EXPERIMENTAL INVESTIGATION OF HYBRID EPOXY COMPOSITES WITH COCONUT FIBER, BAMBOO FIBER & PLASTIC PARTICULATES

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ABSTRACT

Although plastic is one of the materials that is used the most in the world today, it seriously pollutes the environment and fills landfills to capacity. Plastic garbage may be recycled to recover material that can be used to create new plastic goods including particle boards, plastic lumber, and containers. In order for this to occur, the waste plastic will first be broken down into tiny pieces so that it may be transported and processed further. The vast amounts of these plastic categories that are now on the market will eventually end up in landfills. Because of its high waste generation, lack of biodegradability, and rapid depletion of natural resources owing to its short life cycle, this is causing difficulties with waste products and increasing the quantity of material used in manufacturing.We are creating this project model to recycle plastic garbage from homes, businesses, and other areas where there is a lot of plastic waste. The act of gathering, sorting, processing, and reusing plastic waste items that would otherwise become solid trash is known as plastic recycling or reprocessing. A waste plastic shredder is a device that crushes old plastic bottles into smaller pieces so they may be more easily transported and utilized to create new products. With the use of a plastic shedding machine, we can determine that plastic is shredded; for this reason, we also develop and produce plastic shredder machines.

Key words: Mechanical properties, epoxy, hybrid composites, and plastic shredder

I. INTRODUCTION:

1. Plastic Shredder Machine

1.1 shredder machine

Although plastic is one of the materials that is used the most in the world today, it seriously pollutes the environment and fills landfills to capacity. Plastic garbage may be recycled to recover material that can be used to create new plastic goods including particle boards, plastic lumber, and containers. In order for this to occur, the waste plastic will first be broken down into tiny pieces so that it may be transported and processed further. The feeding unit, the shredding unit, the machine frame, and the power transmission unit are all part of the shredder.

The machine's performance was assessed, and test results revealed a linear relationship with all variable parameters (shredding time (t), specific mechanical energy (sme), throughput (tp), and recovery efficiency (re)) as well as the variable operation speeds. The machine speed also showed a correlation with a regression less than 1. The machine has a throughput of 27.3 kg/hr and an efficiency of 53% for all plastic types and 95% for polyvinyl chloride types. The equipment is easy to use, and at the time of fabrication, the expected cost of manufacturing a single unit was about, making it reasonably priced for small and medium-sized waste plastic recycling company owners to purchase.

Since its invention more than a century ago, plastic has grown to be an indispensable component of our daily lives. It is among the materials that are utilized the most often in the modern world. They are divided into five main groups: low density polyethylene (ldpe), polyvinyl chloride (pvc), polypropylene (pp), high density polyethylene (hdpe), and polyethylene terephthalate (pet). The vast amounts of these plastic categories that are now on the market will eventually end up in landfills. This is causing issues with waste products because of how much garbage it produces, how biodegradable it is, how quickly natural resources are being depleted because of how short its life cycle is, and how much more material is needed to produce it.

Plastic bottles account for 11% of waste in landfills, which has detrimental effects on the environment. Over 60% of the world's municipal solid waste (MSW) is made up of plastic garbage, of which 22%

is recovered and 78% is disposed of. In the United States, plastic garbage accounted for 11.8% of the 246 million tons of municipal solid waste produced in 2005. Nearly all US states, including Michigan, have recycling rates close to 100%. In Brazil, recycling potential has been enhanced to the point that 15% of all plastics used are recycled and used again in industry. Numerous studies on the problems with solid waste in Nigeria have been conducted locally as well as for Nigerian cities and municipalities. India and Africa in general, although there is currently little research being done on plastic garbage in Nigerian cities and towns. Nigeria and other developing nations must purchase virgin plastic at a high cost since recycling rates are often poor in these nations.

The obstacles associated with recycling efforts in these nations stem from the large and expensive machinery that is often available for recycling purposes. In order to overcome these obstacles, a low-cost waste plastic shredding machine that is simple to run and requires little expertise on the part of low- to medium-income earners has to be developed utilizing locally accessible materials. This will get the recycled plastic ready for use in Nigerian product manufacturing. The process of collecting, sorting, processing, and reusing plastic waste materials that would otherwise become solid trash is known as plastic recycling or reprocessing.

A waste plastic shredder is a device that crushes old plastic bottles into smaller pieces so they may be more easily transported and utilized to create new products. The idea for this machine's design came from the long-standing custom of using scissors to cut items into smaller pieces and scratching, which rabbits use for ripping or burrowing. By creating cutting blades to cut waste plastic and some with sharp, curved edges to attract plastic into the cutting blades' teeth, these two conventional ways were included into the machine's design. The feeding unit, the shredding unit, the power unit, and the machine frame are the four main parts of the waste plastic shredder. A 10 horsepower electric motor may power the device.

1.2 machine description and operation:

The feeding unit, the shredding unit, the power unit, and the machine frame are the four basic parts of the waste plastic shredder. The feeding unit, which feeds waste plastic into the shredding machine, is constructed from 16-gauge mild steel sheet with a 9 mm thick plate diameter of 200 mm by 550 mm. The discarded plastic is broken into smaller pieces in the shredding device. The unit is composed of a 200 mm diameter cylinder measuring 55 mm in length and a 50 mm shaft composed of 30 mm mild steel rod. Cutter shafts consisting of 12 mm mild steel with nine serrated teeth spaced two millimeters apart are attached to the shaft. The cylinder is equipped with identical, sharp-edged blades for shredding used plastic. The shredding unit's 16-gauge mild steel outlet is located below it. Through the outlet, the shred waste plastic exits the shredding equipment freely. The device is driven by a 10-hp electric motor via a belt and pulley system, with a driven pulley of 110 mm in diameter and a driver pulley measuring 60 mm.

1.3 design consideration:

The recycled plastic waste shredding machine's design took a number of aspects into account, including power requirements, compactness, convenience of use, safety, and total production costs. The choice of materials was also influenced by factors such as cost, availability, durability, and convenience of production.

Machine components:

Volume of the hopper = area of cross-section of the hopper × width of hopper= ½ (a + b) h × width…

Volume of pet bottle (coca cola) in the shredding chamber:

No of bottle to fill the hopper = volume of hopper/ volume of pet bottle

Volume of pet bottle (coca-cola bottle) =

$$\text{Area} \times \text{height} = \frac{\pi d^2}{4} \times h \ldots(2)$$

Determination of shaft diameter

$$d^3 = \frac{16}{\pi\tau}\sqrt{(k_b m_b)^2 + (k_t m_t)^2} \ldots (3)$$

hall et al.

Where,

D = diameter of the shaft = 30 mm

t = allowable shear stress of metal with key way = 40 × 106 n/m^2

Mb = maximum bending moment = 25.61 nm

Mt = torsion moment = 22.3 n

Kb = combined shock and fatigue factor applied to bending moment = 2.0 (sudden loading)

Kt = combined shock and fatigue factor applied to tensional moment = 2.0 (sudden loading)

1.4 performance evaluation procedure:

One kilogram (1 kg) each of the four different plastic types (polyethylene terephthalate (pet), the high density polyethylene (hdpe), the polyvinylchloride (pvc) and the polypropylene (pp) were shredded at varied motor speed using 10 hp three-phase electric motor as the prime mover.

the shredded waste plastic, q, was weighed to determine the quantity of the actual shredded waste plastic before sieving into three different sizes in order to determine their average size and area using excel 2014. The shredding time (t), the specific mechanical energy (sme), throughput (tp) and recovery efficiency (re) of the machine were also determined using the relationship below:

Specific mechanical energy = power (p) × time (t)

Output mass (q)

Throughput (tp)=output mass of recycled waste plastic (q)

Time taken for recycling (t)

Recycling efficiency (re)= output mass of recycled waste plastic (q) × 100

II. INTRODUCTION OF COMPOSITES

2.1 composites:

The ideas of composites materials is not a new or recent one. Nature is full of examples where in the idea of composite materials is used. The coconut palm leaf, for example, is nothing but a cantilever using the concept of fiber reinforcement. Wood is a fibrous composite: cellulose fibers' in a lignin matrix. The cellulose fibers have high tensile strength but are very flexible (i.e. Low stiffness), while the lignin matrix joins the fibres' and furnishes the stiffness. Bone is yet another example of a natural composites that supports the weight of various members of the body. It consists of short and short collagen fibers embed in a mineral matrix called apatite. In addition to these naturally occurring composites, there are many other engineering materials that are composites in a very general way and that have been in use for very long time. The carbon black in rubber, portland cement or asphalt mixed with sand, and glass fibers in resin are common examples. Thus, we see that the idea of composite materials is not that recent. Nevertheless, one can safely mark the origin of the distinct discipline of the composites materials as the beginning of the 1960s. It would not be too much off mark to say that a concerted research and development effort in composite materials began in 1965. Since the early 1960s, there has been an increasing demand for materials that are stiffer and stronger yet lighter in fields as diverse as aerospace, energy and civil constructions. The demands made on materials for better overall performance are so great and diverse that no one material can satisfy them. This naturally led to a resurgence of the ancient concept of combining different materials in an integral-composite material to satisfy the user requirement. Such composites material system results in a performance unattainable by the individual constituents, and they offer the great advantage of a flexible design; that is, one can, in principle tailor make the material as per specifications of optimum deign.

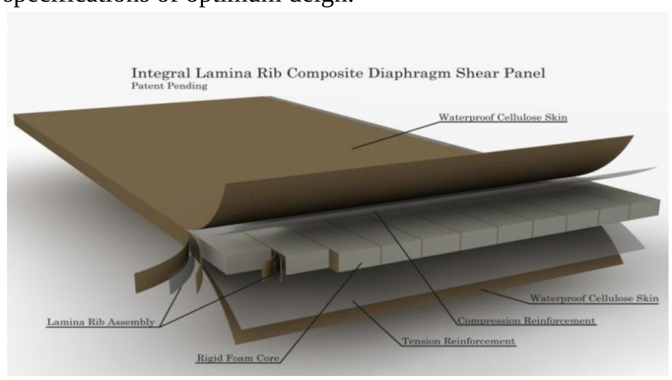


fig:1 hybrid epoxy composite

2.2 preparation methods:

Hand lay-up technique:

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 hardener (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 schematic of hand lay-up is shown in figure 1. 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. Capital and infrastructural requirement is less as compared to other methods. Production rate is less and high volume fraction of reinforcement is difficult to achieve in the processed composites. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, dias board, deck etc. Generally, the materials used to develop composites through hand lay-up method

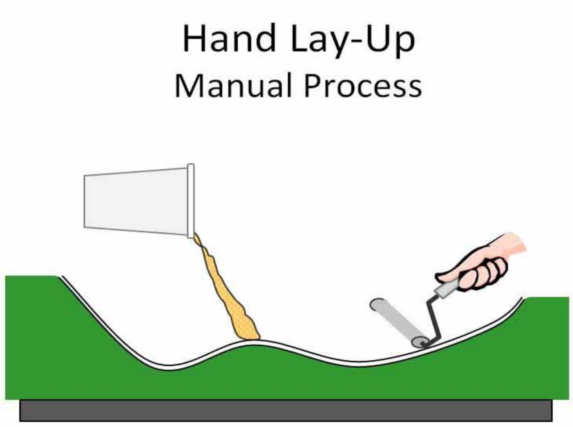


Fig:2.handmade lay-up process

Epoxy resin

Epoxy resins are formed from a long chain molecular structure similar to vinylester with reactive sites at either end. In the epoxy resin, however, they these reactive sites are formed by epoxy groups instead of ester groups, the absence of ester groups means that the epoxy resin has particularly good water resistance. The epoxy molecule also contains two ring groups and at its center 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 resistant properties.

Epoxies differ from polyester resin in that are cured by a hardener rather than a catalyst. The hardener , often an amine, is used to cured the epoxy by an addition reaction where both materials take place in the chemaical reaction.

density	1.35 g/cc
young's modulus	3200 mpa
poisson's ratio	0.35

design of plastic shredder blade:

Properties and specifications of plastic shredder blade:

- Type of material = en31 material
- Diameter of blade = 80 mm
- Thickness of blade = 10 mm
- Height of blade = 120 mm
- Thermal conductivity = 46 w/m k
- Chemical composition = c (0.25—29%),cu (0.20%), fe (98%), m n (1.03%)
- Melting point = 2570 degree fahrenheit
- Impact strength = 31 j
- Ultimate tensile strength = 841 m pa
- Specific gravity = 7.75 – 8.05 gm/cm3

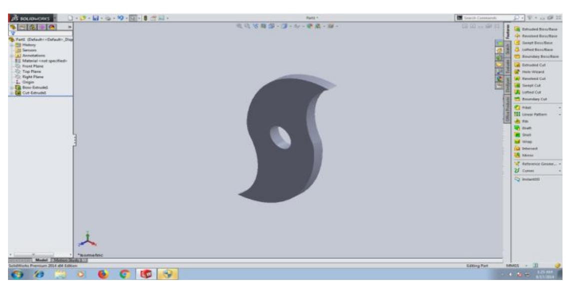


Fig: 3. plastic shredder machine cutting blade

Design of plastic shredder box (mechanism holding head box):

Properties and specifications of plastic shredder box (mechanism holding head box):

- Type of material = mild steel
- Diameter of hole = 25 mm
- Thickness of box = 10 mm
- Width of box = 200 mm
- Length of box = 380mm
- Impact strength = 31 j
- Ultimate tensile strength = 290 m pa

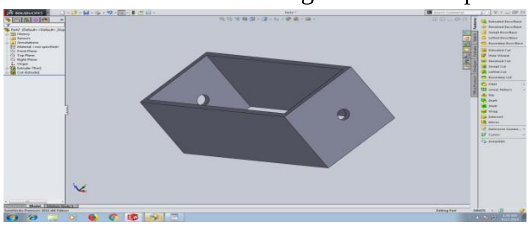


Fig: 4. design of plastic shredder box (mechanism holding head box):

design of pulley:

Specifications and properties of pulley:

- Type of material = aluminum
- Diameter of pulley = 50 mm (inside diameter)
- Ultimate tensile strength = 290 m pa
- Specific heat = 0.900 j/ gm k

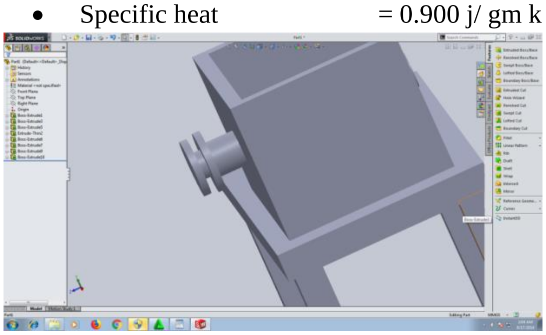


Fig:5. pulley

Design of electrical motor

Specifications of electrical motor:

- Speed = 1440 rpm
- Single phase motor
- Power = 230v
- Foot mounted
- Psc = 2.5amps
- 90s frame
- Aluminum body
- Model = 710
- Sakthi industries,coimbatore

specification of resins and hardner**:**

Type of material	**Property**	**Specification**	**Units**
Araldite ly 556 resin	Viscosity (at 25 degree centigrade)	10000 - 12000	M pa. S
Araldite ly 556 resin	Density (at 25 degree centigrade)	1.15-1.20	Gm/cc
Araldite ly 556 resin	Flash point	>200	C
Aradur hy 951 hardener	Viscosity (at 25 degree centigrade)	10-20	M pa. S
Aradur hy 951 hardener	Density (at 25 degree centigrade)	0.97-0.99	Gm/cc
Aradur hy 951 hardener	Flash point	>180	C

III. WEIGHT FRACTION OF THE FIBER:

The weight of the matrix was calculated by multiplying density of the matrix and the volume. Corresponding to the weight of the matrix the specified weight percentage of fibers is taken. For hybrid combination weight of fiber obtained is shared by two natural fibers

Volume ratio;

Fiber = 30%

Resin = 50%

Plastic = 20%

Volume of resin = 210x0.5 = 105g
Volume of plastic = 196.98x0.2 = 39.396g
Volume of fiber = 193.6x0.3 = 58.086g
Density of resin = 1.2g/cc
Density of fiber = 10g/cc
Density of plastic = 0.92g/cc
weight of the fiber = density of the fiber x volume of the mould
Weight of the fiber = volume of the fiber x density of the fiber
= 58.086 x 10
= 580.86 g
Weight of the resin = volume of resin x density of resin
= 105 x 1.2
= 126g
Weight of the plastic = volume of plastic x density of plastic
= 39.396 x 0.92
Weight of the plastic = 36.24456g
Density of composite = volume of fiber x density of the fiber = (0.3x58.086) + (0.5x1.2)
= 18.018g

Flexural test:

Flexural test is also known as bending test and consists in applying a point load at the center of composites material specimen. The flexural tests were done on the universal testing machine according to astmd790 with the crosshead speed of 10 mm/min. According to the astmd790 standard the dimensions of specimen used are shows the flexural testing astdm-d790 size of (100x12.5x10) machine with specimen.

$$\text{Flexural stress} = 3pl/2bd^2$$

Where;

p = brake load
b = width of specimens (mm)
d = thickness of the specimen

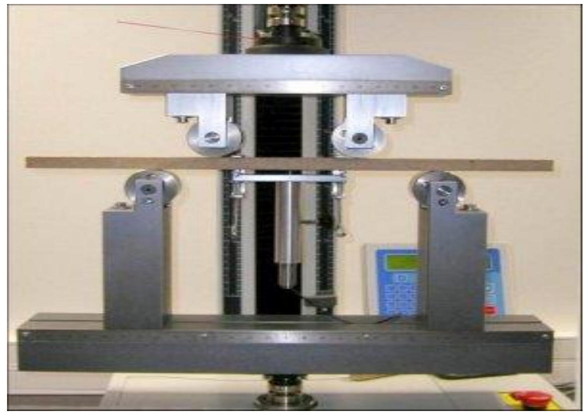


Fig: 6. flexural testing machine

tensile test:

The tensile test specimen is prepared according to the astm d6368 standard and the machine specifications are also chosen according to the astm d6368.

IV. RESULTS AND DISCUSSIONS

4.1 mechanical characteristics of composites:

The usage of natural fiber reinforced hybrid composites in different fields like aerospace, automobiles and other light weight applications has been increasing day by day due to their improved properties. In this part the investigation of the mechanical properties of reinforced hybrid composites of long continuous of different fiber weight fractions and their influence on the mechanical properties is carried out. The mechanical tests performed on the samples are:

A. Impact test
B. Flexural test

Results of mechanical properties of hybrid composites:

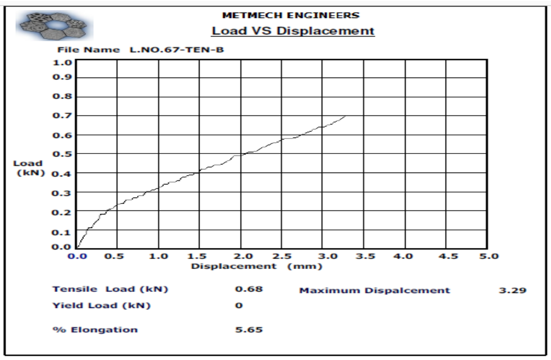
Table4.1: tensile properties of coconut fiber/ plastic hybrid composites

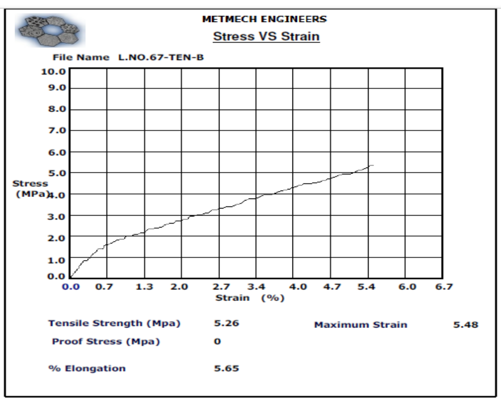
orientation	maximum strain (mpa)	% elongation	Tensile strength (mpa)
90^0	117.7	118.7	56.3

Table4.2: tensile properties of coconut fiber and bamboo / plastic hybrid composites

% weight fraction (p/b)	orientation	maximum strain (mpa)	% elongation	Tensile strength (mpa)
40/60	90^0	54.8	56.5	52.6

Tensile test graphs generated directly from computer





Comparison graphs of tensile test

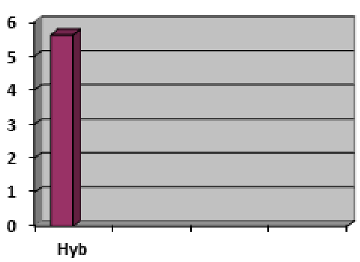


Fig:7. graph of tensile strength of 90^0 orientation fibers with coconut fiber / plastic

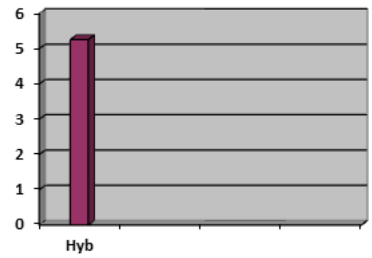
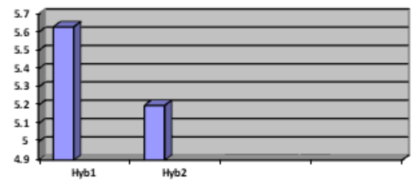


Fig:8. graph of tensile strength of 90^0 orientation fibers with coconut fiber and bamboo / plastic

Combination of both graphs:



From shows the tensile strength behavior of various composites with 40/60 weight fractions. It can be observed that tensile properties of coconut fiber / plastic hybrid composites shows a tensile strength of 5.63 mpa and tensile properties of coconut fiber and bamboo / plastic hybrid composites shows a tensile strength of 5.21 mpa respectively in 90^0orientation . Which is high when compared other fiber like banana and pine apple

Table4.3: flexural properties of coconut fiber/ plastic hybrid composites

% weight fraction (p/b)	Orientation	brake load (n)	flexural strength
40/60	90^0	540.000	575

table4.4: flexural properties of coconut fiber and bamboo / plastic hybrid composites

% weight fraction (p/b)	Orientation	brake load (n)	flexural strength

40/60	90^0	200.000	433.15

Flexural tests graphs generated directly from computer

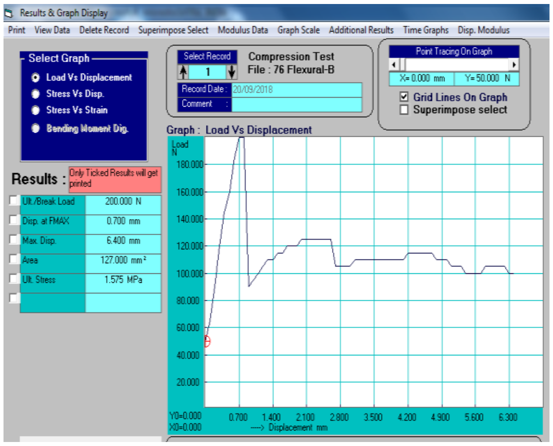


fig:9. graph of flexural strength of 90^0 orientation fibers with coconut fiber / plastic

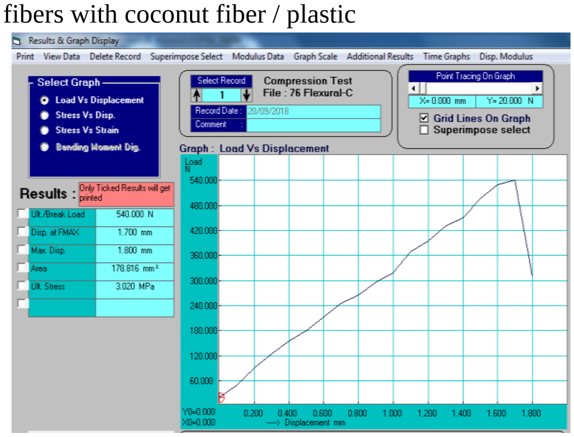


Fig:10. graph of flexural strength of 90^0 orientation fibers with coconut fiber / plastic

Comparison graphs of flexural test;

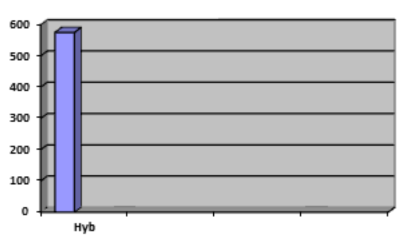


Fig:11. graph of flexural strength of 90^0 orientation fibers with coconut fiber / plastic

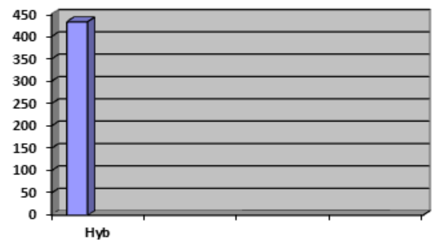
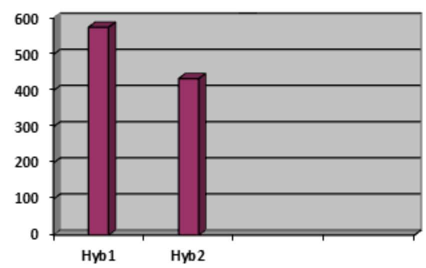


Fig: 12.graph of flexural strength of 90^0 orientation fibers with coconut fiber / plastic

Combination of both graphs:



From shows the flexural strength behavior of various composites with 40/60 weight fractions. It can be observed that flexural properties of coconut fiber / plastic hybrid composites shows a flexural strength of 575 mpa and tensile properties of coconut fiber and bamboo / plastic hybrid composites shows a flexural strength of 433.75 mpa respectively in 90^0orientation . Which is high when compared other fiber like banana and pine apple

V. CONCLUSION AND FUTURE SCOPE

In the current study, hybrid composites reinforced with plastic, bamboo, and coconut fiber are made using the weight fraction of composites. Tensile and flexural strength are two examples of mechanical qualities that are assessed using the ASTM standards. One of the materials that is utilized the most globally these days is plastic. Plastic has benefits and drawbacks, but the drawbacks outweigh the benefits. One of the most significant drawbacks of plastic is its very long decomposition time—more than 400 years—which is excessive. Therefore, recycling plastic is necessary to increase its reuse and reduce its usage. With the help of this device, plastic may be broken down into tiny bits for better trash management. Our effort aims to recycle plastic waste from homes, businesses, and other sources. There is a lot of plastic garbage in these places. However, the devices that may be utilized to recycle this garbage are quite expensive. Therefore, the goal of this research is to shred plastic trash as cheaply as feasible. One of this machine's benefits is that it reduces labor effort, which lowers costs. Thus, with the aid of blades, we want to create this to shred plastic garbage.

The following conclusions have been drawn from the experimental study on coconut fiber, bamboo, and plastic reinforced hybrid composites:

- Using the hand lay-up approach, a hybrid composite reinforced with coconut fiber, bamboo, and plastic has been successfully manufactured.
- Low-cost, lightweight, and environmentally friendly materials include coconut fiber, bamboo, and plastic reinforced hybrid composite with epoxy matrix.
- Compared to pineapple fiber, which has a tensile strength of 51.9 mpa, the coconut fiber and plastic reinforced hybrid composite sample has the highest tensile strength of 56.3 mpa, indicating that it is preferable to utilize it.
- Tensile strength in mixed instances is lower than in pure cases.
- At 900 hybrid natural fiber composite, the maximum flexural strength is 575 mpa.
- In comparison to pure natural fiber composites, hybrid natural fiber composites—which include plastic-reinforced bamboo, coconut fiber, and hybrid composites made of coconut fiber—have high flexural strength.

Future scope of the work:

- By conducting experimental and semi-analytical analyses on various fiber content proportions, the project is expanded.
- It is possible to examine the samples' thermal characteristics.
- It is possible to ascertain the other characteristics of composites, such as moisture absorption and fatigue behavior.

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