

CHAPTER 1

INTRODUCTION

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composite is a multiphase material that exhibits a significant proportion of the properties of both constituent phases such that a better combination of properties is realized. This is termed as the principle of combined action.

1.1 USE OF COMPOSITES

The composite industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years. The various reasons for the use of composites are due to

- To increase stiffness, strength and dimensional stability.
- To increase tough and impact strength.
- To increase heat deflection temperature.
- To increase mechanical damping.
- To reduce permeability to gases and liquids.
- To modify electrical properties.
- To reduce cost.
- To decrease thermal expansion.
- To increase chemical wear and corrosion resistance.
- To reduce weight.

Composites are material with light weight, high strength-to-weight ratio and good stiffness properties. They have come forward in replacing conventional materials like metals, wood etc. Composite results from research and innovations from past few decades have progressed from glass fiber for aerospace and automobiles. Powder metallurgy is one of the modern technologies to develop light weight composites. Powder metallurgy is defined as mixing different metal powders to form finished and semi-finished components by compressing it. After compressing subsequent heating at elevated

temperature in a furnace, under a progressive atmosphere is done so as to obtain satisfactory strength and density.

1.2 CLASSIFICATION OF COMPOSITES

Composites are commonly classified at two distinct levels. The first level of classification is usually made with respect to the matrix constituent. The major composite classes include organic-matrix composites (OMCs), metal-matrix composites (MMCs), and ceramic-matrix composites (CMCs). The term “organic-matrix composite” is generally assumed to include two classes of composites: polymer-matrix composites (PMCs) and carbon-matrix composites (commonly referred to as carbon-carbon composites). In each of these systems, the matrix is typically a continuous phase throughout the component. The second level of classification refers to the reinforcement form particle reinforced, fibre reinforced and structural composites.

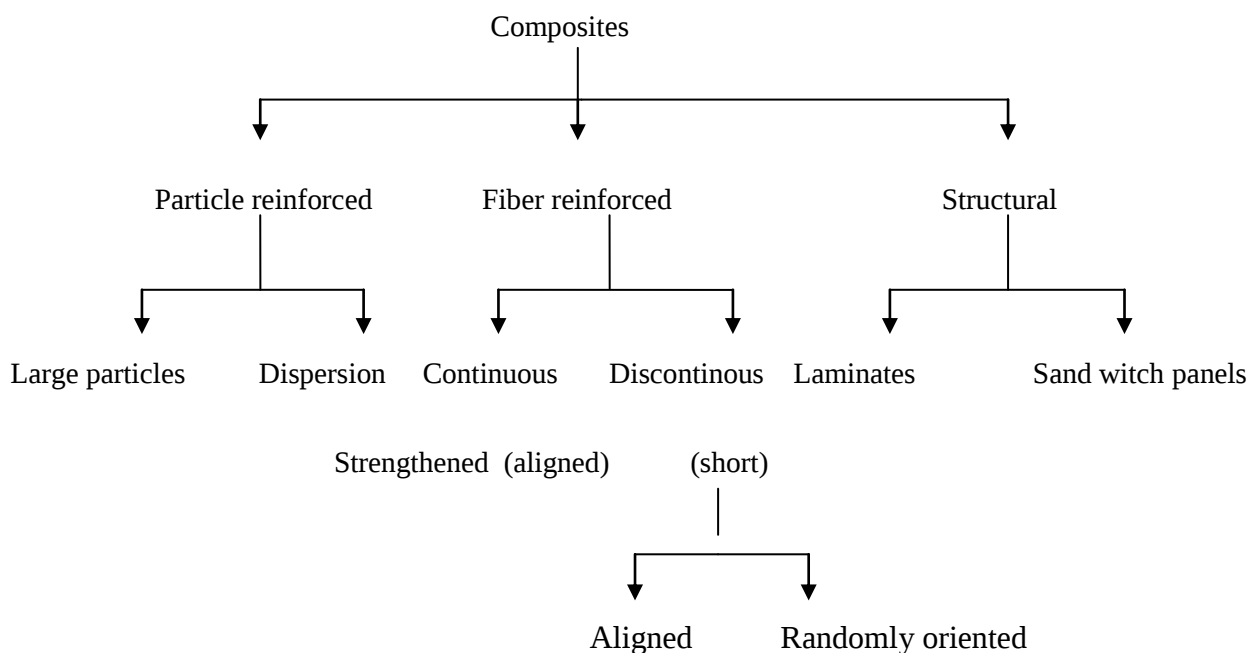


Figure 1.1: A simple classification schemes for the various composite types

The dispersed phase for particle-reinforced composites is equiaxed (i.e., particle dimensions are approximately the same in all directions) and the dispersed phase for fiber-reinforced composites has the geometry of a fiber. (i.e. a large length-to-diameter ratio). Structural composites are combinations of composites and homogeneous materials. Examples of these three groups include concrete, a mixture of cement and aggregate, which is a particulate composite fiber glass, a mixture of glass fibers imbedded in a resin matrix, which is a fiber composite and plywood,

alternating layers of laminate veneers, which is a laminate composite.

1.2.1 Particle Reinforced Composite

These can be further classified under two subgroups: -large particle and dispersion strengthened composites. The distinction between these is based upon reinforcement or Strengthening mechanism.

1.2.2 Large-Particle Composites

The term large indicate that particle-matrix interactions cannot be treated on the atomic or molecular level. Properties are a combination of those of the components. The rule of mixtures predicts that an upper limit of the elastic modulus of the composite. Concrete is a familiar example of large-particle composite.

1.2.3 Dispersion-Strengthened Composites

This type of composite contains small particulates or dispersions, which increase the strength of the composite by blocking the movement of dislocations. The dispersion is typically a stable oxide of the original material. Particle-matrix interactions occur on the atomic or molecular level and lead to strengthening. Particles like oxides do not react so the strengthening action is retained at high temperatures. A common example is sintered aluminium powder (SAP). Particles for dispersion-strengthened composites are normally much smaller (diameter between 0.01 mm and 0.1mm).

1.2.4 Fiber-Reinforced Composites

These are strong fibers imbedded in a softer matrix to produce products with high strength to weight ratios. The matrix material transmits the load to fibers, which absorb the stress. The length to diameter ratio of the fibers used as reinforcement influences the properties of the composite. The higher the aspect ratio the stronger the composite. Therefore long continuous fibers are better than short ones for composite construction. However continuous fibers are more difficult to produce and place in the matrix. Shorter fibers are easier to place in the matrix but offers poor reinforcement.

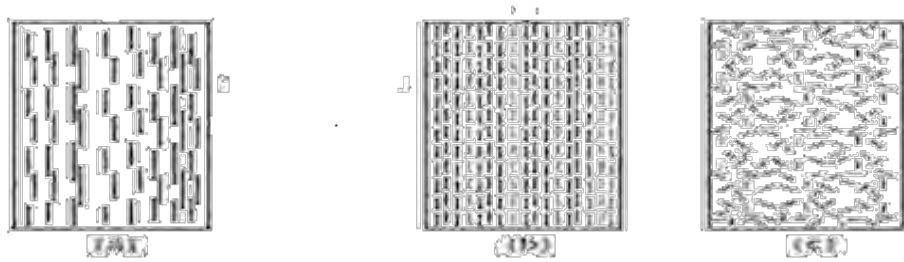


Figure 1.2: Representation of (a) Continuous and aligned fiber composites (b) Discontinuous and aligned fiber composites (c) Discontinuous and randomly oriented composites.

1.2.5 Structural Composites

Laminar Composites

When multidirectional stresses are imposed within a single plane, aligned layers that are fastened together one on top of another at different orientations are frequently utilized. These are called laminar composites. These are generally designed to provide high strength and low cost at a lighter weight. A familiar laminar composite is plywood.

Sandwich Structures

These have thin layers of facing materials over a low density material or comb core, such as apolymer foam or expanded metal structure. A familiar sandwich-structured composite is corrugated cardboard. The corrugated paper core is covered by two faces of thin paper. In structures of this type the facing material serves to fix the inner core in place. The core provides the strength. Typical face materials include aluminium alloys, fiber-reinforced plastics, titanium, steel and plywood. The popular core consists of a „honeycomb“ structure, which finds wide use in industries such as the aircraft industry, where higher strength and lower weight are important factors. The honeycomb structure consists of thin foils that have been formed into interlocking hexagonal cells with axis oriented perpendicular to the face panels.

1.3 APPLICATIONS OF COMPOSITES

The composites are use in versatile lightweight and durable material aluminum composite performs well for internal and external application. It applicable in sheet metal, automobiles, aircrafts and aerospace.

1.4 ADVANTAGES AND DISADVANTAGES OF COMPOSITE

Advantages

- High resistance to fatigue and corrosion degradation.
- High strength to weight ratio.
- Due to greater reliability, there are few inspections and structural repairs.
- It is easier to achieve smooth aerodynamic profiles for drag reduction.
- High resistance to impact load.
- Manufacture and assembly are simplified.
- Improved friction and wear properties.
- Excellent heat sink properties

Disadvantages

- High cost of raw materials and fabrication.
- Composites are more brittle than wrought metals.
- Transverse properties are weak.
- Matrix is weak therefore low toughness.

1.5 METAL MATRIX COMPOSITES (MMCs)

The matrix in a metal matrix composite (MMC) is usually an alloy, rather than a pure metal. There are three types of such composites namely,

- Dispersion-strengthened, in which the matrix contains a uniform dispersion of very fine particles with diameters in the range 10-100 μ m.
- Particle-reinforced, in which particles of sizes greater than 1 μ m are present.
- Fiber-reinforced, where the fibers may be continuous throughout the length of the Component or less than a micrometer in length and present at almost any volume fraction from 5 to 75%.

1.5.1 The Advantages of MMC over Polymer Matrix Composites are

- Higher temperature capability
- Fire resistance
- Higher transverse stiffness and strength
- No moisture absorption
- Higher electrical and thermal conductivities
- Better radiation resistance
- No out gassing
- Fabric ability of whisker and particulate-reinforced MMCs with conventional Metal working equipment.

1.5.2 The Disadvantages of MMCs Compared to Monolithic Metals and Polymer Matrix composites

- Higher cost of some material systems
- Relatively immature technology
- Complex fabrication methods for fiber-reinforced systems (except for casting)
- Limited service experience.

1.5.3 PROCESSING OF MMCs

Accordingly to the temperature of the metallic matrix during processing the fabrication of MMCs can be classified into three categories:-

(a) Liquid phase processes

(b) Solid state processes and

(c) Two phase (solid-liquid) processes.

Liquid Phase Processes

In liquid phase processes, the ceramic particulates are incorporated into a molten metallic matrix using various proprietary techniques, followed by mixing and casting of the resulting MMC eg-stir casting method of fabrication of MMCs

Solid State Processes

Solid state fabrication of Metal Matrix Composites is the process, in which Metal Matrix Composites are formed as a result of bonding matrix metal and dispersed phase due to mutual diffusion occurring between them in solid states at elevated temperature and under pressure. Example-powder metallurgical method etc

1.6 METHODOLOGY

The methodology flow chart is shown in figure 1.5 in order to achieve the objectives of this project and is listed below.

- Mixing the preferred material (Aluminum & Iron oxide) by using the chuck of lathe in order to get homogenous mixture.
- Compacting the mixture with a varying the pressure 80,100,135 & 175mpa.
- Sintering the samples for 3 to 4 hours with the temperature of 400⁰, 450⁰ & 500⁰C.
- Conducting mechanical testing, studying the hardness & wear characteristics.
- Analysis sample characterization by using an optical microscope.

1.6.1 OBJECTIVES

- Mixing of powder
- Fabrication of die and punch
- Compaction process
- Sintering temperature
- Testing of specimen

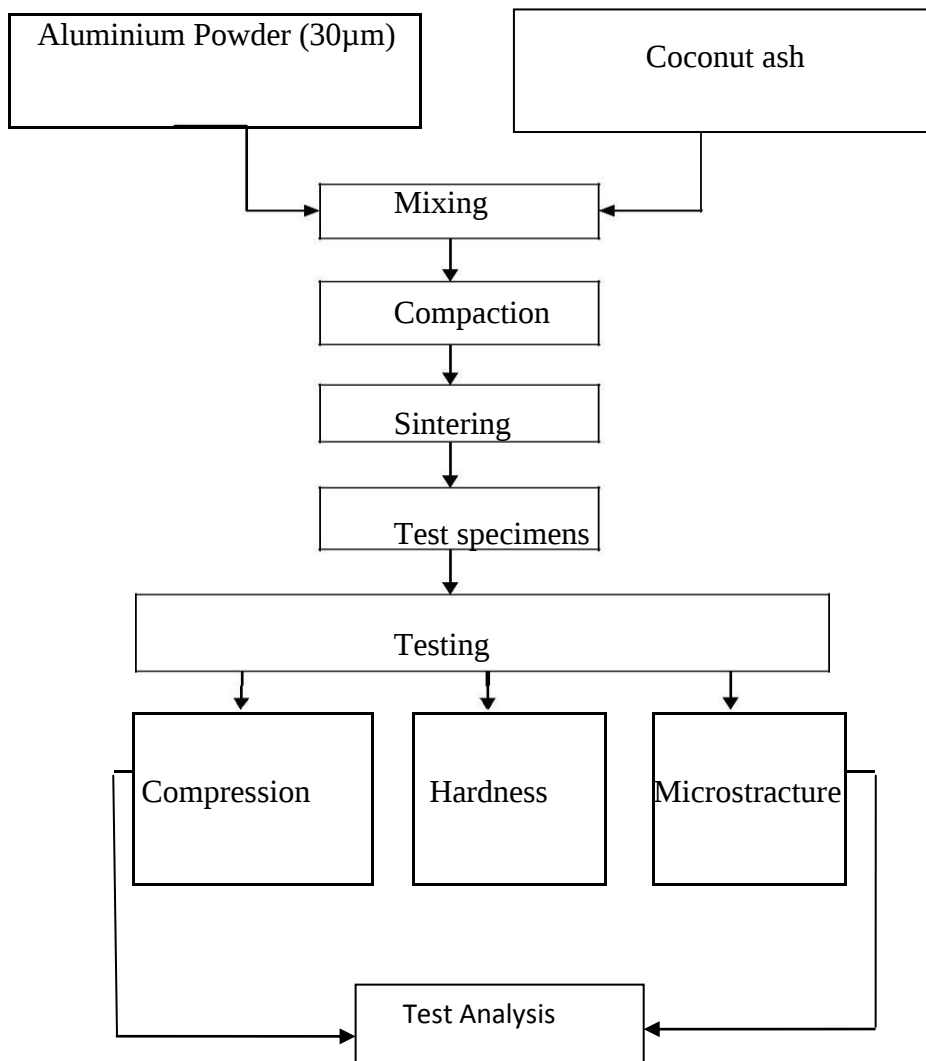


Fig:1.3 Flow Chart of Aluminum and coconut shell ash Composite

1.7 POWDER METALLURGY METHOD

Powder metallurgy is defined as mixing different metal powders to form finished and semi-finished components by compressing it. After compressing, subsequent heating at elevated temperature in a furnace under a progressive atmosphere is done so as to obtain satisfactory strength, density without losing essential shape. The powder metallurgy process generally consists of four basic steps: powder manufacture, powder blending, compacting, and sintering.

1.7.1 Powder compaction

Powder compaction is the process of compacting metal powder in a die through the application of high pressures. Typically the tools are held in the vertical orientation with the punch tool forming the bottom of the cavity. The powder is then compacted into a shape and then ejected from the die cavity. In a number of these applications the parts may require very little additional work for their intended use; making for very cost efficient manufacturing. The density of the compacted powder is directly proportional to the amount of pressure applied. Pressure of 10000kg/mm² to 50000 kg/mm² are commonly used for metal powder compaction.

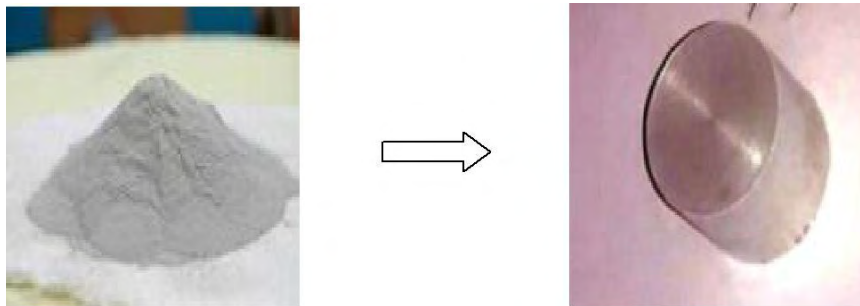


Fig:1.4 Aluminum powder compaction

1.7.2 SINTERING

Solid state sintering is the process of taking metal in the form of a powder and placing it into a mold or die. Once compacted into the mold the material is placed under a high heat for a long period of time. Under heat, bonding takes place between the porous aggregate particles and once cooled the powder has bonded to form a solid piece.

Sintering can be considered to proceed in three stages. During the first, neck growth proceeds rapidly but powder particles remain discrete. During the second, most densification occurs, the structure recrystallizes and particles diffuse into each other. During the third, isolated pores tend to become spheroidal and densification continues at a much lower rate. The words Solid State in Solid State Sintering simply refer to the state the material is in when it bonds, solid meaning the material was not turned molten to bond together as alloys are formed.

One recently developed technique for high-speed sintering involves passing high electrical current through a powder to preferentially heat the asperities. Most of the energy serves to melt that

portion of the compact where migration is desirable for densification; comparatively little energy is absorbed by the bulk materials and forming machinery.

Naturally, this technique is not applicable to electrically insulating powders. To allow efficient stacking of product in the furnace during sintering and prevent parts sticking together, many manufacturers separate ware using Ceramic Powder Separator Sheets. These sheets are available in various materials such as alumina, zirconia and magnesia. They are also available in fine medium and coarse particle sizes.

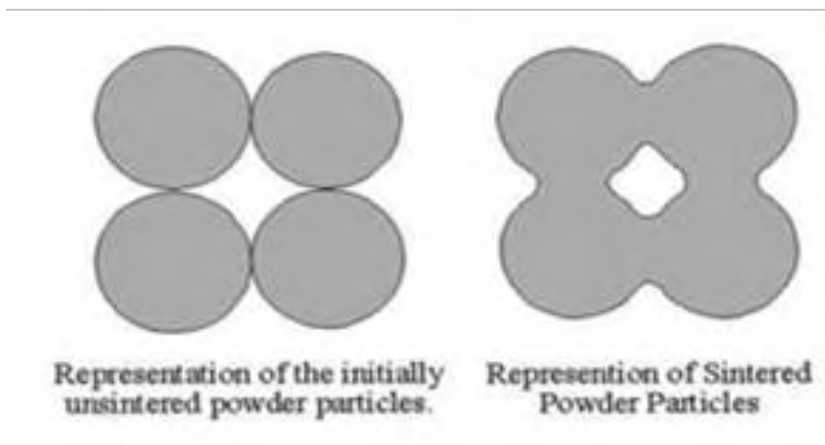


Fig: 1.5 Representation of un sintered& sintered powder particles

1.7.3 ADVANTAGES AND LIMITATIONS OF POWDER METALLUGY

Advantages

- Freedom to start with raw materials of high purity having characteristics of consistent uniformity.
- Maintaining this purity to end use by the control of fabricating step.
- Cleaner quieter operation and longer life.
- Control of grain size and relatively much uniform structure.
- Excellent reproducibility.
- Improved physical properties
- No requirement of high qualified or skilled personnel.
- Possibility of producing new materials, composition of metals and non-metals which are quite impossible to prepare by normal methods.
- Greater freedom of design in the case of production of machined part.

Limitations

- It is difficult to secure exceptionally high purity powder with satisfactory quality, without which it is impossible to prepare the parts with optimum physical properties.
- It is unprofitable to manufacture articles in very small quantity because of the great expense of suitable tooling and equipment.
- High investment is needed in heavy presses for making large parts.
- Porous materials are liable to oxidize at the surface as well as throughout the whole body due to its porosity.

1.7.4 APPLICATIONS OF POWDER METALLURGY

The applications of powder metallurgy are as following-

Refractory Metals:-

Components made of tungsten; molybdenum and tantalum by powder metallurgy are used in electric light bulbs, fluorescent lamps, radio valves, oscillator valves, mercury rectifiers and x-ray tubes in the form of filament, cathode anode screen and control grids.

Refractory carbides:-

Refractory carbides made by powder metallurgy has caused major breakthrough in modern industries dealing with construction (part of lathe, threaded guides etc.) instrument construction (numerous gauge, indenters etc.), wire drawing mills (blocks jaw, wire guide etc.), shearing processes (cutting, deep drawing etc.).

Automotive Application:-

The powder metallurgy components are used in motor car industry like porous bearing include all starters, screen wipers, sliding roofs, vehicle dynamos, clutches brake. Electrical contacts, crankshaft, drive or cam shaft sprocket, piston rings and rocker shaft brackets, door mechanism, connecting rod and brake linings are other powder metallurgy parts for automotive applications.

Aerospace Applications:-

Powder metallurgy is playing an important role in rocket, missile, satellites and space vehicles. Example- Silver-infiltrated tungsten are use in nozzles for rockets and missiles, metal powder such as beryllium, aluminium, magnesium and zirconium in the form of solid fuels are used in rockets and missiles.

Application in Defense:-

Metal powders play an important role in military and national defense system.