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Review

A Review on Characterization of Hybrid Fibre Reinforced Polymer Composite

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Abstract

Fibre reinforced polymer composite are well recognized materials for automobile, aerospace, packaging and construction industries due to its properties such as light weight, low cost and high specific strength. Hybridization of fibres has become very popular technique to increase the properties of single fibre reinforced polymer composite. This paper presents review on mechanical properties, thermal properties, water absorption properties, dynamic mechanical analysis and tribological behaviour of hybrid fibre reinforced polymer composite. Finding of this study shows that hybridization can improved mechanical, thermal and dynamic mechanical property, and decrease water absorption property and wear rate.

Keywords: Hybrid; Natural fibre; Polymer; Characterization

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1. Introduction

Fibre reinforced polymer composite is consist of either synthetic or natural fibre as reinforcement and polymer as matrix. Synthetic fibre like glass, carbon and aramid has been frequently used in aerospace and automobile industries due to low density, high stiffness and strength. In spite of these properties of synthetic fibre, they have serious drawbacks like biodegradability, recyclability, initial processing cost and health hazards etc. Natural fibres like jute, banana, sisal, hemp etc. have potential to replace these synthetic fibres for environmental concern due to its properties such as lightweight, low cost, environmental friendly, high flexibility, renewability, biodegradability, high specific strength, high toughness, and easy processing [1-8]. Natural fibres also suffer by some limitations like low strength and high water absorption property. These limitations can be improved by using hybridization technique. Hybrid composite are those which have more than one reinforcement in a single matrix or single reinforcement with multiple matrix or multiple reinforcement with multiple matrix. Hybridization can increase the mechanical properties of single fibre polymer composite due to following reason:

- In hybridization, two types of fibres having same length but with different diameters into a polymer matrix provides some advantages over the use of one fibre in the composites. Different diameters of fibres increased the effective area for fibres matrix adhesion so that uniform transfer of stress could take place [9].
- In hybridization two different fibres are used with their different modulus. The high modulus fibre provides the stiffness and load bearing capacity whereas low modulus fibre provides more damage tolerant and reduced the material's cost [10].
- In hybridization two different fibres are used with their different elongation at break. The fibre having low elongation will break first and then the load may be carried by the fibre having high elongation without the failure of matrix, inducing better stress transfer from matrix to fibres and thus resulting in increased mechanical properties [11].

In this review, mechanical properties, dynamic mechanical analysis, thermal properties, water absorption property and tribological property of hybrid fibre reinforced polymer composite are discussed.

2. Characterization of hybrid fibre reinforced polymer composite

2.1 Mechanical properties of hybrid fibre reinforced polymer composite

Many researchers have added synthetic fibre with natural fibre reinforced polymer composite and they found positive result of hybridization in terms of increase in mechanical properties of single natural fibre reinforced polymer composite [12-15]. Kumar et al. [16] studied the effect of glass fibre loading with banana fibre reinforced polypropylene composite. The hybrid composite is prepared by injection moulding process with various weight fractions of fibres. They reported that the mechanical properties are improved due to incorporation of glass fibres with banana composite. AlMaadeed et al. [17] studied the effect of addition of glass fibre with date palm wood flour reinforced hybrid polypropylene composites. They found increase in tensile strength and tensile modulus of date palm polypropylene composite due to reinforcement of glass fibres.

Many researchers [18-22] have also used additional high strain natural fibre with natural fibre reinforced polymer composite. It is observed that addition of high strain natural fibre have increased the mechanical properties of single natural fibre reinforced polymer composite. Shanmugam et al. [23] investigated the

effect of jute fibre loading on mechanical properties of unidirectional palm stalk fibre reinforced polyester composite. They found that addition of jute fibre into palm fibre reinforced polyester composite has increased its mechanical properties. Boopalan et al. [24] investigated the effect of jute fibre loading on mechanical properties of banana fibre reinforced epoxy composites. They found its positive effect in terms of increased mechanical properties of banana composite. Venkateshwaran et al. [25] fabricated banana/sisal reinforced epoxy composite and studied its mechanical properties. They found that hybrid sisal and banana composites show the better mechanical properties than single banana and sisal composite.

2.2 Dynamic mechanical properties of hybrid fibre reinforced polymer composite

Dynamic mechanical analysis has become a far used technique to determine the interfacial characteristics of natural fibre reinforced polymer composite. Many researchers have reported studies on dynamic mechanical analysis of natural fibres reinforced polymer composites. Idicula et al. [26] reported study on the dynamic mechanical analysis of hybrid banana /sisal fibre reinforced polyester composites. Dynamic mechanical analysis of hybrid composite is evaluated in terms of storage modulus, loss modulus and damping factor using three point bending test, within temperature range 30-150 ℃ at different frequencies. At 40 vol. % fibre content the storage modulus and peak width of $Tan\delta$ is found the maximum but the $Tan\delta$ height is the minimum. Shanmugam et al. [23] proposed study on dynamic mechanical properties of alkali treated hybrid palmyra palm leak stalk / jute fibre reinforced polyester composite. The results indicated that addition of jute fibres to palmyra palm leak stalk fibre and alkali treatment of fibres has enhanced storage and loss modulus. The maximum damping behavior is observed for composite with higher jute fibre content. Jawaid et al. [19] studied the dynamic mechanical analysis of hybrid jute/oil palm epoxy composite. Storage modulus of palm fibre reinforced epoxy composite is increased due to incorporation of jute fibres while damping factor shifts toward higher temperature.

2.3 Thermal properties of hybrid fibre reinforced polymer composite

Thermal analysis of composite is used to find out the thermal stability of composites. Kasama et al. [27] studied the thermal properties of sisal/glass fibre reinforced polypropylene composite. It is reported that the decomposition temperature is increased with increasing glass fibre contains in composites. Boopalan et al. [9] studied the thermal properties of hybrid jute/banana fibre reinforced epoxy composite. They suggested that the hybrid composite (50% jute and 50% sisal of 30 wt. %) shows the higher thermal stability as compared to others composites. Jawaid et al. [28] reported the studies on thermal properties of hybrid oil palm/woven jute fibre reinforced epoxy composite. Addition of woven jute fibres in oil palm fibre reinforced epoxy composite increased its thermal stability. Naidu et al. [29] studied the thermal properties of sisal/glass fibre reinforced polyester composite. Thermal conductivity of hybrid sisal/glass fibre is found higher than sisal reinforced composite but lower than glass fibre reinforced polyester composite. Dhakal et al. [30] reported studies on thermal properties of hybrid hemp/glass fibre reinforced polyester composite. They reported that the hybrid composite shows better thermal stability as compared to other composites. Saw et al. [31] reported study on thermal properties of hybrid jute/bagasse fibre reinforced epoxy composite. They suggested that the hybrid composites show better thermal stability than other single fibre composites.

2.4 Water absorption properties of hybrid fibre reinforced polymer composite

Water absorption properties of composites are reported by different researchers and found that hybridization can decrease the water absorption properties of single fibre reinforced polymer composite. Venkateshwaran et al. [25] investigated the water absorption properties of hybrid banana/sisal fibre reinforced epoxy composite. It is observed that the addition of sisal fibre in banana fibre reinforced composite of up to 50 %

results in decreasing the water absorption properties. Thwe et al. [32] investigated the environmental behavior of hybrid bamboo/glass fibre reinforced polypropylene composite. The moisture absorption level of bamboo fibre reinforced polypropylene samples is found higher than hybrid bamboo/glass fibre reinforced polymer composites. Moisture gain decreased with increasing the glass fibres content in the composite. Mishra et al. [33] investigated the water absorption behavior of (palm/sisal)/glass fibre reinforced polyester hybrid composites with different weight percentage of fibres. They reported that the water absorption property of hybrid composites is found lower than unhybrid composites. Velmurugan et al. [34] investigated the water absorption behavior of randomly oriented hybrid palmyra/glass fibre composites with different weight fractions of fibre content. Addition of glass fibre with palmyra fibre in the matrix decreases the moisture absorption properties of the composites. Kushwaha et al. [35] investigated the water absorption behavior of the bamboo/glass fibre reinforced epoxy and polyester matrix hybrid composites. The hybrid composite shows the lower moisture uptake from 26% to 16% compared to bamboo fibre polyester composite.

2.5 Tribological properties of hybrid fibre reinforced polymer composite

Tayeb [36] explained the tribological behavior of sugarcane and glass polyester composite. He suggested that the sugarcane polyester composite shows better degree of wear resistance and friction coefficient as compared to glass fibre reinforced polyester composite. Kumar et al. [37] investigated the frictional coefficient of hybrid sisal/glass fibre reinforced epoxy composites with different sliding speeds such as 0.2, 2 and 4 mm/s with constant applied load of 10 N. The results indicates that the increasing the fibre length of the composites the frictional coefficient is found to increased. The optimal improvement is found at 2 cm treated fibre reinforced composites compared to untreated ones. Biswas et al. [38] investigated the erosion wear behavior of short bamboo/E-glass fibre reinforced epoxy hybrid composites with various weight compositions. The result of erosion rate versus impact velocity curve reported that 15 wt. % bamboo/glass fibre reinforced composites shows the least erosion rate compared to other composites.

3. Conclusions

The mechanical properties, dynamic mechanical analysis, thermal property, water absorption property and tribological property of hybrid fibre polymer composite are discussed and following conclusions are reported.

- Mechanical properties like tensile, flexural and impact property of single fibre reinforced polymer composite can be improved using hybridization technique.
- Dynamic mechanical properties such as storage modulus, loss modulus, damping and glass transition temperature are found to improve due to hybridization.
- Thermal property of single fibre reinforced polymer composite can be also increased due to hybridization.
- Wear rate, coefficient of friction and water absorption property of single fibre reinforced polymer composite are found to decrease due to hybridization.

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