CHARACTERIZATION OF CHICKEN FEATHER REINFORCED POLYPROPYLENE COMPOSITES FOR AUTOMOBILE APPLICATIONS

A PROJECT REPORT

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ABSTRACT

Composite materials are light weight, high strength to weight ratio and stiffness properties and these properties of composites used to replace the conventional materials like metals, woods, etc. Presently, feathers might be considered as waste because their current uses are economically marginal and their disposal is difficult.
The presence of hollow honeycomb structures, their low density, high flexibility and possible structural interaction with other fibers when made into products such as textiles provides them unique properties unlike any other natural or synthetic fibers. In this study chicken feathers were used to produce composites boards. The waste chicken feathers were collected from poultry units and are cleaned with a polar solvent like ethanol and dried. These feathers in pre-determined weight proportion are processed to make random orientation and made in to a composite using polypropylene as a matrix by compression moulding technique. The composite boards were subjected to tensile test, flexural test, impact test and the fractured surfaces were observed under SEM as declared. To analyze the acoustic properties of composite board's impedance tube was constructed and the acoustic property was measured.

KEYWORDS— Chicken feather, Polypropylene, Epoxy resin, Compression moulding,

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CHAPTER-1

INTRODUCTION

Chicken feathers are waste products of the poultry industry. Billions of kilograms of waste feathers are generated each year by poultry processing plants, creating a serious solid waste problem [2]. Traditional disposal strategies of chicken feather are expensive and difficult. They are often burned in incineration plants, buried landfills, or recycled into low quality animal feeds. However, these disposal methods are restricted or generate green house gases that pose danger to the environment.

Chicken feathers are approximately half feather fiber (barbs) and half quill (rachis) by weight, the quill being the stiff central core with hollow tube structure. Both feather fiber and quill are made of keratin (about 90% by), an insoluble and highly durable protein found in hair, hoofs, and horns of animals. Keratin consists of a number of amino acids but largely made up of cystine, lysine, proline, and serine. These amino acids tend to cross-link with one another by forming disulfide or hydrogen bonds resulting in fibers that are tough, strong, lightweight, and with good thermal and acoustic insulating properties [18,19].

Chicken feathers are approximately 91% protein (keratin), 1% lipids, and 8% water [1]. 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[8] .

Textile structures reinforced composites, specifically with fibres, have gained importance in engineering and technical applications due to their light weight, higher tenacity, superior elasticity and strength, good thermal resistance, low density, and better rigidity [3].

The composite reinforcement application of the chicken feather fibres offers much more effective way to solve environmental concerns compared to the traditional disposal methods. Some of the advantages of the chicken feather fibres are inexpensive, renewable, and abundantly available. The chicken feather fibre as a composite reinforcement having certain desirable properties including lightweight, high thermal insulation, excellent acoustic properties, non-abrasive behavior and excellent hydrophobic properties [2]. The Chicken feather fibre has the lowest density value compared to the all natural and synthetic fibres.

Composites refer to a material consisting of two or more individual constituents. The reinforcing constituent is embedded in a matrix to form the composite. Composite structures are quite common in nature where fiber and matrices are combined. The automotive industry has adopted composites slowly due to their higher costs. Particulate reinforced plastics have been used for some time but fiber reinforced composites have only really been used in high end sports cars but are starting to make their way into traditional vehicles.

Natural fibers have been involved in an emerging kind of polymer composites taking advantage of the outstanding properties that nature confers them. Thus, several types of bio fibers have recently attracted increasing interest of engineers and scientists since mimic their structures or make use of all their potential is a motivating challenge in polymeric materials field. Bio fibers can be obtained from different renewable natural sources, those from vegetal origin have been the most exploited, however alternative raw materials, such as keratin bio fibers are coming into view[13]. Keratin, as fiber, can be found in hair and feathers. Human hair keratin and wool have been studied since many years ago, due to textile and medical implications, whereas keratin from feathers has not been highlighted enough. Keratin fiber has a hierarchical structure, with a highly ordered conformation, is by itself a bio composite, product of a large evolution of animal species. Keratin fibers from feathers are non-abrasive, eco-friendly, biodegradable, insoluble in organic solvents, and also have good mechanical properties, low density, hydrophobic behavior and finally low cost [6]. These characteristics make keratin fibers from chicken feather a suitable material to be used as a high structural reinforcement in polymer composites. However the development of keratin fibers as a new reinforcement must be based on a complete characterization in order to know their features, advantages and restrictions. Thus, keratin fibers from chicken feathers are shown as a novel eco-friendly material.

Fibre reinforced composite materials are composed of fibres and matrix material that is bind and protect the fibres (A composite material is one in which two or more materials that are different (structure, properties) are combined to form a single structure with identifiable interfaces at multi-scales to achieve properties that are superior to those of its constituents.). The fibres are usually the load bearing members, while the polymeric matrix provides transverse integrity and transfers the load onto the fibres.

Besides of the properties of two main components of fibre and matrix, the fibre/matrix inter phase also plays a crucial role for the load transfer. It is not a distinct phase, as the inter phase does not have a clear boundary. This region exits between bulk fibre and bulk matrix and may contain several different layers as in the case of sizing.

1.1 OBJECTIVE OF THE PROJECT

- Blending of various proportions of chicken feather and polypropylene for preparing the board.
- Characterization of composite board for its mechanical properties (tensile strength, impact strength, flexural rigidity, thickness).
- To construct the impedance tube and analyze the acoustic properties of composite board.

CHAPTER-2

LITERATURE REVIEW

2.1 SCOPE OF CHICKEN FEATHER FIBERS IN COMPOSITES

Environmental concerns always encourage study to replace synthetic materials with a variety of natural materials. Natural fibers have recently attracted scientist's attention because of their advantages from the environmental standpoint, but almost all the research has been focused on cellulose from vegetable sources. Currently, the keratin fiber from chicken feathers is recognized as an almost infinite source of high performance materials, but it needs further studies to demonstrate a basis for innovative technologies and useful raw materials. Economic interest about feather fiber usage has been gradually increasing [12].

None of the natural or synthetic fibers commercially available today have a density as low as that of chicken feather fibres. Such unique properties make barbs preferable for many applications such as textiles and composites used for acoustics and automotive applications. In addition to the unique structure and properties, barbs are cheap, abundantly available and a renewable source for protein fiber.

2.1.1 Types of Chicken Feather

Five commonly recognized categories of chicken feathers are

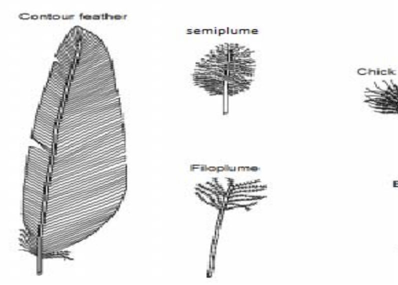


Figure 2.1 Five primary types of chicken feathers

Contour feathers cover the body surface and include flight feather which are constantly rearranged with sebum from the uropygeal, or preen gland to ensure barbules stay interlocked. Powder feathers are white particles that waterproof contour feathers. Down feathers provide insulation and do not have barbicels [13]. Semi-plumes are similar to, but larger than down feathers. Filo-plumes, at the base of every contour feather are rich in nerve endings that relate proprioceptive input or feather position.

Contour, or vaned, feathers give birds their color and provide the first layer of defense against physical objects, sunlight, wind, and rain. Contour feathers are found on a bird's back, tail, and wings, and are primarily responsible for flight. Each contour feather has a feather shaft and a flat vane extending from it. The naked portion of the shaft that is implanted in a bird's skin is the calamus. The portion bearing branches is the rachis, which is filled with a porous substance termed the medulla. Branches are termed barbs and provide an axis from which barbules can branch. Barbules are very closely spaced and interlock via hook lets, or barbicels, in order to provide strength and repel water. Flightless birds, including the emu and the ostrich, have few, if any, hook lets.[5] Thus, it can be assumed that hook lets are not abundant in chickens. A typical contour feather is diagrammed in Figure 2.1.

Down feathers are smaller than contour feathers and lack barbules and the accompanying hook lets. They are soft and fluffy, located beneath the contour feathers. They provide most of a chicken's insulation. There are several subcategories of down feathers, including natal down, present only at hatching, and powder down, which is a specialized feather type that sheds a fine, white keratin powder [5]. The waxy powder is composed of granules so small that it is unwettable and thus forms a waterproof barrier for contour feathers. A powder down feather is depicted in Figure 2.1.

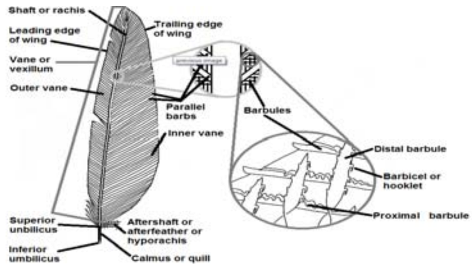


Figure: 2.2 Elements of Contour Feather

The semi-plume is a feather type that mediates between the categories of contour and down. Semi plumes share characteristics with both; they have a large rachis and predominantly downy vanes. Filo plumes are smaller than semi plumes, with only a few barbs at the tip of a fine shaft. These likely serve a sensory function in chickens, registering vibrations and changes in pressure. The smallest type of feather is the bristle, which is stiff and has few, if any, short barbs near the tip. Bristles are protective in function and are found on a chicken's head, at the base of the beak, around the eyes, and covering the nostrils [11].

2.1.2 Chemical Structure- Keratin

Feathers consist of about 91% keratin, 1.3% fat, and 7.9% water. Keratin is a hard protein that is also found in hair, skin, hooves and nails. Birds and reptiles have their own keratins, very different from the α-keratins in mammals. Bird and reptile keratins are composites made up from both fibrous and matrix components. The fibrous feather keratin can stretch approximately 6% before breaking, unlike hair α-keratin that can stretch to twice its length. The β-keratin does not lie flat but twists gradually.

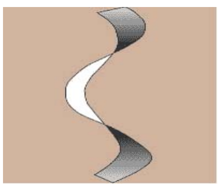


Figure: 2.3 β-keratin - the β-sheet twists gradually

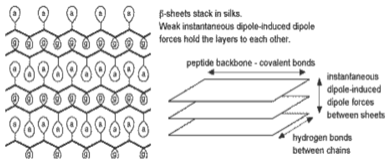


Figure: 2.4 β-sheet twists gradually

Each polypeptide chain in these β-keratins has a central helical section with less regular regions at each end. These regions contribute to the matrix component and have some -S-S- (cysteine) cross-links. Silks have also many β-sheets in their structures but they are different from the β-keratins because they have very few -SS-links. β-keratin contains ordered α-helix or β-sheet structures and some disordered structures. The feather has barb and quill parts [4].

The feather barb fraction has slightly more α-helix over β-sheet structure, whose melting point is 240 ºC. The quill has much more β-sheet than α-helix structure and has a melting point of 230 ºC. Feather keratin has an average molecular weight of about 60,500 g/mol, ranging from 59,000 to 65,000 Daltons [11]. Feather keratins are composed of about 20 kinds of proteins, which differ only by a few amino acids. The distribution of amino acids is highly non uniform, with the basic and acidic residues and the cysteine residues concentrated in the N- and C-terminal regions. The central portion is rich in hydrophobic residues and has a crystalline β-sheet conformation.

Feather keratin is a special protein. It has a high content of cysteine (7%) in the amino acid sequence, and cysteine has -SH groups and causes the sulfur–sulfur (disulfide) bonding [7]. The high content cysteine makes the keratin stable by forming network structure through joining adjacent polypeptides by disulfide cross-links. The feather keratin fiber is semi-crystalline and made up from a crystalline fiber phase and an amorphous protein matrix phase linked to each other. The crystalline phase consists of α-helical protein braided into micro fibrils where the protein matrix is fixed by intermolecular interactions, especially hydrogen bonds. In protein, hydrogen bonds are many and strong.

Table.no.2.1 Amino acid content in keratin fiber from chicken feather [15]

Functional groups	Amino acids	Contents(as% mole)
Negatively charged	Aspartic acid	5
	Glutamic acid	7
Positively charged	Arginine	5
Conformationally special	Proline	12
	Glycine	11
Hydrophobic	Phenylalanine	4
	Alanine	4
	Cysteine	7
	Valine	9
	Isoleucine	5
	Leucine	6
	Tyrosine	1
Hydrophilic	Threoninc	4
	Serine	16

2.1.3 Physical Structure of Chicken Feather

The big part of a feather's physical structure is the barb. Just like general feathers, barbs also have branching structure and nodes along the barb shown in Figure 2.3. Feathers have a hierarchical structure beginning with the level of the central barbs which grow directly from the quill. The central bars are tiny "quill" which also grow barbs [5]. Nodes and barbs on the feather fiber are related with memory properties and improve the structural strength.

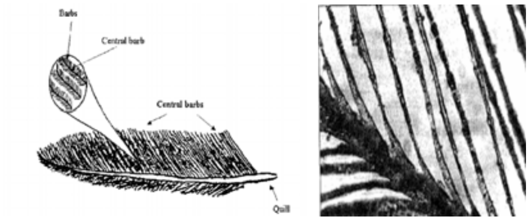


Figure: 2.5 Schema Of Chicken Feathers

2.1.4 Physical Properties of Feather Fibers

In keratin protein there are both hydrophilic and hydrophobic amino acids, but 39 of the 95 amino acids are hydrophilic. Serine is the most abundant amino acid and the 9-OH group in each serine residue helps chicken feathers to absorb moisture from the air. Feather fiber is, therefore, hygroscopic. Chicken feather fibers and quill have a similar content of moisture, around 7%. Fiber diameter is approximately 5-50 µm. Fiber length through different processing can be different, but it can be expected to be 3-13 mm [9]. Therefore, the fiber aspect ratio (length/diameter) can be in the range of 400-260. Because the chicken feather fiber is not completely solid, the fiber's volume always includes both solid matter (the walls of fiber) and air (the hollow inside the fiber).

The density of chicken feather fibers is always interpreted as apparent density. It is reported that density of chicken fibers is 0.89 g/cm3 and measured by displacing a known volume and weight of ethanol with an equivalent amount of fiber. Since the chicken feather fiber is mainly made up of the structural protein keratin, its chemical durability is primarily determined by keratin [11]. Because keratin has extensive cross-linking and strong covalent bonding within its structure, the feather fiber shows good durability and resistance to degradation. The chemical durability experiments showed that chicken feather fibers degrade rapidly in alkali environments , but significantly less in near-neutral and slightly acidic conditions.

2.2 PREFACES TO POLYPROPYLENE

Polypropylene fibres are produced in a variety of shapes and with differing properties. The main advantages alkali resistance, relatively high melting point (165□c) and the low price of raw material. Their disadvantages are poor fire resistance, sensitivity to sunlight and oxygen, a low modulus of elasticity and poor bond with the matrix. These disadvantages are not necessarily critical. Embedment in the matrix provides a protective cover, helping to minimize sensitivity to fire and other environmental effects [16]. The mechanical properties, in particular modulus of elasticity and bond can be enhanced and special fibres for use with cementations matrices have been developed and are marketed commercially.

The polypropylene fibres are made of high molecular weight iso tactic polypropylene. Because of the sterically regular atomic arrangement of the macromolecule, it can be more readily produced in a crystalline form, and then processed by stretching to achieve a high degree of orientation which is necessary by stretching to achieve a high degree of orientation which is necessary to obtain good fibre properties. The polypropylene fibres can be made in three different geometrics, all of which have been studied in relation to the reinforcement of cementations matrices: monofilaments, film, and extruded tape. The last two forms are more commonly used for mortar and concrete reinforcement, since they can provide some mechanical anchoring effects.

Polypropylene is a polymer which combines versatility with a low price. It is a vinyl polymer and can be made with different tacticity. Polypropylene is commonly made from the monomer propylene by a Ziegler-Natta polymerization, the result is an iso tactic polymer, in which all the methyl groups are on the same side of the chain.

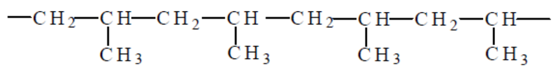


Figure: 2.6 Chemical Structure of Isotactic Polypropylene

Isotactic polypropylene has good mechanical properties as well as low density. It is a non-polar material. The crystallinity is about 60 - 70% . The crystalline isotactic polypropylene is insoluble in all common solvents at room temperature, it starts swelling and is finally dissolved by specific solvents only at temperatures generally higher than 100°C. Its tensile strength, surface hardness and stiffness are higher than that of polyethylene. Under suitable polymerizing condition, propylene produces fiber forming polypropylene. For producing the polymer (iso-tactic) 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 fig.)
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.

Homo-polymer 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.

A major advantage is Polypropylene is having 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 polyethylene for many purposes.

2.2.1 Properties of Polypropylene Stable Fibre (PPSF)

1. lowest specific gravity of 0.91(provides excellent covering).
2. Negligible moisture absorption (0.05%).
3. Provides very warm feel (warmer than wool and acrylic).
4. Fabric containing PPSF wicks away moisture from skin to atmosphere due to the capillary action.
5. PPSF is resistant to many acids, alkalies and solvents.
6. PPSF is resistant to attack of mildew/moths/insects and a wide range of bacteria.
7. Not prone to static charge generation.
8. Highly resilient fibre

Table. no. 2.2 properties of polypropylene fibre

s.no	Property	value
1	Fibre denier	2.5
2	Fibre tenacity(gm/denier)	5.5-6
3	% oil pick up	0.4-0.5
4	Crimps per cm	5.4-5.8

2.2.2 Epoxy Resins

The large family of epoxy resins contains some of the highest performance resins available at this time. The generic term epoxy resin describes a class of thermosetting resins prepared by the ring-opening polymerization of compounds containing an average of more than one epoxy group per molecule. Epoxy resins traditionally are made by reacting epichlorohydrin with bis-phenol A, which are linear polymers that cross-link, forming thermosetting resins basically by the reaction with the hardeners [16].

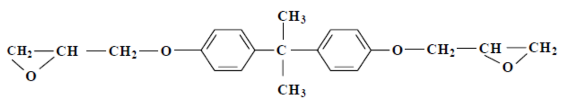


Figure: 2.7.Structure of Typical Epoxy Resin

The advantages of epoxy resins are low polymerization shrinkages, excellent mechanical strength, good electrical properties and chemical resistance. The epoxy molecule also contains two ring groups at its centre which are able to absorb both mechanical and thermal stresses better than linear groups and therefore give the epoxy resin very good stiffness, toughness and heat resistance. The primary disadvantages of the epoxy resins are that they require long curing times and, in general, their mold release characteristics are poor.

The epoxy resins are characterized by their high adhesive strengths. This property is attributed to the polarity of aliphatic hydroxyl groups and ether groups that exist in both the initial resin and cured system. The polarity associated with these groups promotes electromagnetic bonding forces between epoxy molecules and the substrate.

2.3 COMPOSITES

2.3.1 Definition of Composite

A Composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. Composites are a combination of two materials in which one of the material is called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other material called the matrix phase. Typically, reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material.

The essence of the concept of composites is that the load is applied over a large surface area of the matrix. Matrix then transfers the load to the reinforcement, which being stiffer, increases the strength of the composite. It is important to note that there are many matrix materials and even more fiber types, which can be combined in countless ways to produce just the desired properties. Composites have a higher specific strength than many other materials. A distinct advantage of composites over other materials is the ability to use many combinations of resins and reinforcements, and therefore custom tailor the mechanical and physical properties of a structure.

Composites have an advantage over other materials because they can be molded into complex shapes at relatively low cost. This gives designers the freedom to create any shape or configuration. Boats are a good example of the success of composites. One reason the composites industry has been successful is because of the low relative investment in setting-up a composites manufacturing facility. This has resulted in many creative and innovative companies in the field.

The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. Disadvantages of composites include high raw material costs and usually high fabrication and assembly costs; adverse effects of both temperature and moisture; poor strength in the out-of plane direction where the matrix carries the primary load susceptibility to impact damage and delaminations or ply separations; and greater difficulty in repairing them compared to metallic structure[17].

As there is a high emphasis on greenhouse gas reductions and improving fuel efficiency in the transportation sector, all car manufacturers, suppliers, assemblers, and component producers are investing significantly in lightweight materials Research and Development and commercialization. All are moving towards the objective of increasing the use of light weight materials and to obtain more market penetration by manufacturing components and vehicle structures made from lightweight materials. Because the single main obstacle in application of lightweight materials is their high cost, priority is given to activities to reduce costs through development of new materials, forming technologies, and manufacturing processes.

Specific properties of composites are listed below:

- High strength to weight ratio
- High stiffness to weight ratio
- High modulus to weight ratio
- Light weight
- Directional strength
- Corrosion resistance
- Weather resistance
- Dimensional stability
- High impact strength
- Long term durability
- Low maintenance
- Low thermal conductivity

Composite strength depends on the following factors:

- Inherent fibre strength, fibre length , number of flaws.
- Fibre shape.
- The bonding of the fibre(equally stress distribution).
- Moisture (coupling agent).

2.3.2 Classification of Composites

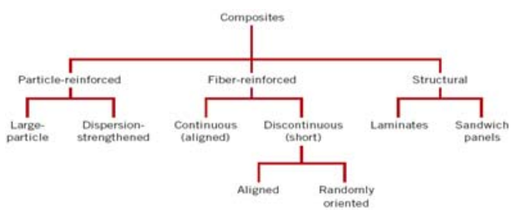


Figure: 2.8. Classification of composites

2.3.3Particle-reinforced composites

They are again two kinds: dispersion-strengthened and particulate-reinforced composites. These two classes are distinguishable based upon strengthening mechanism–dispersion-strengthened composites and particulate composites.

In dispersion-strengthened composites, particles are comparatively smaller, and are of 0.01-0.1μm in size. Here the strengthening occurs at atomic/molecular level i.e. mechanism of strengthening is similar to that for precipitation hardening in metals where matrix bears the major portion of an applied load, while dispersions hinder/impede the motion of dislocations.

Particulate composites are other class of particle-reinforced composites. These contain large amounts of comparatively coarse particles. These composites are designed to produce unusual combinations of properties rather than to improve the strength. Mechanical properties, such as elastic modulus, of particulate composites achievable are in the range defined by rule of mixtures as follows:

upper bound is represented by:

$$E_c(u) = E_m V_m + E_p V_p$$

Lower bound is represented by:

$$E_c(l) = \frac{E_m E_p}{E_p V_m + E_m V_p}$$

Where E and V denote elastic modulus and volume fractions respectively while c, m, and p represent composite, matrix and particulate phases.

2.3.4 Fiber-reinforced composites

Fiber reinforced composites provide improved strength, fatigue resistance, Young’s modulus and strength to weight ratio over the constituent materials. This is achieved by incorporating strong, stiff, yet brittle fibers into a more ductile matrix. Generally speaking the fiber supplies the strength and stiffness while the matrix binds the fibers together and provides a means of transferring the load between fibers. The matrix also provides protection for the fibers.

Many factors must be considered when designing a fiber-reinforced composite including the length, diameter, orientation, amount and properties of the constituents, and the bonding between them. The method used to produce the final product is also very important as it dictates the type of properties just mentioned as well as the quality of the product.

Fiber dimensions are characterized by their aspect ratio *l/d* where *l* is the fiber length and *d* is the diameter. The strength improves when the aspect ratio is large. Fibers often fracture because of surface imperfections. Making the diameter small reduces its surface area, which has fewer flaws. Long fibers are preferred because the ends of the fiber carry less of the load. Thus the longer the fiber, the fewer the ends and the higher the load carrying capacity of the fibers. In most fiber-reinforced composites, the fibers are strong, stiff and light weight. If the composite is used at elevated temperatures, the fiber should also have a high melting temperature. The specific strength and specific modulus of fibers are important characteristics given by:

$$\text{Specific Strength} = \frac{TS}{\rho} \qquad \text{Specific modulus} = \frac{E}{\rho}$$

Where *TS* is the tensile strength, *E* is the elastic modulus and *r* is the density.

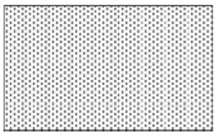
a. Short (discontinuous) fiber reinforced composites

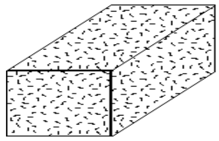
Length of fibers, their orientation and volume fraction in addition to direction of external load application affects the mechanical properties of these composites [21].

2.4 COMPRESSION MOULDING

Compression molding is the oldest mass production process for polymer products. The main reason for this choice of process in this case gives a clue to one of the features of the process, namely the low level of orientation in the moldings. Compression molding is simple, discontinuous technique using a mold inserted between heated metal platen in a hydraulic press. The polymer compound is molten in the heat mold and kept under pressure to fill the mold completely.

In the case of a thermoplastic compound the whole package has to be cooled under pressure before the article can be ejected from the mold. This is very impractical and is only applied for single productions in the laboratory. However, for thermosetting compounds, cooling is not necessary for ejection of the article as it has already solidified at the processing temperature due to strong cross linking. It will be clear that temperature and pressure are critical variables determining the cycle time and the quality of the article. Complete filling of the mold during cross linking is rather tricky, but nevertheless compression molding is very often used for processing of thermosetting resins. The same holds for the production of certain rubber articles although the degree of cross linking should remain much lower in order to preserve the desired elasticity.





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b. Continuous fiber (long fiber) reinforced composites

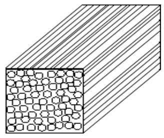


Figure: 2.9 Fibre reinforced composites

Most fiber-reinforced composites provide improved strength and other mechanical properties and strength-to-weight ratio by incorporating strong, stiff but brittle fibers into a softer, more ductile matrix. The matrix material acts as a medium to transfer the load to the fibers, which carry most off the applied load. The matrix also provides protection to fibers from external loads and atmosphere. These composites are classified as either continuous or discontinuous. Generally, the highest strength and stiffness are obtained with continuous reinforcement.

Discontinuous fibers are used only when manufacturing economics dictate the use of a process where the fibers must be in this form. The mechanical properties of fiber-reinforced composites depend not only on the properties of the fiber but also on the degree of which an applied load is transmitted to the fibers by the matrix phase.

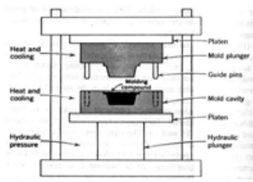


Figure: 2.10 compression moulding machine

2.4.1The principle of the compression moulding process can be outlined as follows.

1. The mold is held between the heated platens of the hydraulic press;
2. A prepared quality of molding compound is placed in the mould, usually by hand, and the mould placed in the press;
3. The press closes with sufficient pressure to prevent or minimize flash at the mold part line;
4. The compound softens and flows to shape; the chemical cure then occurs as the internal mould temperature becomes high enough;
5. If necessary, cooling takes place, although for the vast majority of thermosets this is not needed.
6. The press is opened and the molding removed. Frequency, the mould is removed from the press and opened on the bench to extract the molding. It is reloaded with a fresh charge before returning it to the press to commence another cycle.

The advantage of compression molding is its ability to mold large, fairly intricate parts. Compression molding produces fewer knit lines and less fiber-length degradation than injection molding.

Typical Advantages of Compression Molded Composites

- Dimensionally stable
- Substitute multiple simple parts into one intricate part
- Non-corrosive benefits (chemical resistance, galvanic protection)
- Higher performance, lighter weight, and lower cost than other metal parts
- Lower part labor content.

2.6 ACOUSTIC PROPERTIES OF COMPOSITES

The noise control plays an important role in assuring acoustically pleasant environments. One of the most important factors in noise reduction is represented by the materials used in different structures with soundproofing role.

Noise contributes to driver fatigue, a major cause of accidents and reducing it is a valuable contribution to road safety. Sound is propagated through the air and by vibration of the car body and there are three basic mechanisms for reducing it: by absorption, by damping and thirdly by isolation or insulation. In general a thick piece of material will absorb more sound than a thinner piece of the same material. Density, air porosity and thickness of the material influence sound absorbency. Damping can be obtained by putting soft materials next to a harder material such as the metal car-body structure [22].

Natural fiber reinforced composites can be used to reduce the noise level. Composite materials offer higher specific strength, stiffness and energy absorption than metals which is driving their use across many industry sectors. They are used extensively in motorsport and increasingly in the automotive sector because of their potential to reduce mass. Impact structures in motorsport are required to act as both load-bearing members and energy absorption devices.

Recently, car manufactures have been interested in incorporating natural fiber composites into both interior and exterior parts. This serves a two-fold goal of the companies; to lower the overall weight of the vehicle thus increasing fuel efficiency and to increase the sustainability of their manufacturing process.

Many automotive components are already produced in natural composites, mainly based on polyester or PP and fibres like flax, hemp or sisal. The adoption of natural fibre composites in this industry is lead by motives of a) price b) weight reduction and c) marketing ('processing renewable resources') rather than technical demands.

2.5.1 Various Techniques for Acoustic Measurements

Measurement techniques used to characterize the sound absorptive properties of a material are:

- Reverberation Room Method
- Impedance Tube Method

2.5.2 Impedance Tube Method

It is based on the transfer function between two fixed microphones located at two different positions in the tube wall. This method will be called the 2p method. The standing wave pattern in their case was built up from a broadband stationary noise signal. By using the measured transfer function, the incident and reflected waves can be recovered mathematically. From these the reflection coefficient of the sample can be calculated for the same frequency band as the broadband signal. The impedance and absorption coefficient can be calculated as well. The method is as accurate as the Standard wave ratio method and considerably faster.

Usually the acoustical sample is put at one end of a tube and a loud speaker is mounted at the other end. The loudspeaker generates sound and this result in a forward traveling sound wave. A part of the sound is reflected, causing a backward traveling sound wave. The reflection coefficient is determined by measuring sound is traveling in the forward and backward direction. Imagine that the sample in the tube is fully sound reflecting, so that all the sound that travels along the tube is reflected at the end. In such a case the sound intensity (the net flow of sound energy in one direction) in the tube will be zero. If on the other hand the sample is fully sound absorbing, the sound intensity will be large. How large the sound intensity is depends on the amount of noise, which is generated by the loudspeaker. The ratio of the sound intensity to the energy density is zero for a full reflecting sample [20].

Typically the absorption coefficient of a material increases with increasing angle of incidence up to a certain angle. Beyond this angle a decrease in the absorption coefficient is usually observed. One explanation for this is the contribution of the so called shear waves that propagate in the flexible porous material. As a result the absorption coefficient at normal incidence is slightly less than the absorption coefficient measured at random incidence for porous materials. The normal impedance on the other hand is a complex vector that is oriented normal to the surface of the porous material and directed inward. In this case one can speak of the normal surface impedance of a material measured with oblique incident sound waves. For sound-absorbing materials the impedance measured with the impedance tube method depends strongly on the thickness of the material because the sound waves reflect at the backing plate. Therefore some authors advise the use of acoustic properties that are independent of the test configuration such as the characteristic impedance and the propagation coefficient in the material. One technique to derive these two coefficients is to measure the surface impedance of the material with two different thicknesses.

2.5.3 Experimental Setup

The impedance tube is straight with a uniform cross sectional and with rigid, smooth, non-porous walls without holes or slits (except for the microphone positions) in the last section. The walls are massive and thick enough so that they are not excited into vibration by the sound signal and do not have any vibration resonances in the working frequency range of the tube. The test specimen provided was tightly fitted to one end of the tube. Two microphones were fitted into the tube wall to measure the sound pressures. These microphones were further connected to circuit board that is used in the analysis of the data collected [24]. The sound source was connected to the other end of the impedance tube.

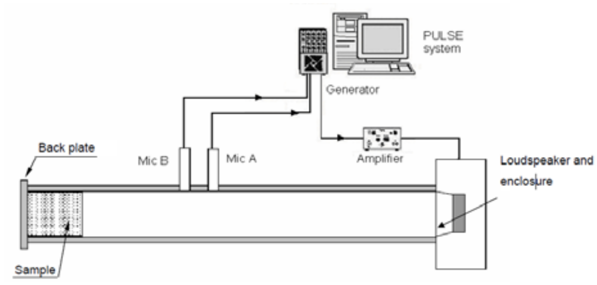


Figure: 2.11. Experimental setup of impedance tube

2.5.4 Construction of the Impedance Tube

The apparatus is essentially a metal tube with a test sample at one end and a loudspeaker (sound source) at the other. The impedance tube used is straight, with a constant cross section and with rigid, smooth, non-porous walls without holes or slits in the test section. The tube is massive and sufficiently rigid to avoid;

1. Transmission of noise into the tube from outside.
2. Vibration excitation by the sound source or from background sources (e.g., doors closing).

Two microphones whose type and diameters were chosen and fitted into the ports provided in the wall of the impedance tube.

CHAPTER 3

MATERIALS AND METHODS

3.1PROCESS FLOW

Collection of chicken feather

↓

Grading of feathers

↓

Purification of chicken feather

↓

Preparation of web by using miniature carding machine

↓

Hand Laying of feathers

↓

2.5.5 Experimental Procedure

The test sample is mounted at one end of a straight, rigid, smooth and airtight impedance tube. Plane waves are generated in the tube with the help of a loudspeaker fixed at the other end. The complex acoustical transfer function between the two microphone signals is determined and used to compute the normal incidence complex reflection factor, the normal-incidence absorption coefficient, and the impedance ratio of the test material. These quantities are determined as functions of frequency with a frequency resolution, which is determined from the sampling frequency. The usable frequency range depends on the width of the tube and the spacing's between the microphones [25]. An extended frequency range may be obtained from the combination of measurements with varying widths and spacing's between the microphones.

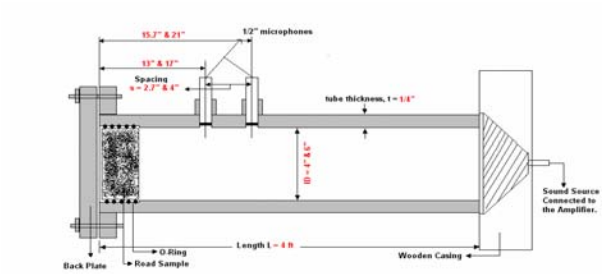


Figure: 2.12. Dimensions of the two-microphone impedance tube.

Composite board prepared by compression moulding method
(Chicken feather and polypropylene, Chicken feather and epoxy resin)

↓

Testing (tensile strength, flexural, impact)

↓

Fabrication of impedance tube and testing the acoustic property.

Since the process parameters were already optimized in the earlier work that optimized parameters were choose for this project work. The term CFP indicates combination of chicken feather and polypropylene. The term CFE indicates combination of chicken feather and epoxy resin. The samples are mentioned as CFP1 ,CFP2, CFP3 ,CFP4 ,CFP5, CFP6, CFP7,CFE1,CFE2,CFE3,CFE4,CFE5,CFE6,CFE7.

Table no. 3.1 Process particulars

Sample	Proportion	Time	Temp	pressure
CFP1	90/10	3 MIN	165 □ C	5 BAR
CFP2	80/20	3MIN	165 □ C	5 BAR
CFP3	70/30	3 MIN	165 □ C	5 BAR
CFP4	90/10	9 MIN	175 □ C	15 BAR
CFP5	80/20	9 MIN	175 □ C	15 BAR
CFP6	70/30	9 MIN	175 □ C	15 BAR
CFP7	100%PP	9 MIN	175 □ C	15 BAR
CFE1	90/10	3 MIN	165 □ C	5 BAR
CFE2	80/20	3 MIN	165 □ C	5 BAR
CFE3	70/30	3 MIN	165 □ C	5 BAR
CFE4	90/10	9 MIN	175 □ C	15 BAR
CFE5	80/20	9 MIN	175 □ C	15 BAR
CFE6	70/30	9 MIN	175 □ C	15 BAR
CFE7	100%RESIN	9 MIN	175 □ C	15 BAR

3.2 MATERIALS

1. Chicken feather(Reinforced material):

The Chicken feather was obtained from the poultry farms. Then it is purified by treating Chicken feather with mild alkalis (Ethanol) with mild soaping is carried out. After purification the edges of feathers are removed and it is used for the study.

2. Polypropylene (Resin):

Polypropylene (CH_2 =CH-CH_3), the byproduct 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 (iso-tactic) with a regular structure, polymerization should take place. Raw polypropylene is purchased and taken for web conversion.

3.3METHODS

3.3.1 Washing and Sterilization

1. **Washing**

The untreated Chicken feather was washed with the 5% soap solution followed by rinsing. The wet washed Chicken feather was dried on moderate heat.

2. **Sterilization**

Samples of washed CF were dipped at room temperature (21°C) for 30 minutes respectively) polar solvent and water, with pH adjusted to 8, then rinsed with water, then soaping process is carried out and air-dried.

3.4 WEB PREPARATION FROM MINIATURE CARDING

In this project, we have planned to produce the composites using compression moulding technique. Formation of web by feeding the opened polypropylene fiber into carding machine.

3.4.1 Formation of Web from Carding

After the opening of polypropylene fed into miniature carding machine and the web is produced. And the GSM of produced web is around 1500.

Figure: 3.1 Webs produced using the miniature carding machine

3.5 MANUFACTURE OF CHICKEN FEATHER REINFORCED COMPOSITE

Fibrous webs are cut into pieces (250mm X 250mm with thickness 3mm) according to the aluminum mould and placed on the mould. Feathers are cut and laid over the web layers to get the required weight/unit area and compression molded at optimized parameter. Several of such fiber webs with randomly laid feathers were compression molded by optimizing the following parameters.

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 .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 produced.

Figure: 3.2 Compression Moulding Machine

This composite manufacturing process consists of four stages,

Step 1**:** The randomly arranged chicken feather in to fibrous webs of (250mm X 250mm with thickness 3mm) is placed on the aluminum foil. And this arrangement is kept at the bottom plate of the compression moulding machine.

Step 2: Another aluminum foil is placed over the fibrous web and the parameters are optimized.

Step 3: Compression moulding machine starts and the composite is compressed for specific time.

Step 4: Finally the composite is removed from the machine and it is cooled for about 15min and composite is detached from the mould plates.

The following figure shows the chicken feather reinforced composites by using compression moulding technique.

Figure: 3.3 Chicken feather and Polypropylene Composite Board

Figure: 3.4 Chicken Feather And Epoxy Resin Composite Board

CHAPTER 4

CHARACTERIZATION OF COMPOSITES

The composites were conditioned in a standard testing atmosphere of 21 °C and 65% relative humidity for at least 24 hours before testing.

- Tensile tests
- Flexural tests.
- Impact tests.

4.1 Tensile test

One of the most common testing methods, tensile testing, is used to determine the behavior of a sample while an axial stretching load is applied. These types of tests may be performed under ambient or controlled (heating or cooling) conditions to determine the tensile properties of a material. Tensile testing is performed on a variety of materials including metals, plastics, elastomers, paper, composites, rubbers, fabrics, adhesives. Tensile testing is commonly used to determine the maximum load (tensile strength) that a material or a product can withstand. Tensile testing may be based on a load value or elongation value.

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.

Sample Size

The sample size for testing the tensile strength is following,

- Length - 150 mm
- Width – 12 mm

Figure: 4.1 Instron tensile strength tester

4.2 Impact Test

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.

Sample Size

The samples required for performing impact strength must have the following dimensions:

- Length -65 mm
- Width - 12 mm

Figure: 4.2 Impact strength tester

4.3 Flexural test

A flexure test produces tensile stress in the convex side of the specimen and compression stress in the concave side. This creates an area of shear stress along the midline. To ensure the primary failure comes from tensile or compression stress the shear stress must be minimized. Flexure testing is often done on relatively flexible materials such as polymers, wood and composites. There are two test types; 3-point flex and 4-point flex. In a 3-point test the area of uniform stress is quite small and concentrated under the center loading point. In a 4-point test, the area of uniform stress exists between the inner span loading points (typically half the outer span length).

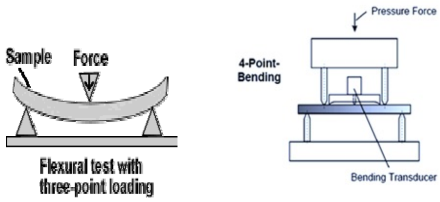


Figure: 4.3 Testing of fiber reinforced materials

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 kilograms.

Sample Size

The required sample size for performing flexural strength using universal testing machine is as follows:

- Length - 127 mm
- Width – 12 mm

CHAPTER 5

RESULTS AND DISCUSSION

5.1 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 composites is following,

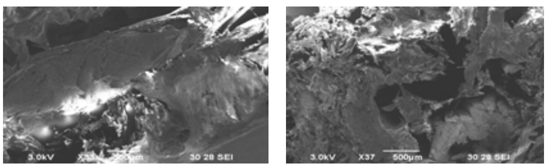
Table 5.1 Result for Tensile strength of composite

S.NO	SAMPLE	PROPORTION	MAXIMUM LOAD IN N
1	CFP1	90/10	80.83
2	CFP2	80/20	177.17
3	CFP3	70/30	268.32
4	CFP4	90/10	84.68
5	CFP5	80/20	174.48
6	CFP6	70/30	289.21
7	CFP7	100%PP	164.36
8	CFE1	90/10	94.66
9	CFE2	80/20	102.53
10	CFE3	70/30	186.58
11	CFE4	90/10	89.50
12	CFE5	80/20	98.50
13	CFE6	70/30	138.07
14	CFE7	100%RESIN	112.56

Inference

The tensile strength results of control and different proportion of fibre loaded composites were compared in figure 5.1 and 5.2. These results show that the control composites tensile properties were significantly lower when compared to the chicken feather reinforced composites. The polypropylene based composites had better tensile properties than the epoxy resin based composites. When the chicken feather content increased the maximum load also increased. The maximum load for chicken feather and polypropylene composite is 289.21 N. The maximum load for chicken feather and epoxy resin composite is 186.58 N. In the present investigation it was observed that combination 70/30 resin/reinforcement shows better results for tensile strength.

5.1.1 SEM tensile fraction analysis of chicken feather composite board (Material: chicken feather and polypropylene)



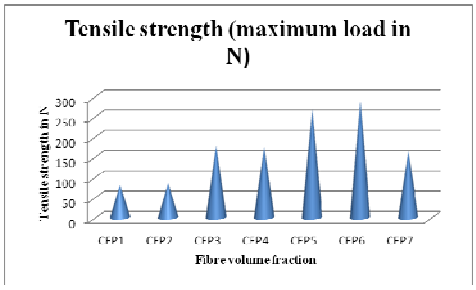


Figure 5.1. Tensile strength of chicken feather and polypropylene composite

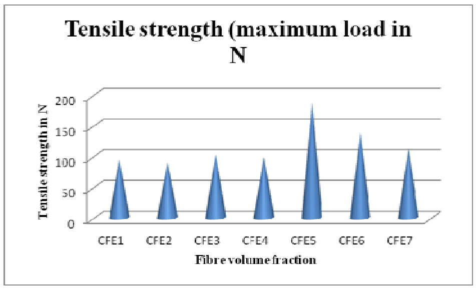


Figure 5.2. Tensile strength of chicken feather and epoxy resin composite.

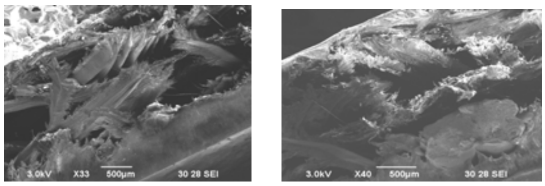
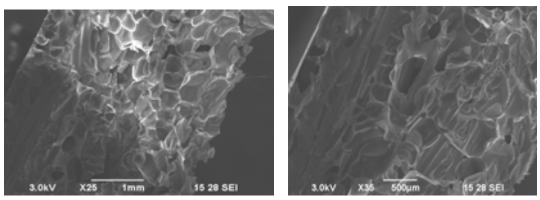


Figure: 5.3 SEM Image of Fracture surface of chicken feather reinforced polypropylene composite board

5.1.2 SEM tensile fraction analysis of chicken feather composite board (Material: chicken feather and epoxy composite)



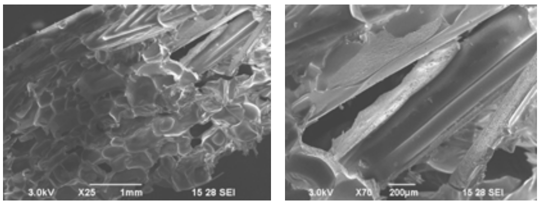


Figure: 5.4 SEM Image of Fracture surface of chicken feather reinforced epoxy resin composite board

Interfacial properties of chicken feather reinforced polypropylene and epoxy resin based composites were investigated by SEM and are shown in figure 5.3 and 5.4. SEM observations indicated that based on the processing variables there is some considerable difference in the fibre –matrix interaction between the composites. Interfacial bonding between the chicken feather and matrix is not good, as indicated by the gap between them. Severe damage on the surface of composite board is observed. Gaps between chicken feather and matrix are clearly found for composite board manufactured with high pressure and temperature.

5.2 RESULTS FOR IMPACT STRENGTH OF COMPOSITE

The composites are subjected to Charpy Impact Strength tester to determine the impact strength. A result of the study of impact strength properties of chicken feather composites follows,

Table. no. 5.2 Results for Impact Strength of Composite

S.NO	SAMPLE	PROPORTION	IMPACT STRENGTH(JOULES)
1	CFP1	90/10	0.655
2	CFP2	80/20	1.076
3	CFP3	70/30	3.264
4	CFP4	90/10	0.678
5	CFP5	80/20	1.048
6	CFP6	70/30	3.482
7	CFP7	100	0.422
8	CFE1	90/10	0.988
9	CFE2	80/20	1.671
10	CFE3	70/30	4.286
11	CFE4	90/10	0.876
12	CFE5	80/20	1.742
13	CFE6	70/30	4.381
14	CFE7	100	0.629

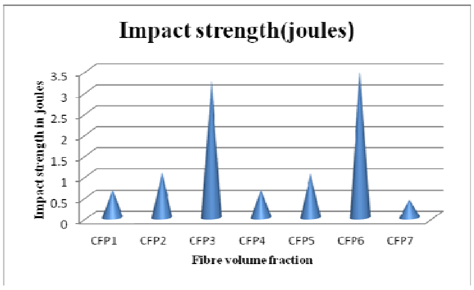


Figure 5.5. Impact strength of chicken feather and polypropylene composite

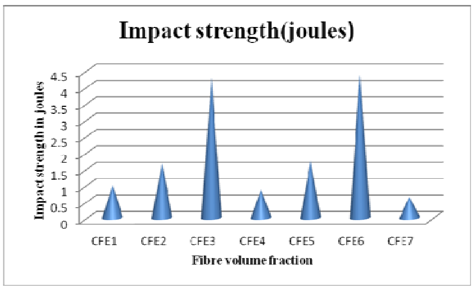


Figure 5.6. Impact strength of chicken feather and epoxy resin composite

Inference

The charpy impact property is important characteristic of the composite structure due to its automotive application. When the chicken feather content increases the impact values also increased. The 70% chicken feather loaded composites have improved impact values in comparison with the 90% chicken feather loaded composites. The epoxy resin and chicken feather composites have higher impact strength than polypropylene composites. The investigation shows that mean impact strength of chicken feather was obtained high of maximum 4.381 Joules for combination of 70/30(resin/reinforcement).

5.2.1 SEM impact strength analysis of chicken feather composite board (Material: chicken feather and polypropylene)

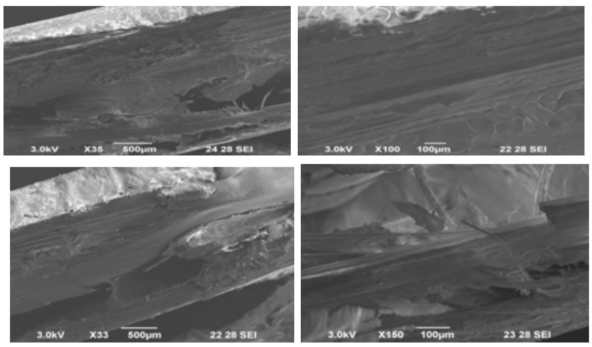


Figure: 5.7 SEM Image of Fracture surface of chicken feather reinforced polypropylene composite board

5.2.2 SEM impact strength analysis of chicken feather composite board (Material: chicken feather and epoxy composite)

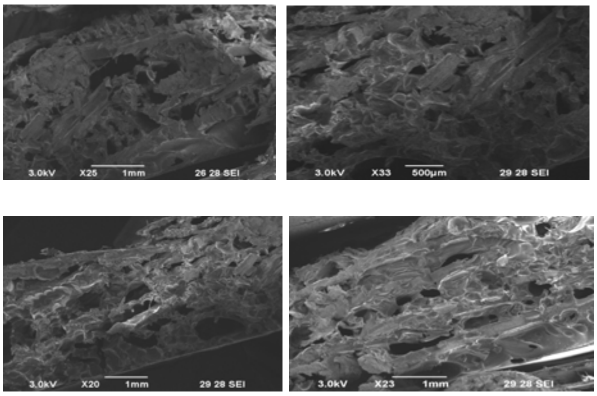


Figure: 5.8 SEM Image of Fracture surface of chicken feather reinforced epoxy resin composite board.

Interfacial properties of chicken feather reinforced polypropylene and epoxy based composites were investigated by SEM and shown in figure 5.7 and 5.8. The interfacial bonding between chicken feather and epoxy resin is not good, as indicated by the gap between them and high proportions of feather composite withstand more force. The impact strength of chicken feather and polypropylene composite is moderate. Damage occurred on surface of the composite board.

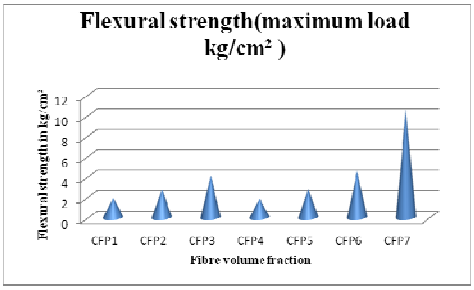


Figure 5.9. Flexural strength of chicken feather and polypropylene composite

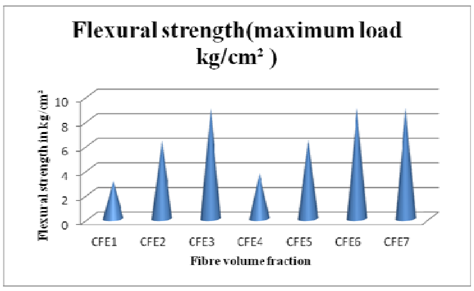


Figure 6.0. Flexural strength of chicken feather and epoxy resin composite

5.3 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 composite follows,

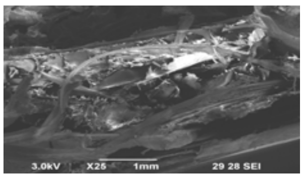
Table.no. 5.3 Result for flexural strength of composite

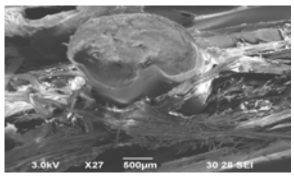
SAMPLE	PROPORTION	MAXIMUM LOAD (KG/CM²)
CFP1	90/10	1.918
CFP2	80/20	2.756
CFP3	70/30	4.107
CFP4	90/10	1.855
CFP5	80/20	2.865
CFP6	70/30	4.568
CFP7	100	10.575
CFE1	90/10	3.037
CFE2	80/20	6.368
CFE3	70/30	8.936
CFE4	90/10	3.698
CFE5	80/20	6.563
CFE6	70/30	9.013
CFE7	100	9.042

Inference

The flexural strength results are compared in figure 5.9 and 6.0. The control composites had considerable higher flexural strength in comparison with the chicken feather reinforced composites. For both polypropylene and epoxy resin composites have extensively superior flexural strength than the chicken feather reinforced composites. The flexural strength values of epoxy resin composites were higher than polypropylene composites. When the proportion of chicken feather increases the flexural strength values also increased significantly. In the present investigation it was observed that combination of 70/30 (resin/ reinforcement) shows highest flexural strength.

5.3.1 SEM flexural strength analysis of chicken feather composite board (Material: chicken feather and polypropylene)





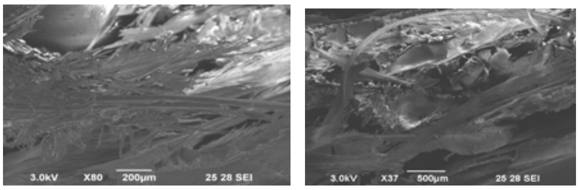
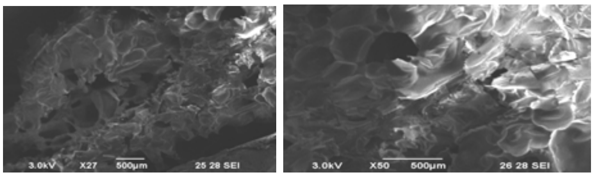


Figure 6.1: SEM Image of Fracture surface of chicken feather reinforced polypropylene composite board

5.3.2 SEM flexural strength analysis of chicken feather composite board (Material: chicken feather and Epoxy resin)



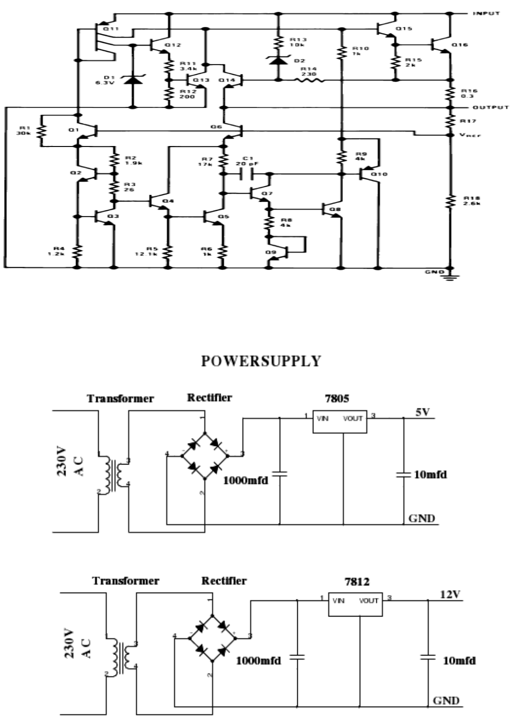


Figure : 6.3 circuit diagram of impedance tube

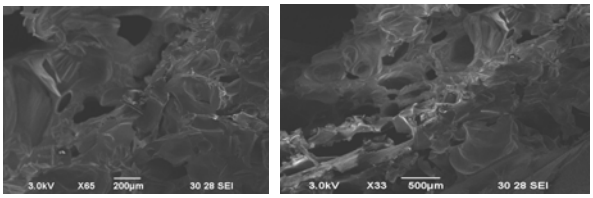


Figure: 6.2 SEM Image of Fracture surface of chicken feather reinforced epoxy resin composite board

Interfacial properties of chicken feather reinforced polypropylene and epoxy resin based composites were investigated by SEM and shown in figure 6.1and6.2. SEM observations indicated that based on the processing variables there is no considerable difference in the fibre matrix interaction between the composites. There is no feather pull out occurrence. Interfacial bonding between the chicken feather and resin is good.

5.4 ACOUSTIC PROPERTY MEASURED BY IMPEDANCE TUBE

The length of the tube is 4 ft. The material chosen for the impedance tube was acrylic. ½ inch condenser microphones are fitted in to the tube wall and then these microphones are connected to circuit board. The sample is fixed at one end of the tube and loudspeaker is fixed at another end of the tube.

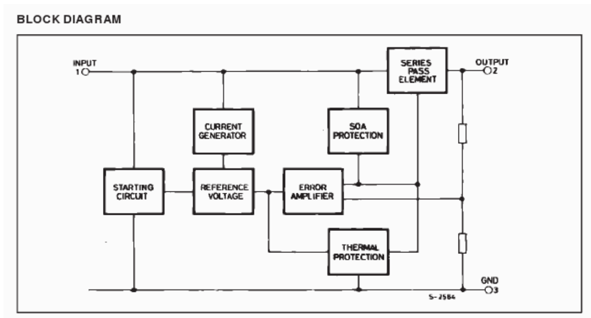


Figure : 6.4 Block diagram of impedance tube

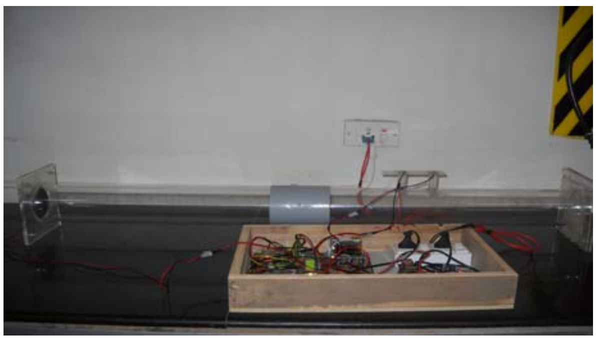


Figure: 6.5 Experimental setup of impedance tube

5.4.1 RESULTS FOR ACOUSTIC PROPERTY OF COMPOSITE

Table no: 5.4 Acoustic property of composite at 500 hz

S.NO	SAMPLE	INPUT (HZ)	OUTPUT(HZ)	DIFFERENCE
1	CFP1	500	495	5
2	CFP2	500	482	18
3	CFP3	500	478	22
4	CFP4	500	490	10
5	CFP5	500	485	15
6	CFP6	500	473	27
7	CFP7	500	498	2
8	CFE1	500	493	7
9	CFE2	500	490	10
10	CFE3	500	485	15
11	CFE4	500	490	10
12	CFE5	500	488	12
13	CFE6	500	483	17
14	CFE7	500	495	5

Table no: 5.4 Acoustic property of composite at 1000 hz

S.NO	SAMPLE	INPUT (HZ)	OUTPUT(HZ)	DIFFERENCE
1	CFP1	1000	968	32
2	CFP2	1000	973	27
3	CFP3	1000	962	38
4	CFP4	1000	977	23
5	CFP5	1000	975	25
6	CFP6	1000	960	40
7	CFP7	1000	985	15
8	CFE1	1000	975	25
9	CFE2	1000	973	27
10	CFE3	1000	967	33
11	CFE4	1000	974	26
12	CFE5	1000	970	30
13	CFE6	1000	965	35
14	CFE7	1000	980	20

Inference

From the sound absorption measurement test it was observed that the 70/30 proportion have maximum absorption value at 500 and 1000 frequency level.

CHAPTER 6

CONCLUSION

The Feasibility of using chicken feather fiber to reinforce polypropylene and epoxy resin has been explored in this paper. If the poultry waste can be utilized and used any engineering applications they will be preferred due to low-cost and superior characteristics and the most importantly they will not cause ecological and health problems anymore. The tensile property of chicken feather reinforced composites has significantly higher value than control composite. It is evident that the reinforcement material increases the tensile property of composite.

The charpy impact values of the chicken feather reinforced composites are considerable better when compared with control composites. For impact property the reinforced composites (3.482 Joules) indicate around four times higher than control composite (0.422 Joules).

The flexural properties of control composites have significantly superior properties compare to chicken feather reinforced composites. The reinforcement material decreases the flexural property of the composites.

It can be concluded that the chicken feather reinforced composite have potential applications due to its improved tensile and impact behavior. The flexural properties can be enhanced with the increasing percentage of the chicken feather and also with different resin. Another way to enhance the composite properties is to determine an effective treatment to eliminate lack of adhesion between matrix and chicken feather. The acoustic property of composites is analyzed by impedance tube method.

The mechanical and sound absorption properties of the chicken feather reinforced composites were determined. Thus the utilization of the cheaper goods and applying it in a high performance application is possible with the help of this composite technology.

FUTURE SCOPE OF THIS PROJECT

- The proportion of chicken feather can be increased and polypropylene fiber and epoxy resin can be reduced to produce better sound absorbing property of the composite.
- The end uses and applications of these composites can be implemented to improve better results.
- Non-woven material can be produce from these fibrous webs and its properties can be studied.
- The proportion of chicken feather can be increased and polypropylene fiber and epoxy resin can be reduced to produce better mechanical properties of the composite.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Temp	81.03375	1	81.03375	1.093635	0.405432	18.51282
proport	38452.39	2	19226.2	259.4775	0.003839	19
Error	148.1916	2	74.0958			
Total	38681.62	5				

Table 1.2 Results for tensile strength of Chicken feather and epoxy resin composites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
pressure	554.8817	1	554.8817	1.725481	0.319444	18.51282
proport	5883.99	2	2941.995	9.14854	0.098536	19
Error	643.1616	2	321.5808			
Total	7082.034	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Time	554.8817	1	554.8817	1.725481	0.319444	18.51282
proporti	5883.99	2	2941.995	9.14854	0.098536	19
Error	643.1616	2	321.5808			
Total	7082.034	5				

ANOVA

Source of	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*

CHAPTER 7

APPENDICES

Appendix 1

Table 1.1 Results for tensile strength of Chicken feather and polypropylene composites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
pressure	81.03375	1	81.03375	1.093635	0.405432	18.51282
proport	38452.39	2	19226.2	259.4775	0.003839	19
Error	148.1916	2	74.0958			
Total	38681.62	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Time	83.25375	1	83.25375	1.131383	0.398914	18.51282
proport	38394.61	2	19197.3	260.8833	0.003818	19
Error	147.1716	2	73.5858			
Total	38625.03	5				

ANOVA

Variation						
Temp	554.8817	1	554.8817	1.725481	0.319444	18.51282
proport	5883.99	2	2941.995	9.14854	0.098536	19
Error	643.1616	2	321.5808			
Total	7082.034	5				

Appendix 2

Table 1.3 Results for impact strength of Chicken feather and polypropylene composites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Temp	0.007562	1	0.007562	0.897135	0.443527	18.51282
proport	8.548189	2	4.274095	507.1003	0.001968	19
Error	0.016857	2	0.008428			
Total	8.572608	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
pressure	0.007562	1	0.007562	0.897135	0.443527	18.51282
proportion	8.548189	2	4.274095	507.1003	0.001968	19
Error	0.016857	2	0.008428			
Total	8.572608	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Time	0.007562	1	0.007562	0.897135	0.443527	18.51282
proportion	8.548189	2	4.274095	507.1003	0.001968	19
Error	0.016857	2	0.008428			
Total	8.572608	5				

Table 1.4 Results for impact strength of Chicken feather and epoxy resin composites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Temp	0.000486	1	0.000486	0.075825	0.808878	18.51282
proport	12.71412	2	6.357061	991.8185	0.001007	19
Error	0.012819	2	0.00641			
Total	12.72743	5				

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
pressure	0.000486	1	0.000486	0.075825	0.808878	18.51282
proport	12.71412	2	6.357061	991.8185	0.001007	19
Error	0.012819	2	0.00641			
Total	12.72743	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Time	0.011971	1	0.011971	0.789769	0.467933	18.51282
proport	13.14635	2	6.573176	433.6679	0.002301	19
Error	0.030314	2	0.015157			
Total	13.18864	5				

Appendix 3

Table 1.5 Results for flexural strength of Chicken feather and polypropylene composites

Anova: Two-Factor Without Replication

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
TEMP	0.042841	1	0.042841	1.200984	0.387471	18.51282
PROPORTION	6.128604	2	3.064302	85.90216	0.011507	19
Error	0.071344	2	0.035672			
Total	6.24279	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
PRESSURE	0.043011	1	0.043011	1.206735	0.386557	18.51282
PROPORTION	6.129006	2	3.064503	85.97971	0.011497	19
Error	0.071284	2	0.035642			
Total	6.243301	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
TIME	0.042673	1	0.042673	1.19524	0.388388	18.51282
proport	6.128202	2	3.064101	85.82396	0.011518	19
Error	0.071404	2	0.035702			
Total	6.242279	5				

Table 1.6 Results for flexural strength of Chicken feather and epoxy resin composites

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
TEMP	0.145393	1	0.145393	3.056962	0.2225	18.51282
PROPORTION	31.54868	2	15.77434	331.6643	0.003006	19
Error	0.095122	2	0.047561			
Total	31.78919	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
PRESSURE	0.145393	1	0.145393	3.056962	0.2225	18.51282
PROPORTION	31.54868	2	15.77434	331.6643	0.003006	19
Error	0.095122	2	0.047561			
Total	31.78919	5				

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
TIME	0.145393	1	0.145393	3.056962	0.2225	18.51282
PROPORTION	31.54868	2	15.77434	331.6643	0.003006	19
Error	0.095122	2	0.047561			
Total	31.78919	5				

CHAPTER 8

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