AML-UoP
APPLIED MECHANICS LABORATORY
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Diploma Thesis

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The influence of nanofillers on the damping properties of composite materials reinforced with natural fibers

Introduction

One property of composite materials that has drawn research attention in recent years is that of damping. The loss factor tanδ serves as a measure characterizing damping. Flax fibers are primarily the focus of research for determining their mechanical and dynamic behavior. Nanoparticles, due to their excellent mechanical properties and large contact surface can be used as additional reinforcement in natural composites by integrating them into the matrix material aiming to optimize damping. In this thesis, initially, specimens of High-Density Polyethylene (HDPE) powder and nano-reinforced HDPE with 0.5wt.% carbon nanotube content were fabricated using the Injection Molding technique. Two (2) reference laminated composite plates were produced in the heat press, one with glass reinforcement and HDPE matrix, and one with flax reinforcement and HDPE matrix as well. To optimize the damping property, three (3) additional laminated composite plates were fabricated in the heat press, two which had flax reinforcement and HDPE matrix with nano-reinforcement (0.5wt.% and 1wt.%), and the last one consisted of flax and HDPE reinforced with 0.8wt.% graphene. Specimens were cut from each plate/material, and their damping was characterized using the Dynamic Mechanical Analysis (DMA) technique by calculating the Loss Factor (tanδ).

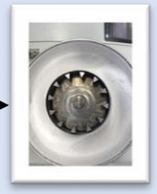
Experimental Procedure for Fabricating HDPE and HDPE+0.5%CNTs specimens by using Injection Molding

Grinding HDPE pellets to make HDPE powder by using Grinding Mill.

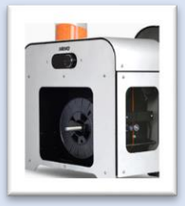
Grinding Mill

Mixing HDPE powder with CNTs.

HDPE-powder inside the Grinding Mill



Making filament out of HDPE/CNTs powder by using the Filament Maker.



Filament Maker

Filament chopped down to pellets with Pelletizer and then they became filament again by using Filament Maker.

Pelletizer

Filament chopped down to pellets with Pelletizer again. Then they are grinded to powder with Grinding Mill.

Injection Molding Device

Powder used to produce HDPE and HDPE_0.5%CNTs specimens with Injection Molding.

HDPE_0.5%CNTs specimens produced.

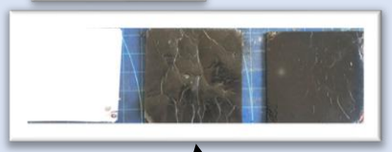
Neat HDPE specimens produced.

Experimental Procedure for Fabricating Laminated Composites Plate specimens by using the Heat Press

Inserting aluminum plates filled with nano-reinforced (or non) HDPE pellets in the heat press.

HDPE pellets before inside the heat press.

Film layers are produced and laminated plates with layers of flax or glass fabric with the use of the heat press.



Film layers, HDPE, HDPE_0.5%CNTs and HDPE_1%CNTs, from left to right.

Finally, five different laminated plates are produced, and 2 specimens are cut from each plate.

Five different laminated composite plates were prepared using the heat press. Glass/HDPE, Flax/HDPE, Flax/HDPE_0.5%CNTs, Flax/HDPE_1%CNTs and Flax/HDPE_08%Graphene, from left to right.

Specimens cut off from composite plates, Glass/HDPE, Flax/HDPE, Flax/HDPE_0.5%CNTs, Flax/HDPE_1%CNTs and Flax/HDPE_08%Graphene , from left to right.

***Fiber Volume Ratio (Vf) achieved for every Laminated Composite plate produced.**

Laminated Composites	Fiber Volume Ratio (Vf)
Flax/HDPE	38%
Glass/HDPE	35%
Flax/HDPE_0.5%CNTs	42%
Flax/HDPE_1%CNTs	40%
Flax/PP_0.8% Graphene	43%

Results

DMA Conditions

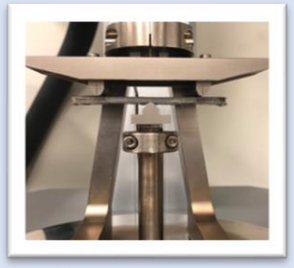
- Frequency = 10 Hz
- Temperature = (21-26) C

For 1st Exp. Proced.:

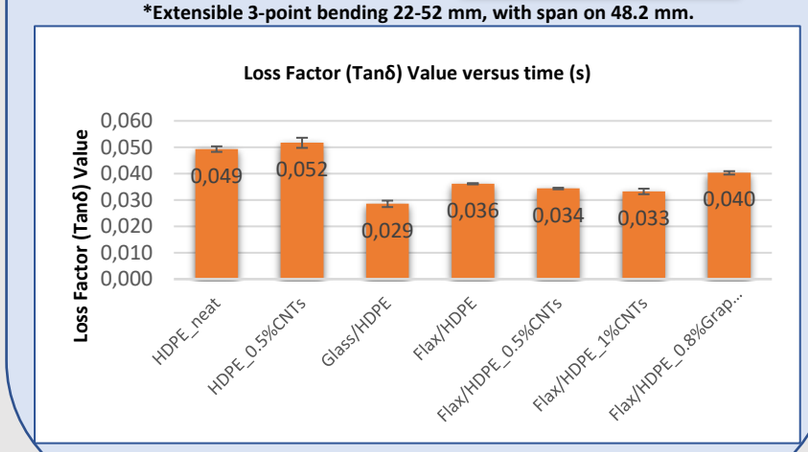
- Stat F = -5 kN
- Dyn F = 2 kN

For 2nd Exp. Proced.:

- Stat F = -10 kN
- Dyn F = 5 kN



***Extensible 3-point bending 22-52 mm, with span on 48.2 mm.**



Conclusions

- **Comparing Flax/HDPE and Glass/HDPE composites, it is observed that the first one shows 24.1 % greater damping than the second one. The increased damping of Flax/HDPE is due to the damping mechanisms developed between the flax fibers and HDPE matrix (damping due to internal friction between fiber/matrix, damping due to the interface, damping due to the viscoelastic nature of the matrix).**
- **For the Flax Fiber Reinforced Composites, an optimization of the Tanδ value was achieved with Flax/HDPE_0.8%Graphene composite, which showed 11.1% greater damping than the Flax /HDPE composite. The 2D structure and the better dispersion of Graphene inside the HDPE matrix were the reasons why damping improved more in relation with the HDPE_0.5%CNTs and HDPE_1%CNTs composite.**
- **Overall, out of those seven (7) different kinds of specimen that were made, the one that showed the greater Loss Factor (tanδ) was the nano-enhanced HDPE with 0.5% wt. specimen (produced with Injection Molding), with a value of 0.052.**