

Retraction

Retracted: Investigation on Heat Deflection and Thermal Conductivity of Basalt Fiber Reinforced Composites Prepared by Hand Layup Method

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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- [1] R. M. Reddy, S. Ravi, P. K. Singh et al., "Investigation on Heat Deflection and Thermal Conductivity of Basalt Fiber Reinforced Composites Prepared by Hand Layup Method," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 1294374, 6 pages, 2022.

Research Article

Investigation on Heat Deflection and Thermal Conductivity of Basalt Fiber Reinforced Composites Prepared by Hand Layup Method

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Recent trends are shifting to the use of composite materials and their demands for making alternate materials to metals due to weight ratio, while the synthetic fiber composite also creates environmental hazards. To overcome these issues, composite materials with natural fiber reinforcement are being developed. The current work is concerned with the fabrication of composite laminates using the traditional hand layup method, with 40% reinforcement of basalt fiber mat and sawdust filler and 60% epoxy, with quantifying the thermal effects of composite laminates varying with four different weight fractions of basalt fiber and sawdust filler materials. The results revealed that maximum thermal conductance, heat deflection temperature, and coefficient of linear thermal expansion values are 0.254 W/mK, 95°C, and $2.9 \times 10^{-5}/^{\circ}\text{C}$, respectively, which increases sawdust filler loading resist the thermal effect compared to basalt fiber loading of hybrid composite.

1. Introduction

Fiber-reinforced plastics (FRPs) are effectively utilized for different utilizations of the present aviation innovation, as a result of their astounding explicit properties, for example, high explicit quality and solidness, low weight, and the capability of advancement by orientating (particularly persistent) fibers along the load conducts [1, 2]. The presentation of infusion formed short basalt fiber, hemp fiber, kenaf, and hemp/basalt fiber HDPE composites [3, 4]. Hybridization of hemp fibers

with basalt filaments was found to altogether expand the mechanical properties and the crystallinity effect of hemp-fiber reinforced composites along these lines recommending that short hemp/basalt fiber hybrid HDPE composites are a promising contender for semiauxiliary applications [5]. They are investigating the thermal properties of the composite and mechanical characterization are made it is found out from earlier research works [6, 7]. The point of this examination is to explore the impact of sugar palm fiber on varied properties of seaweed/thermoplastic sugar palm starch agar composites. By

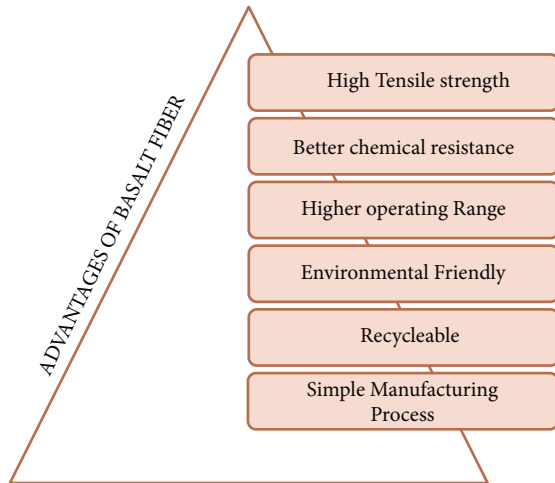


FIGURE 1: Merits of basalt fiber.

displaying higher thermal conductivities when Al_2O_3 and $\text{Mg}(\text{OH})_2$ are added, the fire resistance qualities can be improved when adding SiC nanocomposites to the mix inhibits flame propagation [8]. When blended banana/sisal hybrid fibers are chemically treated with sodium hydroxide (NaOH) and prostate-specific membrane antigen, the thermal conductivity of the reinforcement fibers is reduced. This study looked into the heat conduction of fiber-strengthened composites [9]. The expanding behavior has been studied in a variety of settings with a wide range of pH levels. With 35% filler content for UP/jute/ ZrO_2 composites, the best results were obtained [10]. The unidirectional neem wood epoxy composite has more fiber and better mechanical characteristics than the other combinations [11]. A further study combined organic neem and plant fibers with a polymeric matrix to create laminates with enhanced thermal characteristics compared to single fiber power, as well as showing that composite laminates with silane chemical treatment outperformed composite laminates with untreated mode [12]. The developed composite laminates were made of basalt/banyan fibers reinforced with epoxy matrix, and the thermal properties such as heat deflection temperature, thermal conductivity, and thermal expansion coefficient were evaluated. The results showed that the basalt fiber has improved thermal stability compared to banyan fiber loading into the composite laminates and the advantages are shown in Figure 1 [13].

The abovementioned types of literature were used to begin this research work, which deals with the reinforcement of basalt fiber, sawdust cellulose filler, and epoxy polymer matrix to fabricate the composite laminates by hand layup method for four different fiber and filler sequences to examine the thermal conductivity, heat deflection temperature, and coefficient of linear thermal expansion of basalt fiber composites.

2. Materials and Experimental Methods

Material selection for making the composite laminates is a very important factor that needs to be considered for this composite; in this present study, deals with the materials are basalt fiber which is extracted from rocks [14] and to create

in the mat form has been supplied by Go green private Limited. Another material that is investigated is sawdust filler extracted from natural wood [15], which has been supplied by the CP Timber Industry, Chennai, India. The adhesive material of biphenyl type epoxy polymer with Araldite Hy 951 hardener is a matrix material [16] that has been supplied by Javanthee Enterprisers, Chennai, and the properties are tabulated in Table 1.

2.1. Fabrication Process of Hybrid Composite. The combination of natural fiber and natural filler is reinforced with thermosetting polymer to make four different composite laminates with varying basalt and sawdust weight fraction such as 100/25, 70/50, 50/75, and 25/100 in grams, and a constant epoxy matrix of 190 g (epoxy resin/hardener ratio of 10:1) by using traditional hand layup technique to fabricate the four laminates. Initially, the wood mold box was prepared with the dimensions of 25 cm \times 25 cm and cleaned thoroughly and the mold releasing agent of liquid wax was applied to remove laminates without any defects [17]. The epoxy matrix and basalt fiber mat and sawdust cellulose are ready to be applied on the mold box, epoxy matrix was blended with sawdust during the fabrication process by using an electric stirrer, the first layer of epoxy matrix is applied on the mold box covered with laminate sheets to get the fine surface finish, and the second layer of basalt fiber mat was applied and rolled properly with a roller for spreading the matrix evenly to all the fiber portion for better adhesion and again the matrix and reinforcement materials are followed up to 10 mm of composite laminates [18]. The process was repeated for other samples, and then the laminates are moved to the hot furnace at a curing rate of 50 C/min up to 120 mins and then compressed with 10 kg on each sample for 24 hrs in atmospheric temperature for better curing between the fiber, filler, and matrix materials [19]. After 24 hrs, the laminates are taken to conduct the thermal behaviors of thermal conductivity, heat deflection temperature, and coefficient of linear thermal expansion for the hybrid composite, and the weight ratio of basalt fiber composite is given in Table 2. The fabrication process of basalt fiber composite is shown in Figure 2.

2.2. Experimental Testing of Composite Laminate. The basalt fiber with sawdust cellulose and epoxy matrix was used and the composite laminates were fabricated to evaluate the thermal properties such as thermal conductivity, heat deflection temperature, and coefficient of linear thermal expansion of hybrid composite. As per the ASTM E1530 testing methodology, to assess the resistance to thermal transmission, the guarded heat flow meter technique is used and a heat flow meter is employed to evaluate the thermal conductivity of the composite material at an average temperature of 55°C. [20]. Short-term heat resistance test was conducted as per the ASTM D1525 standard by using VICAT softening temperature apparatus for plastic standard [21]. The ASTM Standard D696 for Coefficient of Linear Thermal Expansion of Plastics Between -28°C and 32°C using a Vitreous Silica Dilatometer of basalt fiber composite [22].

TABLE 1: General properties of materials used in the present work.

Property	Basalt fiber	Sawdust filler	Epoxy matrix
Category	Natural fiber	Natural filler	Thermosetting polymer
Type	Bidirectional woven mat	Nanoparticles	Clear liquid
GSM	200	—	—
Density	2.52 g/cc	0.8 to 1 g/cc	1.25 g/cc
Tensile strength in (MPa)	45	—	40
Thermal conductivity (W/mK)	1.9	0.89	0.2

TABLE 2: Weight ratio of basalt fiber composite laminates.

Sample	Weight of basalt fiber (g)	Weight of sawdust filler (g)	Weight of epoxy matrix (g)	Weight of composite laminate (g)
A	100	25	190	315
B	75	50	190	315
C	50	75	190	315
D	25	100	190	315



FIGURE 2: Fabrication process of basalt fiber composite.

3. Results and Discussion

The developed composite laminates of basalt fiber reinforced with sawdust-blended epoxy matrix were analyzed, and thermal properties and the thermal conductivity of basalt fiber composite are shown in Figure 3; the output from this analysis revealed that basalt fiber occupied the major impact during the thermal conductivity and increasing the basalt fiber loading to this composite can increase the thermal conductivity, and at the same time, with the increase in sawdust filler loading, the thermal conductivity of the hybrid composite will decrease. Among the four samples, sample A shows higher thermal conductivity of 0.254 W/mK, and the least value occurs in sample D which is 0.165 W/mK and also the comparison between these samples 35% higher thermal conductivity due to increase of basalt fiber into the composite laminates. Similar work was conducted by another researcher in which a developed composite made of neem/banyan fibers with sawdust filler loading composite revealed that fiber content can increase thermal conductivity compared to filler loading into the fabrication of composite laminates [23].

In sample B, thermal conductivity is 0.196 W/mK which is 23% lesser than sample A and 8% more than sample C; incorporating 25 g sawdust filler can reduce the thermal conductivity of hybrid composite by 23%, and at the same

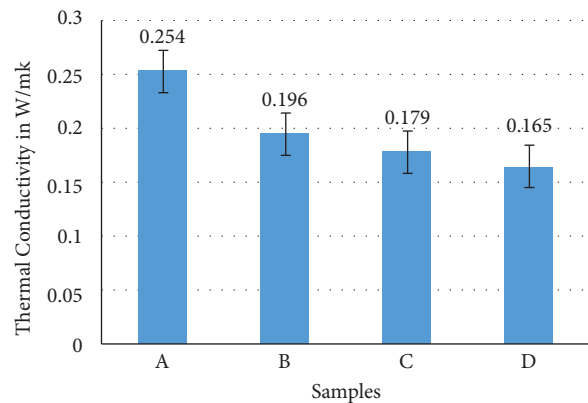


FIGURE 3: Thermal conductivity of basalt fiber composite.

time in sample C, thermal conductivity of 0.179 W/mK shows that increasing the sawdust filler to 50 g can impact thermal conductivity by 29% lesser than sample A. Therefore, basalt fibers are used to improve the thermal conductivity of hybrid composite, and the sawdust cellulose filler can reduce the thermal conductivity of composite fabrication for thermal insulation materials.

Another important property in thermal behavior is heat deflection temperature that needs to be conducted for this basalt fiber composite laminates to identify the short-term heat resistance capacity. The heat deflection temperature

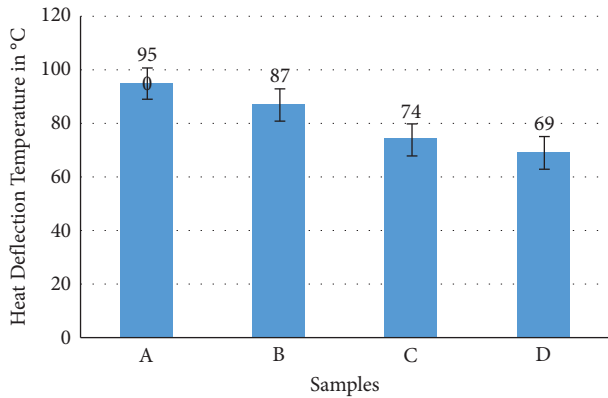


FIGURE 4: Heat deflection temperature of basalt fiber composite.

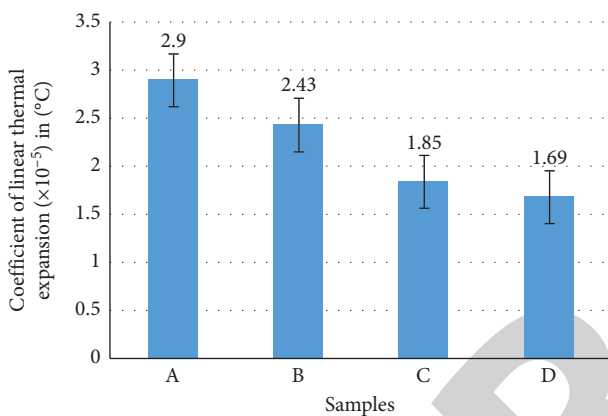


FIGURE 5: Coefficient of linear thermal expansion of basalt fiber composite.

results of basalt fiber composite are shown in Figure 4; the results are revealed similar to the thermal conductivity of hybrid composite, increasing basalt fiber loading to fabricate the composite laminates has given the maximum temperature resistance, and increasing sawdust cellulose filler can reduce the heat deflection temperature of hybrid composite.

The maximum heat deflection obtained in sample A is 95°C which is due to basalt fiber to sawdust filler weight ratio of 4:1, and epoxy matrix is 60% in all the four samples of hybrid composite. The bonding between basalt fiber mat, sawdust filler, and epoxy polymers was good and can increase the thermal behavior; as per the ASTM standard, 1.82 MPa load was applied during the analysis and the basalt fibers in mat form can transfer the load from one to another point smoothly to improve the short-term heat resistant capacity of hybrid composite. A similar mode of results was studied in another sisal fiber developed in which sawdust cellulose composite during the increase of filler materials is resistant to less temperature compared to the fiber form of reinforcement [13]. The least heat deflection temperature occurred in sample D is 69°C which is 27% less heat resistant compared to sample A and 21% less than sample B. Sample C got 74°C with a 2:3 weight fraction of fiber and filler materials, and 15% more heat deflection temperature is present in sample B compared to sample C. Therefore, among all the

four samples, basalt fiber can resist more heat than sawdust cellulose fillers of hybrid composite.

Coefficient of linear thermal expansion of hybrid composite was carried out to analyze the thermal expansion of basalt fiber composite, and the results of thermal expansion for basalt fiber composite are shown in Figure 5.

The higher thermal expansion coefficient obtained in sample A is $2.9 \times 10^{-5}/^{\circ}\text{C}$, thermal expansion is linear in sample B which is $2.43 \times 10^{-5}/^{\circ}\text{C}$, and increasing in basalt weight fraction in the fabrication of hybrid composite with sawdust cellulose can increase the linear thermal expansion of hybrid composite. Sample A has 41% more thermal expansion than sample D; therefore, decreasing the basalt fiber ratio from 100 g to 25 g can reveal the high positive impact during the thermal expansion analyses. Comparison between samples B and C shows that 24% higher thermal expansion occurred in sample B; similar work was conducted with sisal fiber composite and the results revealed that increasing the fiber weight fraction can improve the thermal expansion and the filler loading composite laminates reduce the coefficient of linear thermal expansion of hybrid composite [24, 25]. Based on the results, it can be clearly observed that the interfacial bonding between high sawdust filler loading with basalt fiber composite was improved significantly compared to basalt fiber loading and the composite laminates.

4. Conclusions

The current work focuses on the production of composite laminates employing basalt fiber mat with sawdust fillers reinforced epoxy polymer, and the primary findings from the thermal tests are presented as follows:

- (i) The natural reinforcement of basalt fiber mat and sawdust fillers had significant bonding with an epoxy polymer matrix to fabricate the composite materials.
- (ii) High level of fiber loading on sample A can show the more thermal conductivity is 0.254 W/mK which is 35% more thermal conductance compared to sample E, therefore for thermal insulation materials application has been suitable by using sample E weight ratio and the sawdust filler loading bonding with fibers, a matrix is high and heat is not able to transfer more from one point to another point.
- (iii) Similar results were found in heat deflection temperature and thermal expansion coefficient of hybrid composite sample A is maximum values of 95°C and $2.9 \times 10^{-5}/^{\circ}\text{C}$, which is used to conclude that the basalt fiber composite laminates can be used as thermal insulation materials due to their thermal properties such as very low thermal conductivity, short-term heat resistant, and linear thermal expansion coefficient values sufficient for the thermal insulation applications. Therefore, natural materials of basalt fiber and sawdust fillers are suitable as reinforcement and can replace synthetic fiber usage in thermal insulation applications.

Data Availability

The data used to support the findings of this study are included within the article. Further data or information is available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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