International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 7 ǁ July 2022 ǁ PP. 141-145

Mechanical and Thermal Properties of Hybrid Composites Reinforcing with Natural Fibres– A Review

[1]Alam Irshad, [2]Sagar N K
[1]*M.Tech Scholar, Department of Mechanical Engineering, SIRT Bhopal*
[2]*Asst. prof., Department of Mechanical Engineering, SIRT Bhopal*

Abstract
Manyauthorshave given their contribution towards the development of polymer composite materialsusing natural fibers and fillersas reinforcementand resin as matrix. The developed compositeswere found to play very significant role to producegood properties of the composites. The natural fibers are inexpensive, renewable, biodegradable, and environment friendly materials. Natural fibers are jute, kenaf, coir, areca, sisal, bamboo etc. Many researchers used these fibers in their research to develop a new polymer composite material.Recently, research is being done on the development of some advanced material to getrichmechanical and thermal properties of the composites. For the development of an advance composite material, the hybridization concept is adoptedin which two or more similar or dissimilar fibers in the same matrix are added to get a new unique product known as hybrid composites. This hybrid composite gives rich properties of mechanical and thermal in comparison with the individual one. The hybrid composites are also more environmentally, friendly and reliabletowardsvarious applications. Hybrid composites are being developed by using the natural fibers in the combination like sisal/Sic/GlassFiber, jute/sansevieria fiber, sisal/jute fiber, jute/bamboofiber, jute/kenaf, jute/pineapple etc and epoxy resin as matrix.The hybrid compositeshave various applications inpackaging industry, electrical sector,automobile, railwaysetc. The purposeof this paper is to present a review on mechanical and thermal properties of hybrid composite reinforced with two different natural fibers.

Keywords: *Hybridization,Hybrid composite, Narual fibers, Mechanical properties, Thermal properties*

Date of Submission: 24-06-2022 Date of acceptance: 05-07-2022

I. INTRODUCTION

Natural fibers are having many advantages like biodegradable characteristics, environmentally friendly, low energy combustion and renewable, due to which most of the researchers have used Jute, Kenaf, flax, areca, hemp, sisal and banana fibres as alternative reinforcement materials in fabrication of composite materials. Although it cannot be avoided that natural fibres are having low mechanical properties as compared to synthetic based composites but the water absorbent property of natural fibres is seen considerably more than that of the synthetic fibres. The use of many natural fibres has been reported for different applications such as automotive industries, civil constructions industry, aerospace and electrical industry etc. Presently the researchers are focusing on the use of natural fibers and to develop a new composite by using the combination of natural fibers as reinforcement that can produce good mechanical and thermal properties and replace the synthetic based composite. To get more improvement in the properties of materials, now hybrid composites are being introduced. Hybrid composites are produced by introducing the two or more fibres as reinforcement in one matrix.Many authors mentioned in their research that mechanical and thermal properties of hybrid composite material made up of combining the natural fibers with the matrix were found to be improved.

1.1 Natural Fibers

Natural fibers such as cotton, jute, kenaf, coir, sisal, banana, bamboo, pineapple etc., are attained or produced by plants and animals. They are inexpensive, renewable, biodegradable, and environment friendly materials. Most of the natural fibres are having good absorbability of sweat and other liquids.The Fibers those got from plants likejute, kenaf, cotton, hemp, sisal, pineapple, ramie, bamboo, banana, etc., wood and seeds of flax are preferred to use as the reinforcement in polymer matrix composites. These fibresplay an important role for the applications in the production of composite materials. These fibers have many advantages like low density, low price, good mechanical behavior due to which thes fibers become an attractive reinforcement to the synthetic fibers.Although synthetic fibers possess high specific strength but their applications are very limited because of their inherent higher cost of production.

1.2 Resins

The resins are the materials utilized for the fabrication of fibers reinforcement composites and it is referred to as 'polymers'. All polymers display an important common property and made up of long chain-like molecules making of number of simple repeating units. The polymers prepared by men and machines are generally called 'synthetic resins' or simply 'resins'. They are classified into two categories, 'thermoplastic' and 'thermosetting'.It is known that thermosetting resins possessbetter electrical and thermal insulation due to have dense molecular structures. They also possess low viscosity, good chemical resistance, good creep resistance, proper fiber wet out and excellent thermal stability. There are many thermoset resins are available like epoxy, polyester, vinyl ester etc. and they give their contribution to make composite material. From the literature, many researchers used epoxy resins in their research because of having its excellent adhesion and bonding with natural and synthetic fibers. Epoxy resin also gives its good performance at elevated temperatures and they provide low shrinkage towards curing.

II. LITERATURE REVIEW

2.1. Mechanical Properties

Mechanical properties of any engineering materials provide the information regarding the maximum strength of the material that a material can withstand in different aspects and these properties play very significant role to design engineering products. Therefore, these properties of the new fabricated hybrid composites should be investigated and studied properly.

The hybrid composites containing pineapple/banana fiber as reinforcement usinghand layup techniques. Samples were prepared with different stacking sequences of the fibers and testing wasdone tofind mechanical and thermal properties. From the investigation, sample A4 withPineapple/Banana/Pineapple/Banana, hybrid composite displayed high tensile strength i.e 74.5 MPa andflexural strength 124.82 MPa due to have better bonding between the matrix and fibers. Sample A4 also given thehigh impact strength of the prepared composites because of having pineapple fiber at the outer layer. Investigation shown high thermal properties of A2 composites with four stacking layer of pineapple fiber P-P-P-P because of having moisture content of pineapple fiber in the outer layer and displayed cracks formation at the surface due to weak bonding between matrix and fiber and it shows inter laminar shear properties. More moisture content present in the pineapple fiber improved the flammability characteristics. The hybrid composite sample A1 (Banana-Banana-Banana) displayed large Shore D hardness due to the presence of stiffer banana fibers in the inner and outer layers[8].

The hybrid composite material and it is found from the experimental results that the hybridization with the natural fibres (Areca and Kenaf) gives a significant effect on the mechanical properties of the composite laminates. The Laminates made with kenaf fiber as the skin material and intermediate as with core layers of areca fibers given better results in tensile strength, flexural strength and hardness. This was found because of good adhesion between the kenaf fiber and the matrix material. On the other end, the hybrid laminates made with areca as outer layer and kenaf as alternate and core layer could absorb good compressive strength and impact energy[12].

The hybrid composite with unsaturated Polyester resin as matrix and Kenaf and Areca fibers as reinforcement in mat format. Prepared six samples with Kenaf and areca fibers applying different stacking sequences with 10 % wt. of wood dust as filler material and investigated the different mechanical properties. Tensile strength was obtained high i.e. 55 MPa for the specimen made up with Kenaf fiber is taken at the top and bottom and less tensile strength was found for the specimen made up with area fiber at the top and bottom was applied. Good adhesion and bonding between the fibers and matrix was reported. Filler material i.e. wood dust was uniformly dispersed with the unsaturated polyester resin[13].

The hybrid composite by combining sisal and polylactic acid and studied the mechanical properties. The wt. % of fiber content of sisal was varied from 5 to 15 wt. %. This resulted that an increase in sisal fiber made with different weight ratio (4:1, 1:1 and 1:4) of oil palm and kenaf fiber and maintaining the overall fiber loading to 50 wt. %. From the results, it is revealed that increasing the content of kenaf fiber improves the tensile and flexural properties because of developing the good bonding between the kenaf fiber and matrix. It is also found that kenaf fiber can transfer higher load resulting in superior tensile and flexural properties as compared to oil palm fiber. A composite made with pure oil palm fiber absorbs maximumimpact energy because of its interlocked structure. The research further concluded that the natural hybrid composites can compete with synthetic fiber composites if designed appropriately [14].

The composite material made with polypropylene polymer and areca fiber and investigated the mechanical properties of developed composite for automobile components. The specimen were fabricated by keeping 5, 10 and 15 wt. % of areca fibers. From the results, it was found that the composites with 5 wt. % given better mechanical properties as compared to other combinations of composites. Also, it has been reported

that further increase in areca fiber content decreases the strength due to weak bonding between the reinforcement and the matrix [11].

The hybrid composite of unsaturated polyester resin reinforced with sisal/ bamboo fiber and investigated the mechanical properties. From the results, it was got that mechanical properties for sisal composite keeping higher fiber length and high fiber content with 50 wt. % bamboo fiber rise up the tensile strength up to 19 %, flexural strength about 5 % and impact strength upto 29 % as compared to with the sisal fiber composites[17].

The hybrid epoxy composite reinforced with bamboo fiber and studied the mechanical properties. From the results, it has been found that the flexural modulus and fracture toughness of the bamboo composites increases as the fiber length and fiber content increases. The failure of the composites was happened due to matrix crack, rupture of the fibers, de-bonding and fiber pulled-out[20].

A fabricated hybrid composite using unsaturated polyester resin with the addition of banana/kenaf fiber and studied the mechanical properties of the hybrid composite. The reinforcement was applied in two weaving patterns namely plain and twill after that random orientation. From the results, it got that hybridization of kenaf and banana fibersrise up the mechanical properties. Tensile, flexural and impact strength of woven fibers were got higher than the random fibers. Good adhesion and proper bonding between the woven fiber and matrix was good due to which results were got better as compared to randomly oriented fibers[15].

Thefabricated composite material by using thermoplastic polyurethane as matrix with the addition of kenaf fiber as reinforcement and investigated mechanical properties. In the developed composite, kenaf fibers added as reinforced with 10 and 30 wt. % . Investigation shown that the tensile strength and resilience decreased when fiber content increases. The samples made with 10 wt. % of kenaf fiber produced better properties. It was also concluded that the kenaf fibre-based composites plays significant role in lightweight automobile applications[4].

Thehybrid composite with kenaf/glass fibers as reinforcement and studied the mechanical properties. This composite plays a significant role in to make the car bumpers. This research resulted the mechanical properties of the hybrid composites found similar to that of Glass Mat Thermoplastic (GMT) that can also used to make the car bumpers. In this research it was found that hybrid natural fiber composites can also be used successfully in structural parts of a car[5].

Thehybrid composite by using jute/basalt fiber as reinforcement material and studied the effect of stacking sequences of the fibres layers to investigate the mechanical properties of composite. Combination of jute as skin layers and basalt fibers as core layer, produced the highest tensile strength and combination of composite with the outer skin and core layer of jute fibers resulted in maximum flexural strength. The composite with pure jute fiber sample produced high impact. From the conclusion, it was suggested that stacking sequences influence the mechanical properties[10].

The specimen of hybrid epoxy composite by reinforcing jute (J) /kenaf (K) fiber and tested the samples by applying different stacking sequence of the fibres. The influence of stacking sequence on the mechanical properties of jute (J) /kenaf (K) fiber composites was studied. Specimen were fabricated with constant fiber loading i.e. wt. % of fiber is 30. Samples were prepared with the combination of three different stacking sequences J/K/J, K/J/K and pure epoxy based. The hybrid composite K/J/K produced a maximum tensile and flexural strength i.e. 43 MPa and 75 MPa. Tensile and flexural modulus were got 3.6 GPa and 4.3 GPa for the same sample. Kenaf fiber made as the outer skin layer becomes good bonding between the matrix materials as compared with other composites. The study summarized that proper stacking sequences plays a significant role for the finding of composite strength and it has been suggested that this composite can be applied for the interior lining of aerospace and automobile designing components[7].

The samples of carbon/aramid fiber-based epoxy composites and investigated about the stacking sequence and hybrid ratio effectstowards the mechanical properties.Investigation shown that the appropriate stacking sequences and hybrid ratio of the fibers changes and improves the mechanical properties. Composites made with inner carbon layer given higher tensile strength than other composites and composites with the outer layer of carbon/aramid developed better flexural strength[18].

Thefabricated hybrid composite by adding reinforcement as bagasse/sisal fibers by applying with different stacking sequences and focused the mechanical properties of the composite. By adding the three layers of sisal fibers, the hybrid composite reflected highest tensile strength because of having good bonding between the matrix materials. Investigation resulted in load transfer of high amount, improved flexural, compressive strength. Composite shown good hardness with bagasse as skin layers and sisal as the core layer. There was no pores and cracks found and these grown up the properties[6].

2.2. Thermal Properties

There are three methods of testing known as thermogravimetric-analysis (TGA), differential scanning-calorimetry (DSC), and dynamic mechanical-analysis (DMA) through which the thermal properties are determined. TGA is one of the most popular techniquesto make the analysis of thermal properties in the composites.The type of polymer matrix material, Adhesion property (bonding) between fibers and matrix, weight percentage of fiber, and fiber reinforcement responsible are responsible for thermal analysis of natural fiber, many researchers reported their results towards thermal effects of natural fiber composites.

The hybrid epoxy composite reinforcing with jute/fiber glass and studied electrical and thermal properties of the composites. First sample consisting epoxy strengthened glass fiber with volume fraction 50%, 2nd type sample made with 25% glass fiber + 25% jute and the third type sample made of jute and epoxy strengthened with a volume fraction of epoxy (50%). Investigation displayed high thermal conductivity and electrical conductivity for first type sample (epoxy glass with 50% volume fraction) as compared to two other type samples (jute-glass fiber-epoxy and jute-epoxy). Third sample of jute and epoxy displayed low thermal conductivity [19].

Ahybrid composite by using kenaf/pineapple leaf fiber as reinforcement and studied the thermal properties of the developed composite. From the investigation it was seen that stability of the kenaf fiber reinforcement is high compared with pineapple leaf fiber addition. On the addition of Kenaf fiber, composite given better thermal properties. The composite makes good bonding between the matrix and the fibres[1].

The developed hybrid composite using kenaf/bamboo fiber as reinforcement and studied the thermal properties of composites. The composites was fabricated with by maintaining two different fiber ratio of 30 wt. % and 70 wt. %. The overall fiber content chosen as 40 wt. %. The composite fabricated using similar proportion of kenaf and bamboo fibers then it given good impact towards the behaviour of thermal properties. There is a good bonding between the fibres and matrix and this results in high stress transfer rate and lower coefficient of thermal expansion[3].

The hybrid composite reinforced with sisal fiber by applying 5, 10 and 15 wt. % fiber loading conditions and focussed on the finding of thermal properties. Investigation shown that 10 wt. % of sisal fiber played role as a nucleating agent for the PLA resin. Increasing the contents of sisal fiber makes the fibers for accumulating in the PLA resin and it disrupts the characteristics towards the beneficial[14].

The hybrid polyester composite reinforcing by sisal/kenaf fibers and thermal analysis of hybrid polyester composite was carried out . Investigation shown that thermal stability grown up to about 4 % higher than with single fibre reinforcement . At 300℃ weight loss was observed about 10 % and 9 % of the composites made with 40 wt. % of kenaf/sisal fiber and at the same temperature, weight loss of composite was found only 7 % and 6 % for 10 wt. % of kenaf fiber and 40 wt. % sisal fiber[9].

Theprepared epoxy hybrid composite with the addition of areca palm fiber as reinforcement. Investigation shows higher thermal conductivity when temperature of polymer composites is increases. For 90^0 fibers angle orientation, the thermal conductivity is obtained at higher side i.e., 0.215 W/mK. Thermal analysis displayed that the stability of areca Palm fiber composite's increases. It has been concluded that the fabricated composites are light weight and show good thermal and mechanical properties. These fiber reinforced composites can be used in the preparation of ship building, aircraft components, automobile interior parts, electronic goods etc[16]. Thehybrid epoxy composite using bamboo as reinforcement and studied the thermal properties of composites. Investigation given excellent thermal stability for bamboo epoxy composite than the fully epoxy composite[20].The hybrid composite by using kenaf/pineapple leaf fiber as reinforcement and focussed on the investigation thermal properties. Prepared hybrid composite provided thermal stability in higher side in comparison to the individual fiber reinforcement composites[2].

III. CONCLUSION

In this study, it has been summarized that many researchers reported about the mechanical and thermal properties of hybrid composites reinforced with the combination of natural fibres/natural fibres or natural fibre/synthetic fibre-based.

Study shows that the combination of two natural or natural/synthetic fibres improved the mechanical and thermal properties of the hybrid composites as compared to individual fibre reinforced polymer composites. The epoxy-based composites reinforced with jute fibers highlighted the rich mechanical and thermal response in comparison to other epoxy-based composites.

It was also reported that physical properties of fibres, any treatment, modification and orientation of the fibres are the causes to affect the mechanical properties of the hybrid composites. Some authors shown their results for covering the thermal analysis of hybrid composites but further more research is required to know the effects of hybridization on the thermal properties.

Furthermore, many options may be possible for new research regarding the combination use of natural fibers as reinforcement with the polymer matrix to develop a new hybrid composite material.

The hybrid composites have good applications in the fabrication of automobile parts construction and building, electrical industries and also in other sectors as compared to single fibre-reinforced polymer composites.

The hybrid composites prepared by the combination of natural/natural and natural/synthetic fibres are environmentally friendly, cost effective and producing good comparable mechanical and thermal behaviourin comparison to others.

REFERENCES

[1]. Asim, M., Jawaid, M., Paridah, M. T., Saba, N., Nasir, M. and Shahroze, R. M., (2019) 'Dynamic and Thermo-Mechanical Properties of Hybridized Kenaf/PALF Reinforced Phenolic Composites', Polymer Composites, Vol.40, No.10, pp. 3814–3822.

[2]. Asim, M., Paridah, M.T., Jawaid, M., Nasir, M. and Saba, N., (2018) 'Physical and Flammability Properties of Kenaf and Pineapple Leaf Fibre Hybrid Composites', IOP Conference Series: Materials Science and Engineering, Vol.368, No.1, pp. 1-15.

[3]. Chee, S. S., Jawaid, M., Sultan, M. T. H., Alothman, O. Y. and Abdullah, L. C., (2019) 'Thermomechanical and Dynamic Mechanical Properties of Bamboo/Woven Kenaf Mat Reinforced Epoxy Hybrid Composites', Composites Part B: Engineering, Vol.163, pp. 165–174.

[4]. Datta, J. and Kopczyńska, P., (2015) 'Effect of Kenaf Fibre Modification on Morphology and Mechanical Properties of Thermoplastic Polyurethane Materials', Industrial Crops and Products, Vol.74, pp. 566–576.

[5]. Davoodi, M. M., Sapuan, S. M., Ahmad, D., Ali, A., Khalina, A. and Jonoobi, M., (2010) 'Mechanical Properties of Hybrid Kenaf/Glass Reinforced Epoxy Composite for Passenger Car Bumper Beam', Materials and Design, Vol.31, No.10, pp. 4927–4932.

[6]. Jafrey, J. D. J., Manoharan, S., Saikrishnan, G. and Arjun, S., (2019) 'Influence of Bagasse/Sisal Fibre Stacking Sequence on the Mechanical Characteristics of Hybrid-Epoxy Composites', Journal of Natural Fibers, Vol.2, No.2, pp. 1–11

[7]. Khan, T., Sultan, M. T. H., Shah, A. U. M., Ariffin, A. H. and Jawaid, M., (2019) 'The Effects of Stacking Sequence on the Tensile and Flexural Properties of Kenaf/Jute Fibre Hybrid Composites', Journal of Natural Fibers, Vol.8, No.1, pp. 1–12.

[8]. M. Ramesh, Jafrey Daniel James Dhilip, S. Akilan, B. Ganeshprasad, and G. Hari Shankar (2020), 'Influence of Stacking Sequence on Mechanical and Thermal Characteristics of Banana Pineapple Fiber Reinforced Epoxy Composites', Journal of Natural Fibers,

[9]. Nimanpure, S., Hashmi, S. A. R., Kumar, R., Bhargaw, H. N., Kumar, R., Nair, P. and Naik, A., (2019) 'Mechanical, Electrical, and Thermal Analysis of Sisal Fibril/Kenaf Fiber Hybrid Polyester Composites', Polymer Composites, Vol.40, No.2, pp. 664–676.

[10]. Prasad, L., Saini, A. and Kumar, V. (2019) 'Mechanical Performance of Jute and Basalt Fiber Geo-Grid-Reinforced Epoxy Hybrid Composite Material', Journal of Natural Fibers, Vol.1, No.8, pp. 1–11.

[11]. Pavankalyan, S., Paul, R. C. and Kamalakannan. K., (2018) 'Experimental Investigation of Areca fiber Reinforced Polypropylene Polymer Composite for Automotive Components', International Journal of Pure and Applied Mathematics, Vol.118, No.24, pp. 1–12

[12]. Sathyaseelan P, PrabhukumarSellamuthu& Lakshmanan Palanimuthu (2020) 'Influence of Stacking Sequence on Mechanical Properties of Areca-kenaf Fiber-Reinforced Polymer Hybrid Composite', Journal of Natural Fibers 2020.

[13]. P.Sathyaseelan, PrabhukumarSellamuthu, (2019) 'Influence of Stacking Sequences on Tensile Behaviour of Areca-Kenaf Hybrid Epoxy Composite', International Journal of Engineering and Advanced Technology (IJEAT), Vol.8, No.6, pp.3040-3044.

[14]. Samouh, Z., Molnar, K., Boussu, F., Cherkaoui, O. and Moznine, R. E., (2019) 'Mechanical and Thermal Characterization of Sisal Fiber Reinforced Polylactic Acid Composites', Polymers for Advanced Technologies, Vol.30, No.3, pp. 529–537.

[15]. Sreenivasan, V. S., Rajini, N., Alavudeen, A. and Arumugaprabu, V., (2015) 'Dynamic Mechanical and Thermo-Gravimetric Analysis of Sansevieria Cylindrica/Polyester Composite: Effect of Fiber Length, Fiber Loading and Chemical Treatment', Composites Part B: Engineering, Vol.69, pp. 76–86.

[16]. S. P. Kumar Gudapati., K. Supraja., A.V. Ratna Prasad, 'Thermal Conductivity Characterization Of Areca Palm Fiber Reinforced Polymer Composites', International Journal of Pure and Applied Mathematics, Vol.119, No.17, pp.1871-1880

[17]. Venkatesh, R. P., Ramanathan, K. and Raman, V. S., (2016) 'Tensile, Flexual, Impact and Water Absorption Properties of Natural Fibre Reinforced Polyester Hybrid Composites', Fibres and Textiles in Eastern Europe, Vol.24, No.3, pp. 90–94.

[18]. Wang, T., Song, B., Qiao, K., Ding, C. and Wang, L., (2019) 'Influence of the Hybrid Ratio and Stacking Sequence on Mechanical and Damping Properties of Hybrid Composites', Polymer Composites, Vol.40, No.6, pp. 2368–2380.

[19]. Zahra K. Hamdan, Ahmed Ali Farhan Qgaili, Zaineb w. metteb and Fadhel Abbas Abdulla, (2021) 'Study the electrical, thermal behaviour of glass/jute fibre hybrid composite material', IOP Publishing: Annual Conference on Science and Technology Research (ACOSTER) 2020, pp. 1-6

[20]. Zhang, K., Wang, F., Liang, W., Wang, Z., Duan, Z. and Yang, B., (2018) 'Thermal and Mechanical Properties of Bamboo Fiber Reinforced Epoxy Composites', Polymers, Vol.10, No.6, pp.1-18.