Experimental Investigation of Vibration Characteristics of PF Based Wood Polymer Composite

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Abstract **Wood polymer composites are alternatives to mineral fillers due to their more strengthened properties. The composite specimens were fabricated using hot press method. Vibration in a material system leads to more noise levels, premature wear, failure of material and unsafe operating conditions. The present work investigates the vibration characteristics damping ratio and natural frequency of untreated and chemically treated wood polymer fabricated composites.**

Keywords — Hot press, PF, WPC, damping.

I. INTRODUCTION

Wood and natural fibers are the alternatives to mineral fillers. Over the few past years, prices of plastics increases. Use of natural powder or fiber in the production of plastics reduces the cost. Hence there is an increased demand for the agro-based component. Vibration in a material system leads to more noise levels, premature wear, failure of material and unsafe operating conditions. In the case of structural applications, materials can experience more vibrations due to dynamic loading. The dynamic loading creates vibrations at the natural frequency of the material. Vibrations of this type can cause catastrophic failure of the structure [1].

Dynamic characteristics of a material system are associated with the damping property of a material due to its impact on reliability, safety, and performance of a system [2].

Polymeric materials exhibit more damping than metallic materials due to their viscoelastic behavior [3].Genc G et al.[4] have reported the mechanical behavior of flax and glass fiber composite materials. They found that natural flax fibers show high damping property than glass fiber composites. Damping in mechanical engineering is the influence which causes an oscillatory system to either not oscillate or reduce a system's amplitude. Damping ratio is a dimensionless measure which describes how oscillations in a system decay. It is defined as the ratio of the damping coefficient to the critical damping coefficient. Wood is an organic material. It is a natural composite consisting of cellulose fibers surrounded by a lignin matrix. The cellulose fibers are strong in tension, whereas lignin resists compression [5].

The wood is very compact material because lignin present in wood prevents the penetration of water into the wood [6].Due to its unique and independent mechanical properties in the directions of three mutually perpendicular axes, longitudinal, radial, and tangential wood is considered to be as orthotropic material [7].Wood–plastic composites (WPCs) are the extruded or molded products of required shape and size. The cellulose fiber and other constituents are filled in plastic material. The plant is the source of wood - a fibrous material [8]. The study of vibration characteristics of a material system is essential to design and use it for a specific application. The objective of this study is to investigate the vibration characteristics of PF based un-treated and chemically (5 % and 10 %) treated wood plastic composites under different compositions.

II. MATERIALS AND METHODS

Waste wood flour of honne, neem and saguvani are collected from local sawmills in Davangere, Karnataka. Due to their high strength and modulus properties, coconut shell powder is used as a secondary filler for the development of composite.The coconut shell powder is collected from a local supplier in Hassan, Karnataka. The collected wood flour and coconut shell powder were screened to remove any impurities present in them to avoid ill effects during the fabrication of composite specimens. These wood flours are used as reinforcement materials 1, 2 and 3 in this work.

Phenol Formaldehyde (PF) resins are synthesized by the reaction of phenol with formaldehyde. These resins are high dimensional stability, lightweight, excellent corrosion, and temperature resistance up to 300 - 350° C. Because of these advantages phenol formaldehyde is chosen as the matrix material over other thermoset polymers. Phenol formaldehyde resin supplied from AKOLITE Synthetic Resins, Mangalore, is used as matrix material in this work.

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Fabrication and experimental procedure

The un-treated honne wood flour and coconut shell powder of average size 850 µm are initially screened to remove any impurities present in them. The wood flour thoroughly mixed with PF resin in a rotary drum type blender according to the calculated volume ratio. The metallic mold of 300 mm × 300 mm × 10 mm which is filled with reinforcement and matrix material is placed in a hydraulic hot press at a pressing temperature of 120° C and pressing pressure of 5 N/mm2 for 15 minutes for curing. To avoid the degradation of wood composites, the low pressing temperature of 120° C is maintained compared to melting temperature (200° C) of PF resin. The mold is taken out from the hot press is allowed for cooling to facilitate the setting of resin and wood powder material. Minimum of four replications of each type of WPCs are fabricated, and these composites after trimming are put in room temperature before the test, for 48 hours. The same procedure is used for the fabrication of the remaining two types of composites. This provides one set of un-treated honne, neem and saguvani wood composite specimens named as HWPC,NWPC and SWPC respectively. The wood flours namely honne,neem and saguvani are chemically treated with (5 and 10 %) of sodium hydroxide , benzyl chloride and acrylic acid. The chemically treated honne,neem and saguvani wood composites are fabricated and designated as HWPC5T, HWPC10T, NWPC5T, NWPC10T, SWPC5T, SWPC10T respectively. Similarly untreated honne, neem and saguvani WPCs are fabricated and designated as HWPC, NWPC and SWPC respectively.

The vibration damping test is conducted as per ASTM E756-05 standard [9] to evaluate the vibration characteristics of these fabricated composite specimens. The dimensions of the composite specimens used are 300 mm × 300 mm × 10 mm. Figure 2.1 shows the loading arrangement of the fabricated wood plastic composite specimen for vibration damping modal analysis.

Figure 2.1. Loading arrangement of specimen for vibration damping modal analysis test

III. RESULTS AND DISCUSSION

Damping properties of un-treated wood plastic composite

Figures 3.1 show natural frequency and damping ratio (experimental values) of un-treated honne, neem, and saguvani WPCs. It is observed from the Figure 3.1 that, saguvani wood composite of 30 % composition shows natural frequency of 30.28 Hz and it increases from 32.81 Hz to 41.46 Hz. The remaining two types honne and neem wood composite also shows the same pattern of increasing of natural frequency with increase in wood flour content. The reason for this might be due to poor interfacial bonding between wood flour used and resin at 60 % composition.

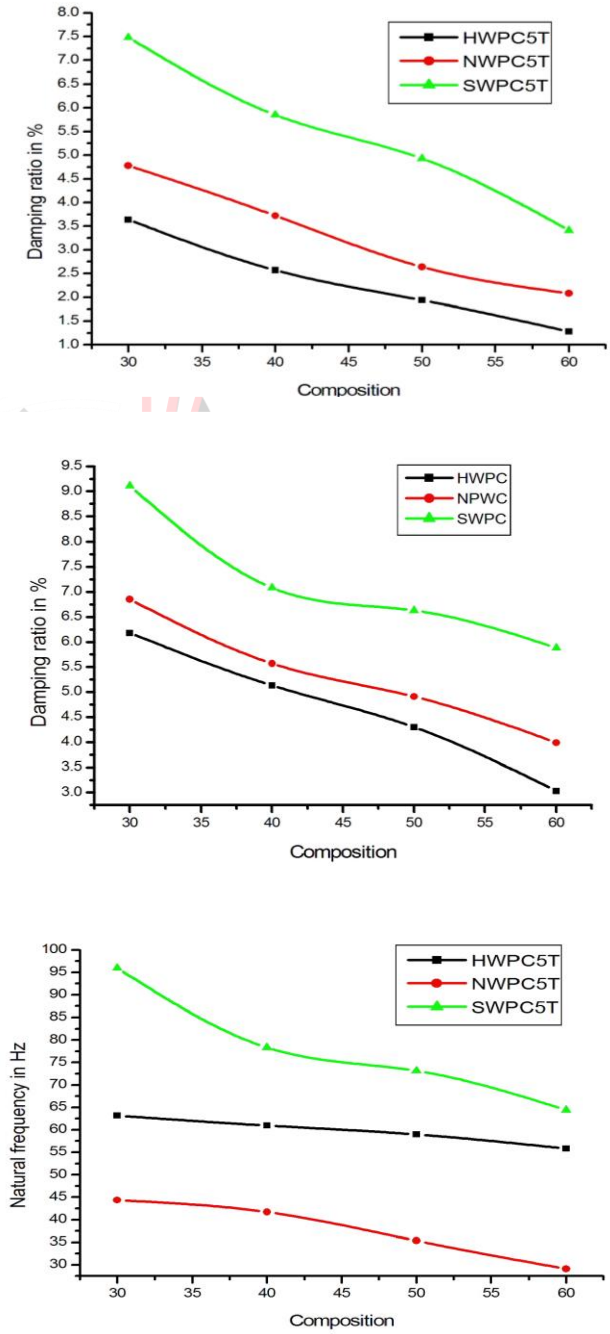

Figure 3.1 Effect of wood flour content on the damping ratio of un-treated honne, neem, and saguvani WPC.

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Damping properties of chemically treated wood plastic composite

The effect of wood flour content on natural frequency and damping ratio of chemically treated honne, neem and saguvani WPCs are shown in Figures 3.2 and 3.3. From the Figure 3.2, it is observed that saguvani wood composite (10 % treated) of 30 % composition exhibits highest damping ratio of 9.11 whereas honne wood composite (5 %treated), 60 % composition shows 1.78 damping ratio. Chemically treated wood composites show a higher damping ratio than un-treated composites. Figure 3.4 (a), (b) and (c) shows the SEM images of 30 % composition un-treated and chemically treated honne wood plastic composite. From Figure 3.4 (a), it is observed that the bonding between phenol formaldehyde and honne wood flour is poor due to gaps and voids which are present in the un-treated honne wood plastic composite. However, from the Figure (b) and (c), it is found that, due to minimum gaps and voids, the interfacial bonding between chemically treated wood flour and PF material is strong.

Chemical treatment of reinforcement material improves the interfacial adhesion between matrix and reinforcement. Due to this, there will be minimum voids and gaps in the composite. In the case of the un-treated composite, there will be more voids and gaps than treated one. It indicates poor interfacial adhesion between matrix and reinforcement material. These gaps and voids lead to dissipation of energy by flour/matrix friction, when the material is subjected to vibration [10]. Due to high damping ratios, these wood composite materials are suitable for damping applications such as automotive, air craft and structural.

Figure 3.2 Effect of wood flour content on the damping ratio of chemically treated (5 % and 10 %) honne, neem, and saguvani WPC.

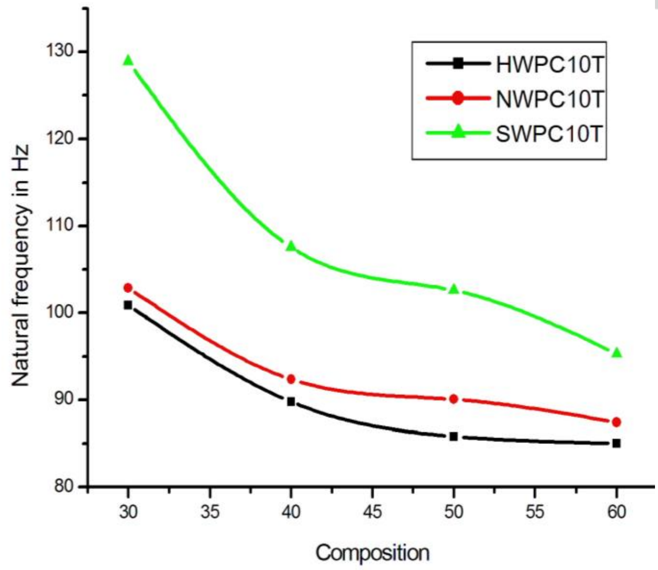
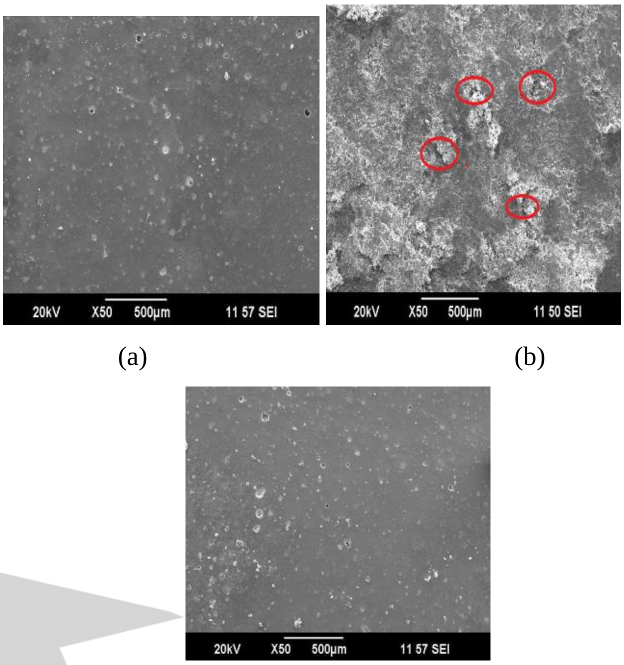


Figure 3.3 Effect of wood flour content on the natural frequency of chemically treated (5 % and 10 %) honne, neem, and saguvani WPC.



(c)

Figure 3.4 SEM images of 30 % composition (a) HWPC (b) HWPC5T (c) HWPC10T composite

IV. CONCLUSION

The present work investigates the vibration damping properties of both un-treated and chemically treated, hot-pressed phenol formaldehyde based honne, neem and saguvani WPCs at different mixing ratios. The fabrication of honne, neem and saguvani wood composite with phenol formaldehyde as the matrix material are technically feasible for various structural purposes. The mixing ratios and raw material characteristics play a major role in the damping characteristics of these composites. The damping ratio of these composites indicates the damping capability of the composite. The experimental results clearly indicate that chemically treated wood composites exhibit a higher damping ratio than the un-treated wood composite

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