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Investigation And Mechanical Properties of Kenaf Fiber, Curaua Fiber, Lotus Fiber, With Amla Powder Using Hand Layup Technique

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***Abstract:** Natural fibers have been integral to human civilization since its earliest days. With growing customer demand for sustainable products and advancements in technology, the use of natural fibers has gained significant importance across industries like aerospace, automotive, and marine. The aim of the project is to study the fabrication of the composite was carried out using epoxy resin as the matrix and the Kenaf Fiber(22%)+Amla Powder(5%), Curaua Fiber(18%)+Amla Powder(5%), Lotus Fiber(25%)+Amla Powder(5%),Kenaf Fiber(11%)+Curaua Fiber(9%)+ Amla Powder(5%), Curaua Fiber(7%)+Lotus Fiber(15%)+Amla Powder(5%),Kenaf Fiber (13%)+Lotus Fiber(10%)+Amla Powder(5%), Curaua Fiber(7%)+Kenaf Fiber(7%)+Lotus Fiber(6%)+Amla Powder(5%) as reinforcement. In accordance with the ASTM guidelines followed for the a forementioned testing, the plates were labelled and divided into several specimen sizes. Tests were carried out to determine the mechanical properties such as Tensile, Hardness, Impact, and Flexural strength. The results were studied and compared with the seven composites materials and its process that the material developed can be used in structural applications with strong dependence on its mechanical properties.*

***Key Words**: - Kenaf Fiber, Amla Powder, Reinforcement, Mechanical properties, Flexural Strength.*

I. 1.INTRODUCTION

Natural fibers, which occur in the vegetable or animal kingdom, exhibit a polymeric nature in terms of their chemical composition. In contrast, natural fibers found in minerals resemble crystalline ceramics. A distinguishing characteristic of natural fibers is their typically heterogeneous composition, consisting of various compounds, whether chemical or physical in nature. Synthetic fibers can be further classified into polymers, metals, ceramics, or glass, with a unique subclass known as whiskers. Whiskers, being monocrystalline and short, boast exceptional strength, approaching theoretical limits due to the absence of crystalline imperfections like dislocations and grain boundaries. These whiskers usually obtained through vapor phase growth, exhibit diameters of a few micrometers and lengths ranging from a few millimeters, resulting in aspect ratios (length/diameter) that can vary from 50 to 10,000. However, a drawback of whiskers lies in their non-uniform dimensions and properties. Natural fibers offer notable advantages, including low density, suitable stiffness, mechanical properties, and high disposability and renewability. They are recyclable and biodegradable, contributing to environmental sustainability. Over the past decade, there has been increased interest in composites of polymers reinforced by natural fibers, such as Jute, Coir, and Hay fibers, which exhibit excellent reinforcing capabilities when compounded with polymers. The unique aspect of designing parts with fiber-reinforced composite materials lies in the ability to tailor mechanical properties to suit specific applications, aiming for an optimal weight-to-strength ratio.

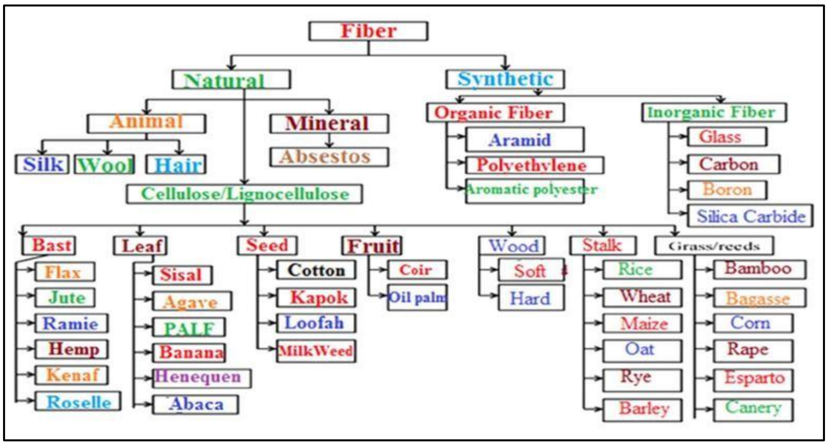

Figure 1: Classification Of Natural Fibers According to Origin with Examples

II. MATERIALS USED

2.1.Lotus Fiber:

Lotus fiber is a natural fiber obtained from the stem of the lotus plant, particularly the Nelumbo nucifera species, commonly known as the sacred lotus. It has been used for centuries in various cultures, especially in parts of Asia, for its strength, softness, and eco-friendly qualities.

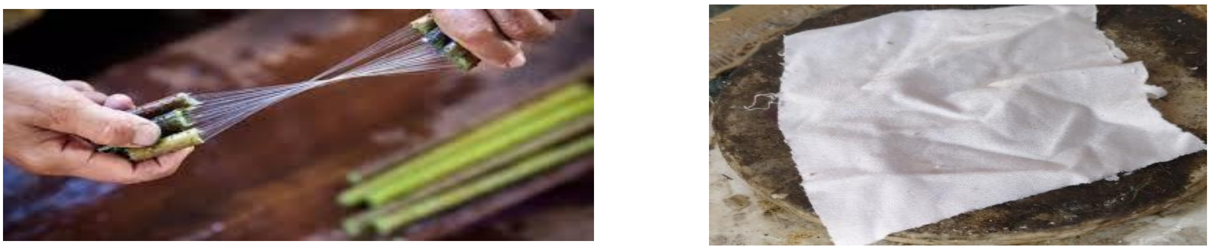
Figure 2.1: Lotus Fiber

2.2.Kenaf Fiber

Kenaf fiber is a natural fiber derived from the bast of the kenaf plant (Hibiscus cannabinus). It is a member of the hibiscus family and is closely related to cotton and okra. Kenaf is native to Africa and has been cultivated for thousands of years for its fiber, seeds, and as a forage crop. The kenaf plant typically grows up to 3-4 meters in height within 4-5 months of planting, making it one of the fastest-growing plants. Its fiber is found in the plant's outer bark, or bast, and is harvested by stripping the bark from the plant's stalks. Kenaf fiber is long, slender, and relatively strong, making it suitable for various industrial applications.


Figure 2.2: Kenaf Fiber

2.3.Curaua Fiber:

Curaua fiber is a natural fiber derived from the leaves of the Curaua plant (Ananas lucidus), a species of bromeliad native to the Amazon rainforest, primarily found in Brazil. This fiber has been gaining attention for its eco-friendly properties, strength, and versatility.


Figure 2.3: Curaua Fiber

2.4.Amla Powder:

Amla powder (also known as Indian gooseberry powder) is derived from the dried fruit of the Phyllanthus emblica plant. It's known for its rich vitamin C content and various health benefits, such

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as boosting immunity, improving skin health, and promoting hair growth. In recent years, there has been growing interest in using amla powder as a reinforcement material in various applications, especially in composite materials and natural fibers. Amla powder has been explored as an additive to reinforce materials, particularly in the field of composites—a combination of natural fibers with polymers, often used in the automotive, construction, and packaging industries. The use of amla powder for reinforcement is an example of utilizing plant-based, sustainable materials for various industrial application.

Figure 3.4: Amla Powder

2.5.Epoxy Resin:
Epoxy resins are widely used in fiber-reinforced composites due to their excellent adhesion, high strength, and durability. They offer good chemical resistance and can be easily tailored to specific applications.

Figure 2.5: Epoxy Resin

PROPERTY	VALUE
Viscosity(cp)	12,000-13000
Density (g/cm^3)	1.16
Tensile Strength(MPa)	73
Elongation(%)	4
Flexural Strength(MPa)	60
Heat Distortion Temperature(^{0}C)	100

Table 2.1 Properties of Epoxy Resin

2.6. Hardener:
Hardener was used as a binder during the fabrication. It has low viscosity, cure at room temperature, good mechanical strength and Good resistance to atmospheric and chemical degradation. HY951 is a type of hardener, also known as Aradur HY951 that is a low viscosity, unfilled epoxy casting resin system. It cures at room temperature and has a high filler addition possibility.

Figure 2.6: Epoxy (LY 556) And Hardener (HY951)

III. METHODOLOGY

3.1.Hand Lay Up Process:
Hand lay-up technique is the simple and cheapest method of composite processing. The infrastructural need for this technique is also minimal. The standard test procedure for Mechanical properties of fiber-resin composites; ASTM-D790M-86 is utilized to according to the measurements. The mold is prepared on smooth clear film with 2 way tape to the required measurement. At that surface mold is prepared keeping the 2 way tape on the clear film.

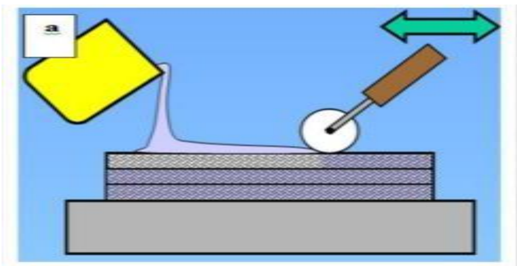


Figure 3.1: Hand Layup Process

3.2.Compositions Used:

- KENAF FIBER+ AMLA POWDER
- CURAUA FIBER+AMLA POWDER
- LOTUS FIBER + AMLA POWDER
- KENAF FIBER+ CURAUA FIBER+ AMLA POWDER
- LOTUS FIBER + CURAUA FIBER + AMLA POWDER
- KENAF FIBER+ LOTUS FIBER + AMLA POWDER
- LOTUS FIBER + CURAUA FIBER +KENAF+ AMLA POWDER

3.3.Pure Fibers:

TYPE	FIBER (%)	EPOXY (%)	HARDENER (%)	AMLA POWDER (%)
KENAF	22	67	6	5
CURAUA	18	70	7	5
LOTUS	25	64	6	5

3.4.Combination of Fibers

TYPE	FIBER (%)	EPOXY (%)	HARDENER (%)	AMLA POWDER (%)
KENAF+CURAUA	20	68	7	5
CURAUA+LOTUS	22	67	6	5
KENAF+LOTUS	23	66	6	5
KENAF+CURAUA+LOTUS	20	68	7	5

3.5.Steps Involved In the Fabrication of Specimen:

Figure:3.5.Process of Fabrication

IV. MECHANICAL TESTINGS OF SPECIMENS

4.1.Specimens Before And After Tensile Testing:

Figure 4.1.1: Before testing

Figure 4.1.2: After testing

4.2.Specimens Before And After Flexural strength Testing:

Figure 4.2.1: Before Testing

Figure 4.2.2: After Testing

4.3.Specimens Before And After Hardness & Impact Testing:

Figure 4.3.1: Before Testing Figure

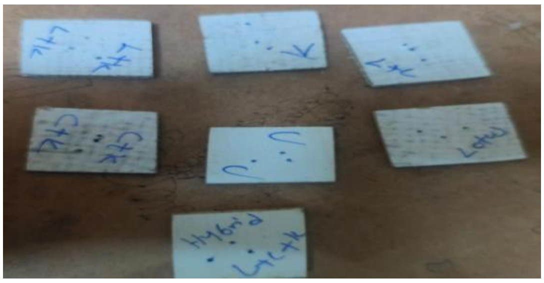


Figure 4.3.2: After Testing

V. RESULTS AND DISCUSSIONS

5.1Mechanical Characteristics of Composites:

S.N O	COMPOSITE	TESILE TEST(N/mm^2)		FLEXURAL TEST(N/mm^2)		IMPACT TEST	HARDNESS
		LOAD(N)	ELONGATION (mm)	LOAD(N)	ELONGATION (mm)	(J)	NUMBER
1	KENAF FIBER	860	5.6	4.34	4.3	22	70
2	LOTUS FIBER	700	5.2	3.49	4.6	15	60
3	CURAUA FIBER	780	4.8	3.83	3.4	18	65
4	CURAUA+LOTUS FIBER	1350	5.4	6.53	3.1	32	85
5	KENAF+CURAUA FIBER	1050	5.5	5.49	5.4	26	80
6	KENAF+LOTUS FIBER	1300	5.3	6.47	5.1	35	81

7	KENAF+CURAUA+ LOTUS FIBER	1550	4.6	7.86	3.4	45	90

Table 5.1: Testing results

5.2.Tensile Test Calculations:

S. NO	COMPOSITE	TENSILE TEST(N/mm^2)			
		LOAD(N)	ELONGATION (mm)	TENSILE STRESS (N/mm^2)	STRAIN
1	KENAF FIBER	860	5.6	0.264	0.033
2	LOTUS FIBER	700	5.2	0.223	0.031
3	CURAUA FIBER	780	4.8	0.248	0.029
4	CURAUA+LOTUS FIBER	1350	5.4	0.430	0.032
5	KENAF+CURAUA FIBER	1050	5.5	0.334	0.033
6	KENAF+LOTUS FIBER	1300	5.3	0.414	0.032
7	KENAF+CURAUA + LOTUS FIBER	1550	4.6	0.494	0.027

Table 5.2: Tensile Test Results

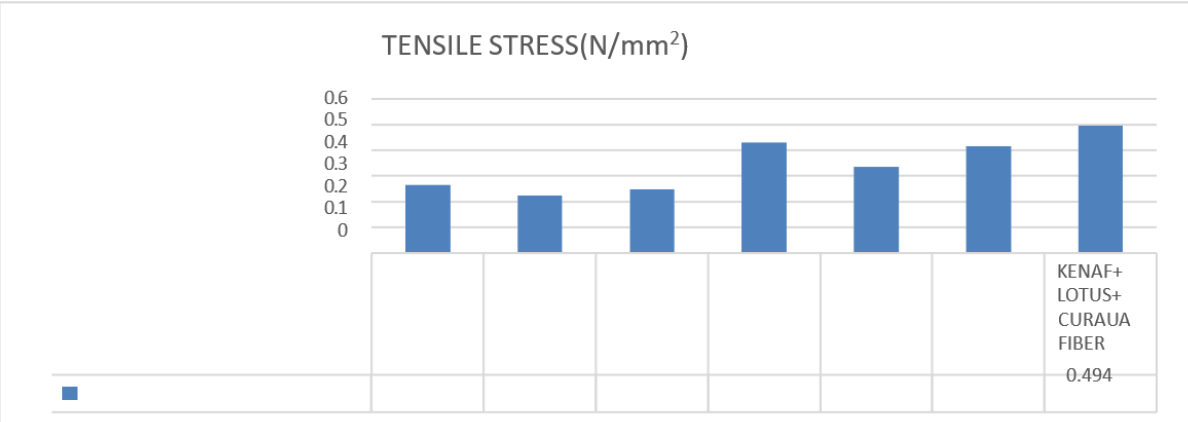


Figure 5.2.1: Tensile Stress Test Results

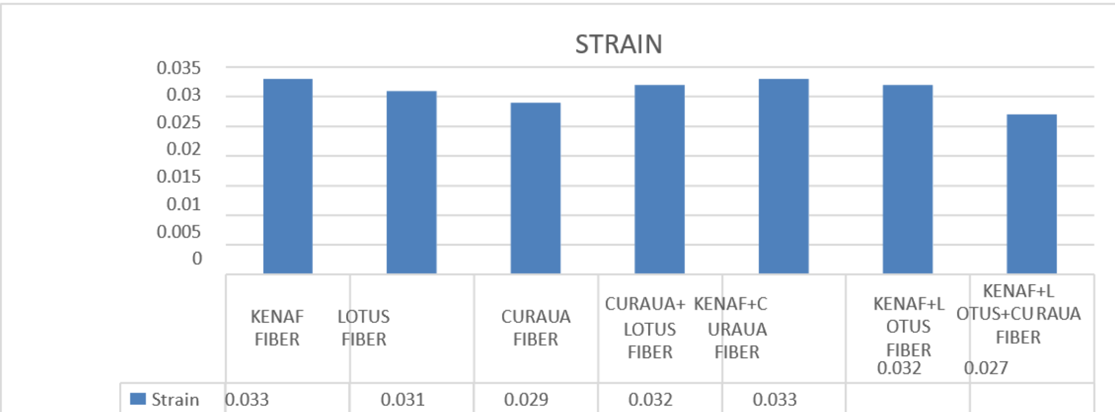
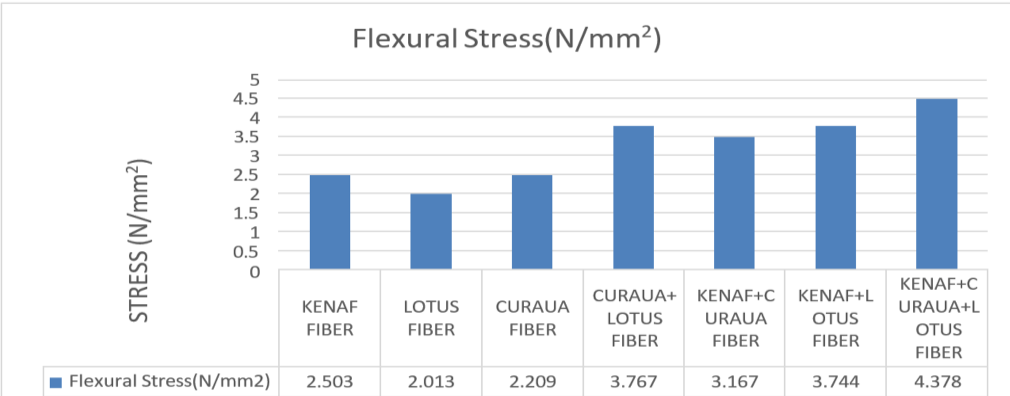


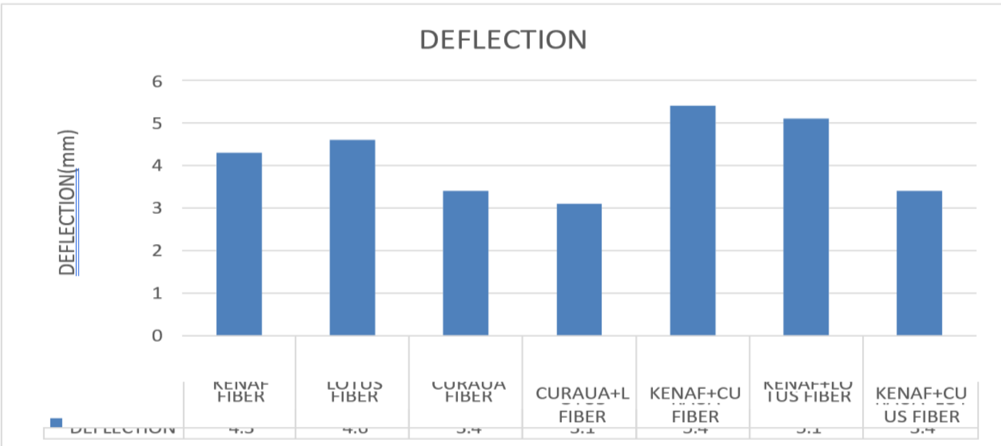
Figure 5.2.2: Tensile Strain Test Results

5.3.Flexural Test Calculated Values:

S.NO	COMPOSITE	FLEXURAL TEST(N/mm^2)		
		LOAD (N)	DEFLECTION (mm)	FLEXURAL STRESS (N/mm2)
1	KENAF FIBER	4.34	4.3	2.503
2	LOTUS FIBER	3.49	4.6	2.013
3	CURAUA FIBER	3.83	3.4	2.209
4	CURAUA+LOTUS FIBER	6.53	3.1	3.767
5	KENAF+CURAUA FIBER	5.49	5.4	3.167
6	KENAF+LOTUS FIBER	6.47	5.1	3.744
7	KENAF+CURAUA+LOTUS FIBER	7.86	3.4	4.378

Table 5.3: Flexural test results





Flexural test results

5.4.Impact Test:

S.NO	COMPOSITE	IMPACT TEST (JOULES)	IMPACT STRESS (J/mm^2)
1	KENAF FIBER+AMLA POWDER	22	1.83
2	LOTUS FIBER+AMLA POWDER	15	1.25

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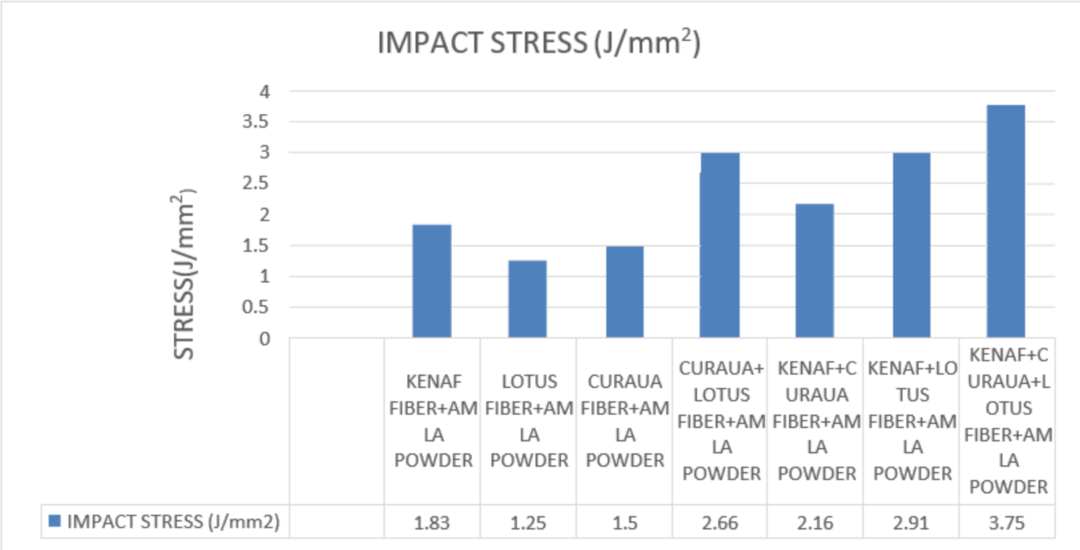
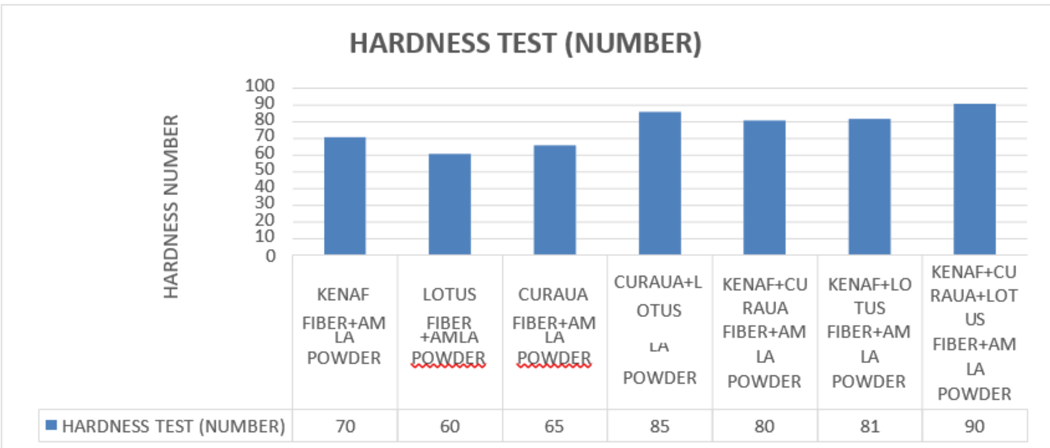
3	CURAUA FIBER+AMLA POWDER	18	1.50
4	CURAUA+LOTUS FIBER+AMLA POWDER	32	2.66
5	KENAF+CURAUA FIBER+AMLA POWDER	26	2.16
6	KENAF+LOTUS FIBER+AMLA POWDER	35	2.91
7	KENAF+CURAUA+LOTUS FIBER+AMLA POWDER	45	3.75



Impact test results

5.5.Hardness Test Calculations:

S.NO	COMPOSITE	HARDNESS TEST (NUMBER)
1	KENAF FIBER+AMLA POWDER	70
2	LOTUS FIBER +AMLA POWDER	60
3	CURAUA FIBER+AMLA POWDER	65
4	CURAUA+LOTUS FIBER+AMLA POWDER	85
5	KENAF+CURAUA FIBER+AMLA POWDER	80
6	KENAF+LOTUS FIBER+AMLA POWDER	81
7	KENAF+CURAUA+LOTUS FIBER+AMLA POWDER	90



Hardness Test results

VI. CONCLUSIONS & FUTURE SCOPE

6.1.Conclusions:

- The fabrication process of the natural fibers has been completed successfully
- The cutting of the specimens is done according to the ASTM standards
- While testing the specimens, the following results are obtained
- During tensile test, the composite Kenaf Fiber+Curaua Fiber+Lotus Fiber+ amla powder having the highest tensile strength of 0.4944 Mpa and having the strain of 0.027
- During the Flexural test, the composite Kenaf Fiber+Curaua Fiber+Lotus Fiber+ amla powder having the highest flexural strength of 4.378 Mpa and having the strain of 2.06 among all the 7 composites
- During the Impact test, the composite Kenaf Fiber+Curaua Fiber+Lotus Fiber+ amla powder having the highest impact strength of 3.75 J/mm^2 among all the 7 composites
- During the hardness test the composite Kenaf Fiber+Curaua Fiber+Lotus Fiber+ amla Powder having the highest hardness number of 90 among all the 7 composites
- After all the tests has performed on the specimens, the Kenaf fiber + curaua fiber + Lotus fiber+ amla powder combination shows a best result in the tensile strength, impact strength, hardness test and as well as flexural strength. Finally based on above investigations, it is proposed that Kenaf fiber + Curaua fiber + Lotus fiber+ Amla powder having good mechanical properties when comparing with other results.

6.2.Future Scope:

The extension of this project work can be done by considering the following points:

- The fiber can also take in the form of powder to fabricate the specimen which may increases the strength.
- Different type reins can be used to find the mechanical properties like strength, wear resistance
- By considering different process parameter and different composites which improves the properties of composites.

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