DEVELOPMENT OF SOUND PROOF BOARD USING CHICKEN FEATHER FIBER AND JUTE FIBER COMPOSITE

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

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ABSTRACT

Chicken feathers are disposed into the waste stream, land filling and animal feed without any use. In recent survey, about 3.8 billion pounds of chicken feather are dumped as waste. This creates a major environmental pollution.

As an alternative to land filling or animal feed the feather can be formed into value-added products finding profit. In this project we have explained the new way of using the chicken feather into sound proof composites.

The chicken feathers were collected from the poultry unit and impurities were removed using soap solution and then it is sterilized by using ethanol. After that the fibers were extracted by manually. Accordingly the jute fiber was cut into required length and it was softened by using soap solution.

The chicken feather and jute fibers were mixed with polypropylene staple fibers in the ratio of 50:50 respectively. Then the mixed fibers are fed to the miniature carding machine and the web was produced.

The prepared webs are used to produce composites using the compression molding machine and composite specimens are produced at optimized conditions. The mechanical properties of the prepared composites are tested (Tensile, Impact, and Flexural)

Finally, the sound proof testing is carried out for the prepared specimens.

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INTRODUCTION

1. INTRODUCTION

Natural fiber reinforced polymer composites have raised great attention and interest among materials scientists and engineers in recent years due to the considerations of developing an environmental friendly material and partly replacing currently used glass or carbon fibers in fiber reinforced composites. The use of synthetic polymers, toxin substances and non-biodegradable products, because of their hazardous after effects on environment and human health, which helps to re-established the needs of natural fibers.

The acoustical environment is very important for everyone. Noise control and its principles play an important role in creating an acoustical environment. This can be achieved by using sound absorbing material. Fibrous, porous and other kind of materials are used for sound absorption. In this project we have attempted to produce sound proof board using chicken feather and jute fiber reinforced composite.

Normally chicken feather is the waste after the process of chicken so we make use of that feathers for composite. Jute is an attractive natural fiber for use as reinforcement in composite it has biodegradable, low cost, renewable nature and low specific gravity than synthetic fibers.

Both chicker feather and jute fiber has excellent thermal and acoustic insulation property. The thermal property of the sound proof material is very important because when we speak the kinetic energy will produce and that energy will convert into heat energy. So we decide to use for sound proof application.

This investigation is to develop an eco-friendly, light weight sound proof composite from a cheap and easily available material at a lower cost. Both chicken feather and jute fiber has low specific gravity and the polypropylene matrix we use also have very low specific gravity in manmade fiber class so the light weight material is achieved.

In this project we decided to offer the noise problems in seminar halls, TV halls and cinema theatres and produce the cost effective sound boards.

LITERATURE REVIEW

2. LITERATURE REVIEW

In this chapter we are going to discuss the following,

1. Structure and properties of chicken feather fiber, Jute fiber and polypropylene.
2. Composite manufacturing techniques and testing
3. Sound absorption property

2.1 CHICKEN FEATHER FIBER

Jefferey W. Kock [6.1] Said, Feathers distinguish birds from other vertebrates and play an important role in numerous physiological and functional processes. Most adult birds are covered entirely with feathers, except on the beak, eyes, and feet. Feathers not only confer the ability of flight, but are essential for temperature regulation. Feathers are highly ordered, hierarchical branched structures, ranking among the most complex of keratin structures found in vertebrates. There are five commonly recognized categories of feathers: contour, down, semiplume, filoplume, and bristle. That differences in keratin organization result in approximately 30 macroscopically distinct poultry feather types.

2.1.1 STRUCTURE OF CHICKEN FEATHER

2.1.1.1 Morphological structure

Feathers' quills and fibers are both made of the protein keratin, the stuff of hair, nails, and wool. But the quill is hard and has a disorganized microscopic structure, while the fibers are soft and posses a very orderly microstructure. A single keratin fiber has a maximum diameter of 50 μm. Quill fractions are composed of both inner and outer quill; outer quill is more densely structured than inner quill, which is porous. The packing within outer quill keratin is less ordered and/or has less cross-linking than packing within fiber and inner quill keratin. Thus, it is the outer quill component of a quill fraction which is weaker. Outer quill would be weakened by mechanical stresses that the feather fiber and inner quill would be able to withstand. Feathers are extremely light, and they are hollow, yet very strong. The following fig shows the physical structure of the chicken feather,

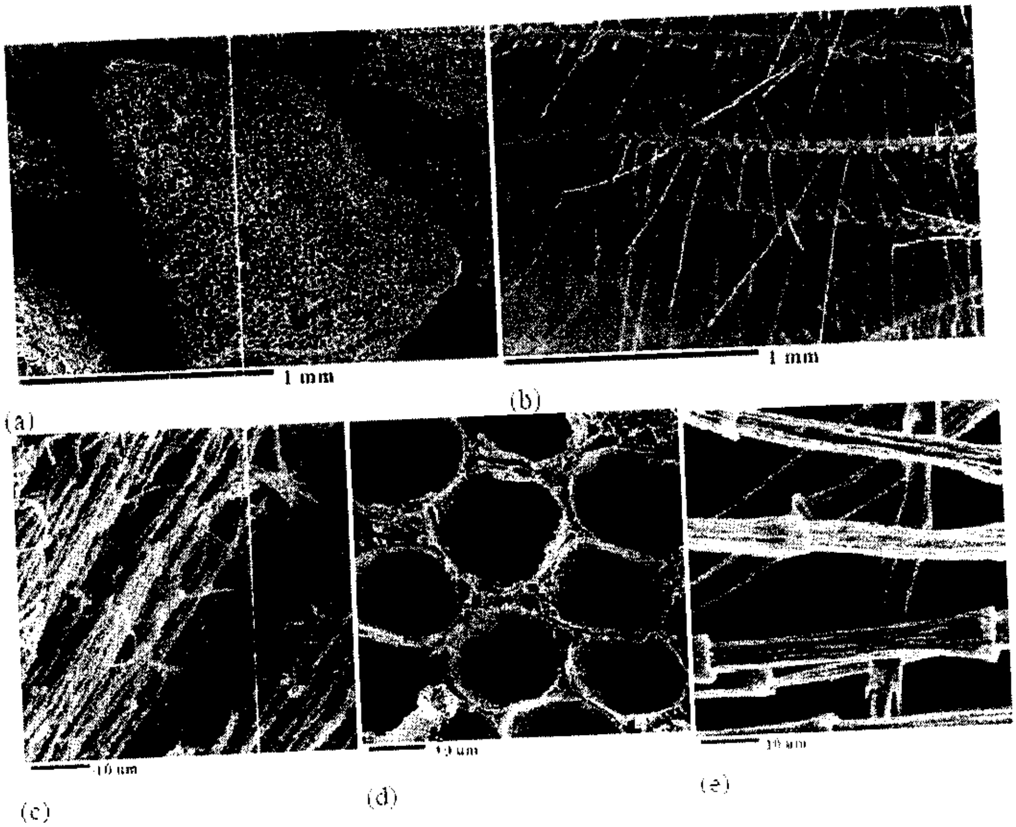
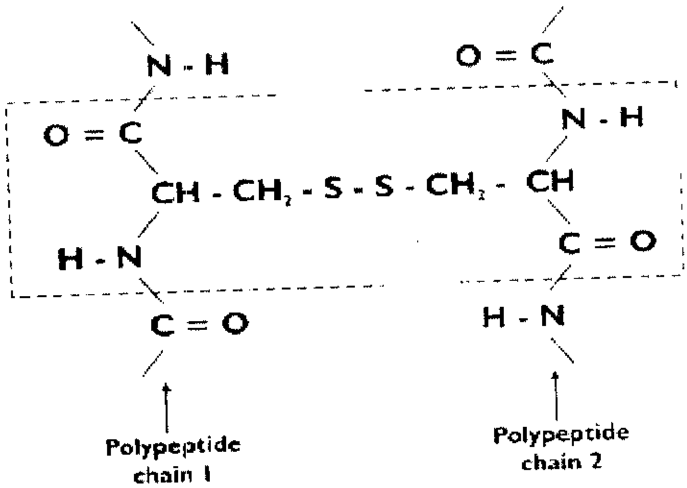


FIG.2.1 Shows SEM image of chicken feather (a) inner quill, (b) Fiber, (c) outer quill, (d) inner quill, and (e) fiber.

2.1.1.2 Chemical structure



Shows Diagrammatic representation of the diamino-acid cystine residue linking two polypeptide chains by covalent bonding

The feather keratin can contain both α-helical and β-sheet conformations. Chicken feather fiber primarily consists of α-helical conformations, and some β-sheet conformations are present. Chicken feather outer quill consists almost entirely of β-sheet conformations, and few α-helical conformations are present. Hard β-sheet keratins have a much higher cystine content than soft α-helix keratins and thus a much greater presence of disulfide (S-S) chemical bonds which link adjacent keratin proteins.

These strong covalent bonds stabilize the three-dimensional protein structure and are very difficult to break. This suggests that chicken feather outer quill would be stronger than chicken feather fiber. However, a study of the thermal properties of chicken feather fractions suggests that outer quill is weaker than fiber and inner quill.

2.1.2 CHEMICAL COMPOSITION OF CHICKEN FEATHER FIBER

The chemical composition of chicken feather is following,

Protein (keratin)	91%
Lipids	1%
Water	8%

Table 2.1 Shows chemical composition of chicken Feather

The amino acid sequence of a chicken feather is very similar to that of other feathers and also has a great deal in common with reptilian keratins from claws. The sequence is largely composed of cystine, glycine, proline, and serine, and contains almost no histidine, lysine, or methionine.

2.1.3 ELEMENTAL ANALYSIS OF CHICKEN FEATHER FIBER

Element	%
Carbon	47.83
Nitrogen	13.72
Hydrogen	6.48
Sulphur	2.16
Others	29.81

Table 2.2 Shows Elemental Analysis of Chicken Feather

2.1.4 THE PHYSICAL PROPERTIES OF CHICKEN FEATHER FIBRE

2.1.4.1 Moisture Content

Keratin can be considered to have both hydrophilic and hydrophobic properties. While 39 of the 95 amino acids in the keratin monomer are hydrophilic, serine, the most abundant amino acid, gives chicken feathers the ability to attract moisture from the air, because of the free OH group on the surface of each serine molecule. Thus, chicken feather fiber may be considered to be hygroscopic. The higher T_g indicates a tighter keratin structure to which water is more strongly bonded. Fiber and inner quill do not begin to lose water below 100°C.

2.1.4.2 Aspect Ratio

Fiber diameters were found to be in the range of 5-50 μm by scanning electron microscopy. The other examination of fibers was reported to have diameters of 6-8 μm and lengths of 3-13 mm. These values correspond to aspect ratios of 400-2200. It is found that fibers had a constant diameter of approximately 5 μm and lengths between 3.2 and 13 mm. These values correspond to aspect ratios of 600-2600

2.1.4.3 Apparent Specific Gravity

The density of the chicken feather fiber is 0.89 g/cm^3 it was obtained Feather fiber Corporation, by displacing a known volume and weight of for the density of solid keratin. It is reported fiber lengths of 3.2-13 mm. Ethanol with an equivalent amount of fiber.

The value may be higher due to the presence of shorter fibers (as short as 3.2 mm in length). The hollows, or voids, inside chicken feather fibers may become more accessible to ethanol as fiber length decreases. For a fiber of some critical length, the void inside of this fiber acts as a part of its surface, and as a result only the solid matter of this fiber will be accounted for by a measurement of apparent density. Assuming a density of 1.3 g/cm^3 for the solid matter of chicken feather fiber (keratin), apparent density results will approach 1.3 g/cm^3 as fiber length decreases.

2.1.4.4 Chemical Durability

The structure of keratin, the primary constituent of chicken feathers, affects its chemical durability. Because of extensive cross-linking and strong covalent bonding within its structure, keratin shows good durability and resistance to degradation. Efforts to extract keratin proteins from feathers illustrate this point. Extraction is a difficult task because it can only be achieved if the disufide and hydrogen bonds are broken. The found keratin to be insoluble in polar solvents, such as water, as well as in nonpolar solvents. The most common method for dissolving feather keratins is solubilization with concomitant peptide bond scission via acid and alkali hydrolysis, reduction of disulfide bonds with alkaline sodium sulfide solutions, or a combination of enzymatic and chemical treatment. Although these techniques are effective for extracting keratin (75% yield), they require extremely high reagent concentrations that are much higher than keratin fibers would ever be exposed to in nature. One can deduce from this that keratin is a relatively sturdy, stable protein.

2.1.4.5 Thermal insulation

Jing Gao, Weidong Yu and Ning Pan [6.2], Thermal insulating materials were used to prevent heat loss, which can occur by conduction, convection, phase change and radiation, individually or collectively. Heat transfer from one side of the fiber assembly to the another side was a complex phenomenon affected by numerous factors, such as density of the assembly, quantity of entrapped air, moisture content and transport and the motion of the contained air.

The result confirmed the thermal insulation property of the feather fiber is more than wool.

2.1.4.6 Other properties

Narendra Reddy, Yiqi Yang said [6.3] the following properties,

1. The low density, excellent compressibility and resiliency, ability to dampen sound, warmth retention and distinctive morphological structure of feather barbs make them unique fibers.
2. The density chicken feathers is about 0.8 g/cm^3 compared to about 1.5g/cm^3 for cellulose fibers and about 1.3 g/cm^3 for wool.
3. The tensile properties of barbs in terms of their strength and modulus are similar but the elongation is lower than that of wool.

2.2 JUTE FIBER

2.2.1 GENERAL INTRODUCTION

Shanei said [6.4], Jute comes under the classification of bast fiber, which occur in dieotyledonous plants between the outer bark and the woody central cylinder. Each fiber consists of bast or sclerenchymous cells overlapped in such a way that they produce continuous filaments. They provide strength as well as flexibility to the stem of the plant.

Corchorus and capsularis corchorus olitorius are the two species of the genus corchorus (linden tree family), which are grown for jute fiber production. These are native to tropics and sub-tropics, occurring as herbs, or small shrubs. These are annual plants and when cultivated, may grow to a height of about 12 feet.

2.2.2 CHEMICAL COMPOSITION OF JUTE

In chemical composition, jute is different from linen and cotton, being composed of a modified form of cellulose called lignocelluloses [bastose], which is compound of linen and cellulose. Jute is coloured yellow by iodine and sulphuric acid, whereas pure cellulose is coloured blue. With dilute chromic acid in the presence of hydrochloric acid, jute gives a blue colour. When treated with ammoniacal solution of cupric oxide, the fibers swell considerably but do not dissolve readily. A solution of ferric ferricyanide colours lignocellulose a deep blue owing to the reduction of the ferric compound by the lignone.

2.2.3 PROPERTIES OF JUTE FIBER

2.2.3.1 Tenacity

The tenacity of jute varies from 3.5 - 4.5 gpd at 4cm.test length. At very short specimen lengths the tenacity may be as high as 6 – 7 gpd. It remains practically constant cver the humidity range 35 – 80%.Under very dry and very wet conditions, it decreases appreciably. Its breaking elongation under normal atmospheric conditions is 1 – 1.2%. The high tenacity and low extensibility of jute in spite of its poor crystallinity are attributed to its high degree of orientation of the cellulose chains and to the presence of linkages between the different constituents in the amorphous region.

2.2.3.2 Stiffness

Stiffness of a fiber is a measure of its resistance to bending and is expressed as a ratio of breaking strength/breaking strain. This is high in case of jute at normal moisture content. On account of its stiffness and rigidity, jute fiber resists packing and twisting of fibers in the yarn and gives rise to low inter-fiber friction. Therefore, a certain degree of pliancy is imparted to the fibers before drawing and spinning by applying an oil-in-water emulsion to the raw fibers.

2.2.3.3 Length to breadth ratio

The cells of jute fiber vary from 0.05 – 0.19 inch in length and 20 – 22 in thickness, the mean length/breadth ratio being 90

2.2.3.4 Specific gravity

Jute fibers have a specific gravity of 1.48 – 1.50 and their specific heat is 0.324. It is highly combustible.

2.2.3.5 Thermal insulation

Jute is a very good insulator of heat and electricity. The bound air within the material [or fabric] offers a great resistance to heat transfer.

2.2.4 CHEMICAL TREATMENT OF JUTE FIBER

Jute is more sensitive to the action of chemicals, than cotton or linen. Therefore, it cannot be bleached as treatment with alkalis and bleaching powder weakens, and disintegrates the fiber considerably. The use of sodium silicate, soda ash, or sodium hydroxide is not recommended. Lime water makes the fiber brittle. Ammonia gives a harsh feel and decreases its luster.

When jute is hydrolyzed by heating with 1% sulphuric acid at 110'C under pressure, some formic and acetic acids are formed suggesting that lingo cellulose contains formyl and actyle groups.

2.3 POLYPROPYLENE

2.3.1 GENERAL INTRODUCTION

Shanei said [6.4]. Propylene (CH_2=CH-CH_3), the bi product of the oil refineries, is one of the constituents obtained from thermal or catalytic cracking of petroleum. Under suitable polymerizing condition, propylene produces fiber forming polypropylene. For producing the polymer (isotactic) with a regular structure, polymerization should take place.

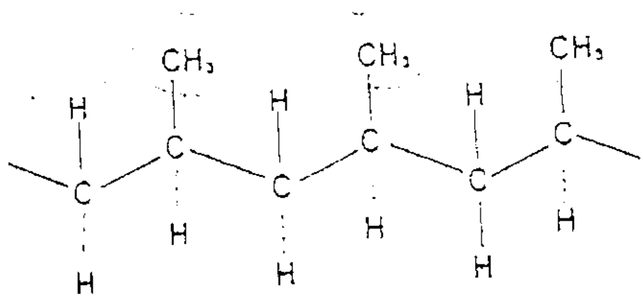
1. Always in head-to-tail arrangement in contrast to head-to-head (or tail-to-tail) addition. (shown in below structure)
2. Without branching by chain transfer or by co-polymerization of a monomer with its low molecular weight polymer and
3. In such a way the monomers arrange themselves in order configuration

Polypropylene is spun by melt spinning, because it is cheap process. Further, since the polymer has a high degree of polymerization, it is difficult to dissolve in organic solvents. The filament, extruded at 100^0C above the melting point, is cooled in air chamber and is collected on bobbins. Rapid cooling or quenching produces small crystals, in contrast to large crystals formed by slow cooling. The filament is than hot drawn and twisted.

A major advantage is Polypropylene's higher temperature resistance; this makes PP particularly suitable for items such as trays, funnels, pails, bottles, carboys and instrument jars that have to be sterilized frequently for use in a clinical environment. Polypropylene is a translucent material with excellent mechanical properties and it has gradually replaced the polyethylenes for many purposes.

2.3.2 STRUCTURE

$$-[\ CH_2 - \overset{\displaystyle CH_3}{\overset{|}{CH}}\ ]-$$



POLYPROPYLENE REPETING UNIT

2.3.3 PROPERTIES OF POLYPROPYLENE

FG.Torres, ML.Cuoillas said [6.5], Homopolymer polypropylene is translucent, Colorless transparent, smooth and glossy with hard surface, strong, highly resistant to temperature changes and with electrical insulation properties Water-resistant, water repellant and physiologically harmless.

Glass transition temperature:	10°C.
Melting temperature	173°C.
Amorphous density at	25°C: 0.85 g/cm^3.
Crystalline density at	25°C: 0.95 g/cm^3.
Molecular weight of repeat unit:	42.08 g/mol

2.3.3.1 Physical properties

Density (g cm^{-3})	0.9
Flammability	HB
Limiting oxygen index (%)	18
Radiation resistance	Fair
Refractive index	1.49
Resistance to Ultra-violet	Poor
Water absorption - equilibrium (%)	0.03

2.3.3.2 Mechanical Properties

Abrasive resistance - ASTM D1044	13-16 mg/1000 cycles
Coefficient of friction	0.1-0.3
Elongation at break (%)	150-300, for biax film >50
Hardness – Rockwell	R80-100
Izod impact strength (J m^{-1})	20-100
Tensile modulus (GPa)	0.9-1.5, for biax film 2.2-4.2,
Tensile strength (MPa)	25-40, for biax film 130-300,

2.3.3.3 Thermal Properties

Coefficient of thermal expansion ($x10^{-6}$ K^{-1})	100-180
Heat-deflection temperature 0.45MPa (C)	100-105
Heat-deflection temperature - 1.8MPa (C)	60-65
Lower working temperature (C)	-10 to -60
Specific heat (J K^{-1} kg^{-1})	1700 – 1900
Thermal conductivity @23C (W m^{-1} K^{-1})	0.1-0.22
Upper working temperature (C)	90-120

2.3.3.4 Chemical Resistance

Acids – concentrated	Good-Fair
Acids – dilute	Good-Fair
Alcohols	Good
Alkalis	Good
Aromatic hydrocarbons	Fair
Greases and Oils	Good-Fair
Halogenated Hydrocarbons	Good-Poor
Halogens	Poor
Ketones	Good

2.3.3.5 Electrical properties

Dielectric constant @1MHz	2.2-2.6
Dielectric strength (kV mm^{-1})	30-40
Dissipation factor @ 1MHz	0.0003 - 0.0005
Surface resistivity (Ohm/sq)	10^{13}

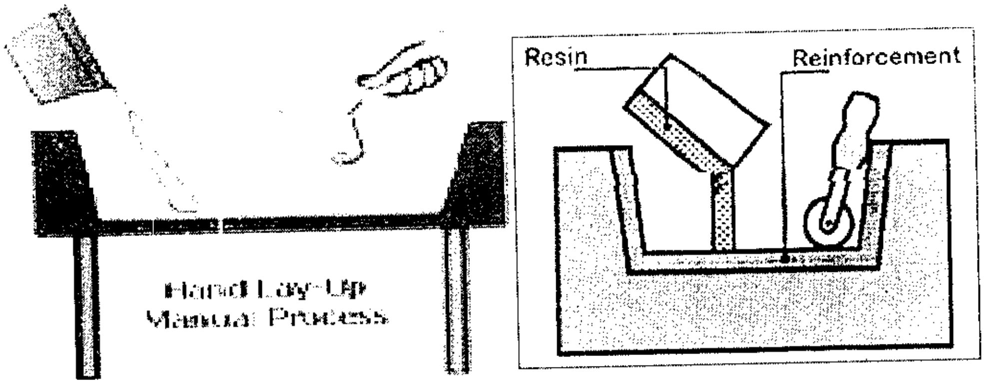


FIG.2.2 Shows Hand Lay Up Process

2.4.3.1.2 SPRAY-UP (CHOPPING)

Spray-up or chopping is an open mold method similar to hand lay-up in its suitability for making boats, tanks, transportation components and tub/shower units in a large variety of shapes and sizes. A chopped laminate has good conformability and is sometimes faster than hand lay-up in molding complex shapes. In the spray-up process the operator controls thickness and consistency, therefore the process is more operator dependent than hand lay-up. Although production volume per mold is low, it is feasible to produce substantial production quantities using multiple molds

Process Description - As with hand lay-up, gel coat is first applied to the mold prior to spray-up of the substrate laminate. Continuous strand glass roving and catalyzed resin are fed through a chopper gun, which deposits the resin-saturated "chop" on the mold. The laminate is then rolled to thoroughly saturate the glass strands and compact the chop. Additional layers of chop laminate are added as required for thickness. Roll stock reinforcements, such as woven roving or knitted fabrics, can be used in conjunction with the chopped laminates. Core materials of the same variety as used in hand lay-up are easily incorporated.

Molds - These are the same molds as in hand lay-up simple, single-cavity, molds of fiberglass composites construction. Molds can range from very small to very large and are low cost in the spectrum of composites molds.

Major Advantages - Simple, low-cost tooling, simple processing; portable equipment permits on-site fabrication; virtually no part size limitations. The process may be automated.

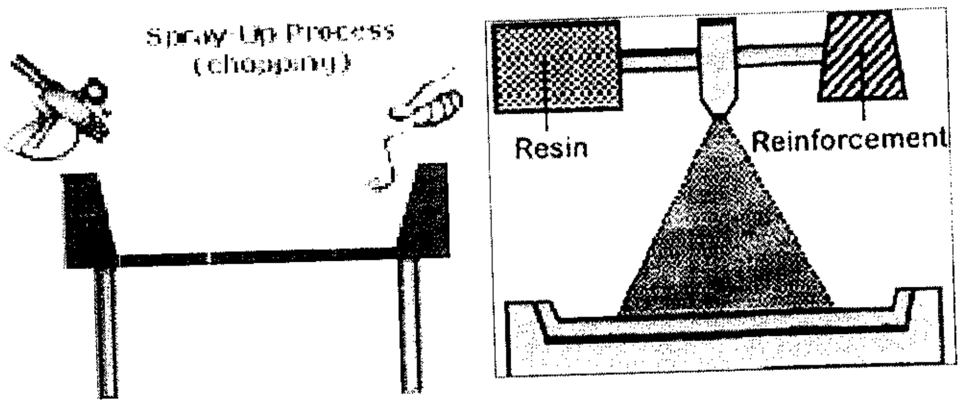


FIG.2.3 Shows Spray Up Process

2.4.3.1.3 FILAMENT WINDING

Filament winding is an automated open molding process that uses a rotating mandrel as the mold. The male mold configuration produces a finished inner surface and a laminate surface on the outside diameter of the product. Filament winding results in a high degree of fiber loading, which provides high tensile strengths in the manufacture of hollow, generally cylindrical products such

2.4 COMPOSITE MATERIAL

2.4.1 INTRODUCTION TO FIBER REINFORCED COMPOSITE

Textile-reinforced composite materials (TRCM) are part of the general class of engineering materials called composite materials. It is usual to divide all engineering materials into four classes: metals, polymers, ceramics and composites. A rigorous definition of composite materials is difficult to achieve because the first three classes of homogeneous materials are sometimes heterogeneous at submicron dimensions (e.g. precipitates in metals). A useful working definition is to say that composite materials are characterized by being multiphase materials within which the phase distribution and geometry has been deliberately tailored to optimize one or more properties. This is clearly an appropriate definition for textile-reinforced composites for which there is one phase, called the matrix, reinforced by a fibrous reinforcement in the form of a textile.

2.4.2 INTRODUCTION TO THERMOPLASTIC COMPOSITE MATERIAL

Throughout the prior two decades, fiber reinforced composite materials were principally fabricated using thermosetting matrices. Disadvantages stemming from the use of thermosets include brittleness, lengthy cure cycles and inability to repair and/or recycle damaged or scrapped parts. These disadvantages led to the development of the thermoplastic matrix composite system. Compared with thermosets, composites fabricated from thermoplastic materials typically have a longer shelf life, higher strain to failure, are faster to consolidate and retain the ability to be repaired, reshaped and reused as need arises. However, as in many polymers composite systems, these materials frequently suffer from a lack of adequate fiber-matrix adhesion. In addition, the use of thermoplastics introduces the problem of adequate fiber tow penetration. Thermoplastic melts, as opposed to thermosetting resins, have a substantially higher viscosity. Thermoplastic matrices must be able to withstand high temperatures in order to effect a sufficient reduction in viscosity. Additional problems caused by high matrix viscosity during consolidation include de-alignment of reinforcing fibers during consolidation as well as the introduction of voids within the final composite product. All of these problems can be addressed by appropriate design regarding the fiber-matrix interface as well as optimization of composite fabrication procedures. Composites prepared with satisfactory matrix dispersion within the fiber tows as well as reasonable fiber-matrix adhesive interaction typically results in composites with good mechanical properties.

2.4.3 MANUFACTURING PROCESS OF COMPOSITE

Besso.M said [6.6], There are two general divisions of composites manufacturing processes: **open molding** and **closed molding**. With open molding, the gel coat and laminate are exposed to the atmosphere during the fabrication process. In closed molding, the composite is processed in a two-sided mold set, or within a vacuum bag. There are a variety of processing methods within the open and closed molding categories:

2.4.3.1 Open Molding

- Hand Lay-Up
- Spray-up
- Filament Winding

2.4.3.2Closed Molding

- Compression molding

- Pultrusion
- Reinforced Reaction Injection Molding (RRIM)
- Resin Transfer Molding (RTM)
- Vacuum Bag Molding
- Vacuum Infusion Processing
- Centrifugal Casting
- Continuous Lamination

Selecting which manufacturing process to select depends on a number of factors including cost, materials, size, and most important volume. Below is what processes would be used depending on production amounts:

Low Volume Production

- Hand Lay-Up
- Vacuum Bag Molding
- Vacuum Infusion Processing
- Medium Volume Production
- Filament Winding
- Wet lay-up compression molding
- Resin Transfer Molding
- Centrifugal Casting

High Volume Production

- Compression Molding
- Pultrusion
- Reinforced Reaction Injection Molding
- Continuous Lamination

The most popular method of composite manufacturing is following,

2.4.3.1.1 HAND LAY-UP

Hand lay-up is an open molding method suitable for making a wide variety of composites products including: boats, tanks, bath ware, housings, RV/truck/auto components, architectural products, and many other products ranging from very small to very large. Production volume per mold is low; however, it is feasible to produce substantial production quantities using multiple molds.

Process Description - Gel coat is first applied to the mold using a spray gun for a high-quality surface. When the gel coat has cured sufficiently, roll stock fiberglass reinforcement is manually placed on the mold. The laminating resin is applied by pouring, brushing, spraying, or using a paint roller. FRP rollers, paint rollers, or squeegees are used to consolidate the laminate, thoroughly wetting the reinforcement, and removing entrapped air. Subsequent layers of fiberglass reinforcement are added to build laminate thickness. Low density core materials, such as end-grain balsa, foam, and honeycomb, are commonly used to stiffen the laminate to produce sandwich construction.

Molds - Simple, single-cavity molds of fiberglass composites construction are generally used. Molds can range from very small to very large and are low cost in the spectrum of composites molds.

Major Advantages - Simplest method offering low-cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is a minimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

as chemical and fuel storage tanks, pipes, stacks, pressure vessels, and rocket motor cases.

Process Description - Continuous strand roving is fed through a resin bath and wound onto a rotating mandrel. The roving feed runs on a trolley that traverses the length of the mandrel. The filament is laid down in a predetermined geometric pattern to provide maximum strength in the directions required. When sufficient layers have been applied, the laminate is cured on the mandrel. The molded part is then stripped from the mandrel. Equipment is available for filament winding on a continuous basis and two axis winding for pressure cylinders. Filament winding can be combined with the chopping process and is known as the hoop chop process.

Molds - Mandrels of suitable size and shape, made of steel or aluminum form the inner surface of the hollow part. Some mandrels are collapsible to facilitate part removal.

Major Advantages - The process makes the high strength-to-weight ratio laminates and provides a high degree of control over uniformity and fiber orientation. The filament winding process can be used to make structures which are highly engineered and meet strict tolerances. Because filament winding is automated, the labor factor for filament winding is lower than other open molding processes.

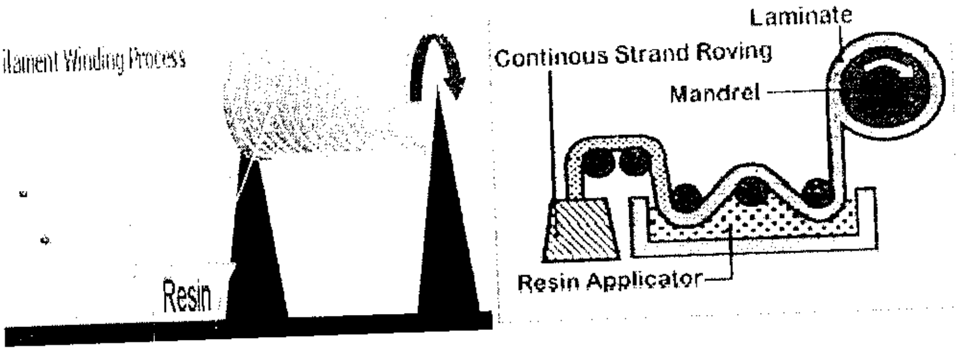


FIG.2.4 Shows Filament Winding Process

2.4.3.2.1 COMPRESSION MOLDING

Compression molding is a high-volume, high-pressure method suitable for molding complex, fiberglass-reinforced plastic parts on a rapid cycle time. There are several types of compression molding including: sheet molding compound (SMC) which are, bulk molding compound (BMC), thick molding compound (TMC), and wet lay-up compression molding. Compression molding tooling consists of heated metal molds mounted in large presses.

Process Description - The mold set is mounted in a hydraulic or mechanical molding press. The molds are heated to 2500 to 4000 F. A weighed charge of molding compound is placed in the open mold. The two halves of the mold are closed and pressure is applied. Depending on thickness, size, and shape of the part, curing cycles range from less than a minute to about five minutes. The mold is opened and the finished part is removed.

Molds - Tooling is usually machined steel or cast alloy molds that can be in either single or multiple-cavity configurations. Steel molds are hardened and sometimes chrome plated for enhanced durability. The molds are heated using steam, hot oil, or electricity. Side cores, provisions for inserts, and other refinements are often employed. Mold materials include cast of forged steel, cast iron, and cast aluminum.

Major Advantages - Compression molding produces fast molding cycles and high part uniformity. The process can be automated. Good part design flexibility and features such as inserts, ribs, bosses, and attachments can be molded in. Good surface finishes are obtainable, contributing to lower part finishing cost. Subsequent trimming and machining operations are minimized in compression molding. Labor costs are low.

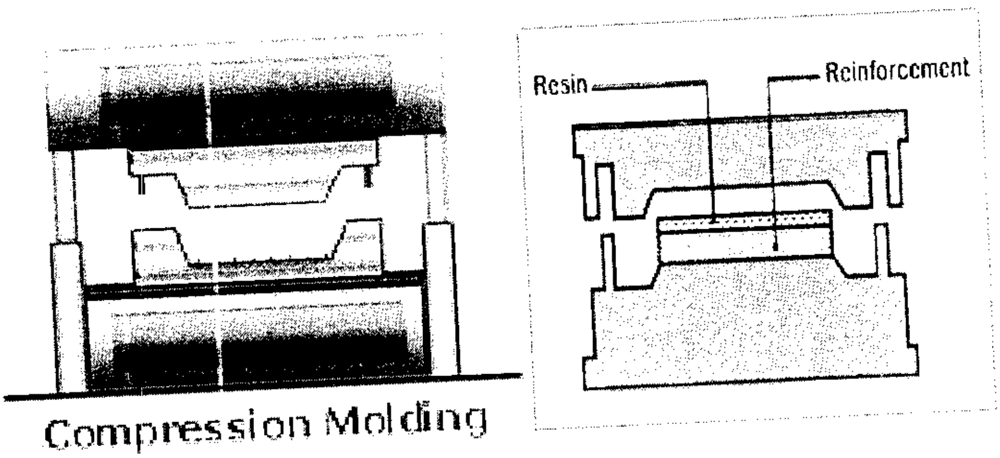


FIG.2.5 Shows Compression Molding Process

2.4.3.2.2 PULTRUSION

Pultrusion is a continuous process for the manufacture of products having a constant cross section, such as rod stock, structural shapes, beams, channels, pipe, tubing, fishing rods, and golf club shafts. Pultrusion produces profiles with extremely high fiber loading, thus pultruded products have high structural properties.

Process Description - Continuous strand fiberglass roving, mat, cloth, or surfacing veil is impregnated in a resin bath, then pulled (pul-trusion) through a steel die, by a powerful tractor mechanism. The steel die consolidates the saturated reinforcement, sets the shape of the stock, and controls the fiber/resin ratio. The die is heated to rapidly cure the resin. Many creels (balls) of roving are positioned on a rack, and a complex series of tensioning devices and roving guides direct the roving into the die.

Molds - Hardened steel dies are machined and include a perform area to do the initial shaping of the resin-saturated roving. The dies include heating which can be electric or hot oil. The latest pultrusion technology uses direct injection dies, in which the resin is introduced inside the die, rather than through an external resin bath.

Major Advantages - The process is a continuous operation that can be readily automated. It is adaptable to both simple and complex cross-sectional shapes. Very high strengths are possible due to the fiber loading and labor costs are low.

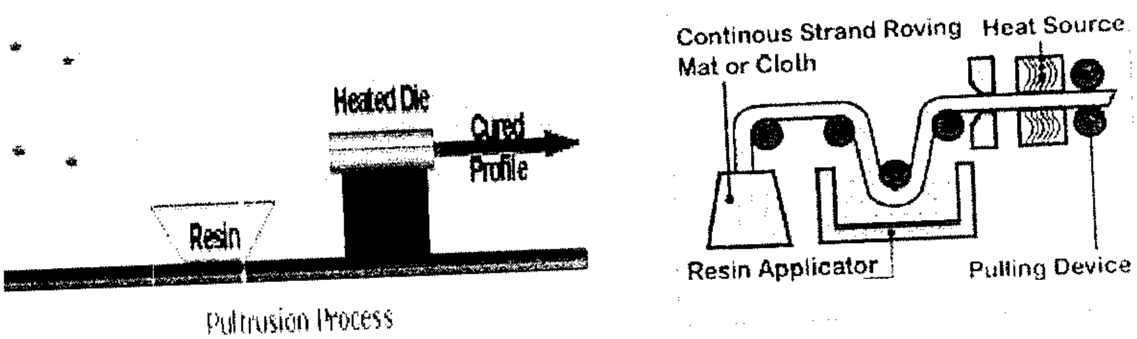


FIG.2.6 Shows Pultrusion Process

placed over the dry reinforcement. Next a flow media consisting of a coarse mesh or a "crinkle" ply is positioned, and perforated tubing is positioned as a manifold to distribute resin across the laminate. The vacuum bag is then positioned and sealed at the mold perimeter. A tube is connected between the vacuum bag and the resin container. A vacuum is applied to consolidate the laminate and the resin is pulled into the mold.

Molds - Molds are similar to those used for conventional open-mold processes.

Major Advantages - Vacuum infusion can produce laminates with a uniform degree of consolidation, producing high strength, lightweight structures. This process uses the same low cost tooling as open molding and requires minimal equipment. Very large structures can be fabricated using this method. Vacuum infusion offers a substantial emissions reduction compared to either open molding or wet lay-up vacuum bagging.

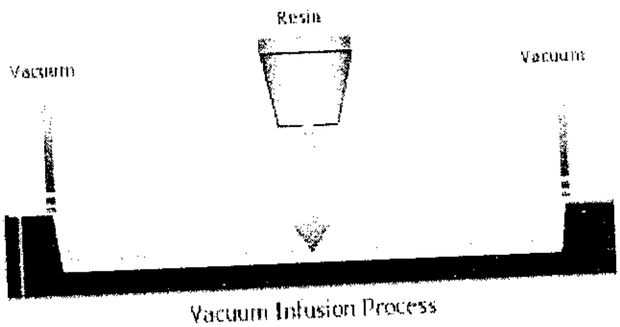


FIG.2.7 Shows Vacuum Infusion Process

2.4.3.2.5 RESIN TRANSFER MOLDING (RTM)

Resin transfer molding is an intermediate volume molding process for producing composites. The RTM process is to inject resin under pressure into a mold cavity. RTM can use a wide variety of tooling, ranging from low cost composite molds to temperature controlled metal tooling. This process can be automated and is capable of producing rapid cycle times. Vacuum assist can be used to enhance resin flow in the mold cavity.

Process Description - The mold set is gel coated conventionally, if required. The reinforcement (and core material) is positioned in the mold and the mold is closed and clamped. The resin is injected under pressure, using mix/meter injection equipment, and the part is cured in the mold. The reinforcement can be either a perform or pattern cut roll stock material. Performs are reinforcement that is pre-formed in a separate process and can be quickly positioned in the mold. RTM can be done at room temperature; however, heated molds are required to achieve fast cycle times and product consistency. Clamping can be accomplished with perimeter clamping or press clamping.

Molds - RTM can utilize either "hard" or "soft" tooling, depending upon the expected duration of the run. Soft tooling would be either polyester or epoxy molds, while hard tooling may consist of cast machined aluminum, electroformed nickel shell, or machined steel molds. RTM can take advantage of the broadest range of tooling of any composites process. Tooling can range from very low cost to very high cost, long life molds.

Major Advantages - This closed molding process produces parts with two finished surfaces. By laying up reinforcement material dry inside the mold, any combination of materials and orientation can be used, including 3- reinforcements. Part thickness is determined by the tool cavity.

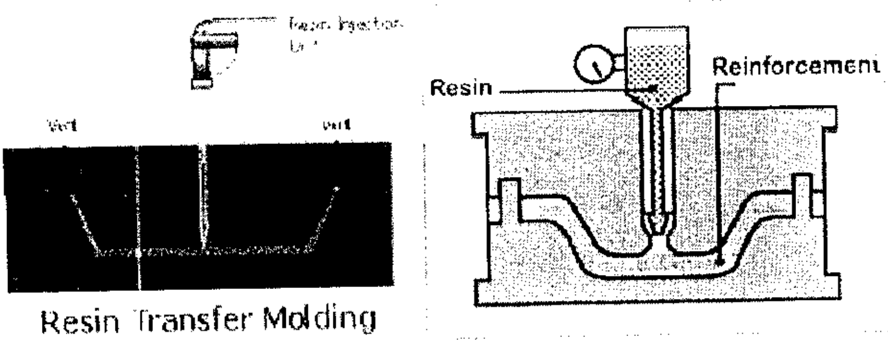


FIG.2.8 Shows Resin Transfer Molding

2.5 ACOUSTIC MATERIALS AND TESTING

SOUND WAVE:

A sound wave is a longitudinal wave where particles of the medium are temporarily displaced in a direction parallel to energy transport and then return to their original position. The vibration in a medium produces alternating waves of relatively dense and sparse particles – compression and rarefaction respectively.

The resultant variation to normal ambient pressure is translated by the ear and perceived as sound. A simple sound wave is illustrated in Figure and may be described in terms of variables like: Amplitude, Frequency, Wavelength, Period and Intensity.

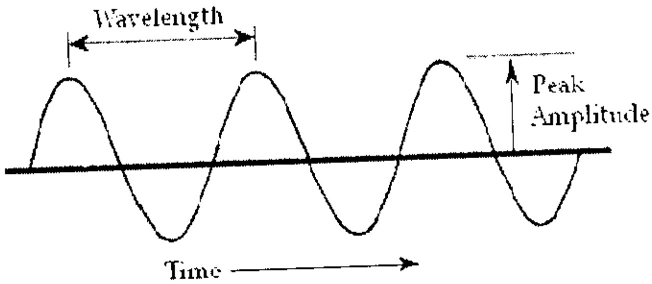


Illustration of simple sound wave

Amplitude refers to the difference between maxima and minima pressure. **Frequency** of a wave is measured as the number of complete back-and-forth vibrations of a particle of the medium per unit of time. A commonly used unit for frequency (f) is the Hertz (abbreviated Hz). The **wavelength** (λ) of a wave is the distance which a disturbance travels along the medium in one complete wave cycle .since a wave repeats its pattern once every wave cycle the wavelength is sometimes referred to as the length of the repeating patterns.

The term '**period**' can be defined as the time required for the completion of one cycle of wave motion. The **intensity** of a sound wave is defined as the average rate at which sound energy is transmitted through a unit area.

Frequency and wavelength are related as follows:

Wavelength [ft] = Speed of sound [ft/sec]/ Frequency [Hz]

Like any wave, the speed of sound (v) refers to how fast the disturbance is passed from particle to particle. Under normal condition of pressure and humidity at sea level, sound waves travel at approximately 344 m/s through air. As explained earlier frequency refers to the number of vibrations, which an individual particle

2.4.3.2.3 VACUUM BAG MOLDING

The mechanical properties of open-mold laminates can be improved with vacuum bagging. By reducing the pressure inside the vacuum bag, external atmospheric pressure exerts force on the bag. The pressure on the laminate removes entrapped air, excess resin, and compacts the laminate. A higher percentage of fiber reinforcement is the result. Additionally, vacuum bagging reduces styrene emissions. Vacuum bagging can be used with wet-lay laminates and prepreg advanced composites. In wet lay-up bagging the reinforcement is saturated using hand lay-up, then the vacuum bag is mounted on the mold and used to compact the laminate and remove air voids.

In the case of pre-impreg advanced composites molding, the prepreg material is laid-up on the mold, the vacuum bag is mounted and the mold is heated or the mold is placed in an autoclave that applies both heat and external pressure, adding to the force of atmospheric pressure. The prepreg-vacuum bag-autoclave method is most often used to create advanced composites used in aircraft and military products.

Process Description - In the simplest form of vacuum bagging, a flexible film (PVA, nylon, Mylar, or polyethylene) is placed over the wet lay-up, the edges sealed, and a vacuum drawn. A more advanced form of vacuum bagging places a release film over the laminate, followed by a bleeder ply of fiberglass cloth, non-woven nylon, polyester cloth, or other material that absorbs excess resin from the laminate. A breather ply of a non-woven fabric is placed over the bleeder ply, and the vacuum bag is mounted over the entire assembly. Pulling a vacuum from within the bag uses atmospheric pressure to eliminate voids and force excess resin from the laminate. The addition of pressure further results in high fiber concentration and provides better adhesion between layers of sandwich construction. When laying non-contoured sheets of PVC foam or balsa into a female mold, vacuum bagging is the technique of choice to ensure proper secondary bonding of the core to the outer laminate.

Molds - Molds are similar to those used for conventional open-mold processes.

Major Advantages - Vacuum bag processing can produce laminates with a uniform degree of consolidation, while at the same time removing entrapped air, thus reducing the finished void content. Structures fabricated with traditional hand lay-up techniques can become resin rich and vacuum bagging can eliminate the problem.

2.4.3.2.4 VACUUM INFUSION PROCESSING

Vacuum infusion is a variation of vacuum bagging where the resin is introduced into the mold after the vacuum has pulled the bag down and compacted the laminate. The method is defined as having lower than atmospheric pressure in the mold cavity. The reinforcement and core material are laid-up dry in the mold. This is done by hand and provides the opportunity to precisely position the reinforcement. When the resin is pulled into the mold the laminate is already compacted; therefore, there is no room for excess resin. Very high resin to glass ratios is possible with vacuum infusion and the mechanical properties of the laminate are superior. Vacuum infusion is suitable to mold very large structures and is considered a low volume molding process.

Process Description - The mold may be gel coated in the traditional fashion. After the gel coat cures, the dry reinforcement is positioned in the mold. This includes all the plies of the laminate and core material if required. A perforated release film is makes per unit of time, while speed refers to the distance, which the disturbance travels per unit of time.

2.5.1 NOISE CONTROL

Andrew Barnard Chip Dayton Said [6.7], With today's growing focus on noise control issues and the emergence of sound quality as an important aspect of product design, acoustic material testing is becoming increasingly relevant to engineers, designers and manufacturers from a broad range of industries. Acoustic material testing is the process by which the acoustic characteristics of materials are determined in terms of absorption, reflection, impedance, and admittance.

"Noise is an unwanted sound and unfortunately most of the machines that have been developed for industrial purposes, for high speed transportation, or to make life more enjoyable are accompanied by noise". A noise system can be broken down into three elements:

- Noise Source – The element which disturbs the air
- Noise Path – The medium through which the acoustical energy Propagates from one point to another
- Noise Receiver – The person who could potentially complain about the quantity or level of noise as perceived at same point

It is necessary to treat at least one element in the noise system if the perceived level of the noise is to be reduced. By reducing the noise level at the source or along the path, the noise level at the receiver is accordingly reduced. Treating the receiver individually in such a way to minimize the sensitivity to high noise levels is another option. But this method is not often followed because of cost of redesign, develop and retool. Treatment of noise receiver is the least desirable approach since each receiver must be treated individually. Treatment of the noise path is conceptually the simplest and therefore the most common approach to a localized noise problem. The approach is to place the material in the path of the noise (generally between the noise source and the noise receiver) so that the level of noise at the receiver is reduced. In general four basic principles are employed to reduce noise: isolation, absorption, vibration isolation and vibration damping. The study here is focused only on the absorption phenomenon of sound, where sound energy is converted into thermal energy.

2.5.2 ACOUSTIC PROPERTIES

Ryu,Yunseon, said [6.8] the following acoustic properties,

1. **Absorption Coefficient:** The fraction of sound energy that is absorbed at any surface.
2. **Complex Reflection Coefficient:** The ratio of the pressure amplitude of the reflected wave to the incident wave.
3. **Complex Acoustic Impedance:** The ratio of the surface sound pressure to the sound particle velocity through the surface.
4. **Complex Acoustic Admittance:** The ratio of the sound particle velocity through the surface to the surface sound pressure.
5. **Transmission Loss:** The ratio of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side.

2.5.3 SOUND ABSORPTIVE MATERIALS

Materials that reduce the acoustic energy of a sound wave as the wave passes through it by the phenomenon of absorption are called sound absorptive materials. They are commonly used to soften the acoustic environment of a closed volume by reducing the amplitude of the reflected waves. Absorptive materials are generally resistive in nature, either fibrous, porous or in rather special cases reactive resonators. Classic examples of resistive material are nonwovens, fibrous glass, mineral wools, felt and foams. Resonators include hollow core masonry blocks, sintered metal and so on. Most of these products provide some degree of absorption at nearly all frequencies and performance at low frequencies typically increases with increasing material thickness. Porous materials used for noise control are generally categorized as fibrous medium or porous foam. A particular interest of this research is to conduct a systematic study on fibrous sound absorbing materials. Fibrous media usually consists of glass, rock wool or polyester fibers and have high acoustic absorption. Sometimes fire resistant fibers are also used in making acoustical products. Often sound barriers are confused with sound absorbing materials. Generally materials that provide good absorption are poor barriers. Unlike, barriers and damping materials, the mass of the material has no direct effect on the performance of the absorptive materials. The performance of absorptive materials depends on many parameters, which are explained in the latter part of this chapter. Absorptive materials are almost always used in conjunction with barriers of some type since their porous construction permits some noise to pass through relatively unaffected. An absorber, when backed by a barrier, reduces the energy in a sound wave by converting the mechanical motion of the air particles into low-grade heat. This action prevents a buildup of sound in enclosed spaces and reduces the strength of reflected noise. The porous nature of absorptive materials renders them susceptible to contamination, moisture retention and deterioration due to physical abuse. To avoid these problems, facings may be attached to at least one side of the absorber. The addition of a facing to acoustical foam has the effect of increasing the lower frequency absorption at the expense of the higher frequencies.

2.5.4 MECHANISM OF SOUND ABSORPTION IN FIBROUS MATERIALS

The absorption of sound results from the dissipation of acoustic energy to heat. Many authors have explained this dissipation mechanism in the past Fridolinetal. Describe the mechanism of sound dissipation as: when sound enters porous materials, owing to sound pressure, air molecules oscillate in the interstices of the porous material with the frequency of the exciting sound wave. This oscillation results in frictional losses. A change in the flow direction of sound waves, together with expansion and contraction phenomenon of flow through irregular pores, results in a loss of momentum. Owing to exciting of sound, air molecules in the pores undergo periodic compression and relaxation. This results in change of temperature. Because of long time, large surface to volume ratios and high heat conductivity of fibers, heat exchange takes place isothermally at low frequencies. At the same time in the high frequency region compression takes place adiabatically. In the frequency region between these isothermal and adiabatic compression, the heat exchange results in loss of sound energy. This loss is high in fibrous materials if the sound propagates parallel to the plane of fibers and may account up to 40% sound attenuation. So, altogether the reasons for the acoustic energy loss when sound passes through sound absorbing materials are due to:

- Frictional losses
- Momentum losses
- Temperature fluctuations

2.5.5 APPLICATION OF SOUND ABSORPTIVE MATERIALS

Acoustical material plays a number of roles that are important in acoustic engineering such as the control of room acoustics, industrial noise control,

ASTM E1376	Measuring the interzone attenuation of sound reflected by wall finishes and furniture panels
ASTM E1408	Laboratory measurement of the sound transmission loss of door panels and door system
ASTM E336	Measurement of airborne sound insulation in buildings
ASTM E1007	Field measurement of tapping machine impact sound transmission through floor-ceiling assemblies and associated support structures
ASTM E1111	Measuring the interzone attenuation of ceiling system
ASTM E1414	Airforne sound attenuation between rooms sharing a common ceiling plenum
ASTM E1050	Impedance and absorption of acoustical materials using a tube, two microphones, and a digital frequency analysis system
ASTM E477	Measuring acoustical and airflow performance of duct linear materials and prefabricated silencers
ASTM E966	Guide for field measurement of airforne sound insulation of building facades and façade elements
ANSI S12.11	Measurement of noise emitted by small air-moving devices
ANSI S12.5	Requirements for the performance and calibration of reference sound sources
ISO 9296	Acoustics-declared noise emission values of computer and business equipment
ECMA 74	Measurement of Airborne Noise Emitted by Information Technology and Telecommunication Equipment

ASTM E1425	Standard Practice for Determining the Acoustical Performance of Exterior Windows and Doors
ISO 354	Acoustics/Measurement of Sound Absorption in a Reverberation Room
ISO 140, Part 3	Laboratory Measurement of Airborne Sound Insulation of Building Elements
ISO 3741	Determination of Sound Power Levels of Noise Sources - Precision Methods for Broad-Band Sources in Reverberation Rooms
ISO 3742	Determination of Sound Power Levels of Noise Sources - Precision Methods for Discrete-Frequency and Narrow-Band Sources in Reverberation Rooms
ISO 7779	Measurement of Airborne Noise Emitted by Computer and Business Equipment
AMA-1-II-67	Ceiling Sound Transmission Test by Two-Room Method
ISO 140, Part 9	Laboratory Measurement of Room-to-Room Airborne Sound Insulation of a Suspended Ceiling with a Plenum Above
ISO 6926	Determination of Sound Power Levels of Noise Sources - Requirements for the Performance and Calibration of Reference Sound Sources
ISO 3822	Laboratory Tests on Noise Emission from Appliance and Equipment Used in Water Supply Installations
SAE J1477	Measurement of Interior Sound Levels of Light Vehicles
SAE J1400	Laboratory Measurement of the Airborne Sound Barrier

	Performance of Automotive Materials and Assemblies
SAE J1637	Laboratory Measurement of the Composite Vibration Damping Properties of Materials on a Supporting Steel Bar
ANSI S12.35	Precision Methods for the Determination of Sound Power Levels of Noise Sources in Anechoic and Hemi-Anechoic Rooms
ANSI S12.34	Determination of Sound Power Levels of Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane
ASTM E1222	Laboratory Measurement of the Insertion Loss of Pipe Lagging Systems
ASTM E2179	Laboratory Measurement of the Effectiveness of Floor Coverings in Reducing Impact Sound Transmission Through Concrete Floors
ANSI S12.51	Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Method for Reverberation Rooms
AAMA 1801	Acoustical Rating of Windows, Doors and Glazed Wall Sections
ANSI S12.54	Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Engineering Method in an Essentially Free Field Over a Reflecting Plane
ANSI S1.10	Method for Calibration of Microphones
ASTM E1816	Standard Practice for Ultrasonic Examinations Using Electromagnetic Acoustic Transducer (EMAT) Techniques
ISO 11201	Noise Emitted by Machinery and Equipment - Measurement

studio acoustics and automotive acoustics. Sound absorptive materials are generally used to counteract the undesirable effects of sound reflection by hard, rigid and interior surfaces and thus help to reduce the reverberant noise levels. They are used as interior lining for apartments, automotives, aircrafts, ducts, enclosures for noise equipments and insulations for appliances. Sound absorptive materials may also be used to control the response of artistic performance spaces to steady and transient sound sources, thereby affecting the character of the aural environment, the intelligibility of unreinforced speech and the quality of unreinforced musical sound. Combining absorptive materials with barriers produces composite products that can be used to lag pipe or provide absorptive curtain assemblies.

Note: All noise control problem starts with the spectra of the emitting source. Therefore, sound absorbing materials are chosen in terms of material types and dimension, and also based on the frequency of sound to be controlled.

2.5.6 PERFORMANCE OF SOUND ABSORPTIVE MATERIALS

For porous and fibrous materials, acoustic performance is defined by a set of experimentally determined constants namely: absorption co-efficient, reflection co-efficient, acoustic impedance, propagation constant, normal reduction coefficient and transmission loss. There are different methods available to determine these acoustical parameters but all of these methods mainly involve exposing materials to known sound fields and measuring the effect of their presence on the sound field.

The performance of sound absorbing materials in particularly is evaluated by the sound absorption co-efficient (α). Alpha (α) is defined as the measure of the acoustical energy absorbed by the material upon incidence and is usually expressed as a decimal varying between 0 and 1.0. If 55 percent of the incident sound energy is absorbed, the absorption coefficient of that material is said to be 0.55. A material that absorbs all incident sound waves will have a sound absorption coefficient of 1. The sound absorption coefficient (α) depends on the angle at which the sound wave impinges upon the material and the sound frequency. Values are usually provided in the literature at the standard frequencies of 125, 250, 500, 1000 and 2000. In comparing sound absorbing materials for noise control purposes, the noise reduction co-efficient (NRC) is commonly used. NRC is the average usually stated to the nearest multiple of 0.05, of the co-efficient at four frequencies 250, 500, 1000 and 2000 HZ. It is intended for use as a single number index of the sound absorbing efficiency of a material. This NRC values provides a decent and simple quantification of how well the particular surface will absorb the human voice.

The sound absorption for a sample of material or an object is measured sometimes in sabins or metric sabins. One sabin may be thought of as the absorption of unit area (1 m2 or 1 ft2) of a surface that has an absorption coefficient of 1.0 (100 per cent). When areas are measured in square meters, the term metric Sabin is used. The absorption for a surface can be found by multiplying its area by its absorption coefficient. Thus for a material with 24 absorption coefficient of 0.5, 10 sq. ft has a sound absorption of 5 sabins and 100m2 is 50 metric sabins. Harris gives four factors that affect the sound absorption co-efficient. They are:

- Nature of the material itself
- Frequency of the sound
- The angle at which the sound wave strikes the surface of the material
- Air gap

More fundamentally, all sound absorptive materials can be characterized by two basic parameters namely: Characteristic Impedance and Complex Propagation Constant. Characteristic impedance is the measure of wave resistance of air. It is the ratio of sound pressure to particle velocity. Attenuation and phase constant which are included in the propagation constant are the measure of how much sound energy is reduced and the speed of propagation of sound respectively. Even other parameters were tried by researchers in order to include various effects like material internal structure, viscous and thermal loss, which are not discussed here.

2.5.7 ACOUSTIC MESUREMENT

There are many different methods to determine the acoustic properties of materials by exposing them to sound field and measure the effect caused by their presence. Concerning to the acoustic material testing methods, the following different standards are used to test the acoustic,

2.5.7.1 Different Standards of Acoustic Testing

Table 2.3 Shows Different Standards of Acoustic Testing

Test methods designation	Short title
ASTM C367	Strength properties of prefabricated architectural acoustical tile or lay-in coiling panels
ASTM C 384	Impedance and absorption of acoustical materials by impedance tube method
ASTM C423	Sound absorption and sound absorption co-efficient by the reverberation room method
ASTM C522	Airflow resistance of acoustical materials

ASTM C523	Light reflectance of acoustical materials by the integrating sphere reflectometer
ASTM E90	Laboratory measurement of airborne sound transmission loss of building partitions
ASTM CE492	Laboratory measurement of impact sound transmission through floor-ceiling assemblies using the tapping machine
ASTM E596	Laboratory measurement of noise reduction of sound isolation enclosures
ASTM E756	Measuring vibration-damping properties of materials
ANSI S12.31	Determination of sound power levels of broad-band noise sources in reverberation rooms
ISO 3744	Determination of sound power levels of noise sources-engineering methods for-free field conditions over a reflecting plane
ANSI S12.32	Determination of sound power levels of discrete frequency and narrow-band noise sources in reverberation rooms
ISO 3745	Determination of sound power levels of noise sources-precision methods for anechoic and semi-anechoic rooms
ANSI S12.10	Measurement and designation of noise emitted by computer and business equipment
ANSI S3.19 (ANSI S3.19-1974)	Measurement of real-ear protection of hearing protectors and physical attenuation of earmuffs
ANSI S12.6	Methods of measuring the real-ear attenuation of hearing protectors
ASTM E1375	Measuring the interzone attenuation of furniture panels used as acoustical barriers

	of Emission Sound Pressure Levels at a Work Station and at Other Specified Positions - Engineering Method in an Essentially Free Field Over a Reflecting Plane
AS/NZS 1270	Acoustics - Hearing Protectors
IEC 60704-1	Household and Similar Electrical Appliances – Test Code for the Determination of Airborne Acoustical Noise Emitted by Household and Similar Electrical Appliances – Part 1: General Requirements
IEC 60704-2-3	Household and Similar Electrical Appliances – Test Code for the Determination of Airborne Acoustical Noise – Part 2-3: Particular Requirements for Dishwashers
ECMA 109	Declared Noise Emission Values of Information Technology and Telecommunications Equipment
ASTM E795	Standard Practice for Mounting Test Specimens During Sound Absorption Tests
AS/NZS 2499	Measurement of Sound Insulation in Building and Building Elements - Laboratory Measurement of Room-to-Room Airborne Sound Insulation of a Suspended Ceiling with a Plenum Above It
AS ISO 354	Acoustics/Measurement of Sound Absorption in a Reverberation Room
ISO 10302	Acoustics - Method for the measurement of airborne noise emitted by small air-moving devices
ISO 8960	Refrigerators, Frozen-Food Storage Cabinets and Food Freezers for Household and Similar Use – Measurement of Emission of Airborne Acoustical Noise

IEC 60704-2-4	Household and Similar Electrical Appliances - Test Code for the Determination of Airborne Acoustical Noise – Part 2-4: Particular Requirements for Washing Machines and Extractors

Generally the following methods are used to measure the acoustic property,

1. Impedance tube method
2. Reverberation room method
3. Anechoic method

2.5.7.2 Impedance Tube Method

Andrew Barnard Chip Dayton [6.7], A sound source (loudspeaker) is mounted at one end of the impedance tube, and a sample of the material is placed at the other end. The loudspeaker generates broadband, stationary random sound waves, which propagate as plane waves in the Tube, hit the sample and reflect. The propagation, contact and reflection result in a standing-wave interference pattern due to the superposition of forward- and backward-travelling waves inside the tube. By measuring the sound pressure at two fixed locations and calculating the complex transfer function using a two channel
Digital frequency analyzer, it is possible to determine the sound absorption and complex reflection coefficients and the normal acoustic impedance of the material. The usable frequency range depends on the diameter of the tube and the spacing between the microphone positions.

This method is described in both ISO 10534-2 and ASTM E1050.

The acoustic properties that can be computed from the impedance tube are listed below.

- Complex Acoustic Frequency Response Function
- Complex Reflection Coefficient
- Normal Incidence Sound Absorption Coefficient
- Normal Specific Acoustic Impedance Ratio
- Normal Specific Acoustic Resistance Ratio
- Normal Specific Acoustic Reactance Ratio
- Normal Specific Acoustic Admittance Ratio
- Normal Specific Acoustic Conductance Ratio
- Normal Specific Acoustic Susceptance Ratio

The most critical property here is normal incidence sound absorption coefficient which is a function of frequency valued between zero and one. Sound absorption is the percent of sound energy being absorbed by the material sample. This is the primary indicator to the way any barrier material will react in any given environment.

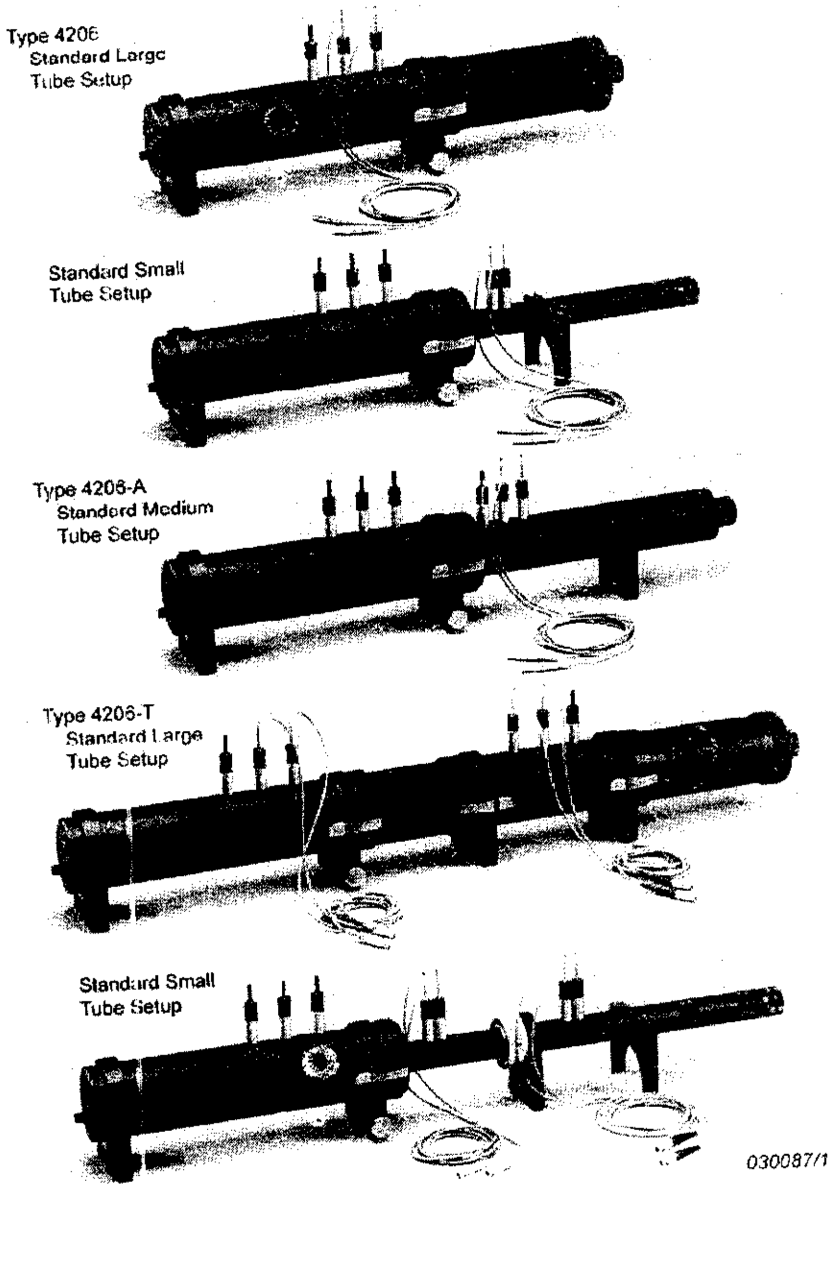


FIG.2.9 Shows Different Impedance Tube Used For Acoustic Testing

2.5.7.3 Reverberation Room Method

Olynyc, T.D.Northwood said, Reverberation rooms are designed for the determination of sound power output of noise sources, transmission loss of partitions, insertion loss of silencers, response characteristics of microphones, and random incidence absorption coefficients of materials. They are also used for high intensity noise level fatigue testing of aircraft, space vehicles and other equipment.

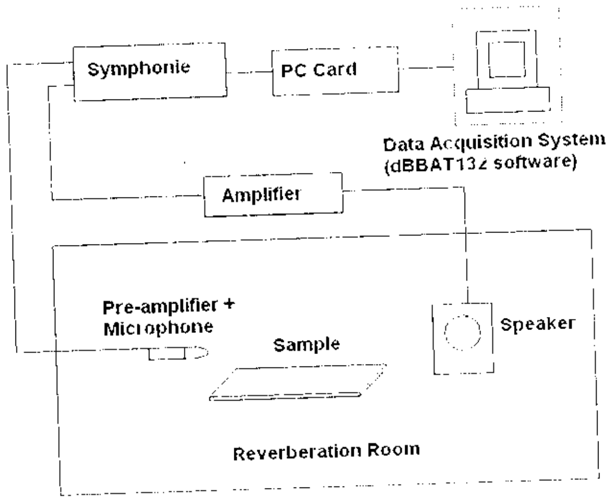
The purpose of reverberation room is to create a highly diffused acoustical measurement environment, defined as a sound field in which the acoustical energy flows equally in all direction.

For measuring sound absorption is concerned with the performance of a material exposed to a randomly incident sound wave, which technically occurs when the material is in diffusive field. However creation of a diffusive sound field requires a large and costly reverberation room. A completely diffuse sound field can be achieved only rarely. Moreover, an accurate value of complex impedance cannot be derived from the absorption coefficient alone since sound is allowed to strike the material from all directions, the absorption coefficient determined is called random incidence sound absorption coefficient, RAC.

The sound absorption co-efficient of reverberation room surface must help insure a satisfactory reverberant field and minimize the effect of source positioning on measurement accuracy. Consistent with current standards, the reverberation room has average sound absorption co-efficient of less than frequency range from 125 to 8000Hz

The highest values of the average sound absorption co-efficient within frequency range of interest should not exceed 0.16.

This method is clearly explained in ASTM C 423 – 72. **The fig.2.10 shows the Schematic configuration of the test set-up.**



2.5.7.4 Anechoic Method

An anechoic room can be considered analogous to a precision acoustical measurement instrument providing a free field environment without noise interference.

An acoustical free field exists in a homogeneous, isotropic medium in which reflecting boundaries, or their effects, are absent. In an ideal free field environment, the inverse square law would function perfectly. This means that the sound level from a spherically radiating sound source decreases six decibels (6 to 8) for each doubling of distance from the source. A room designed and constructed to provide such an environment is called as anechoic room.

A well constructed room must provide good sound isolation against outside noiser so that resulting inside sound will not invalidate acoustic measurements. This may require the use of single or double well construction with appropriately designed vibration isolation to adequately reduce air and/or structure some noise transmission. For best result, anechoic rooms should be individual structures separate from any building walls. The fig. shows the anechoic room,

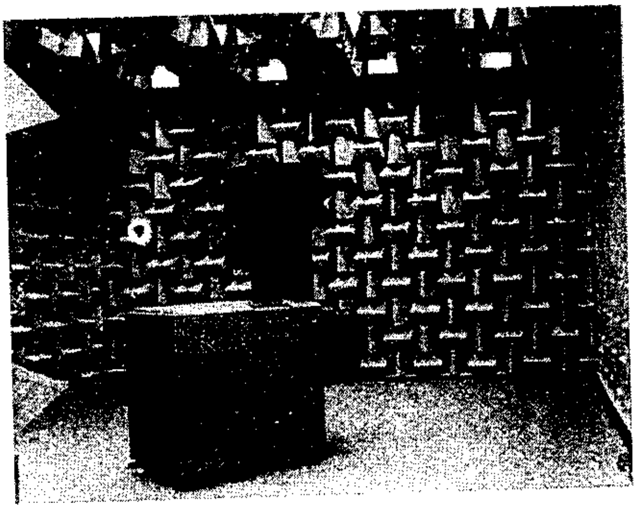


FIG.2.11 Shows Anechoic Room

2.5.7.5 Steady State Method

This method is mostly used when the other will not work. This particular method is described in ASTM E336-71. To measure the transmission coefficient of the materials, a third microphone or even a second pair of microphone can be placed behind the test sample in a second impedance tube.

MATERIALS
AND
METHODS

3. MATERIALS AND METHODS

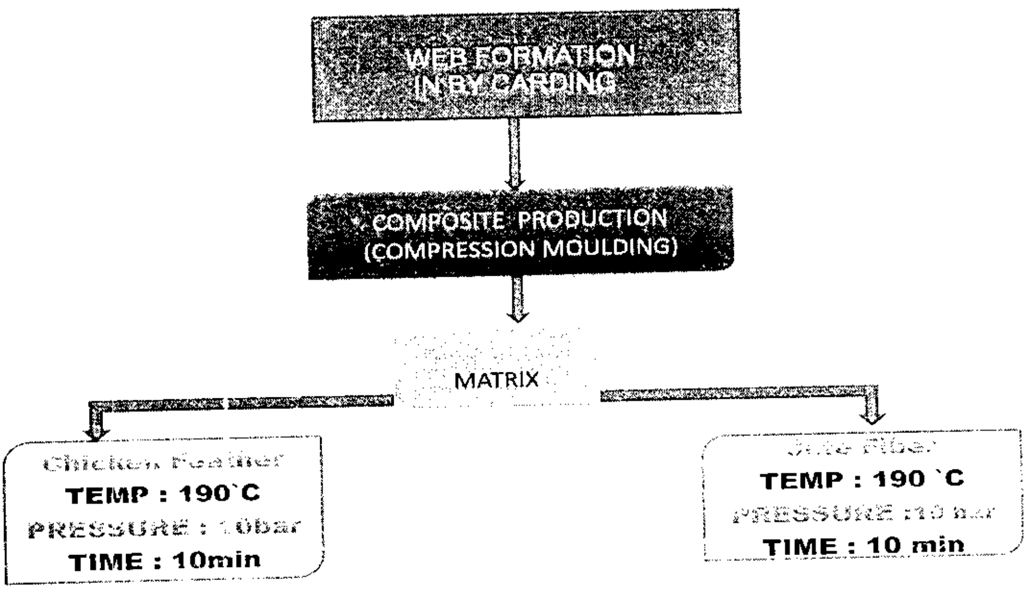
3.1 INTRODUCTION

This chapter explains the methodologies, materials, evaluation techniques used to study the composite properties and sound absorption properties of chicken feather fiber and jute fiber reinforced composites.

3.2 OBJECTIVES

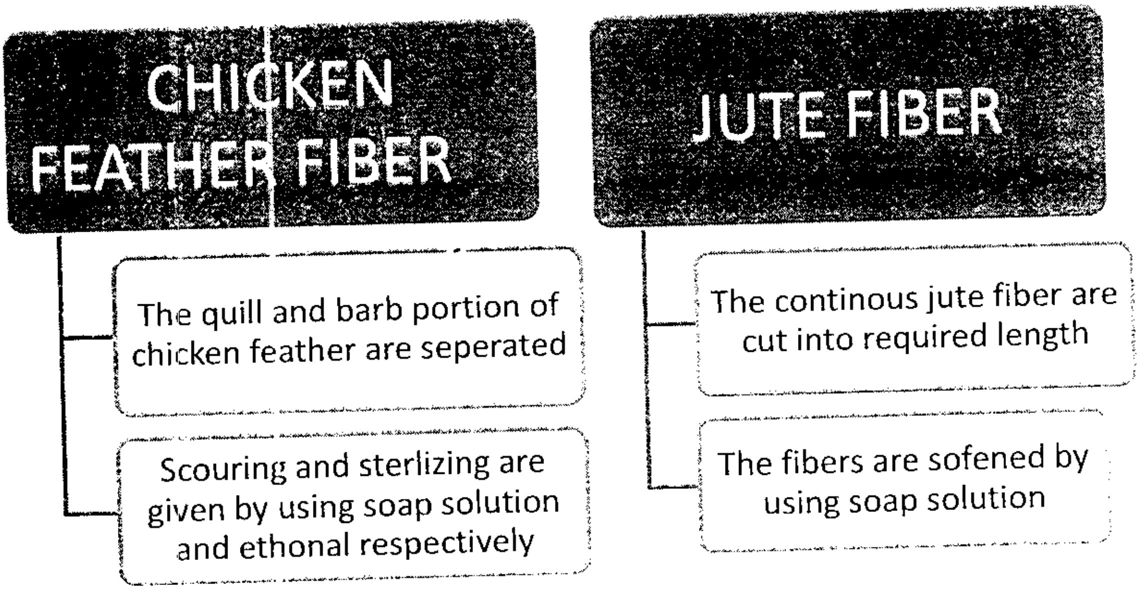
The objectives of our project are:

- To collect the chicken feather, separate the fiber and give pretreatment
- Sterilization by using ethanol
- To produce web
- To produce cock feather and jute fiber composite by using polypropylene as matrix
- To study the mechanical and sound absorption properties



3.3 FIBER COLLECTION, SEPARATION AND PURIFICATION

The chicken feathers are collected in the poultry unit. The quill and barb is separated. The separated feathers are then given hot wash to remove the blood stains. After hot wash the feathers are sterilized using ethanol and dried.



The jute fibers are cut according to the length of chicken feather fiber. Jute fiber is then treated with soap solution for softening, because jute fibers have more brittle than jute fiber.

3.3.1 Mixing

The chicken feather fiber and polypropylene are mixed in the ratio of 50:50.Accordingly jute fiber and polypropylene are mixed in the ratio 50:50.The chicken feather fiber and jute fiber acts as reinforcement and polypropylene acts as matrix.

Now the mould is placed on the heating table and the heating tables are again closed

↓

Set the require pressure and allow the mould inside for test time

↓

Extraction of Composite sample from the mould

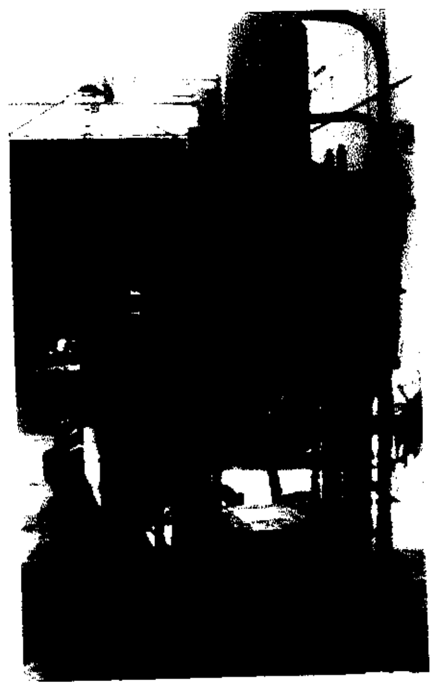


FIG.3.1 Shows Compression Molding Machine

TECHNICAL SPECIFICATIONS OF COMPRESSION MOULDING MACHINE

Maximum capacity	-	20 Tons
Type	-	4 Pillars and Plates
Acting	-	Single acting
Movement	-	Upward stroke
Platen size	-	300*300 mm
No of day light	-	Single
Day light gap	-	150 mm
Stroke length	-	150 mm
Piston diameter	-	120 mm
No of heaters	-	3 nos, 500 watts in each plate
Maximum temperature	-	300^0
Temperature accuracy	-	+/- 5^0
Heaters	-	Cartridge type Electrical Heater dia 25 mm
Heater Controls	-	Digital temperature Controllers "J" type
Timer	-	Digital type
Oil tank capacity	-	15 liters
Maximum Operating Pressure	-	500 bar

3.6 TESTING OF CHICKEN FEATHER FIBER AND JUTE FIBER COMPOSITE

3.6.1 COMPOSITE TESTING

The composites are prepared by same process parameters (temperature, time, pressure) as mentioned above for both chicken feather fiber and jute fiber composite. The prepared composite were tested in terms of mechanical and sound absorption property. In order to test such processes the following test method are used.

COMPOSITE PROPERTIES

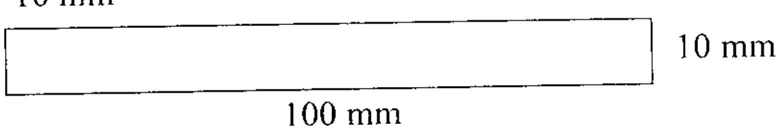
3.6.1.1 Flexural strength Test

Flexural test provides the strength of material in bending expressed as the stress on the outermost fibers of a bent test specimen at the instant of failure. Flexural test produce a Load (N)-Length (mm) diagram which is used to know the peak load up to which the sample can withstand. This data is often used to specify a material, to design parts to withstand application load and as a quality check of materials.

Sample Preparation

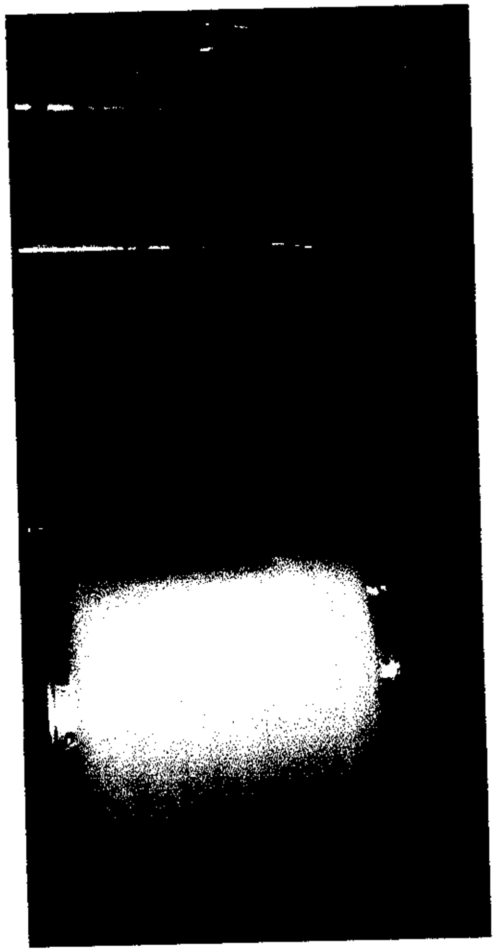
The sample size for testing the flexural strength test is following,

- Length =100 mm
- Width=10 mm



3.3.2 **Carding**

After mixing [chicken feather fiber and polypropylene/jute fiber and polypropylene] the fiber are fed in to the carding machine and web is produced. The miniature carding machine is used to produce the web.



Feed to carding machine **Web delivered from carding machine**

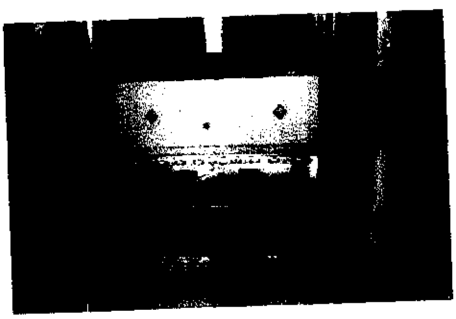
3.4 COMPOSITE MANUFACTURING

Compression molding machine is used to produce the composite. The mould is made of aluminium [250mm*250mm*3mm] the web are cut according to the mould and placed on the mould. Initially the temperature of the compression molding machine is set up to 190 C with 10bar pressure. Generally the web is placed on the bottom jaw [Immovable] and then the top jaw [Movable] is activated to move downwards and it compresses the web for 10min.After 10min by using the handle top jaw is lifted and mould is removed from the bottom jaw. And then water is sprayed on to the surface of the mould for cooling. After that the composite is removed from the mould. Finally the composites are prepared.

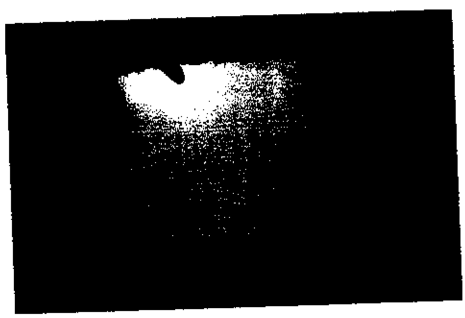
The above procedure is same for both chicken feather fiber and jute fiber composite.

Required size web

Web is inside the template



Compressed stage



Final composite

3.5 COMPRESSION MOLDING MACHINE

The compression molding machine with hydraulic system of loading was employed in this work, which comprises of six heating coils, three on top plate and three on the bottom plate. The molding process is explained with help of a flow chart.

The Aluminium cool mold is taken according to the size

↓

Web is cut according to the mold size and placed on the mould

↓

Set the temperature in the compression molding machine

↓

Keep the two heating tables in contact in the machine by lifting the lever

↓

After the set temperature is reached, the lever is pulled up

↓

Test Procedure

The test is performed based on the ISO 14 125 1998-03.According to the procedure, the test speed is 50 mm/min. The specimen is placed on the clamps and load will be applied on the specimen. The load will be applied until the sample breaks under bending.

The flexural strength testing machine shows the data in **Breaking Load expressed in Newton**

UNIVERSAL FLEXURAL STRENGTH TESTER

SAMPLE UNDER TEST

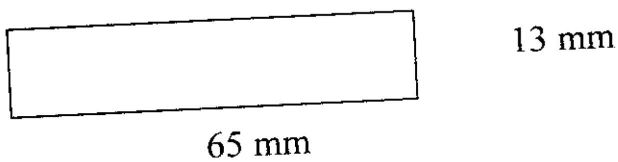
3.6.1.2 Impact Strength Test

The impact strength provides the ability of material to withstand shock loading. The composite material is usually tested by charpy impact tester.

Sample Preparation

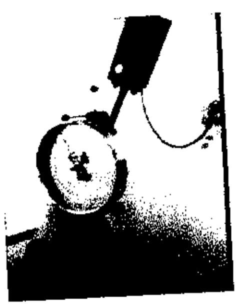
The sample size for testing the impact strength is following,

- Length = 65 mm
- Width = 13 mm

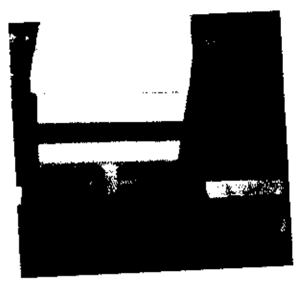


Test Procedure

The test is performed based on the ASTM STP 936 1985-08 in the charpy impact strength tester .According to the procedure, the sample is placed on the sample holder and hammer will be swinged by our hand. The hammer strikes and breaks the specimen and the amount of energy required to break the sample is read from the dial in the instrument. The impact strength testing machine shows the data in **Joules**



CHARPY IMPACT STRENGTH TESTER



SAMPLE FIXED ON HOLDER

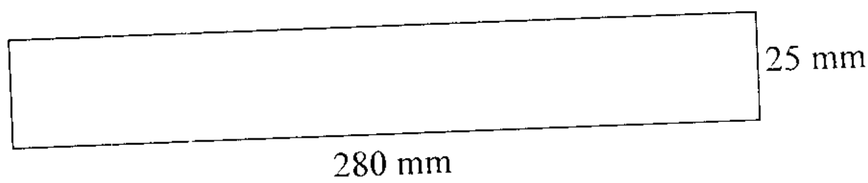
3.6.1.3 Tensile Strength Test

The Breaking strength is a measure of the resistance of the material to a tensile load. The composite tensile strength is usually measured in tensile tester with constant rate of loading.

Sample Preparation

The sample size for testing the tensile strength is following,

- Length = 280 mm
- Width = 25 mm



Test Procedure

Fix the Sample in between two jaws and bottom jaw is movable one. After the sample is fixed the bottom jaw is moving at the principle of constant rate of loading (CRL).

The tensile tester shows the data in **Breaking Load in Newton and Elongation at Break.**

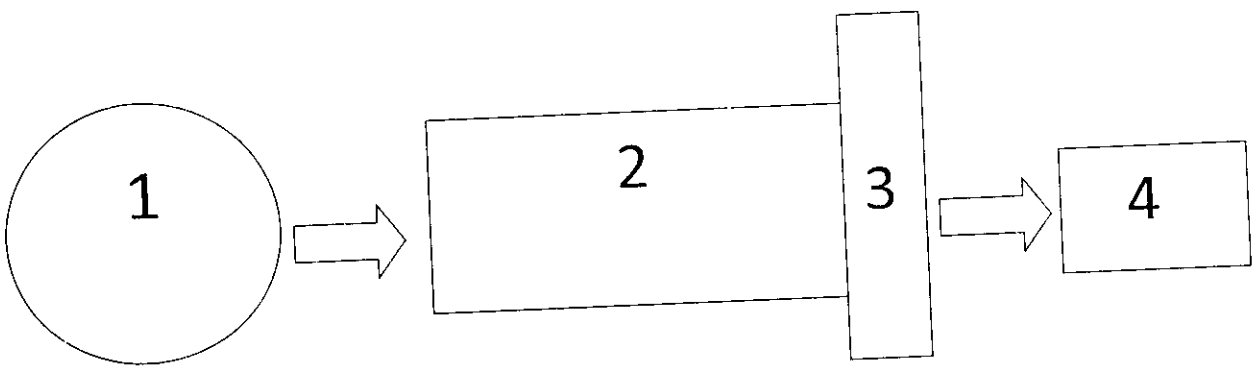
3.6.2 SOUND ABSORPTION TESTING

The sound Absorption property of the composite material was tested in Reverberation room but we create a own method of related standards to test the sound absorption property of chicken feather and jute fiber composite.

In this method, the sound source is created by using Bi-Amp Active speaker which is passed through the composite board and sound absorption property is measured by using "sound level meter"(Lutron SL-4013).

Tones of different frequency ranging from 400Hz to 5000Hz where produced using the NCH tone generator software.

Test Procedure



1 – Sound source (feed sound)

2 – Rectangular box (250mm*100mm)

3 – Composite material

4 -- Sound level meter (decibel)

- **Step 1**: Construct a Rectangular hollow box with a dimension of 250mmX100mm.
- **Step 2**: One side of the box is covered with composite board and other side sound source was passed.
- **Step 3**: Before passing sound source the ambient condition of the room is noted.
- **Step 4**: Measure the sound absorption by using sound level meter on other side.
- **Step 5**: Note the reading at different frequency level(400Hz to 5000Hz)

RESULT
AND
DISCUSSION

4. RESULTS AND DISCUSSION

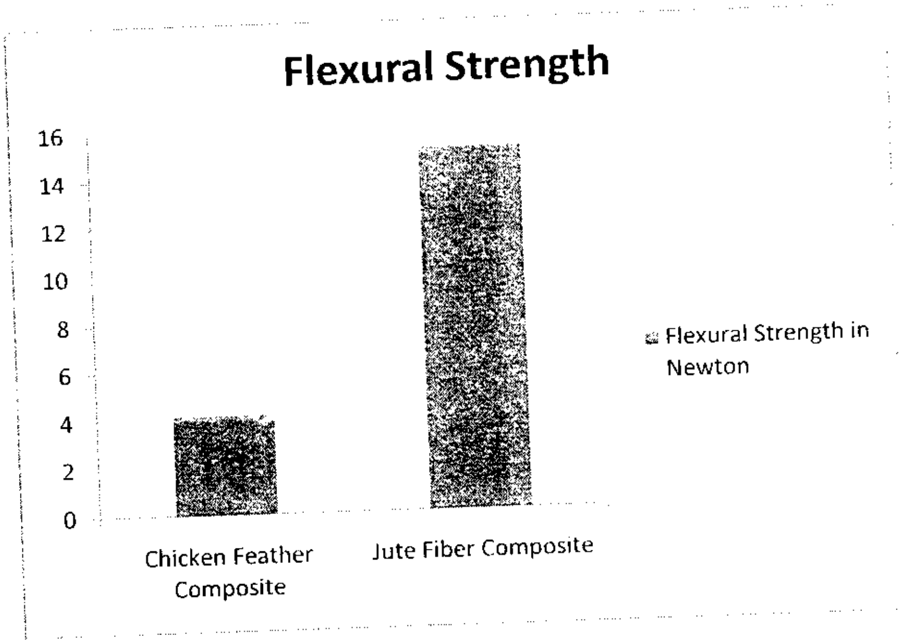
4.1COMPOSITE PROPERTIES

Results for Flexural Strength of Composite

The composites were subjected to a Universal flexural strength tester to determine its flexural strength. Results of the study of flexural properties of chicken feather fiber and jute fiber composite is following,

Mean Flexural Strength for 100% Chicken Feather Fiber is 4.16N

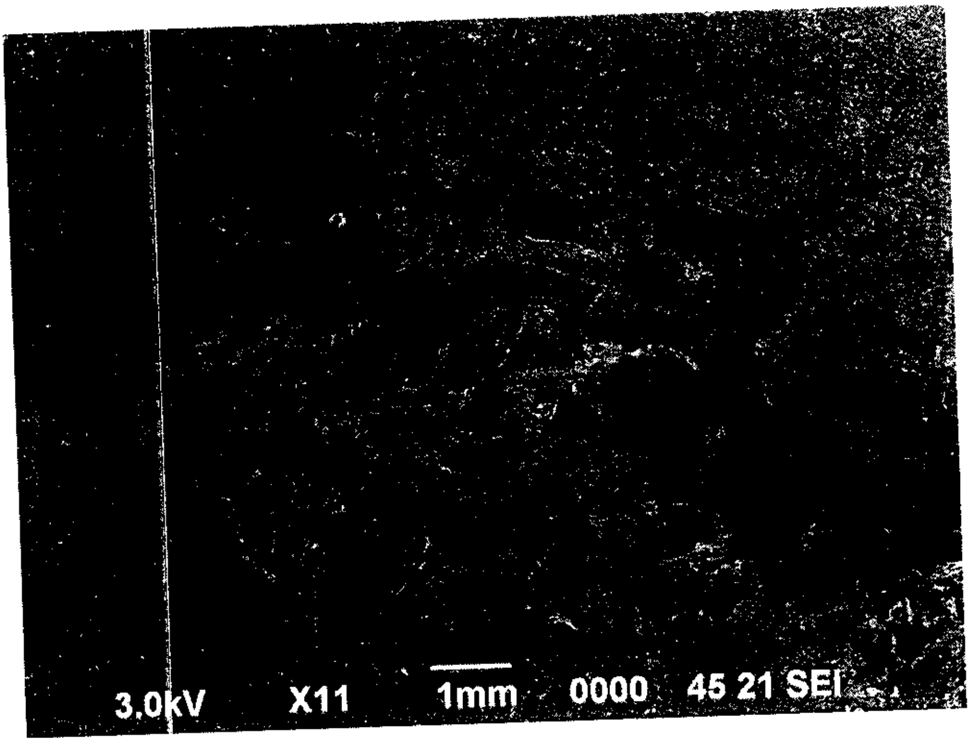
Mean Flexural Strength for 100% Jute Fiber is 15.56N



Sample Size – 100mm*10mm*3mm

INFERENCE

In the present investigation the reinforcement of chicken feather fiber composite has shown lower results than jute fiber composite in terms of flexural strength. The reason may be due to chicken feather fiber strength is lower than jute fibers.



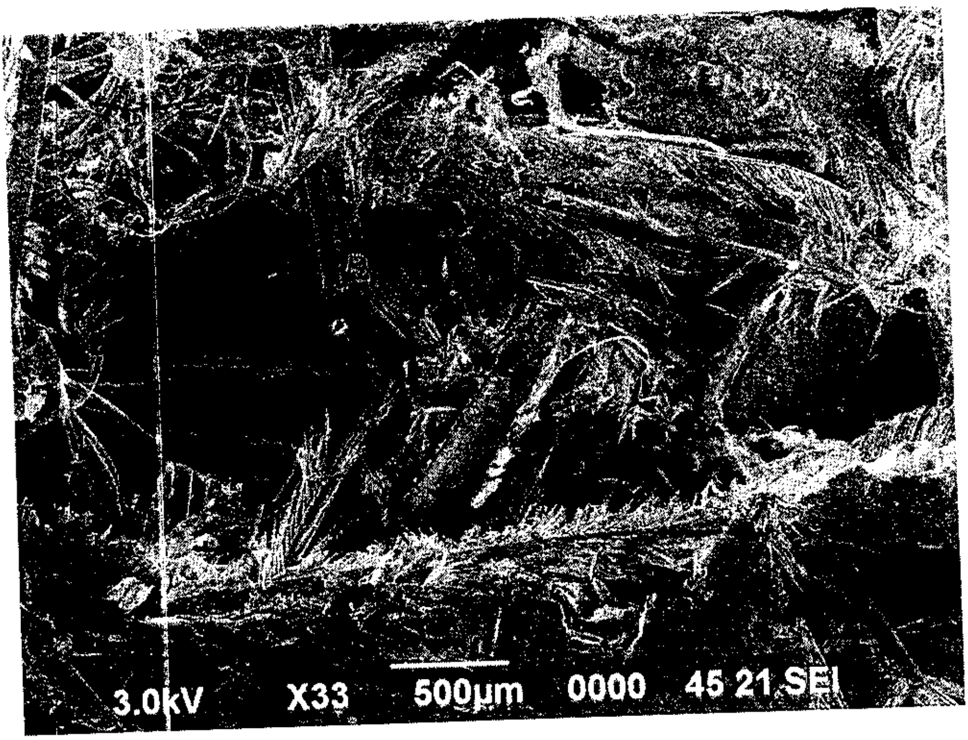


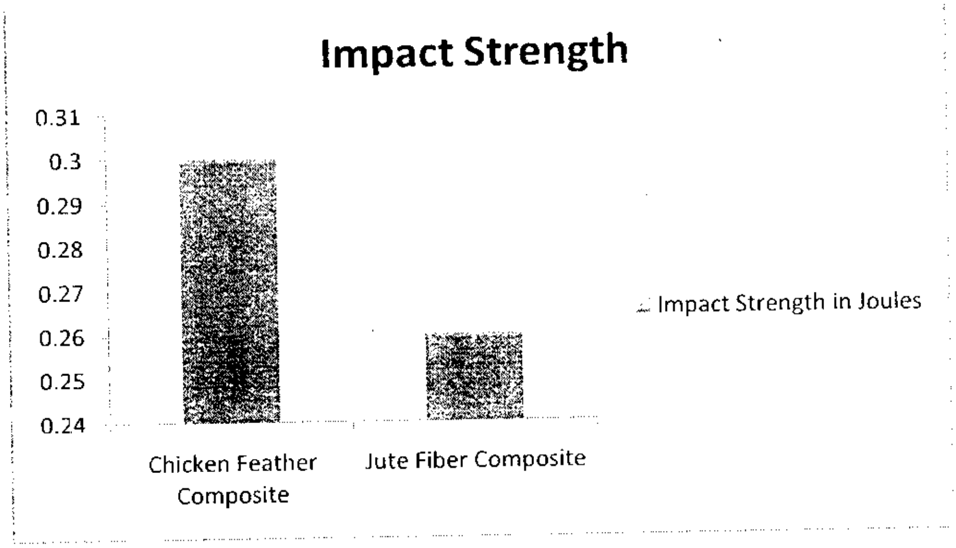
FIG.4.1 Shows the Sem Image Of Flexural Failure

Results for Impact Strength of Composite

The composites are subjected to Charpy Impact Strength tester to determine the impact strength. Results of the study of impact strength properties of chicken feather fibers and jute fibers composites is as follows,

Mean Impact Strength for 100% Chicken feather fiber is 0.3 Joules

Mean Impact Strength for 100% Jute Fiber is 0.26 Joules



Sample Size – 65mm*13mm*3mm

INFERENCE

The investigation shows that mean impact strength of chicken feather fiber is more than jute fiber because chicken feather fiber has more cohession in nature.

The Noise Reduction Co-efficient (NRC) is a single-number index determined and used for rating how absorptive a particular material is. This industry standard ranges from zero (perfectly reflective) to 1* (perfectly absorptive). It is simply the average of the different frequency of sound absorption coefficients. The following shows the conversion of dB to Hz,

Hz=dB*log20

The NRC rating of 100% chicken feather fiber composite is 0.5. This reading shows good sound absorption property.

The results for sound absorption property of 100% Jute Fiber composites is tabulated below

Table 4.2 Shows Sound Absorption Property of 100% Jute Fiber Composite

SOUND INPUT	**SOUND OUTPUT**		
Hz	Without sample(dB)	With sample (dB)	Sound Reduction(db)
400	71.6	68.5	3.1
800	78.2	74.2	4.0
1200	68.5	65.3	3.2
1600	64.4	62.3	2.2
2000	62.7	60.5	2.2
3000	63.8	53.6	10.2
4000	69.3	62.2	7.1
5000	78.9	73.8	5.1

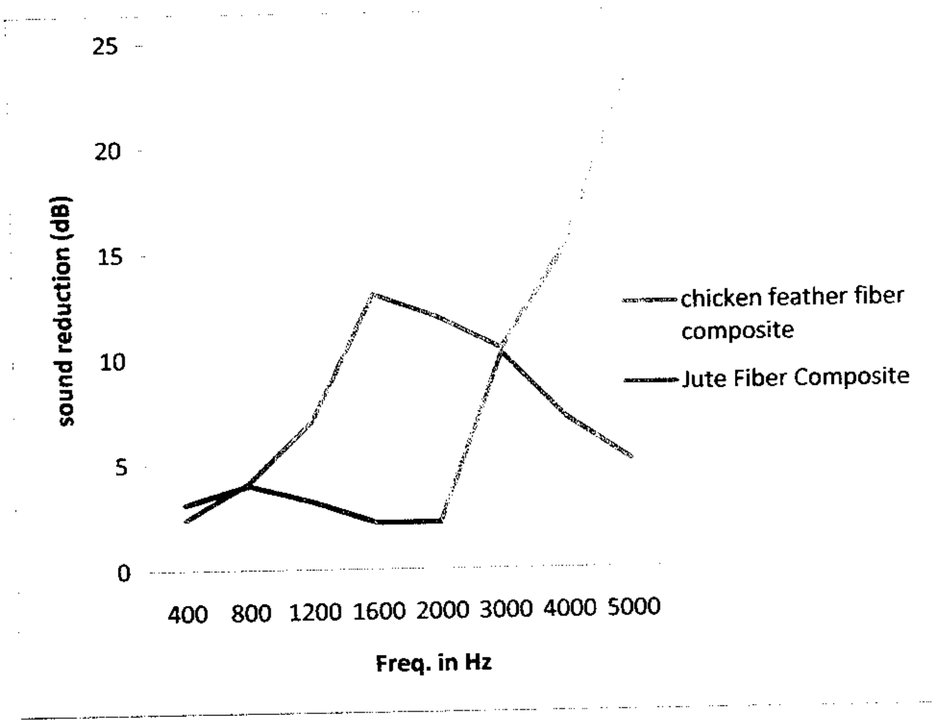
The above tabulated values are shows the sound absorption property of chicken feather fibers and jute fibers composite. Here the result shows the sound reduction is greater for chicken feather fibers composite than the jute fibers composite.

When we are going for maximum frequency the sound absorption property is more for chicken feather fibers composite but in jute fibers composite it will vary.

The NRC rating of 100% Jute fiber composite is 0.3. It shows the sound absorption property of 100% Jute fiber composite is less than of 100% chicken feather fiber composite.

Graphical Representation

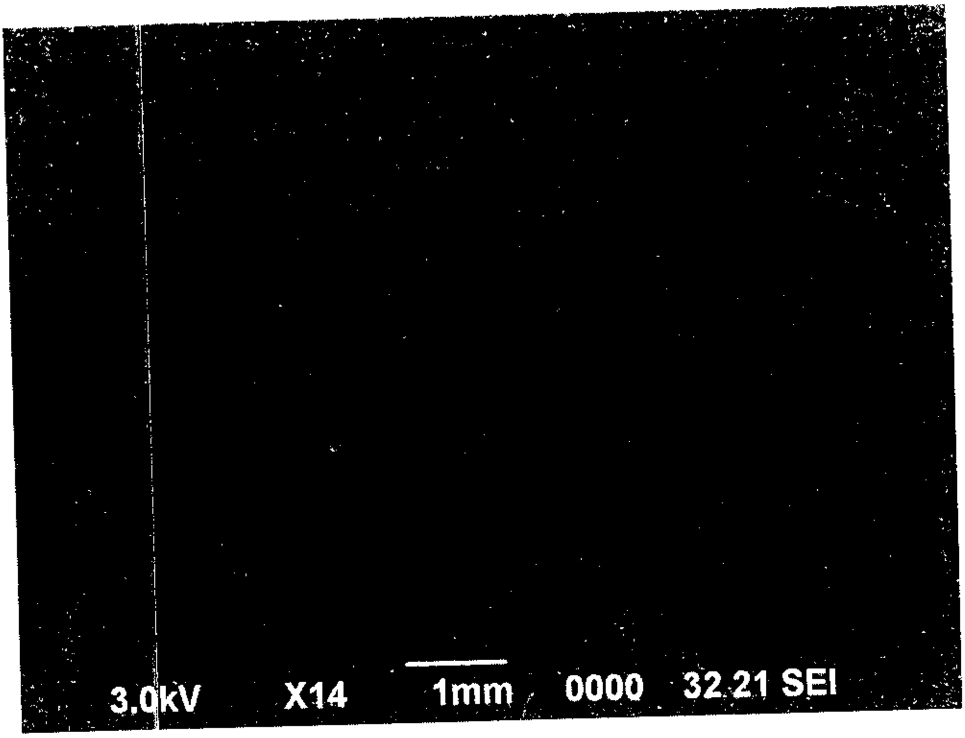
Sound Absorption – Chicken feather fibers Vs Jute fibers Composite



INFERENCE

The chicken feather composite has more sound absorption than jute fiber composite when the frequency of the sound is increased because the chicken feather fibers has high thermal insulation (to absorb sound the material should posses the property of high thermal conductivity, because when the sound of kinetic energy is hitting an object is converted into thermal energy). And chicken feather fibers also have honey comb structure so the air is trapped in this structure.

At 3000Hz, the jute fiber composite has high sound absorption because the resonance occurs when the natural frequency of an object coincides with the frequency of any vibrations applied to the object. According to that jute fiber composite may increase the sound absorption value.



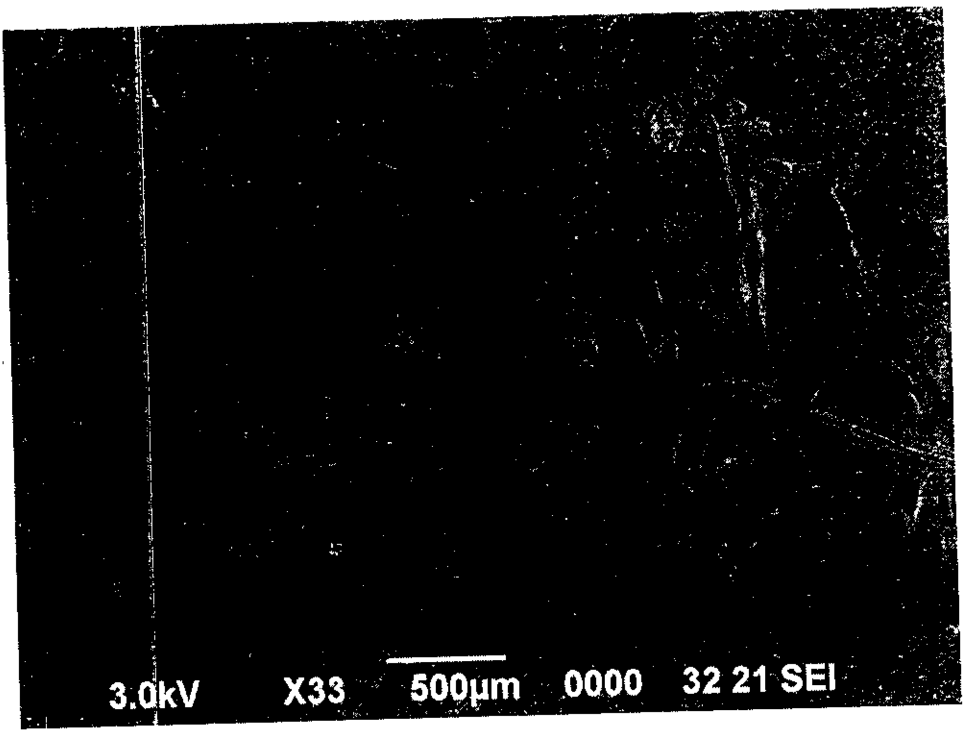


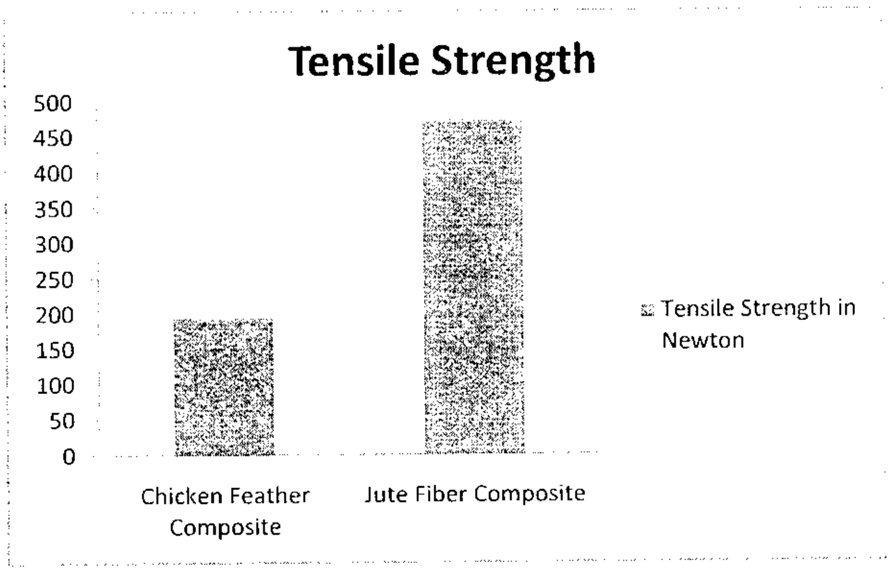
FIG.4.2 Shows the Sem Image Of Impact Failure

Results for Tensile Strength of Composite

The composites are subjected to tensile tester to determine the tensile strength. Results of the study of tensile strength properties of chicken feather fibers and jute fibers composites is following,

Mean Tensile Strength for 100% Chicken Feather fiber is 194 N and Elongation at break is 3.18%%

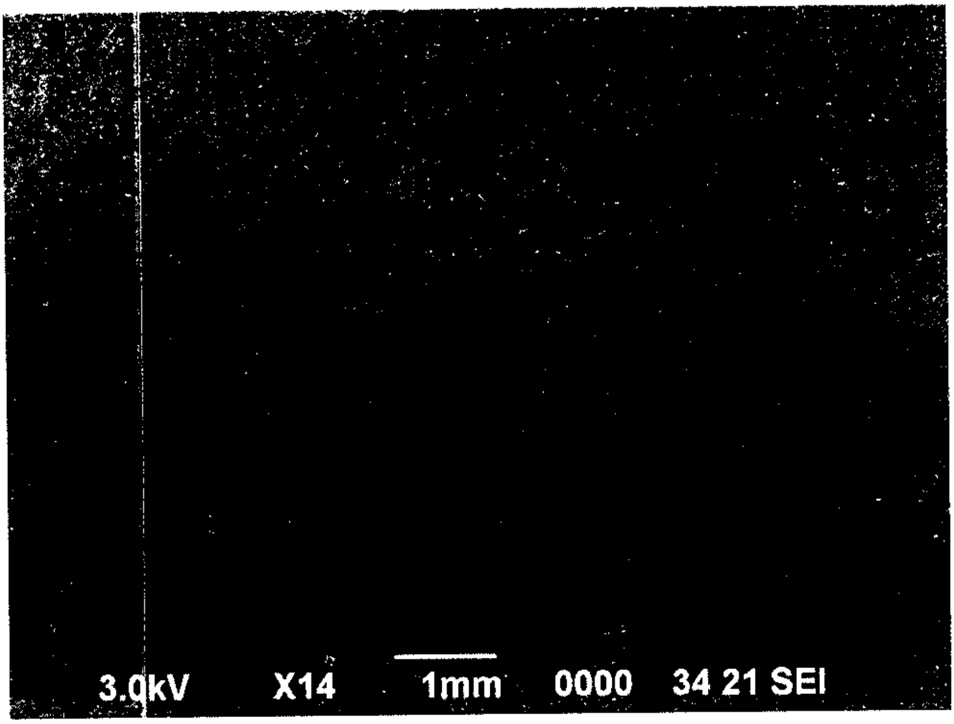
Mean Tensile Strength for 100% Jute fiber is 474 N and Elongation at break is 1.45%



Sample Size – 280mm*25mm*3mm

INFERENCE

In the present investigation the reinforcement of chicken feather fibers into polypropylene has shown lower results than jute fibers into polypropylene in terms of tensile strength. Because the bundle fiber strength is more for jute fiber



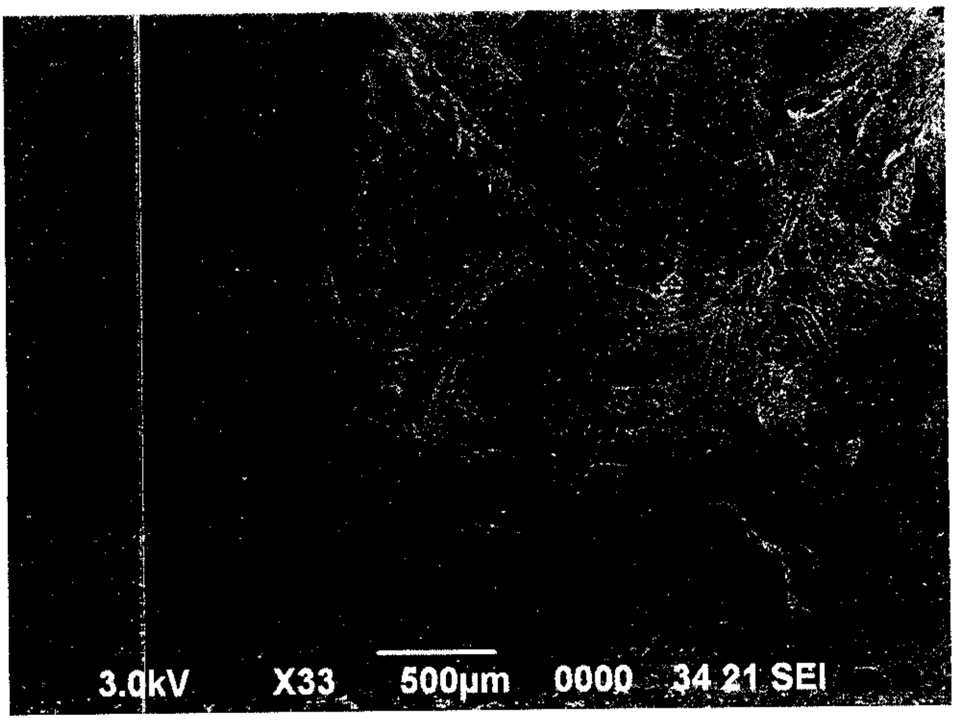


FIG.4.3 Shows the Sem Image Of Tensile Failure

4.2 SOUND ABSORPTION PROPERTY

The composites are subjected to sound absorption test in Reverberation room. The sound source is created by using Bi-Amp Active speaker and the sound is passed through composite material. The sound absorbed by the samples is measured using Lutron sound level meter

The results of sound absorption property of 100% chicken feather fibers composites is tabulated below

Table 4.1 Shows Sound Absorption Property of 100% Chicken Feather Composite

SOUND INPUT	SOUND OUTPUT		
Hz	Without sample(dB)	With sample (dB)	Sound Reduction(db)
400	73.3	70.9	2.4
800	79.0	74.9	4.1
1200	70.0	63.0	7.0
1600	64.6	51.6	13.0
2000	63.8	51.9	11.9
3000	60.4	50.0	10.4
4000	72.6	57.5	15.1
5000	78.2	55.3	22.9

The above 100% chicken feather composite are prepared by 190°C with 10000psi (10 bar) pressure of 10 min.

CONCLUSION

5. CONCLUSION

- The chicken feather and Jute fiber reinforced composite were successfully manufactured and the mechanical, sound absorption properties of chicken feather reinforced composite were determined.
- The flexural and tensile strength of the chicken feather reinforced composite is four times less than the jute fiber composite and the impact strength of both composite is more or less same.
- The sound absorption property of the chicken feather reinforced composite is higher than the jute fiber composite. Because it has good thermal insulation property(Due to honeycomb cross section)
- The chicken feather composite reduce the noise level up to 23dB.where jute fiber composite reduce max. of 10dB. There by we conclude 100% chicken feather fiber composite has good absorption than 100% Jute fiber composite.
- The NRC rating of 100% Chicken feather fiber composite is 0.5 and 100% jute fiber composite is 0.3. The rating shows 100% chicken feather fiber composite sound absorption property is more than 100% Jute fiber composite. Finally we conclude 100% chicken feather fiber has excellent sound absorption property.

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7. Future Scope of the Project

1. The coir fiber and chicken feather can also be blended to produce composite for sound proof application
2. The coir fiber and jute fiber can also be blended to produce composite for sound proof application
3. Instead of producing composite the non-woven and fabric also produce
4. The composite can be produce by changing the molding techniques
5. The composite can be produce by changing the matrix