Research Review on Characterisation of Sisal-Glass Fiber Reinforced Hybrid Epoxy Composite

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Abstract*- The characterisation of epoxy-based hybrid composites was reviewed in this article by incorporating sisal and glass fibres into an epoxy matrix. Hardness, tensile,bending,compressive and SEM analysis tests from various researches of the material were studied.Natural fibres are replacing synthetic fibres because of their Excellent properties, such as high specific strength, low cost, good mechanical properties, non-abrasive nature and biodegradable characteristics. Natural fibre composites, on the other hand, have lower mechanical properties than synthetic composites such as glass fibre reinforced polymer (GFRP). A brief analysis has been conducted in this paper to allow use of one of the natural fibres, "Sisal," which is widely available in India. To improve Engineering and Technology applications, GFR Polymers are mixed with sisal in different sisal fibre proportions. The mechanical properties of sisal-glass fibre composites are reviewed. This paper also aims the mechanical properties of the composite after natural fibre reinforcement, as well as the different factors influencing the mechanical properties of natural fibre composites, are also discussed in this study (NFCs). It also looks at how natural fibres can be used as a alternative for synthetic fibres in a wide range applications.*

Keywords*-* Characterisation, Epoxy Composite,Fiber Reinforcement, Glass Fiber,Mechanical Properties, Natural Fibers, Sisal Fiber

I. INTRODUCTION

The quest for low density, high strength, non – abrasion nature, impact resistance, corrosion resistance of structural materials has intensified in recent years. To meet the above criteria, composite materials must be created by combining two or more different materials. A composite is a combination of material made up of two or more materials that are macroscopically combined but are not soluble in each other. So, the FRP is one of the composite material made up of polymer matrix and high strength fibres like natural or synthetic fibres. A natural fibre reinforced polymer composites have drawn increased research interest as a result of the increasing global energy crisis and environmental risks. Natural fibres have a number of advantages, including their availability, green nature, biodegradability, environmental friendliness, low density, low cost, high specific properties, improved energy recovery, strong thermal properties, low energy consumption, and non-abrasiveness.

So, the physical properties of prepared composites like tensile strength, hardness, bending was studied and analysed from various research papers. The surface analysis of the composite were analysed by scanning electron microscope (SEM). Sisal fibre composites have a low density and high specific properties, and they are less costly than other synthetic fibres, so they can be used in automobiles and other forms of transportation industry in the future.

II. LITERATURE REVIEW

C. Sivakandhan et al.(2020)The tensile strength of a composite material is determined by the strength and modulus of the fibres. As fibre reinforced composites are loaded, the fibres serve as load carriers, transferring stress from matrix to the fibres, resulting in efficient and uniform stress distribution and a composite with good mechanical properties.By addition offibres, the flexural strength and modulus of the composite was increased.The impact test results shows the strength of the fibre hybrid epoxy composites increases with weight fraction of sisal fibre increases up to 35 weight percentage.According to the author, Sisal/epoxy composites have stronger impact properties than jute fibre epoxy composites.SEM study of various hybrid composites shows that the jute composites, is havinggood mechanical properties on comparing with jute and sisal epoxy composites.K. Raju, M. Balakrishnan (2020)According to the author the results of the analysis indicate that the composite made with NaOH-treated fibre has a higher strength than other composite materials. The ratio of glass and palm fibre addition to the composite has a higher tensile strength, according to the tensile strength results.The composite with both palm and glass reinforcement has a higher hardness than the other individual reinforcements, according to the hardness test.The author concluded for low cost and simple decomposition, this hybrid composite of glass and palm fibre reinforcements can be used to replace vehicle components and proportion of the reinforcement may be varied and analysed to get various properties.D. Getu, Ramesh Babu Nallamothu, M. Masresha et al, (2020) Fabricated and found characteristics properties of bamboo and sisal fiber reinforced hybrid composite the hand layup technique was used to create a hybrid composite with bamboo/sisal fibre reinforced polyester.It is found with a 0° fibre orientation, the bamboo/sisal fibre reinforced hybrid composite has a higher tensile strength. The 0°fiber orientation composite has a higher compressive strength than the 90° fibre orientation composite and the bidirectional (0°/90°) fibre orientation composite, according to the compressive strength of the hybrid composite reinforced with bamboo/sisal fibre.The author concluded by inferring all of the findings and comparisons that the fabricated hybrid composite can be used in vehicle parts that do not need a high level of mechanical efficiency but do require light weight and recyclability, such as an interior panel.Suresh Kumar. D, Dr. Sanjeevamurthy, Dr. G. Mallesh (2020)Evaluated the mechanical properties of Sisal /Glass fiber reinforced epoxy composites by fabricating the composites using handlayup technique and discovered that the development of a hybrid composite that combines natural (Sisal) and synthetic (glass) fibres improves mechanical properties, biodegradability, and disposal ease at the end of their service life. Sisal-glass fiber composites can be extensively used where bending load is important it expresses good mechanical properties. R. Siva, B. Kesavaram, J. Jones Martin et al. (2020) Analysed mechanical behavior of sisal and banana fiber reinforced hybrid epoxy compositesby fabricating in the ratio of fiber and resin of 52:48. The sisal/epoxy composite shows the highest tensile strength of 24.5 MPa, Flexural strength of 80.45 MPa, and Impact strength of 1.76 J it shows the pathway to use in lightweight commercial and consumer applications.M. Dhinesh Kumar et al. (2020)Studied on static and dynamic behavior of jute/sisal fiber reinforced epoxy composites there are separate natural fibre reinforced composite laminated plates were fabricated using the hand Lay-up technique in this experimental investigation. On Comparing the flexural strength and tensile strength of the three composite laminated platesit is found that the hybrid composite laminated plate has the highest tensile strength and flexural strength when compared to the other two composite plates. The stacking series (Jute-Sisal / Sisal-Jute) had strong static mechanical properties.Shahana Parbin et al. (2019)According to the authors review on Mechanical properties of natural fiber reinforced epoxy composites. The tensile property of the composite increases to a certain limit of fiber loading and the strength decreases gradually due high fiber loading. The flexural property of the composites are better when compared to virgin epoxy. Flexural property of jute fiber composites is smaller than that of bamboo fiber composites.The impact strength of an epoxy composite increases with increase in fiber stacking without an abrupt destruction.Natural fibres are very compatible with epoxy matrix, according to the source, since both the fibre and the matrix bind to each other very well, forming a strong bond between them.R. Vishnuvardhan et al. (2019)The experimental Investigation on Mechanical Properties of Sisal Fiber Reinforced Epoxy Composite of the authors results declares that the mechanical properties of sisal composites, such as flexural, tensile, and impact strength, are found to improve as the fibre content in the epoxy matrix increases.The water absorption of sisal fibre is observed to increase as the sisal fibre content increases.Prabhu. L et al. (2019) The behavior analysis such as mechanical, chemical and acoustical of Sisal Glass Fiber Reinforced Epoxy Hybrid Polymer Composites shows different weight ratios of sisal and tea fibres were used to test the mechanical properties of sisal-tea-glass fibre reinforced hybrid composites such as tensile, flexural, and effects.The composites strength were found to be growing as more sisal material was hybridised with glass fibre.The SEM micrographs also revealed that hybridization increase interfacial holding between the fibre and matrix stagesRagunath et al. (2018)From the authors evaluations The glass fibre composite (4G6E) specimen had a higher tensile strength than the other specimen compositions, according to the results. Simultaneously, sisal fibre loaded glass fibre composite (2S2G6E) has nearly the same power.It is obviously noted that the sisal fibre does not generate a significant amount of strength on its own. However, when it is filled with glass fibre, it has a substantial increase in power. T. Anbarasan et al. (2018**)**On comparing the fabricated sisal reinforced glass fiber composite values with the turbodiesel cessna 172 jtuses aluminium2024-t3 alloys for its wing structure using CATIA software the structural analysis of the aluminum alloy with the composite shows the result that composite material cannot be used in heavy applications due to its less mechanical properties when compared with aluminium alloys. Composites are useful in lighter automotive applications. K. Senthilkumar et al. (2018)The mechanical properties of sisal fibre reinforced composites can be improved by adding fillers or additives to the matrix until a critical or optimum weight percent is reached. The water absorption of the sisal reinforced composite was also reduced by fibre treatments/additives/filler/hybridization because sisal reinforced composites absorb less moisture when compared to individual fibre reinforced composites.S. Nimanpure et al. (2018)According to the authors electrical and dynamic analysis the results shows at higher frequencies, the composites have good electrical insulating properties. With increasing temperature, the value of electrical properties for both composites increased.Due to its high mechanical strength and electrical insulating material, these composites are specifically used and designed for press board used in transformer assembly and also used in various applications of electrical and aerospace industry.Piyush Prajapati et al. (2018) The lengthyfibres affect the bonding so,it is found that the lack of curling effect, enables better fibre matrix bonding, small size coir fibres were found to be more effective as reinforcement and had the highest tensile strength. Hence, hand-layup method is followed so tensile and flexural strength is more upto 3 layers of glassfiber reinforcement beyond that the properties begin to decrease gradually.Govind Pathak et al.(2018) Experimental studiesshows that the sisal and glass fiber composites turns out high compressive strength and compressive modulus when compared to glass fiber epoxy composites. The presence of glass fiber increases the hardness and impact property of the composite. R.S. Rana et al.(2020)From the experimental investigation it is clearly shows that the mechanical properties like tensile,impact,hardness are increased upto 4% of fiber loading and then it is decreasing gradually. The use of acetone increases the interfacial bonding properties of the composites to exhibit more bonding strength. Not maintaining proper hopmogeneous mixing will lead to formation of air bubbles which is responsible for crack formation in composite and leads to fatigue failure.Ashishkumre et al. (2017) From the authors conclusion it is found that the moisture resisting capacity of the composite is increased by the help of sisal reinforcement. According to the length factor of the fibres the longer the length of the sisal fiber exhibit curling effect which exhibit poor bonding with the matrix and the glass fiber. R.A. Braga, P.A.A. Magalhaes Jr (2015)The study of mechanical,thermal andwater absorbtion property of the composites shows the following conclusions the impact energy is 2.62% more with addition of glass fiber. Addition of glass fiber to jute fiber increases 68.70% of tensile strength and further increased to 92.01%. The thermal properties shows the more percent of jute fiber composite is lost the mass heavily and more percent of glass fiber composite lost the in weight small amount. Finally,addition of more jute fiber absorbed more water when compared to glass fiber composite. Hari Om Maurya et al. (2015) The tensile strength was not increased by reinforcing more sisal fibers. Flexural strength was increased but not much increased. It is increased only to a certain point. Impact properties of short sisal fibres reinforced composite shows maximumresults.V.P. Arthanarieswaran et al. (2014)The three layers of glass fiber with banana-sisal reinforcement exhibited 104Mpa of tensile strength and flexural strength withstands upto 192Mpa.Finally,impact energy of 13.3 J is obtained which is relatively higher for a natural fiber reinforced composites. Ajith Gopinath et al. (2014)The jute-polyester and jute-epoxy composite was prepared as per ASTM standards. The tensile strength for jute-epoxy and jute-polyester composites was found to be 12.46 N/mm2 and 9.23N/mm2 respectively. Various test results shows there is better mechanical properties was exhibited for the jute-epoxy composite when compared to the jute-polyester composite. M.Ramesh et. al (2013) On comparison with the Sisal-GFRP and Jute-GFRP the Sisal-GFRP composite possess high tensile strength and withstand strength upto 68.55Mpa. The failure morphology was analysed by SEM and the results conclude the Sisal-GFRP possess high tensile strength and Jute-GFRP possess high flexural strength.M. A. Kumar et al. (2010)in this research the composite was formed by varying fibre lengh in hand-layup method. The author concludes that the 2cm lengthy fiber composites having high hardness and impact strength when compared to 1cm and 3cm fiber lengths. Addition of alkali shows higher frictional and mechanical properties. So,2cm fiber length composite treated with alkali showed better strength when comparing with the untreated composite.

III. PROBLEM IDENTIFICATION

It was identified that most of the researchers fabricated the composite materials in a traditional technique of hand-layup method which is highly time consuming. On comparison of various types of natural fibers (sisal,banana,kemp,jute etc.,) with glass fiber we found that banana,jute,kemp exhibit moderately low properties when comparing to sisal reinforced composite. The fabrication of sisal-glassfiber epoxy composite in hand-layup method will require high man power and more time. The fabrication of complicated shape by hand-layup method is hard. In hand-layup method assuming length of fibers for the fabrication is tedious process. So,the sisal-glass fiber composite fabricated by chopped particles of fibers requires less time and can be easily mixable in the epoxy matrix,production of complicated shape will be easier, and finally man power required will be less.

IV. CONCLUSION

According to literature survey,the natural fiber reinforced glass fiber composite possess greater mechanical properties,and having greater scope in the automotive applications. Due to its bio-degradability,green nature a wide range of opportunities are available to manufacture this type composites in order to replace the synthetic fibres. In most of the cases the fabrication was carried out in hand-layup method. The mechanical properties of the sisal-glass fiber composite can be increased by forming the composite by mixing fine particles of sisal and glass fiber with epoxy matrix together. So,The process involved will require less man power and complicated shape can be obtained and it will exhibit more strength when compared to traditionally made composite material which is hand-layup method.

REFERENCES

[1] Sivakandhan, C., Murali, G., Tamiloli, N., & Ravikumar, L. (2020). “Studies on mechanical properties of sisal and jute fiber hybrid sandwich composite.”*Materials Today: Proceedings*, *21*(xxxx), 404–407. https://doi.org/10.1016/j.matpr.2019.06.374

[2] Raju, K., & Balakrishnan, M. (2020). “Evaluation of mechanical properties of palm fiber/glass fiber and epoxy combined hybrid composite laminates”. *Materials Today: Proceedings*, *21*(xxxx), 52–55. https://doi.org/10.1016/j.matpr.2019.05.359

[3] Getu, D., Nallamou, R. B., Masresha, M., Nallamothu, S. K., & Nallamothu, A. K. (2020). Production and characterization of bamboo and sisal fiber reinforced hybrid composite for interior automotive body application. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.08.780

[4] Srinivasan, R., & Thirugnanam, S. (2020). Mechanical Properties of Hybrid Fiber Reinforced Epoxy Composites. *I-Manager’s Journal on Mechanical Engineering*, *10*(1), 32. https://doi.org/10.26634/jme.10.1.16744

[5] Siva, R., Kesavaram, B., Jones Martin, J., Mathiselvan, G., Navas, K. B., & Sangeetha, M. (2020). Mechanical behavior of sisal and banana fiber reinforced hybrid epoxy composites. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.10.805

[6] Dhinesh Kumar, M., Senthamaraikannan, C., Jayasrinivasan, S., & Aushwin, S. (2020). Study on static and dynamic behavior of jute/sisal fiber reinforced epoxy composites. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2020.03.064

[7] Parbin, S., Waghmare, N. K., Singh, S. K., & Khan, S. (2019). Mechanical properties of natural fiber reinforced epoxy composites: A review. *Procedia Computer Science*, *152*, 375–379. https://doi.org/10.1016/j.procs.2019.05.003

[8] Vishnuvardhan, R., Kothari, R. R., & Sivakumar, S. (2019). Experimental investigation on mechanical properties of sisal fiber reinforced epoxy composite. *Materials Today: Proceedings*, *18*, 4176–4181. https://doi.org/10.1016/j.matpr.2019.07.362

[9] Prabhu, L., Krishnaraj, V., Gokulkumar, S., Sathish, S., & Ramesh, M. (2019). Mechanical, chemical and acoustical behavior of sisal - Tea waste - Glass fiber reinforced epoxy based hybrid polymer composites. *Materials Today: Proceedings*, *16*, 653–660. https://doi.org/10.1016/j.matpr.2019.05.142

[10] Ragunath, S., Velmurugan, C., Kannan, T., & Thirugnanam, S. (2018). Evaluation of tensile, flexural and impact properties on sisal/glass fiber reinforced polymer hybrid composites. *Indian Journal of Engineering and Materials Sciences*, *25*(5), 425–431.

[11] Anbarasan, T. (2018). *Structural Analysis of Natural Fiber Reinforced Epoxy-Hybrid Composites*. *7*(04), 96–102.

[12] Senthilkumar, K., Saba, N., Rajini, N., Chandrasekar, M., Jawaid, M., Siengchin, S., & Alotman, O. Y. (2018). Mechanical properties evaluation of sisal fibre reinforced polymer composites: A review. *Construction and Building Materials*, *174*, 713–729. https://doi.org/10.1016/j.conbuildmat.2018.04.143

[13] Nimanpure, S., Hashmi, S. A. R., Kumar, R., Nigrawal, A., & Naik, A. (2018). Electrical and dynamic mechanical analysis of sisal fibril reinforced epoxy composite. *IEEE Transactions on Dielectrics and Electrical Insulation*, *25*(5), 2020–2028. https://doi.org/10.1109/TDEI.2018.006661

[14] Prajapati, P., Sharma, C., Shrivastava, R., & Rana, R. S. (2018). Evaluation of mechanical properties of coir and glass fiber hybrid composites. *Materials Today: Proceedings*, *5*(9), 19056–19062. https://doi.org/10.1016/j.matpr.2018.06.258

[15] Pathak, G., Dubey, O. P., & Manoharan, P. K. (2018). Mechanical Properties of Sisal/Glass Fiber Reinforced Hybrid Composites: a Review. *International Journal of Students’ Research in Technology & Management*, *6*(2), 70–76. https://doi.org/10.18510/ijsrtm.2018.6210

[16] Rana, R. S., Kumre, A., Rana, S., & Purohit, R. (2017). Characterization of Properties of epoxy sisal / Glass Fiber Reinforced hybrid composite. *Materials Today: Proceedings*, *4*(4), 5445–5451. https://doi.org/10.1016/j.matpr.2017.05.056

[17] Kumre, A., Rana, R. S., & Purohit, R. (2017). A Review on mechanical property of sisal glass fiber reinforced polymer composites. *Materials Today: Proceedings*, *4*(2), 3466–3476. https://doi.org/10.1016/j.matpr.2017.02.236

[18] Braga, R. A., & Magalhaes, P. A. A. (2015). Analysis of the mechanical and thermal properties of jute and glass fiber as reinforcement epoxy hybrid composites. *Materials Science and Engineering C*, *56*, 269–273. https://doi.org/10.1016/j.msec.2015.06.031

[19] Maurya, H. O., Gupta, M. K., Srivastava, R. K., & Singh, H. (2015). Study on the Mechanical Properties of Epoxy Composite using Short Sisal Fibre. *Materials Today: Proceedings*, *2*(4–5), 1347–1355. https://doi.org/10.1016/j.matpr.2015.07.053

[20] Arthanarieswaran, V. P., Kumaravel, A., & Kathirselvam, M. (2014). Evaluation of mechanical properties of banana and sisal fiber reinforced epoxy composites: Influence of glass fiber hybridization. *Materials and Design*, *64*, 194–202. https://doi.org/10.1016/j.matdes.2014.07.058

[21] Gopinath, A., Senthil Kumar, M., & Elayaperumal, A. (2014). Experimental investigations on mechanical properties of jute fiber reinforced composites with polyester and epoxy resin matrices. *Procedia Engineering*, *97*, 2052–2063. https://doi.org/10.1016/j.proeng.2014.12.448

[22] Ramesh, M., Palanikumar, K., & Reddy, K. H. (2013). Comparative evaluation on properties of hybrid glass fiber-sisal/jute reinforced epoxy composites. *Procedia Engineering*, *51*(NUiCONE 2012), 745–750. https://doi.org/10.1016/j.proeng.2013.01.106

[23] Ashok Kumar, M., Ramachandra Reddy, G., Siva Bharathi, Y., Venkata Naidu, S., & Naga Prasad Naidu, V. (2010). Frictional coefficient, hardness, impact strength, and chemical resistance of reinforced sisal-glass fiber epoxy hybrid composites. *Journal of Composite Materials*, *44*(26), 3195–3202. https://doi.org/10.1177/0021998310371551

[24] Anjaneyulu, J., & Chandra, P. (2020). ScienceDirect Evaluation of mechanical behaviour of Glass fibre-epoxy composite laminates. *Materials Today: Proceedings*, *22*, 2899–2905. https://doi.org/10.1016/j.matpr.2020.03.423

[25] Samal, A., & Soumya, S. (2020). ScienceDirect Comparison study of Mechanical properties of Sisal-Jute and Jute- Banana hybrid composite. *Materials Today: Proceedings*, *21*, 1234–1238. https://doi.org/10.1016/j.matpr.2020.01.075