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Experimental Investigations on Sisal/Palm Fruit/Coir Fibre Reinforced Epoxy Composite Materials

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ABSTRACT: Natural fibre reinforced composite materials shows better properties than other fibre composite materials, many industries and research institutes are using different natural fibres for composite material fabrication, individual fibre composite materials and two or more combination of fibre are used for fabrication. In this investigation sisal/palm fruit/coir fibres are used for fabrication of S-P-C-P-S composite material. Hand lay-up and compression molding processes are combined used for fabrication of S-P-C-P-S composite material. Six different mechanical testings are conducted on this composite material in order to known mechanical properties of it, six testings are tensile test, compression test, flexural test, shear test, impact test and hardness. Different combinations of natural fibres composite material give comparable properties with individual natural fibre composites (sisal, coir and palm fruit fibre composites). S-P-C-P-S composite material shows better values for shear strength, flexural strength, impact energy and Hardness values but tensile strength is low compared to individual fibre reinforced composite materials.

KEY WORDS: Natural Fibre Composite Materials, S-P-C-P-S Composite Material, Hand lay-up Process, Compression Molding Process Tensile Test, Impact Energy and Hardness

I. INTRODUCTION

Now-a-days composite materials are widely using for industrial and research application because their better properties like less carbon emissions, high specific strength, less weight and these materials have other properties like less moisture absorption rate, low thermal conductivity. Composite materials are nothing but combination of two or more different material combination in macroscopic level only and the materials which are produced as a result of combination of different materials must give different properties than those combinational materials. There are two different types of composite materials are present one is artificial composite material and other is natural composite materials, both are having different properties in application-oriented point of view but they are different in nature in different aspects like structure, properties and bonding behaviour between layers.

Natural fibre composite materials are emerging materials because of many reasons like these composites does not harm to environment, biodegradable materials and gives less carbon emissions, these materials are made from natural fibres which are abundantly available in environment and cost of these fibre composites are less compared to other artificial fibre composite materials. Natural fibre composite materials play an important role in environment most of these composite materials are fabricated by using plant and tree waste, like palm sheath, coconut husk, coconut shell powder, palm fruit bunch and borassus flabellifier fibre etc.Many researches are doing research on natural fibre composite material with combinations of different fibres like hemp, flax, sisal, coir, palm and jute etc. these researches help us to know the which fibres gives better properties and which fibre composite material suitable for different applications like industrial, automotive and aerospace. Natural fibres cost is less compared to artificial fibres and gives different mechanical and chemical properties.

Before using composite material for any application, it must be tested under different environmental conditions, alkaline environment of fibre gives the better mechanical properties than other environments (treated with solutions). Flexural property of composite material is maximum in petrol and vegetable oil environment [1], Mechanical properties of composite material affected by curing temperature as the curing temperature increases tensile and flexural strength of composite material increases up to some limit and decreases after limit. Impact strength decreases with increase in curing temperature [2]. Toughness of composite material reduces due to micro-

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compressive defects present in composite material, this also limits load transfer between fibre and matrix material. Aspect ratio 10 or lower reduces defect rate in composite material [3]

Jute-epoxy composite material shows better mechanical properties than jute-polyester composite material, tensile strength is more for jute-epoxy and flexural strength is more for jute-polyester. And impact energy more for jute-polyester composite material, hardness is same for both composites [4]. Low viscous liquid and different fibre orientation mechanisms used in order to prepare highly aligned short fibre composite material, this is fast and continuous production process [5].

II. EXPERIMENTAL WORK

Experimental work related to this study includes different stages like material selection, fabrication method selection, testing standard selection, fabrication of composite material, testing, results and discussion and conclusion of composite materials as shown in Fig. 1. Materials selected on basis of their availability, cost as well as individual strength of fibres and matrix material selected on basis strength and curing temperature of resin, ASTM standards selected for testing of composite material, hand lay-up and compression molding processes are selected for fabrication of composite material, different mechanical testing like tensile, compressive, flexural, impact, shear and hardness tests are selected in order to know composite material mechanical properties.

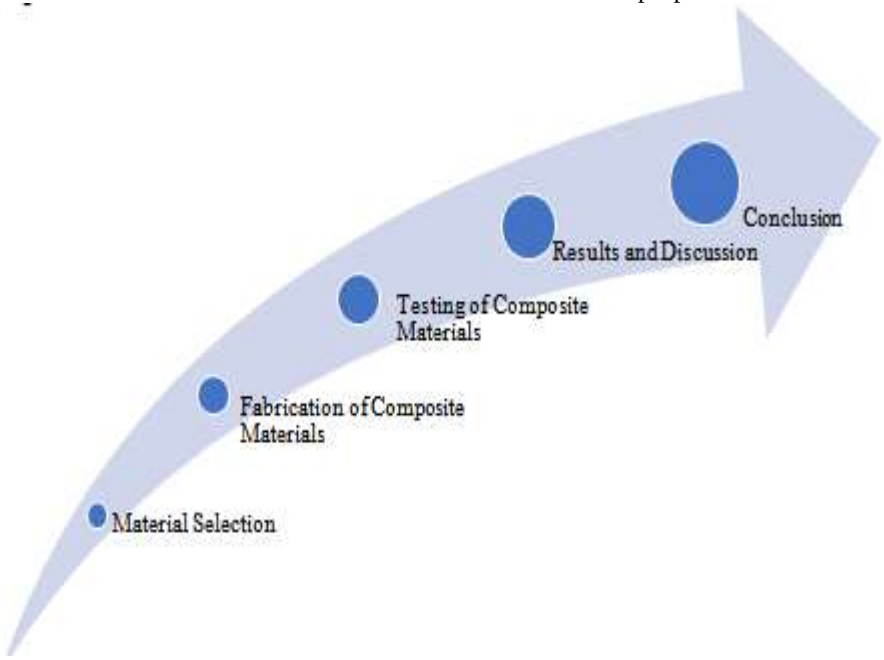

Fig. 1. Stages in Experimental Work

2.1 Materials selection

For fabrication of natural fibre composite material three different fibres are selected like coir fibre (Fig. 2a), sisal fibre (Fig. 2b) and palm fruit fibre (Fig. 2c) as shown in Fig. 2. Coir and palm fruit fibres are extracted manually from coconut and palm fruit shells and sisal fibre are purchased from fibre stores in general sisal fibre extracted from sisal plant leaf, these all are reinforcement materials for composite materials. Matrix material used in this fabrication is epoxy resin LY-556 and Hardener HY-951, these are thermosetting matrix materials.

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Fig. 2. Fibre Laminates

2.2 Fabrication of Composite Materials

Hand lay-up and compression molding processes are used for fabrication of natural fibre composite materials, these methods are easy to use and suitable for better productivity and dimensional accuracy of component. Fabrication of composite material includes different steps they are discussed as follows

- Prepare laminates of fibres according to required dimensions.
- Prepare a die which is used for compression and better dimensional accuracy provision in fabrication process. And decide pattern for composite material as shown in Fig. 3.

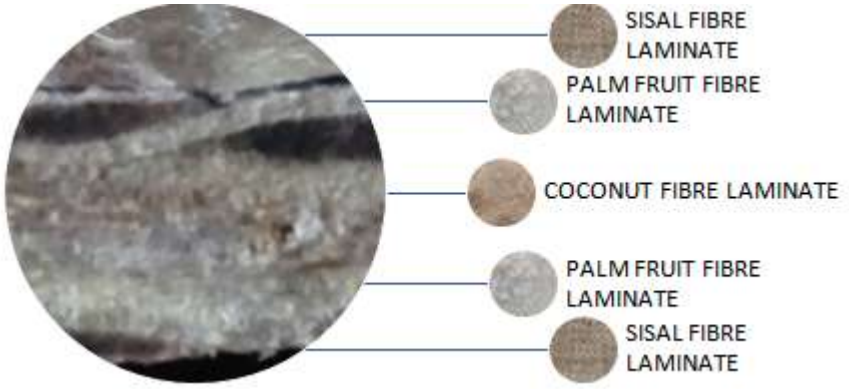

Fig. 3. Pattern for Composite Material

- First of all, apply releasing film (grease) on die and polythene cover used to reduce sticking problem.
- Mix resin and hardener with 10:1 proportion.
- By the application of resin mixture layer-by-layer for different fibre laminates prepare staking of laminates with resin mixture.
- Compress stacking as shown in Fig. 4. of layer by using universal testing machine with 100 KN load application for proper compression.

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Fig. 4. Compression of Stacking of Fibre Laminates

- Allow this material for curing 24 hours at room temperature, Final composite material after 24 hours as shown in Fig. 5.

Fig. 5. Final Composite Material

2.3 Testing of Composite Materials

Composite material is tested in order to know different mechanical properties of its like tensile strength, compression strength, shear strength, flexural strength, impact strength and hardness. Six different testing's are discussed below

- Tensile testing is used to know the strength of material by using universal testing machine for this testing ASTM D 638 is selected.
- For compression testing ASTM D695 is selected, this test gives compressive strength of composite material at different load conditions.
- Inter laminar shear test is conducted on composite material according to ASTM D2344, this gives shear strength of composite material.
- Impact test is conducted according to ASTM D256, it gives impact energy of composite material.
- Bending strength is determines by flexural test according to ASTM D790.
- Hardness test conducted on composite material according to ASTM D2240 it is the shore hardness test which gives shore D value.

III. RESULTS AND DISCUSSION

Finally, natural fibre composite material is fabricated and tested in order to know different mechanical properties of composite materials, In this study composite material fabricated by sisal, coir, palm fruit fibre (S-P-C-P-S) with epoxy as a matrix material and only sisal fibre reinforced, palm fruit fibre reinforced and coir fibre reinforced composite material properties are compared listed in Table 1, in order to know better properties in S-P-C-P-S in composite material and this information used for further development of this material.

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Table 1 Comparison of Properties

PROPERTIES / SAMPLE	TENSILE STRENGTH (Mpa)	COMPRESSION STRENGTH (Mpa)	SHEAR STRENGTH (Mpa)	FLEXURAL STRENGTH (Mpa)	HARDNESS	IMPACT ENERGY (Joules)
SISAL FIBRE COMPOSITES	5 [6]	96[7]	25.9[7]	62[16]	99[6]	4[6]
COIR FIBRE COMPOSITES	22.61 [8]	116.2[14]	1.99[15]	14.66[8]	50[9]	4[8]
PLAM FRUIT FIBRE COMPOSITES	12.272 [10]	21.01[10]	5[12]	53[13]	72[11]	0.85[10]
S-P-C-P-S COMPOSITE	5.64	28	8.4	48.44	59	4

3.1 Tensile Strength

Tensile strength is more for coir fibre epoxy composites more i.e. 22.61 Mpa than other composite materials like sisal fibre reinforced, palm fruit fibre reinforced and S-P-C-P-S composite material as shown in Fig. 6. Tensile strength of natural fibre reinforced composite material i.e. coir fibre reinforced composite materials is more compared to individual or combinational composite material, even though coir fibre having less tensile strength compared to sisal fibres it showing better tensile properties as composite material. The reason behind this property is the when any material undergoes for reinforcing its properties decreases for some fibres and increases for some fibres.

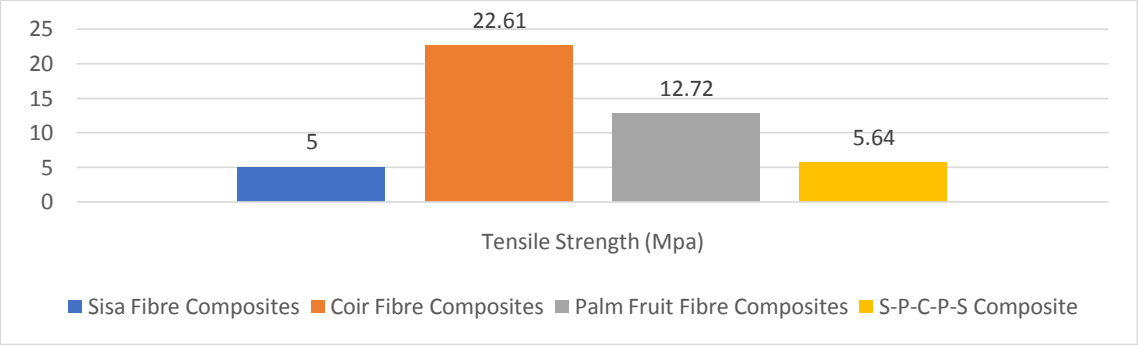

Fig. 6. Comparison of Tensile properties

3.2 Compressive Strength

Compression strength of coir fibre epoxy reinforced composite material is more i.e. 116.2 Mpa, due to its structure of fibre these composite materials is having high compression strength and low compression strength for S-P-C-P-S composite material i.e. 28 Mpa because of some binding problems. Comparison results of compression test as shown in Fig. 7. Compressive strength of coir fibre more because the shape of fibre is not so fine to break and not so big, this fibre has medium diameter range this provides better compresences to composite material. In order to get good compressive strength results fibre must undergo maximum load without breaking its internal bonding as an individual or composite material.

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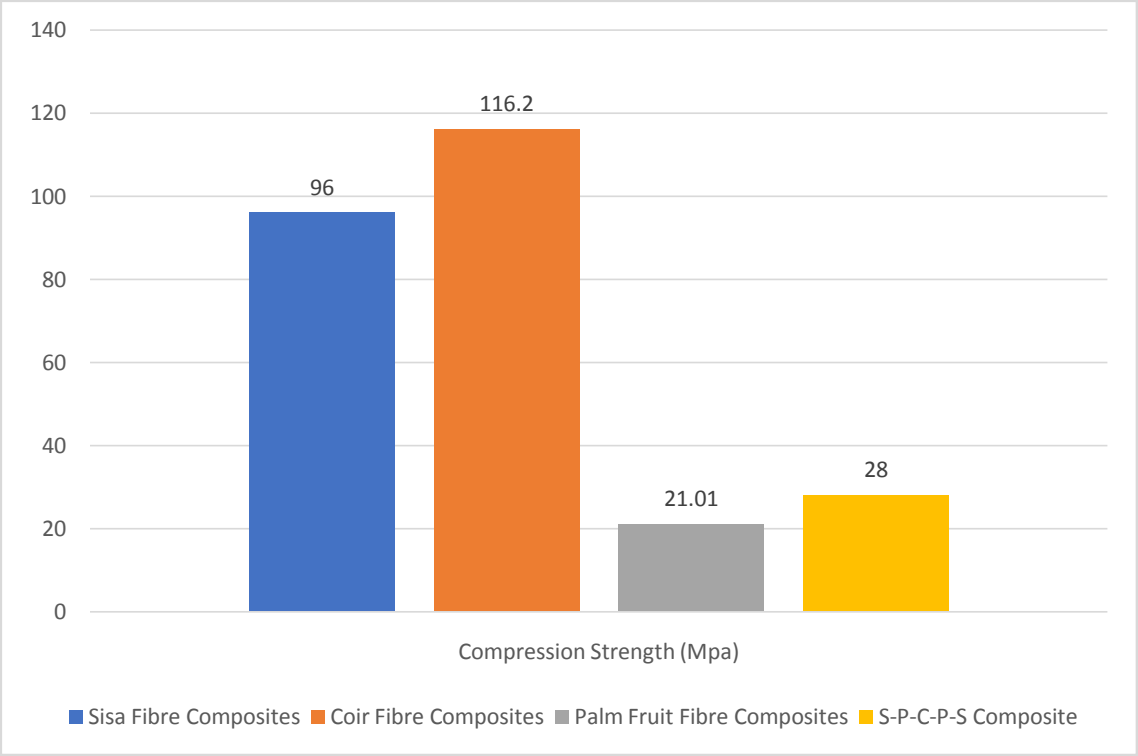

Fig. 7. Comparison of Compressive Properties

3.3 Shear Strength

Sisal fibre reinforced composite material shows better shear properties than other reinforced composite material i.e. 25.9 Mpa and least shear strength for coir fibre reinforced composite material i.e. 1.99 Mpa. S-P-C-P-S composite material gives shear strength as 8.4 Mpa, these comparisons as shown in Fig. 8. Shear strength of sisal fibre reinforced composite material is more compared to other natural fibre composite materials i.e. coir and palm fruit fibre composite materials because sisal fibres have good tensile strength than other fibres, at the time of shear testing bonds within the composite materials are broken up if fibre has maximum tensile strength it can with stand up to some load, it provides better shear values to composite materials.

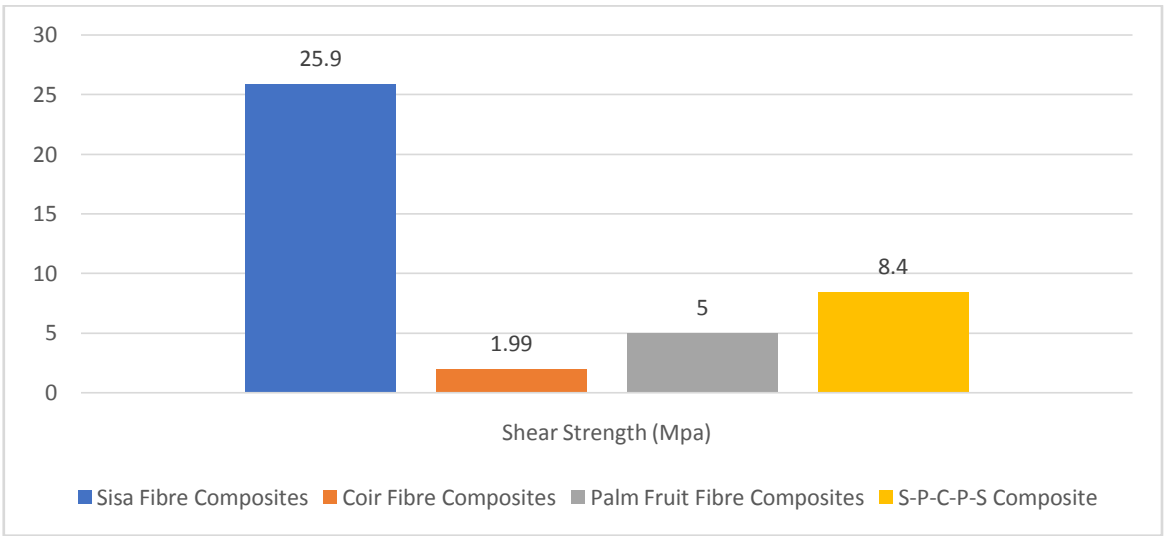

Fig. 8. Comparison of Shear Properties

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3.4 Flexural Strength

Sisal Fibre reinforced composite materials shows better flexural properties and has maximum flexural strength i.e. 62 Mpa and coir fibre reinforced composite has low flexural strength i.e. 14.66. S-P-C-P-S composite material has 48.44 Mpa flexural strength, these comparisons shown in Fig. 9. Almost all three-fibre reinforced composite materials show equal flexural strength only coir fibre composite material has low flexural strength compared to other materials because flexural stress gives bending strength, during test process coir fibres withstand up to some limit after they will break due their nature like hard in nature. All other fibre materials are soft compared to coir fibres.

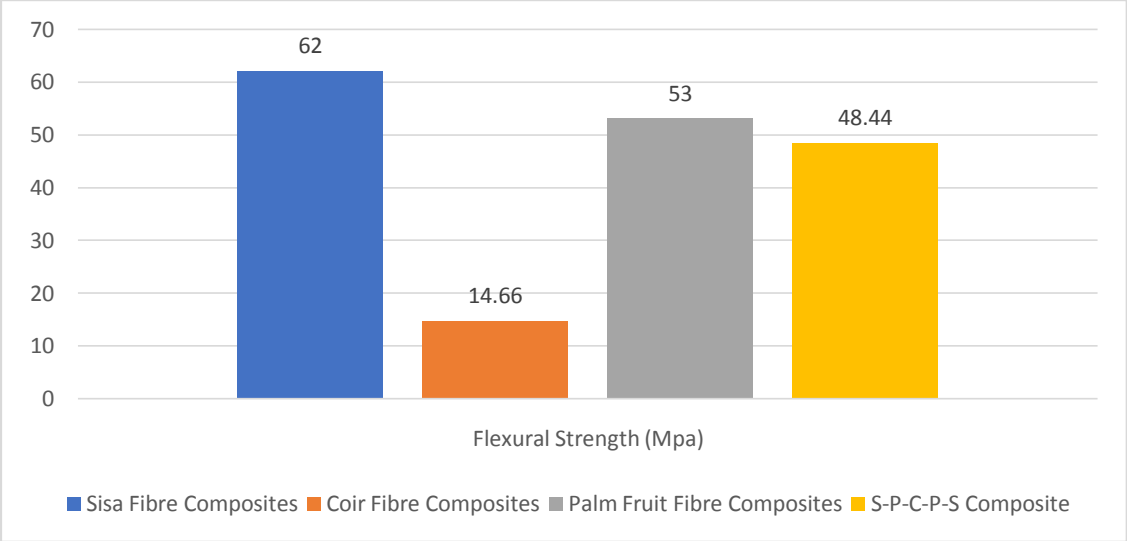

Fig. 9. Comparison of Flexural Properties

3.5 Impact Energy

Impact energy in sisal fibre reinforced, coir fibre reinforced and S-P-C-P-C composite material is same i.e. 4 J, but in palm fruit fibre reinforced composite material is impact energy is less i.e. 0.85 J, these comparisons shown in Fig. 10. Impact energy of three fibre reinforced composite materials are same because of better bonding in composite material like bond between fibre and matrix materials and in palm fruit fibre composite materials bonding is perfect but due to fibre softness it can't absorb more impact energy before breaking of specimen.

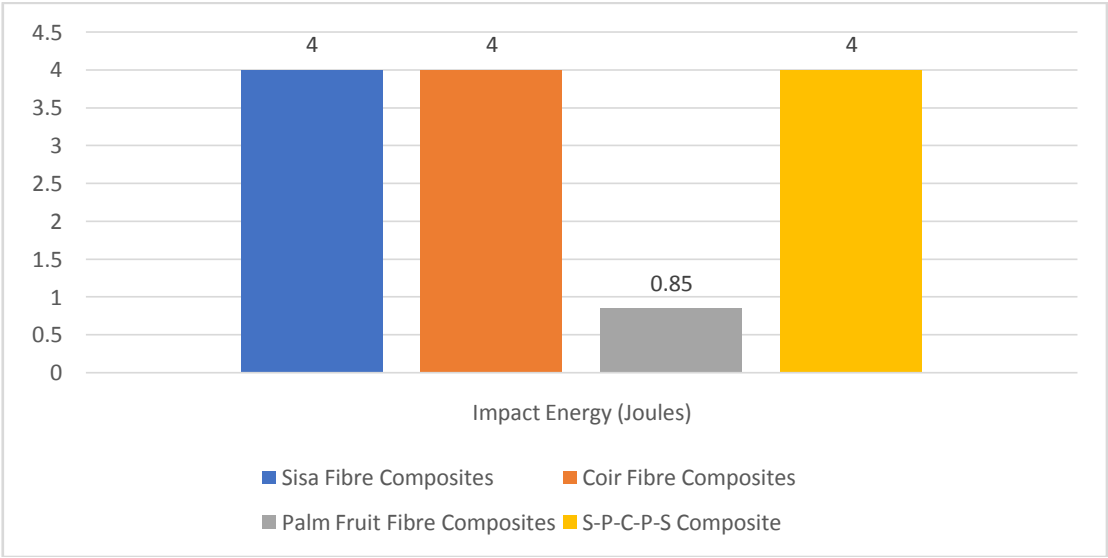

Fig. 10 Comparison of Impact Energies

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3.6 Hardness

Sisal fibre reinforced composite material gives maximum hardness value i.e. 99 HRB than other composite materials, treated palm fruit fibre composite material gives 72 Shore D hardness value and S-P-C-P-S composite material gives 59 Shore D hardness values, these comparisons shown in Fig. 11.

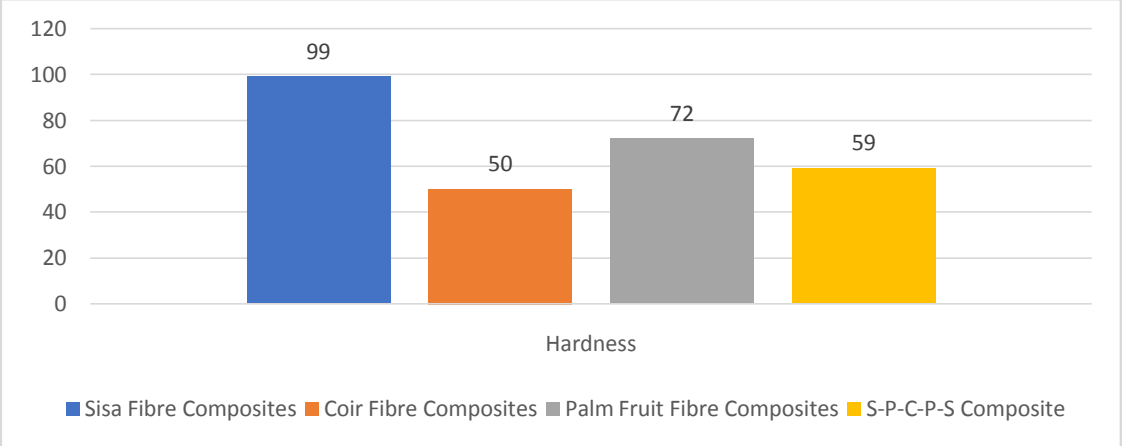

Fig. 11 Comparison of Hardness Values

IV. CONCLUSION

From this experimental investigation it is concluded that natural fibre reinforced composite material shows better properties than artificial fibre composite but in natural fibre composite different reinforced fibre composites have different properties, from this study it is observed that

- Individual fibre reinforced composite material gives better properties than combined natural fibre composite materials.
- Properties of composite material depends on type of resin used for fabrication process.
- Tensile strength of S-P-C-P-S composite material is less compared to other composite materials because of its internal bonding strength.
- Coir fibre reinforced composite material has high compressive strength but S-P-C-P-S composite has low strength because improper resin mixture between coir layer and other layers of composite materials.
- S-P-C-P-S composite material has better shear strength values than individual coir, palm fruit fibre composite material because of fibre laminates better adhesion properties.
- Flexural strength of S-P-C-P-S composite material is less compared to other individual reinforced composite material because during testing process material does not bear maximum bending load because of inside core is coir it has different structure than other fibres.
- All three-fibre (sisal, coir, S-P-C-P-S) reinforced composite materials has equal impact energy values
- Hardness values of composite material depends on testing method, scale of hardness, fibre treatment process of composite material.

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