CHAPTER – 1

INTRODUCTION

Rapid growth in manufacturing industries has led to the need for the betterment of materials in terms of strength, stiffness, density, and lower cost with improved sustainability. Composite materials have emerged as one of the materials possessing such betterment in properties serving their potential in a variety of applications . Composite materials are an amalgamation of two or more constituents, one of which is present in the matrix phase, and another one could be in particle or Fiber form. The utilization of natural or synthetic fibers in the fabrication of composite materials has revealed significant applications in a variety of fields such as construction, mechanical, automobile, aerospace, biomedical, and marine

Research studies from the past two decades have presented composites as an alternative over many conventional materials as there is a significant enhancement in the structural, mechanical, and tribological properties of Fiber-reinforced composite (FRC) material . Though composite materials succeeded in increasing the durability of the material, currently a strong concern regarding the accumulation of plastic waste in the environment has arisen . This concern has compelled researchers around the world to develop environmentally friendly materials associated with cleaner manufacturing processes . Several different composite recycling processes also have been developed to cope with the thousands of tons of composite waste generated in a year. Mechanical recycling includes pulverization,. where decreased sized recycles are being used as filler materials for sheet moulding compounds. In thermal recycling, degradation of composite waste by pyrolysis is done or an enormous amount of heat energy is obtained by burning composite materials with a high calorific value. There also exist more efficient processes such as chemical recycling (solvolysis) and high-voltage fragmentation (HVF). The addition of natural fillers such as natural fibers, cellulose wood powder, and microfibrillated cellulose in the polymers matrix to fabricate eco-friendly composites has improved material properties while minimizing the problem regarding residue accumulation

Many researchers have reported advantages of cellulosic fibers, such as being abundantly available in nature, nontoxic, renewable, cost-effective, and also providing necessary bonding with the cement-based matrix for significant enhancements in properties such as ductility, toughness, flexural capacity, and impact resistance of a material .In modern techniques, inclusion of fly ash, limestone powder, brick powder, and many other mineral additives are used to strengthen the composite structures. Fracture toughness has been enhanced with the addition of fly ash in a concrete composite for structural applications resulting in increased lifespan of the material .Natural fibers are mainly classified as fibers that are plant-based, animal-based, and mineral-based. As the asbestos content in the mineral-based fibers is hazardous to human health, these are not well-explored fibers with respect to research into Fiber-reinforced composite materials, while plant-based fibers provide promising characteristics such as lower cost, biodegradable nature, availability, and good physical and mechanical properties . Plant fibers include leaf fibers (sisal and abaca), bast fibers (flax, jute, hemp, ramie, and kenaf), grass and reed fibers (rice husk), core fibers (hemp, jute, and kenaf), seed fibers (cotton, kapok, and coir), and all other types, which may include wood and roots. Polymer matrices are also divided into a natural matrix and a synthetic matrix, which is petrochemical-based and includes polyester, polypropylene (PP), polyethylene (PE), and epoxy

The latest research contributes the development of hybrid composites with the combination of natural and synthetic fibers. The composite structures consisting of more than one type of Fiber are defined as hybrid composites. There are methods to combine these fibers, which involve stacking layers of fibers, the intermingling of fibers, mixing two types of fibers in the same layer making interplay hybrid, selective placement of Fiber where it is needed for better force, and placing each Fiber according to specific orientation . Among all these, stacking of fibers is the easiest procedure, and others introduce some complications in obtaining a positive hybridization effect. Many researchers got success by developing optimized composite materials for efficient use in particular applications by varying Fiber content, its orientation, size, or manufacturing processes. It is necessary to understand the physical, mechanical, electrical, and thermal properties of FRCs for their effective application. FRCs are currently being employed in copious fields of applications due to their significant mechanical properties. These composite materials sometimes depart from their designed specifications as some defects, such as manufacturing defects, cause them to deviate from the expected enhancement in mechanical properties. These manufacturing defects involve misalignment, waviness, and sometimes breakage of fibers, Fiber/matrix deboning, delamination, and formation of voids in the matrix of a composite material. An increase of 1% voids content in composites and leads to a decrease in tensile strength (10–20%), flexural strength (10%), and interlinear shear strength (5–10%), respectively. It can be eradicated by manipulating the processing parameters of manufacturing processes .

Therefore, there is a need to understand and study different types of composite manufacturing techniques to implement optimized techniques that will avoid defects and give apposite self-sustaining, durable composite material that is efficient for the desired field of application. There are many conventional manufacturing techniques for fabrication of a composite material that have been in practice for the past few decades and some of the recently developed automated composite manufacturing techniques use robot assistance for processing, which leads to complete automation and an immense rise in productivity

1.1 FIBER REINFORCED COMPOSITE

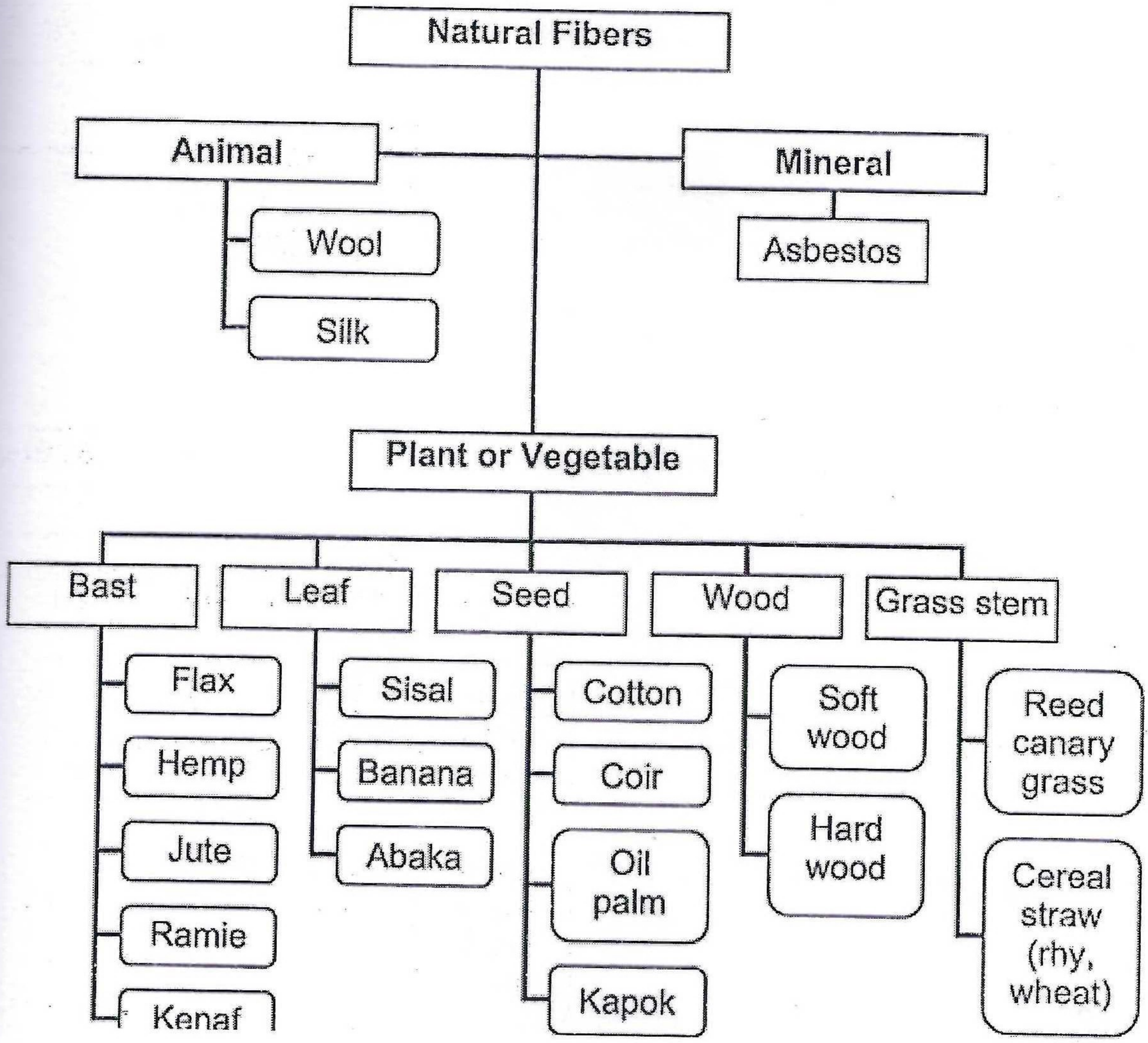
Composites consist of fibers in the matrix structure and can be classified according to fiber length. Composites with long fiber reinforcements are termed as continuous fiber reinforcement composites, while composites with short fiber reinforcements are termed as discontinuous fiber reinforcement composites. Hybrid fiber-reinforced composites are those where two or more types of fibers are reinforced in a single matrix structure . Fibers can be placed unidirectional or bidirectionally in the matrix structure of continuous fiber composites, and they take loads from the matrix to the fiber in a very easy and effective way. Discontinuous fibers must have sufficient length for effective load transfer and to restrain the growth of cracks from avoiding material failure in the case of brittle matrices. The arrangement and orientation of fibers define the properties and structural behavior of composite material . Improvement in properties such as impact toughness and fatigue strength can be seen with the use of chemically treated natural fibers. Fibers of glass, carbon, basalt, and aramid in the dispersed phase were conventionally used in the matrix structure of a fiber-reinforced polymer (FRP) composite materials Significant properties of natural fiber polymer composites (NFPCs) have potential applications in the modern industry, as researchers currently are compelled towards the development of environmentally friendly materials due to stringent environmental laws.

A polymer is generally manufactured by step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers, the result is referred to as a plastic. Composite plastics refers to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties. Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics.

The original plastic material without fibre reinforcement is known as the matrix or binding agent. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibres. The extent that strength and elasticity are enhanced in a fibre-reinforced plastic depends on the mechanical properties of both the fibre and matrix, their volume relative to one another, and the fibre length and orientation within the matrix.[1] Reinforcement of the matrix occurs by definition when the FRP material exhibits increased strength or elasticity relative to the strength and elasticity of the matrix alone

1.2 CLASSIFICATION

Composite materials are classified according to their content, i.e., base material

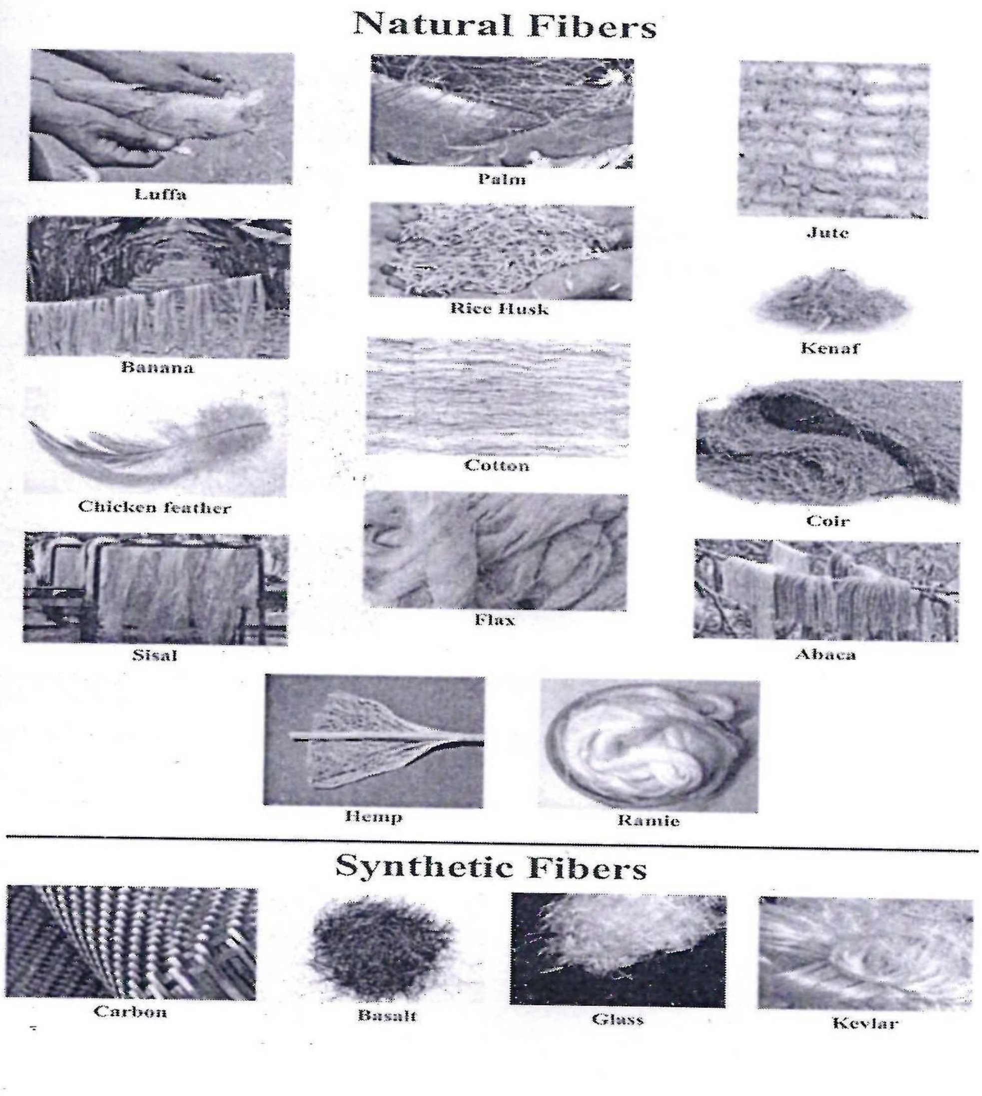


and filler material. The base material, which binds or holds the filler material in structures, is termed as a matrix or a binder material, while filler material is present in the form of sheets, fragments, particles, fibers, or whiskers of natural or synthetic material.Three main categories based on their structure

Fig 1.1

1.3 NATURAL FIBER

Natural fibers (NFs) are a very easy to obtain, extensively available material in nature. They reveal some outstanding material properties like biodegradability, low cost per unit volume, high strength, and specific stiffness. Composites made of NF reinforcements seem to carry some diverse properties over synthetic fibers, such as reduced weight, cost, toxicity, environmental pollution, and recyclability. These economic and environmental benefits of NF composites make them predominant over synthetic fiber-reinforced composites for modern



applications .Depending on the type, natural fibers have similar structures with different compositions. The inclusion of long and short natural fibers in thermoset matrices has manifested high-performance applications

Fig 1.2 NATURAL FIBER

Hemp composite showed a 52% increase in specific flexural strength of a material when compared to GF-reinforced composite with a propylene matrix. Composite material with 5% maleic anhydride-grafted polypropylene (MAPP) by weight mixed with polypropylene (PP) matrix that was reinforced with 15%, by weight, alkaline-treated hemp fibers manifested advancement in flexural and tensile strength by 37% and 68%, respectively .

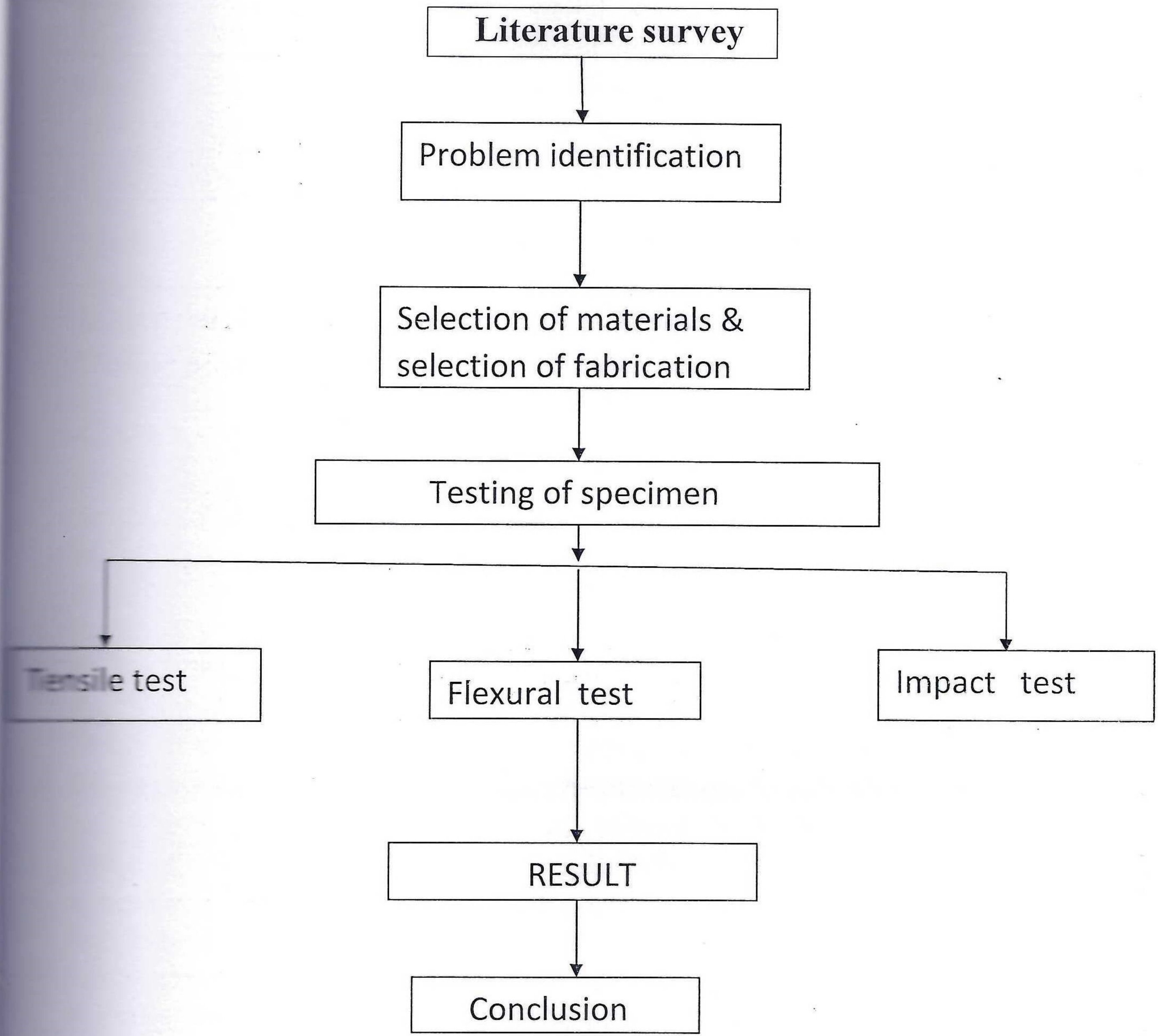
Polymathic acid (PLA) thermoplastic composites with kenaf fiber reinforcement possess tensile and flexural strength of 223 MPa and 254 MPa, respectively . Also, before laminating, removing absorbed water from the fibers results in the improvement of both flexural and tensile properties of kenaf fiber laminates . Previously, polyester samples without any reinforcements showed flexural strength and flexural modulus of 42.24 MPa and 3.61 GPa respectively, while after reinforcement of 11.1% alkali-treated virgin kenaf fibers in unsaturated polyester matrix, composite material showed flexural strength and flexural modulus of 69.5 MPa and 7.11 GPa

The sound and vibration behavior of jute fiber-reinforced polypropylene composites (JF/PPs) have been investigated using a sound transmission loss (STL) test. The results showed an increase in stiffness, damping ratio, and mass per unit area of the material due to increase in transmission loss, as the material possesses high sound absorption properties . Use of short jute fiber (JF) laminates resulted in an enhancement in tensile properties of a material. Also, the material strength and shear modulus increased by 15% and 46%, respectively, with 45° fiber orientation.The study on the free vibration characteristics of ramie fiber-reinforced polypropylene composites (RF/PPs) showed that higher fiber content in a polymer matrix leads to slippage between the fiber and the matrix, and this leads to an increase in the damping ratio during the flexural vibration. That means that an increase in fiber content results in enhancement in damping properties of RF/PP composite

During the growth of a rice grain, a natural sheath forms around the grain, known as a rice husk (RH), which is treated as agricultural waste, but it is utilized as reinforcement in composite materials to investigate enhancement in material properties . For the enhancement of the acoustic characteristics of the material, 5% of RH in polyurethane (PU) foam displayed optimum sound absorption performance

CHAPTER – 3

METHODOLOGY



CHAPTER – 4
DESCRIPTION OF COMPONENTS

4.1 MATERIAL SELECTION:

Reinforcement in the composite material is fiber. There are various types of fibers which can be used as reinforcement and they are carbon fiber , glass fiber, natural fiber, basalt fiber, E-glass fiber, E-glass fiber etc. As per our requirement of materials we are considering Jute fiber.

4.1.1 JUTE FIBER :

Jute fibers are totally biodegradable and recyclable materials, i.e., environmentally friendly materials. Jute fibers have good insulating properties for both of thermal and of acoustic energies with moderate moisture regain and no skin irritatio[34–39]. The current annual worldwide production of jute fiber is about 3.2 million tons and used for various applications. Bag cloth industry is the biggest consumer of jute fibers available in the markets. Jute bags have gained an advantage as being an eco-friendly option instead of both of nonbiodegradable poly bags that are made from petroleum and paper bags that require large quantities of wood. A huge amount of these jute fibers is wasted and is gone to landfill every year, either in the form of slivers resulted from manufacturing of jute cloth or in the form of used cloths after the end-of-life of the jute bags. Therefore, several attempts were carried out in our previous research [40–44] to use the above-mentioned valuable properties of jute fibers, to reuse the wasted jute slivers, to recycle the end-of-life jute bags for fabricating valuable jute/polymer composites, and jute composites. The jute sandwich composite structures were fabricated by attaching two thin but stiff skins made from GFRP laminates to a lightweight but thick core made of jute mat. The overall process and some potential applications for the jute-reinforced polymer matrix composite and sandwich composites with thick jute mat as light core and thin GFRP laminates as stiff skins is illustrated in Figure 4.1.1 These natural fiber composites can be introduced for appropriate applications such as barrier walls against the thermal and acoustic energies for interior construction, lightweight panels for furniture construction, and housings for electronic equipment.

FIG:4.1.1 (JUTE FIBER)

4.2 E-glass fibre:

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

Fibre Manufacture:

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

Fibre dimension and to some extent properties can be controlled by the process variables such as melt temperature (hence viscosity) and drawing/spinning rate. The temperature window that can be used to produce a melt of suitable viscosity is quite large, making this composition suitable for fibre forming.

As fibres are being produced, they are normally treated with sizing and coupling agents. These reduce the effects of fibre-fibre abrasion which can significantly degrade the mechanical strength of the individual fibres. Other treatments may also be used to promote wetting and adherence of the matrix material to the fibre.

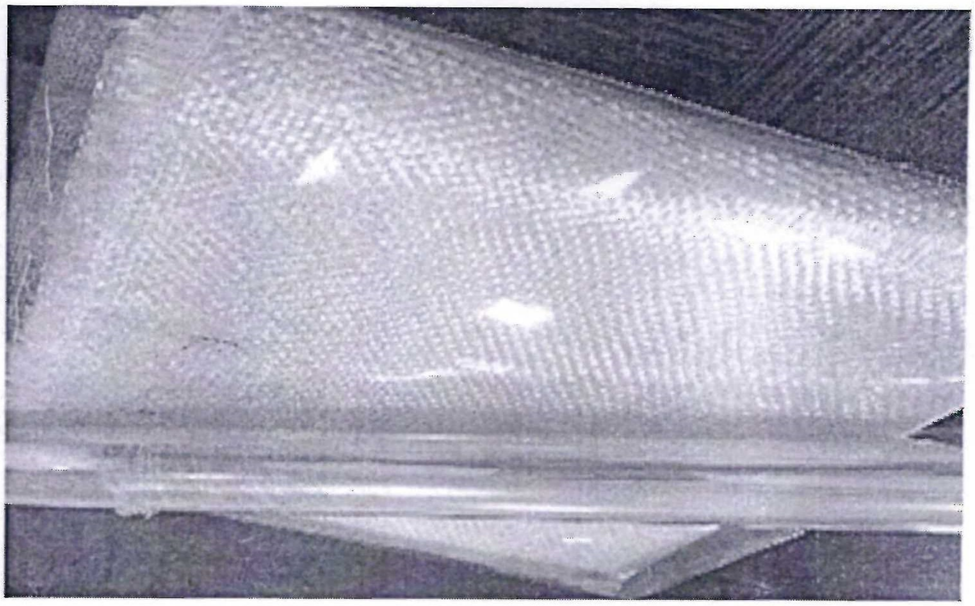


FIG:4.2 E-glass fiber

4.3 EPOXYRESIN (LY556) :

Epoxy resin, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resin may be reacted either with themselves though catalytic homopolymerisation, or with a wide range of co-reactants including poly-functional amines ,acids, phenols, alcohols and thiols.

These co-reactants are often referred to as hardness or curatives and the cross-linking reaction is commonly referred to as curing. Reaction of polyepoxides with themselves or with poly-functional hardeners forms a thermosetting polymers often with high mechanical properties, temperature and chemical resistance. Epoxy has a wide range of applications .Generally epoxy is mainly used as the binders between the fibers.

Properties of Epoxy:

- High adhesive strength
- Low curing contraction
- Good resistance to heat and chemicals.

Advantages of Epoxy:

- Better aqdhesive properties(the ability to bond the reinforcement
- Superior mechanical properties(particularly strength and stiffness)
- Improved resistance to fatigue and micro cracking.
- Reduced degradation from water ingress.

4.4 HARDENERHY951 :

Hardener is a registered trademark of Huntsman Advanced Materials (previously part of Ciba-Geigy) referring to their range of engineering and structural epoxy, acrylic, and polyurethane adhesives. The name was first used in 1946 for a two-part epoxy adhesive.Araldite adhesive sets by the interaction of a resin with a hardener. Heat is not necessary although warming will reduce the curing time and improve the strength of the bond. After curing, the joint is claimed to be impervious to boiling water and all common organic solvents. It is available in many different types of pack, the most common containing two different tubes, one each for the resin and the hardener. Other variations include double syringe-type packages which automatically measure equal parts. This type of dispensing is not exact, however, and also poses the problem of unintentional mixing of resin and hardener.A Research Limited (ARL), founded in the UK in 1934, developed a new synthetic-resin adhesive for bonding metals, glass, porcelain, china and other materials. The name "Araldite" recalls the ARL brand: Araldite.

De Trey Frères SA of Switzerland carried out the first production of epoxy resins.

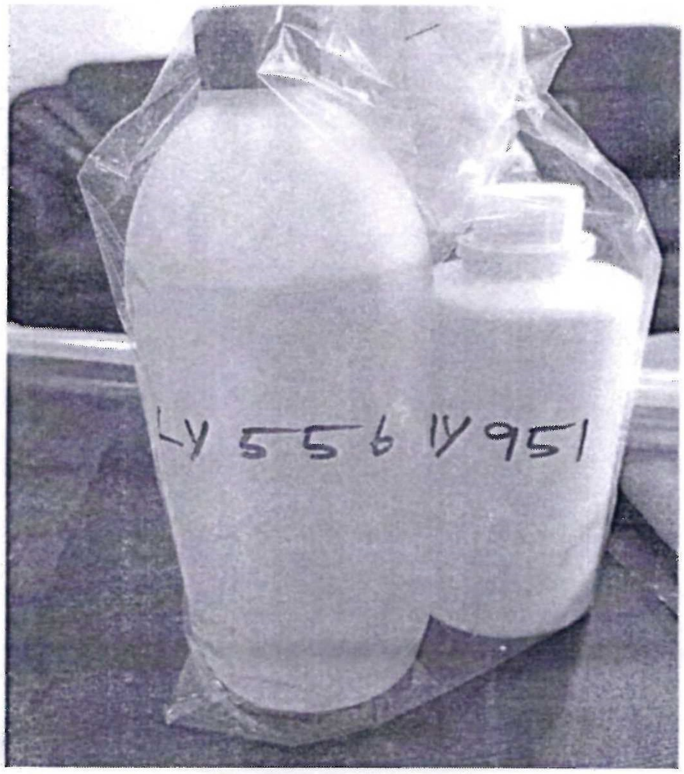


Fig 4.4 Hardener HY951 and Epoxy resin LY556

CHAPTER – 5

FABRICATION METHOD:

5.1Hand lay up Process:

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats are cut as per the mold size and placed at the surface of mold after perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardner (curing agent) and poured onto the surface of mat already placed in the mold. The polymer is uniformly spread with the help of brush. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed.The time of curing depends on type of polymer used for composite processing. For example, for epoxy based system, normal curing time at room temperature is 24-48 hours. This method is mainly suitable for thermosetting polymer based composites.

Fig :5.1 Hand lay up method

Applications:

1. Method is equally applicable for both thermosetting and thermoplastic polymer based composites.
2. A very wide application spectrum ranging from kitchen goods to automobiles, toys, electrical items and aeroplane parts.

Advantages:

1. Production rate is high as the mold cycle time is in few minutes.
2. Good surface finish with different texture and styling can be achieved.
3. High part uniformity is achieved with compression molding process.
4. Good flexibility in part design is possible.
5. Extra features like inserts, bosses and attachment can be molded in during the processing.
6. Raw material wastage is minimum.

CHAPTER – 6

DESCRIPTION OF TESTING

6.1 TENSILETEST:

Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is most commonly used for obtaining the mechanical characteristics of isotropic materials.

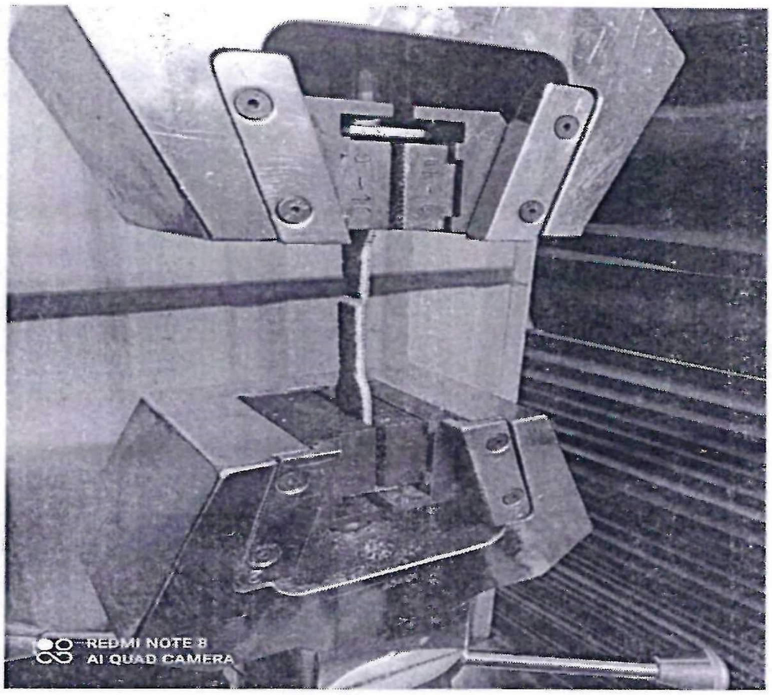


Fig6.1 UTM

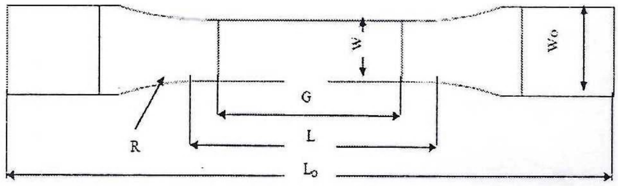
STANDARDS:

ASTM D638-W - Width of narrow section = 13mm

L - Length of narrow section=57mm

Wo - Width of overall= 24mm

Lo -Length overall= 165mm



G -Gauge length= 50mm

6.1.1 TESTING MATERIAL FOR TENSILE :

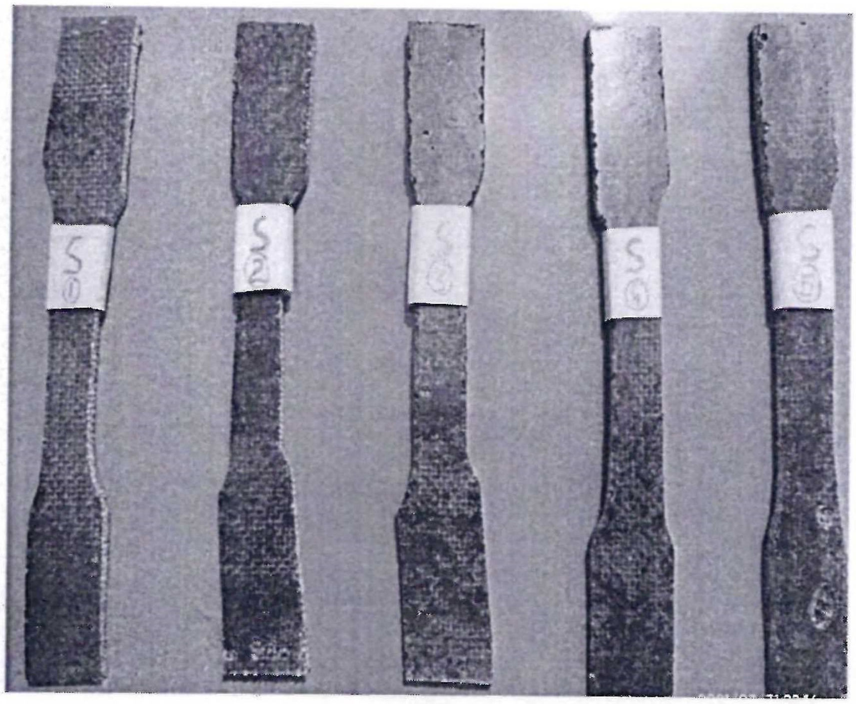


Fig 6.1.1 TENSILE SPECIMEN

6.2 IMPACT TESTING:

Impact testing is an ASTM standard method of determining the impact resistance of materials. A pivoting arm is raised to a specific height (constant potential energy) and then released. The arm swings down hitting a notched sample, breaking the specimen. The energy absorbed by the sample is calculated from the height the arm swings to after hitting the sample. A notched sample is generally used to determine impact energy and notch sensitivity.

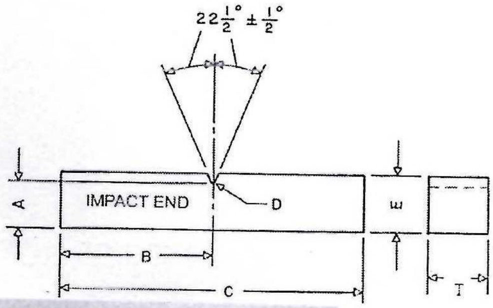
Fig 6.2 IMPACT TEST MACHINE

4.3.1 STANDARDS:

ASTM D256

A – 10.2mm, B – 31.8mm, C – 65.5mm,

D -0.3mm, E – 12.7mm, T – 3.2mm.



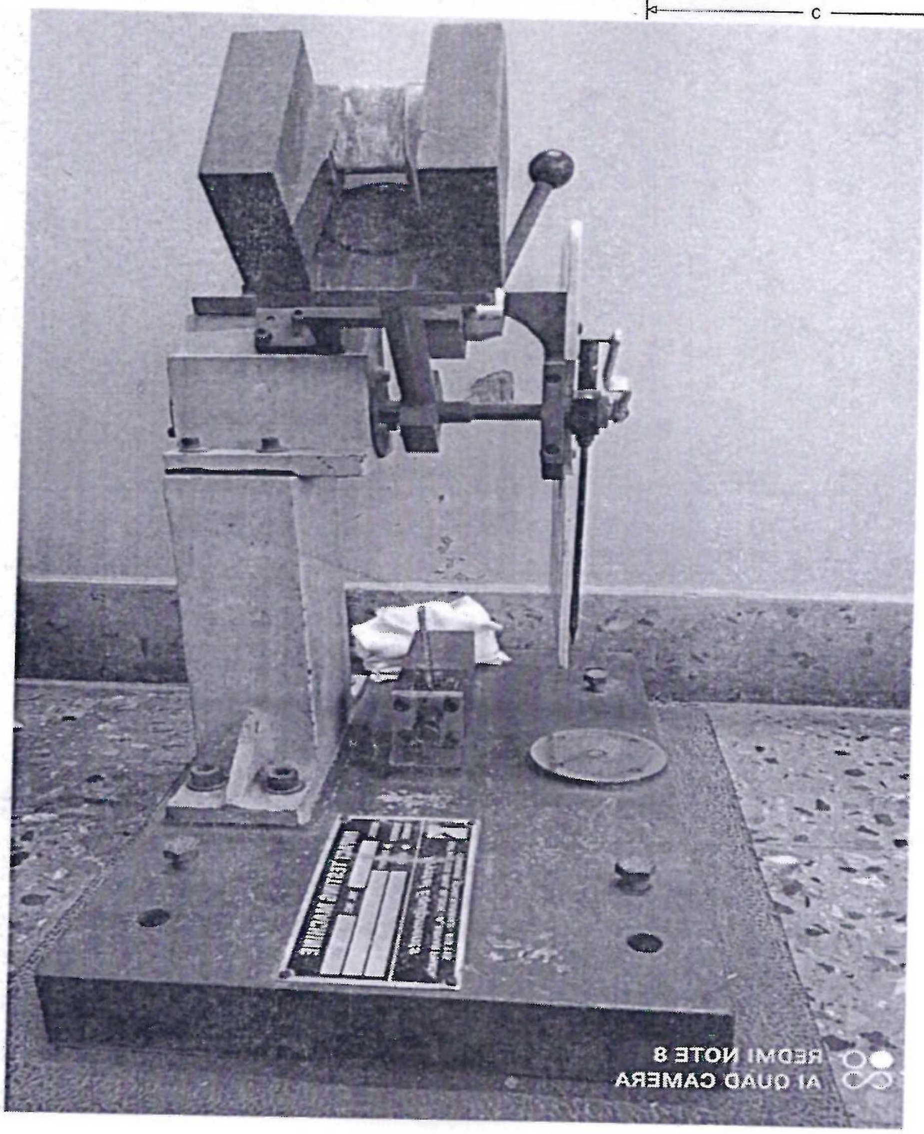


Fig 6.2.1 Impact specimen

6.2.1 Testing material for Impact :

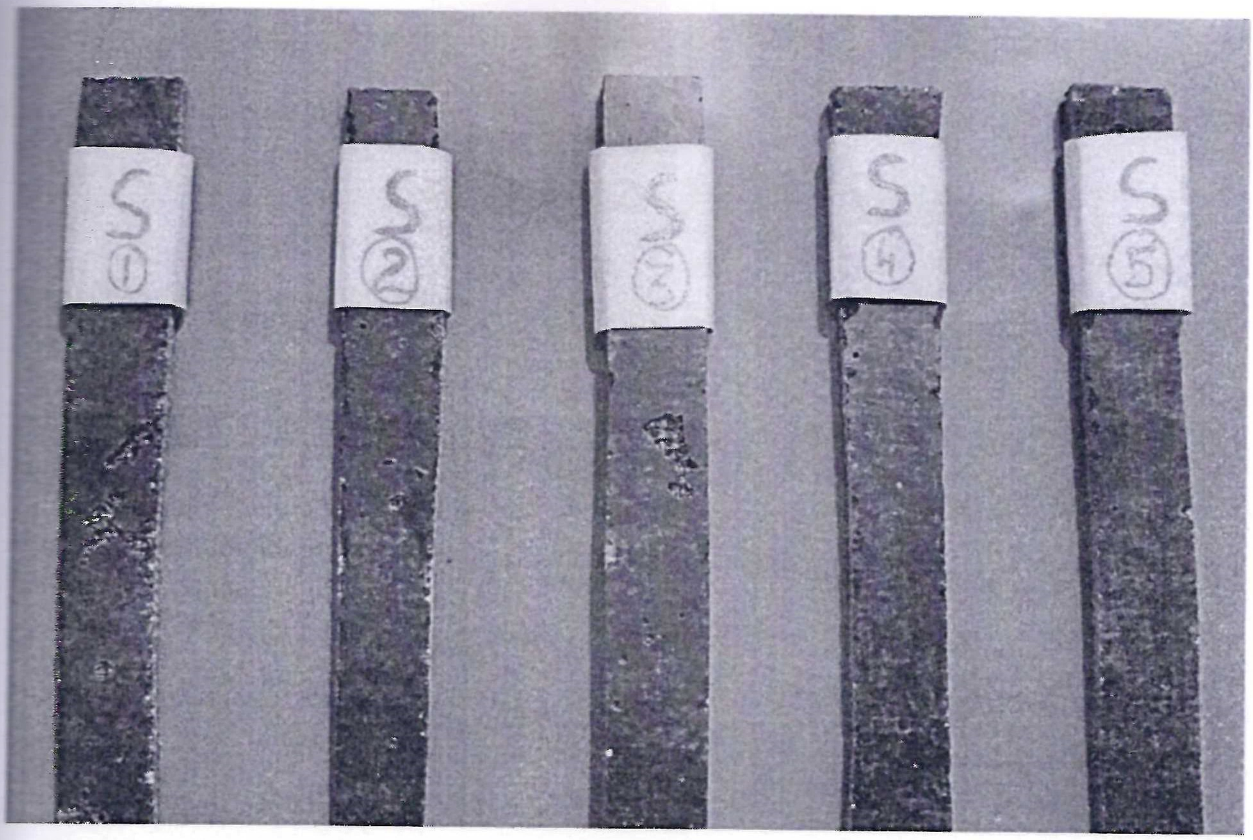
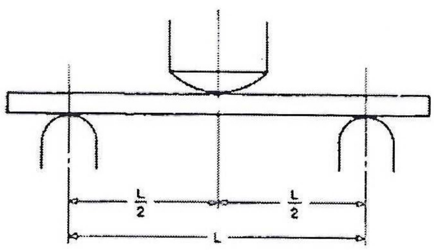


FIG 6.2.1 IMPACT SPECIMEN

6.3 FLUXURAL TEST :

This test is also called bend test with the suitable fixture as given in the specifications and subjected to flexural test. The Test is conducted in the universal testing machine in compression mode. The sample is kept on bendi8ng fixture and the compressive load is given under specified conditions and the curve generated till the failure of the sample takes place.

Fig 6.3FLEXURALTEST MACHINE



4.2.1Standards:

ASTM D790:.

W – Width of the specimen = 13mm

L – Distance between two rollers support = 50 mm

T – Thickness of specimen = 3mm

Total length of the specimen = 100 mm

Fig 6.3.1(a) Flexural test

6.3.1 TESTING MATERIAL FOR FLEXURAL :

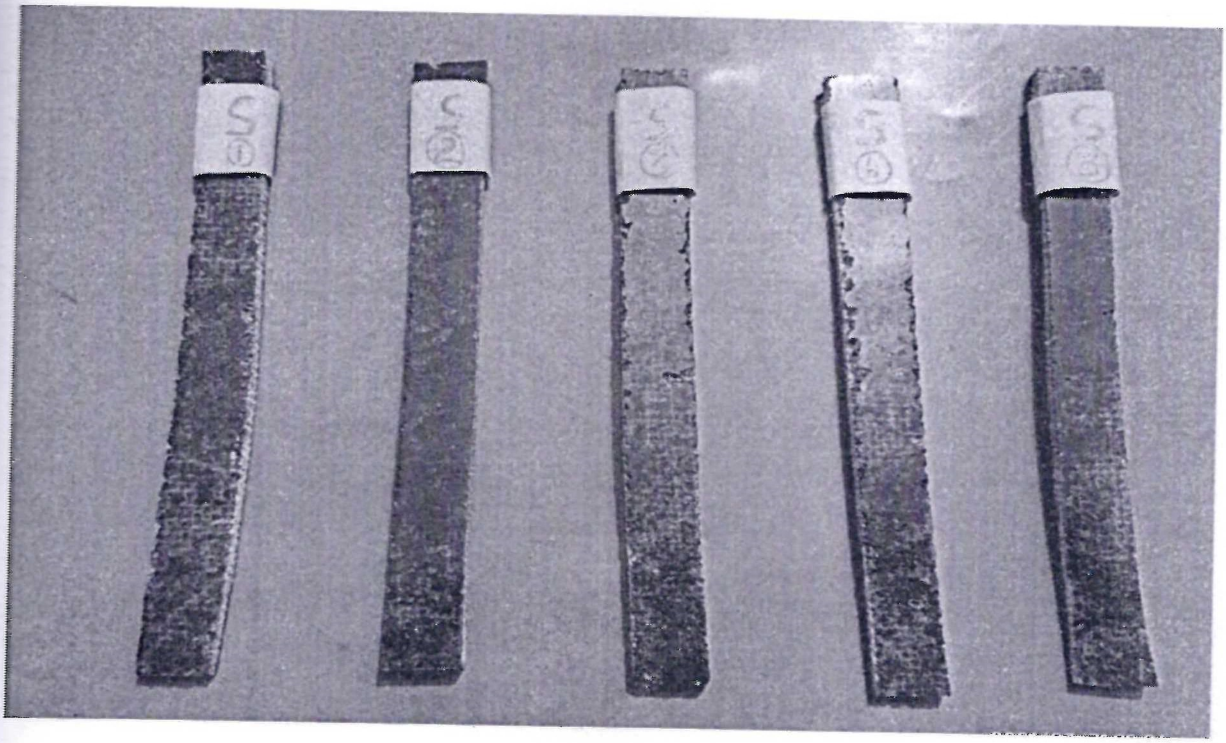


FIG 6.3.1 FLEXURAL SPECIMEN

CHAPTER - 7

TYPES OF COMPOSITION

No of samples	% of filler material(wood powder)	Composition
Sample-1	5%	J/J/E/E/J/J
Sample-2	10%	J/J/E/E/J/J

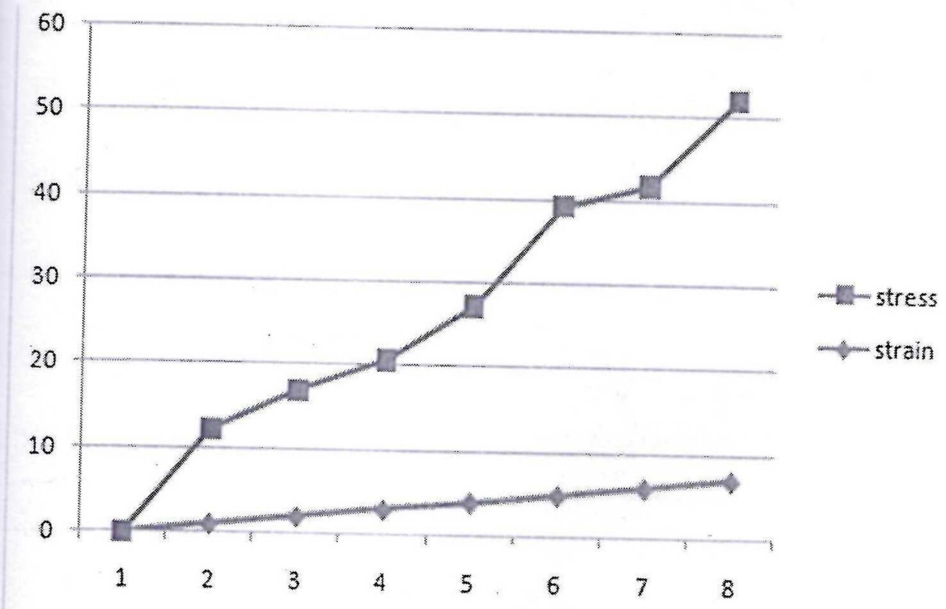
Sample-3	15%	J/J/E/E/J/J
Sample-4	20%	J/J/E/E/J/J
Sample-5	25%	J/J/E/E/J/J

TABLE 7.1 TYPES OF COMPOSITION

CHAPTER-8

Result and calculations:

Tensile result: Sample 1



Sample 2: