Fabrication & Characterisation of sisal /glass fiber as reinforcement epoxy hybrid composites

Dissertation -II

Submitted in partial fulfillment of the requirement for the award of degree

Of

Master of Technology

IN

MECHANICAL ENGINEERING

By

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TOPIC APPROVAL PERFORMA

School of Mechanical Engineering

Program : P17L::M.Tech. (Manufacturing Engineering) [Full Time]

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Supervisor Name : Kamlesh Kumar Mishra **UID :** 14703 **Designation :** Assistant Professor

Qualification : _____ **Research Experience :**_____

SR.NO.	NAME OF STUDENT	REGISTRATION NO	BATCH	SECTION	CONTACT NUMBER
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SPECIALIZATION AREA :Manufacturing Engineering **Supervisor Signature:** _____

PROPOSED TOPIC : Preparation of jute/green epoxy composites: Investigation of micro-structure and mechanical properties.

Qualitative Assessment of Proposed Topic by PAC		
Sr.No.	**Parameter**	**Rating (out of 10)**
1	Project Novelty: Potential of the project to create new knowledge	6.00
2	Project Feasibility: Project can be timely carried out in-house with low-cost and available resources in the University by the students.	5.00
3	Project Academic Inputs: Project topic is relevant and makes extensive use of academic inputs in UG program and serves as a culminating effort for core study area of the degree program.	5.00
4	Project Supervision: Project supervisor's is technically competent to guide students, resolve any issues, and impart necessary skills.	7.00
5	Social Applicability: Project work intends to solve a practical problem.	5.00
6	Future Scope: Project has potential to become basis of future research work, publication or patent.	6.00

PAC Co mittee Members		
PAC Member 1 Name: Ankur Bahl	UID: 11108	Recommended (Y/N): NA
PAC Member 2 Name: Jasvinder Singh	UID: 15854	Recommended (Y/N): NA
PAC Member 3 Name: Dr. Uday Krishna Ravella	UID: 18604	Recommended (Y/N): NA
PAC Member 4 Name: Anil Kumar	UID: 20296	Recommended (Y/N): NA
DAA Nominee Name: Kamal Hassan	UID: 17469	Recommended (Y/N): Yes

Final Topic Approved by PAC: Fabrication and characterization of sisal and glass fiber as a reinforced epoxy hybrid composite

Overall Remarks: Approved (with major changes)

PAC CHAIRPERSON Name: 12174::Gurpreet Singh Phull **Approval Date:** 14 Nov 2017

CERTIFICATE

I hereby certify that the work being presented in the dissertation entitled **"Fabrication and characterization of sisal/glass fiber reinforced epoxy hybrid composites"** in partial fulfillment of the requirement of the award of the Degree of master of technology and submitted to the Department of Mechanical Engineering of Lovely Professional University, Phagwara, is an authentic record of my own work carried out under the supervision of Mr Kamlesh Kumar Mishra Department of Mechanical Engineering, Lovely Professional University. The matter embodied in this dissertation has not been submitted in part or full to any other University or Institute for the award of any degree.

28 November, 2017

Gyan Shankar Pandey
Regd no. 11604552

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

28 November, 2017

Mr Kamlesh Kumar Mishra

COD (ME)

_____

the external viva-voce examination of the student was held on successfully _____

Signature of Examiner

ACKNOWLEDGEMENT

"The true method of knowledge is experiment."

— William Blake

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I would like to thank my parents who have supported in carrying on my studies and research work in this field. I am very obliged to them because without their support and motivation it would not be possible for me to reach at this extent.

(Gyan Shankar Pandey)

ABSTRACT

In the present study, the natural fiber polymer composite mix with the glass fiber, to enhance the mechanical property of composite. In this thesis, sisal and glass fiber will reinforce into the epoxy matrix. In present study acytelated sisal fiber use as a reinforce in the composite, to increase the interfacial bonding between reinforced and matrix material. Glass fiber is also used to enhance the mechanical property. In the study, two fixed layer of glass fibre with different weight percentage of sisal fiber (2%, 4%, 6%%, and 8%) will reinforce with epoxy matrix composite. And the mechanical property of all hybris composite will be studied, like tensile, flexural strength,impact strength and will analyse internal structure of hybrid composite with te help of SEM.

INDEX

LIST OF CONTENTS

1. INTRODUCTION:

1.1 General

Composite material also can be found in our households. E.g. concrete is made up of cement, sand, and gravel. It can also be reinforced with steel which improves around 10000BC the houses were made up of straw bricks, and then in around 4000BC the writing material was fabricated from the papyrus plant. The writing material was prepared in the form of laminates by arranging the fibers of the fabulous plant in a particular direction. Egyptians also made fibers by heat treating the glass material to very high temperature. In an around 1200BC Mongols develop the first modern composite bow. The bow was made from various materials such as wood, leather, bamboo, horn, antler and tendon. The horn and antler were used to make the main body of the bow because it has good flexibility. Tendon was used to adhere and cover the horn and antler. All the pieces are joined together to used glue which is obtained from the bladder of the fish. The string of the bow had made from horse hair, silk along with tendon. The bow was very powerful which shoot within a range of 1.5km.the modern composite can develop after world war-2 because the world war-2 was mostly fought with fighter planes, which requires material to be lightweight and strong. Therefore phenolic resin was used for the first time in the fighter planes by The British royal air force in its mosquito bomber aircraft. Further, the use of radar technology resulted in the development of glass fiber reinforced plastics which were used to make the covering of radar equipment. Modern-day the strength of concrete is high. Another example is wood which is made up of cellulose and lignin. Plywood is also a form of good composite used for making furniture. Our bone is also a composite material containing collagen fiber and hydroxyl appetite matrix.

1.2 COMPOSITE

Composite material is nothing but two or more constituent materials with different physical or chemical properties combine together to make a new material, but the individual material process individual properties. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

1.2.1 TYPES OF COMPOSITE

i. Fibrous Composite
ii. Laminated Composite
iii. Particulate Composite
iv. Hybrid Composite

1.2.1.1 Fibrous Composite

In fibrous composite is mainly consists of fiber as a reinforcement in the matrix. This fiber can be continues fiber or discontinues fiber. Long fibers in various forms are inherently much stiffer and stronger than the same material in the bulk form.

1.2.1.2 Laminated Composite

Laminated composite is mainly made up of at least two or more layer of different materials that are stuck together. These are mainly classified into three categories:

a) Bimetals

These are the laminates of two different metals that having different coefficient of thermal expansion.

b) Clad metals

These are the materials they combine the properties of two or more metals. In this process of cladding or sheathing, one metal is covered by another to obtain the best properties of both. E.g. Aluminum alloy

c) Fiberglass or safety glass

It is a layer of polyvinyl butyl which is a sandwich between two layers of glass. Therefore the brittle behavior of the material is reduced because of the plastic layer in between the layer..

1.2.1.3 Particulate Composite

It contains particles of metals or non-metals suspended in a matrix of another material which can be metallic or non-metallic depends on the particles and matrix which we used in the matrix. This is mainly classified into four types:

a) Non-metallic particle in a metallic matrix

b) Metallic particles in a non-metallic matrix
c) Metallic particles in a metallic matrix
d) Non-metallic particles in metallic matrix
e) Cremates

Examples:

a) Concrete, it's a particulate composite in which sand and gravel particles are combined with mixture of cement and water.

b) Aluminium paint in which Al-particles are suspended in polymer resin when aluminium paint is applied on a surface the Al-particles align themselves giving a good surface finish.

c) Lead particles used in copper alloys and steel to improve machinability.

d) Tool steels are generally made from a combination of oxide particles on metal matrix.

1.2.1.4 Hybrid Composite

In the case of concrete it has both particulate and fibrous. Concrete contains gravel in cement paste and because of steel reinforcement it is fibrous.

1.2.2 CLASSIFICATION OF COMPOSITE

Composite is classified based on the types of reinforcement and the types of matrix used.

1.2.2.1 Matrixes

Matrix acts as a binding agent and different types of matrixes are given below:

a) Polymer matrix
b) Metal matrix
c) Ceramics matrix
d) Carbon matrix

1. Polymer Matrix:The Polymer is defined as the substance which has a molecular structure made from a large number of similar units bonded together. These are mainly classified into two types:

- Thermoplastics Polymers: Thermoplastics are the material which has a linear and branch chain and this can be given different shape by reheating.
- Thermosetting Polymers: Thermosetting plastics are crossed linked chain polymers which has a property that once heated it forms a permanent shape by destroys their cross-linked structure

2. Metal matrixes: Metal matrixes are nothing but the metals which are used as matrixes. Metal matrixes are used where the conducting properties are required..

3. Ceramicmatrixes**:** Ceramic matrixes are the one which uses ceramics as matrix material. These are used where the heat resistant properties are required..

4. Carbon matrixes: Carbon matrixes are used along with the carbon fibers for higher temperature applications are required generally in the range of 1000°C to 2000°C.

1.2.2.2 Reinforcement

Reinforcement is the main load carrying constituent. It should have significantly higher properties in comparison to matrix because it carries most of the load.

1. Fiber reinforcement composite: The composite material which consists of fiber as the reinforcement here in this type of reinforcement's fiber will carry the total load and matrix materials play as binding agents

2. Whiskers: It is also a fiber but it is very short, stubby and rigid in nature when compared with fiber. These are single crystals having very short length

3. Flakes: Flakes are spheroid in shape and they can be packed more densely in comparison with fibers but because of surface defects flake reinforced composites have less strength.

1.3 GREEN COMPOSITE

This thesis report mainly deals with the green composite. The green composite is nothing but the composite material which is made up of green materials in the sense environment-friendly. In this case, it can be bio-degradable or non-bio degradable according to the matrix we are using.

Fiber reinforced polymers are very common especially in the engineering applications. But most of the normal composites are hazardous to the environment. There comes the application of green composite, in this the matrix as well as the fibers also bio-degradable. Most common fibers are plant fibers used to make a green composite. Because not only it

is environmental friendly but also no negative health hazard made this as very interesting now a days for the researchers. The beauty of green composite is it is very easy to fit into any size and shape according to the requirement and wide range applications. In the meantime, it is very difficult to find bio degradable resins and epoxy materials. This made a great interest in PLA (poly lactic acid), about this material it a fully bio degradable material and eco-friendly. The research has been going on this material and researchers have not found any health hazard about PLA .It is produced from lactic acid by fermentation process. PLA can be made from two methods, first is condensation and second is ring opening polymerization.

Talking more about PLA, it is a derived naturally from the starch. In this case, starch can be from any of the plants outcomes for example starch from potato, tapioca, rice, corn etc. But the most suitable material to make PLA is corn starch. The PLA which is made from corn starch is showing very good properties.

The synthesis of PLA from corn starch is shown below:
This is a short description of the process of the PLA in this we can easily identify the making process of the PLA. But in the further making of the Green composite with natural fibers along with PLA is still facing difficulties.

1.4 FIBERS AS REINFORCEMENT

In the case of fibers, we have many options but they are mainly classified into two types natural and synthetic a classification is given below fig 1.3. Talking about the fibers there are vast varieties are already available in the market as well as in some of the papers researchers tried to extract the fibers from the plants. This made an interest to think about a new direction to extract fiber from the Castor Plant. The methods which we used different molar values of NAOH solution and varied temperature this has given a positive feedback for the further processing. The jute fiber also has taken for consideration.

The classification has given a wide variety of options to work on it from that a few commonly used fibers are discussed below:
Types of fibers:
1. Natural fiber

2. Advanced fiber

1.4.1 Natural Fiber

It is again classified into three categories:

a) Plant (or) vegetable fibers
b) Animal fibers
c) Mineral fibers

1. Plant (or) Vegetable Fibers: Start with examples Cotton, Jute, Hemp, Raffia Palm, Maize/Corn, Abaca fiber, Kenaf fiber, Bamboo fiber, Sisal fiber, Banana, Kapok, Coir, flax, Sugar cane and Ramie fiber.

- Cotton: It is obtained from seeds of cotton plant and it contains cellulose. America is the largest exporter of cotton, while china is the largest producer. Worldwide production of cotton is 25 million tons per year. Cotton is used to make jeans, shirt, Towels, undergarments, Bed sheets etc. It has a density of 1.5µm. It contains 90% cellulose 8% water and the rest is combination of fatty substance and waxes.

- Jute fiber: It is produced from the phloem of the plant. It is used the second most commonly used fiber after cotton. It is 100% biodegradable and recyclable. It has high tensile strength and used for making Jute bags, Doormats etc.

- Hemp fiber: It is obtained from Cannabis plant. Hemp is refined into various products such as oil, wax, cloth, paper, fuel etc. It has properties similar to silk and is used to soil canvas.

- Abacas fiber: It is also known as Manila hemp, it is extracted from leaves and stem of Manila hemp plant. It is used for making ropes, tea bags, bank notes, filter paper etc. It is found in Philippines, Ecuador and Costa Rica. The above-given fibers except cotton fiber are the area of interest along with Castor plant for the research. The Castor plant is mostly available in India and India is the second largest producers in the world. This plant is most commonly used for extracting oil.

SCOPE OF THE STUDY

Many aerospace and marine based components are made from this hybrid composite which is made from sisal/glass fibres epoxy. Which can perform in vigorous conditions like in case of many mechanical action.

Also the ongoing demand of these hybrid composites in boards for partitions, celing and wall panel solid.

OBEJECTIVES OF THE STUDY

The main objective of this study is to make hybrid composite with he help of sisal/glass fiber reinforcement epoxy composite by hand-layup method. And to enhance mechanical properties. Because natural hybrid composites are renewable,ecofiendly etc.

2. LITERATURE REVIEW:

The use of material fibers in organic matrix materials is highly beneficial compare to unreinforced materials. natural fibers in organic matrix conduct good strength, toughness, light in weight, cheap, abundant and renewable. With the help of chemical and physical composition determined the physical properties of natural fibers. Many researchers worked on natural fibers and research is also going on nowadays.

G. Hemant Kumar et al. (2017) presented a paper on mechanical properties of glass and sugarcane fibers polymer matrix composite. First thing, they told about importance of chemical importance. Cause of chemical treatment, there is good bonding between in fibers and matrix. With the help of hand layup method, they prepared hybrid composite, and they determine impact test, flexural test and tensile test. They found that sugarcane has good flexible strength between compare to glass fibers. And also seen in case of impact test. And increase of weight fraction of silver fibers both flexible and impact strength will increase.

Tajvidi et al(2011**):** studied the effect of natural fibres of mechanical properties, they compose polypropylene with different-different natural fibres like rice hulls, kenaf fibres, wood flour and newsprint fibres. They found that natural fibres filled polyprolines behave more elastically compare to pure plastic.

M. Jawed et al (2010) presented a paper on the basis of oil palm empty food bunches and jute fibers with reinforced epoxy. They made hybrid composite with help of hand layup method. They conducted test and analyzed flexural strength, impact strength and with the help of SEM, they studied micro structures of fractures surface. They told that, the flexural strength of pure EFB composites slighter less than the hybrid composites. And pure jute composite has more strength compare to hybrid composites. In case of impact strength, the impact strength of hybrid composite is less than pure EFB composites.

So, it's cleared to say that natural fibers have good impact strength. And when the fractured surface was seen by SEM, then it was very smooth, and between fibers and matrix have poor bonding and some crack was also seen over there.

B Vijaya Ram Nath et al (2013): Presented a paper on analysis of mechanical properties of abaca-jute-glass fibre reinforced epoxy composite. And analysed tensile, flexural, shear and impact strength. And also analysed internal structure with the help of scanning

electron microscope. The tensile strength of jute composite less than mixture of abaca and jute composite. And compared with only abaca composite, the strength of abaca and jute composite is much more. And in case of flexural strength B. Vijaya et al found that composites are in increasing order jute composite, abaca and jute hybrid, abaca.

It means, we can say that jute composite has the lowest flexural strength. And flexural modules for abaca-jute-GFRP composite in case of double shear strength all three composites are approximately same.

In case of shier strength, jute and hybrid composite have less impact strength compare to abaca composite.

In case of internal structure with the help of scanning electron microscope they found that fibres orientation is important for mechanical properties. Abaca and jute fibres is cheaper compared to conventional natural fibres like sisal. And jute and abaca more mechanical properties compare to other conventional natural fibres.

Moe Moe et al(2011): published the paper on bamboo glass fibres. They made composite first mix of bamboo fibres reinforced PP matrix is none BFGP and bamboo-glass reinforced pp composite is known as BGRP.

In case of tensile strength, with increase of bamboo fibres content then tensile strength also increased slightly. And addition of MAPP both tensile and modules of BGRP is also increased. It means we can say that mechanical properties depend on fibres content and it's length and also depends on what adhesive is used.

BRAGA et al. (2015) published a paper on jute and glass fibres, with the help of epoxy resin, jute and glass fibres. They made hybrid composites. And they analysed density, tensile strength, flexural strength, flexural modules and impact strength. They found that increasing percentage of glass fibres increased tensile strength and flexural strength is approximately same. And in case of density, it will increase on increasing glass fibres content and decreasing percentage of jute fibres. It means that we can say addition of jute fibres and glass fibres in epoxy increases density, the impact strength, the tensile strength and flexural strength.

Asaithambi et al. (2014) published a paper on banana/sisal fibres reinforced polylactic acid. With the help of injection moulding method they made hybrid composite and also they told importance of heat treatment of fibres surface. It was seen that flexural strength and modules values are more for treated banana/sisal fibres compare untreated banana/sisal fibres. And also it was found that impact strength of untreated banana/sisal fibres is less than compared to treated banana/sisal fibres. In case of tensile strength, tensile strength is more for treated banana sisal fibres compared to untreated banana/sisal fibres.

Yeng-Fong Shih et al (2010) presented a paper on biodegradable green composites reinforced by the fibres recycling. In presence of MRDCF, for the biodegradable plastic (PLA), any increases the mechanical properties of reinforced materials.

Shrivastava et al. (2017) made hybrid composite with the help of coir, glass fibres and epoxy resin. they made hybrid composite by hand layup method. first of all chemical treatment was done of coir. they analysed internal bonding between fibres and matrix increased only causes of chemical treatment. and it removes -OH coating from the surface and make it rough. in case of natural fibres chemical treatment is done mainly with the help of Alkili. in case of tensile strength, it increased with increased weight percentage of coir fibres. and tensile strength is also depend on length of coir fibres. For 10 mm coir fibres, tensile properties is more compare to 15 mm coir fibres. And glass fibres is also effect the properties. It also increased the mechanical properties like tensile strength, flexural strength and impact strength.

Jawaid et al (2017) made hybrid composite with the help of oil palm empty fruit bunches, jute fibres and epoxy. They analysed impact strength, flexural strength, internal structure of hybrid composite with the help of scanning electron microscope. Due to natural fibres, hybrid composites have good mechanical properties and also it's eco-friendly. In case of flexural strength, pure empty fruit bunches have less strength compared to hybrid composite, pure jute composite have more flexural strength compared to hybrid composites. Hybridization was done between jute and oil palm in 1:4. Due to hybridization internal bonding was good of hybrid composites. And in case of impact strength, hybrid composite has less impact strength compare to pure EFB composites. It mean we can say that natural fibres have more impact strength. And the internal structures was analysed by scanning electron microscope. It was seen that hybrid composites have

smooth surface of impact fractured and in case of fibres it was seen that after fracture their internal structure have poor interaction between matrix and fibres. Halder et al (2017) presented a paper with the help of sisal-epoxy and aluminium powder. with the help of hand-layup method and compression moulding process, they composed two composites. first one is without aluminium powder and another is with aluminium powder. They analysed mechanical properties like density, impact strength, tensile strength and micro hardness. With the help of hand layup method, they made hybrid composites. It is discovered that sisal epoxy composites with aluminium powder indicates more thickness than plane one. Since aluminium powder has less void substance than the plane one.

Raj Kumar et al (2014) presented a paper. They made hybrid composite from silk and fibres setup by hard forming system utilizing propylene as matrix minerals. It was concluded that the tensile flexural and impact properties is higher with more percentage of silk and polypropylene. It was discovered that they warm conductivity of composite was low at higher silk and fibres strands constant. The silk/wool mixture fibres of fibres polypropylene were observed to be light in weight and would be wise to mechanical properties.

Kumar et al (2016) presented the paper and checked mechanical properties of woven alovera, sisal, kenaf. They discovered that sisal-kenaf mix gives elastic properties. And alovera-kenaf shows better flexural properties. And alover-sisal kenaf shows good impact strength.

A Shahzad et al (2017) made hybrid composites with the help of fibres, synthetic fibres reinforcement. It was discovered that, with increasing of synthetic fibres the mechanical properties will increase of hybrid composites at a certain level. Fatigue sensitivity increase with content of higher natural fibres.

J. Znang et al (2016) made hybrid composite with the help of hand layup method using glass-carbon fibres. It is demonstrated that hybrid composite with 50% carbon fibres give the best flexural properties. And another composite which is made from carbon glass gives higher compressive strength. This hybrid composite contains light-weight structural properties.

Jawaid et al (2011))made hybrid composite with the help of oil palm empty fruit bunches, jute fibres and epoxy. They analysed impact strength, flexural strength, internal

structure of hybrid composite with the help of scanning electron microscope. Due to natural fibres, hybrid composites have good mechanical properties and also it's eco-friendly. In case of flexural strength, pure empty fruit bunches have less strength compared to hybrid composite, pure jute composite have more flexural strength compared to hybrid composites. Hybridization was done between jute and oil palm in 1:4. Due to hybridization internal bonding was good of hybrid composites. And in case of impact strength, hybrid composite has less impact strength compare to pure EFB composites. It mean we can say that natural fibres have more impact strength. And the internal structures was analysed by scanning electron microscope. It was seen that hybrid composites have smooth surface of impact fractured and in case of fibres it was seen that after fracture their internal structure have poor interaction between matrix and fibres.

Khanam et al (2011) worked on sisal fibres reinforced polymer composites. They made composites with the help of hand layup method. Chemically treated sisal fibres show higher tensile flexural strength. Bonding is increased of sisal fibres due to chemically treatment.

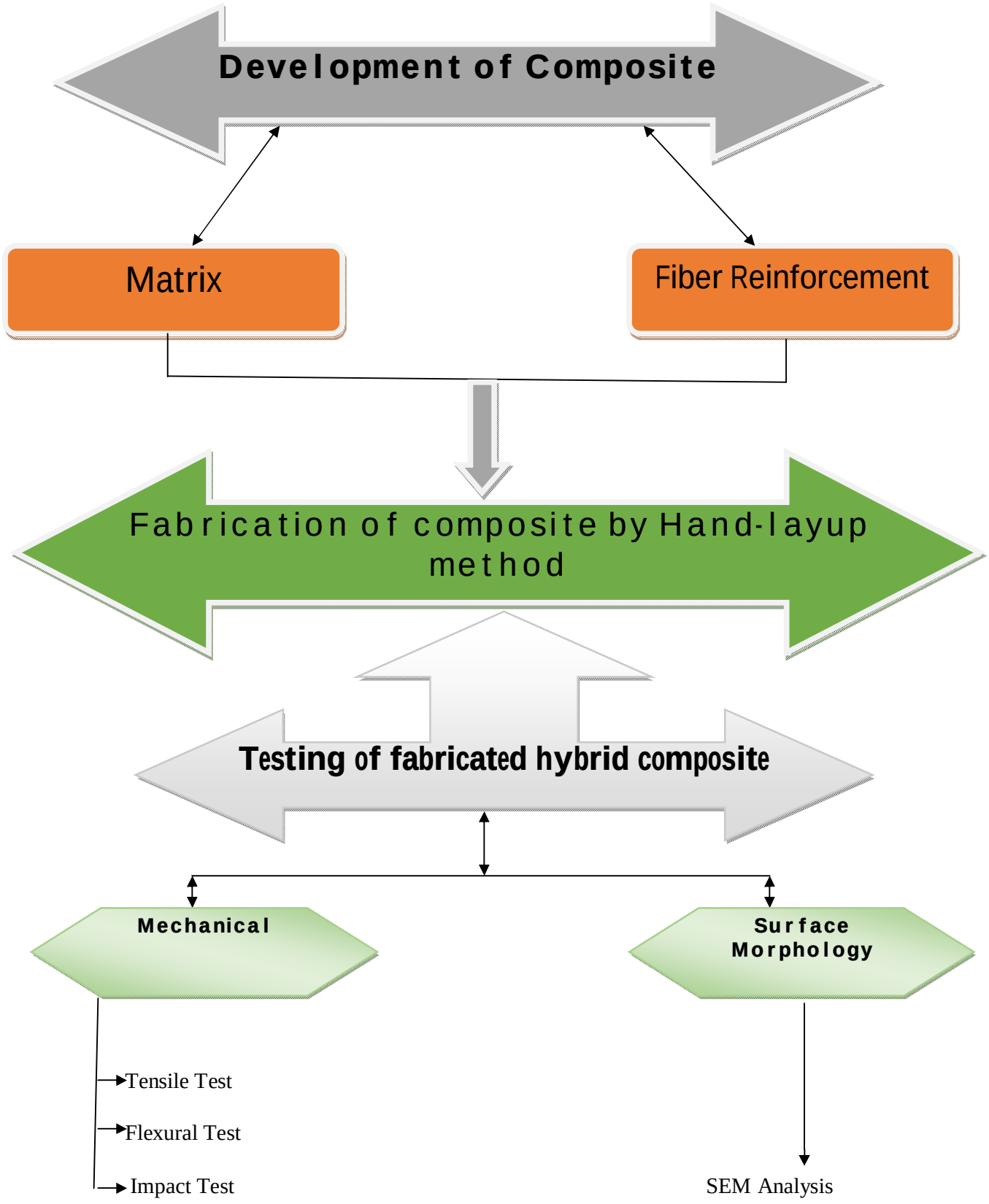
M Sexena et al (2011) presented a paper on bio composites. Sisal fibres contain many mechanical properties like high stiffness, light weight, biodegradable and renewable. Sisal fibres contains high moisture. It is used automobile industry, aerospace etc.

Athijayamani et al (2010) presented a paper on natural fibres reinforced composites. They analysed mechanical properties. The tensile and flexural strength are not depend on sisal fibres, It's depends on mainly on the content of roselle fibres and its length. Sisal also effected the impact strength. With increasing fibres length and content impact strength is decreased. It's cleared to say that with increasing fibres length and content increased tensile and flexural strength and decrease impact strength.

A Chaudhary et al (2011) presented a paper on banana and bagasse-silica-glass fibres. They made hybrid composite and checked mechanical properties. It was seen that mixing of banana and bagasse shows good strength with different weight percentage.

Carlo Santulli et al (2016) presented a paper. They made hybrid composite with glass-plant fibres. And they told importance of chemical treatment. Chemically treated natural fibres show good mechanical properties compared to untreated chemically natural fibres.

3. RESEARCH METHODOLOGY



Mechanical testing

Tensile test

ASTM D3039 standards are used for tensile testing of the samples. Tensile Tests will performe on a universal testing machine, INSTRON 3382 with load capacity of 100kN. Specimen

Flexural test

ASTM D3039 standards are used for flexural testing of the samples. flexural Tests will performe on a universal testing machine, INSTRON 3382 with load capacity of 100kN

Impact test

For analyzing the impact strength of hybrid composite Izod test will use for impact testing. The samples clamped into the tester will hit by a pendulum, release from a height. Dial indicator attache to the pendulum rod directly shows the impact strength.

Surface morphology

SEM Analyses

it is electron scanning microscopewith the help of this we will see internal structure of fabricated composites.

7. PROPOSED WORKPLAN:

The materials have been ordered right now and will arrive by mid-December.

The experimental work will be started from first week of January and will end with results in two weeks.

8. EXPECTED OUTCOME:

Present study and experiment work will show that successful fabrication of sisal /glass fiber reinforced epoxy hybrid composite. Proper homogeneous mixing of sisal, glass fiber with epoxy composite also very important in fabrication of hybrid composite otherwise some non-uniformity will occur like air trapped between it or porosity. It will be seen that the property like tensile, flexural, impact will increase at some certain composition of hybrid composite.

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