for uniform distribution of particles in the castings. The properties of composites are finally dependent on the distribution of the particles. Hence the study of the distribution of the particles in the composite is of great significance. Several investigators have examined the fracture samples of different metal matrix composites; it was observed that the fracture occurred mainly through the matrix in a ductile manner

FUTURE SCOPE OF STUDY:

Due to self-hardening properties of fly ash they have wide spread application. If more number of samples could have been taken with varying composition of fly ash as well as by varying composition of additive to making metal metric composites(MMC) then it could have given more accurate results. From the above analysis of samples & based on the results obtained, it can be suggested that the Strength, tensile strength of the fly ash composite materials can be further increased by adding the necessary additives in a higher percentage amount for better compaction. For which those composites can fulfill the requirements for construction purposes

References

1 A.K.Dhingra, “metal replacement by composite”, *JOM* 1986, Vol 38 (03), p. 17.
2 K.Upadhya, “composite materials for aerospace applications, developments in ceramic and metal matrix composites”, KamaleshwarUpadhya, ed.., warrendale, PA: TMS publications, 1992, pp. 3-24.
3 Greg Fisher, “Composite: Engineering the ultimate material”, Am. Ceram. Soc, Bull. Vol. 63 (2), pp. 360-364.
4 T.G.Nieh, K.R. Forbes, T.C. Chou and J. Wadsworth, “Microstructure and deformation properties of an Al2O3-Ni3Al composite from room temp to 14000C”, High performance Composites for the 1990’s Eds. S. K. Das, C. P. Ballard and F. Marikar, TMS-New Jersey, 1990, pp 85-96.
5 T. W. Clyne, An Introductory Overview of MMC System, Types and Developments, in Comprehensive Composite Materials, Vol-3; Metal Matrix Composites, T. W. Clyne (ed), Elsevier, 2000, pp.1-26.
6 L.M.Manocha& A.R. Bunsell “Advances in composite materials”, Pergamon Press, Oxford, 1980, Vol.2, p 1233-1240.
7 Jartiz, A.E., Design 1965, pp. 18.
8 Kelly, A. (1967) Sci. American 217, (B), 161.
9 Berghezan, A. Nucleus, 8(5), 1966, (Nucleus A. Editeur, 1, rhe, Chalgrin, Paris, 16(e).166
10 Van suchetclan, Philips Res. Repts.Vol. 27.1972, pp. 28.
11 B.D.Agarwal and L.J.Broutman, “Analysis and performance of fiber composites” John Wiley & Sons, New York, 1980, pp.3-12.
12 J.O.Outwater, The Mechanics of Plastics Reinforcement Tension, Mod. Plast: March 1956.
13 R.Wetter, Kunststoffe in der Luft-und Raumfahrt, Kunststoffe, 60, Heft 10 (1970).
14 P.H.Selden, ‘ GlasfaserverstarkteKunststoffe’, SpringerVerlag, 1967.
15 PradeepRohatgi, IUNIDO’s State-of-the-art series: “Advances in Materials Technology: MONITOR”, Compiled by the Industrial Technology Development Division Department of Industrial Promotion, Vienna, Austria, No.17, Feb. 1990.