RECYCLED WOOD PLASTIC COMPOSITE FLOOR PANELS FOR OFF-SHORE SHIPPING CONTAINERS

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Abstract
Within the framework of this study, we aim at the replacement of plywood as ship containers floor material, with a lighter and friendlier-to-rainforests composite material. Wood fibre-reinforced thermoPlastic Composites (WPC) were developed using double-screw extrusion, consisting of recycled waste wood fibres reinforcing recycled High Density PolyEthylene (HDPE) matrix. This shift to WPCs has the dual positive effect of containers freight reduction as well as elimination of the use of natural resources, radically contributing to climate change measures. Following international shipping standards for container flooring, high quality recycled WCPs were developed. HDPE was found to provide acceptable structural performance. To that respect, WPC blends of HDPE matrix reinforced with 30%, 40% and 50%wt wood fibre flour, were fabricated and subjected to 3 point-bending mechanical testing. It was found that the studied WPCs reveal mechanical performance adequate to qualify as replacements of plywood timber flooring in ship containers.

1. Introduction

The increasing demand for greener transportation imposes the need for new environmental-friendly engineering materials to reduce carbon footprint and Green-House Emissions (GHE) [1, 2]. In total 72 million containers operate in off-shore and in-shore missions, a third of which is used for sea transportation [3]. Currently, all shipping containers come with a standard timber flooring based on plywood sourced from rainforests. Plywood’s extensive use has led to the gradual disappearance of animal species as well as to the elimination of forests efficiency to capture CO_2 emissions [3].

At the same time, the majority of plastics and other polymer composites used in industries such as transportation and energy, end up in landfill or are being used for energy recovery mainly via incineration (according to The Incineration of Waste Directive, 2000/76/EC) [4]. A significant amount of wastes stemming from packaging or polymer composites ends up in landfill around Europe or other non-EU countries (EC Waste shipment regulations (259/93/EEC)) [5].

Together with plastics and other waste issues within the EU, around 700 Mt of bio-based waste mass is produced annually of which at present, only a small percentage is recovered or reused for economic benefit.

Therefore, it becomes apparent, that a holistic solution to preserve plywood and at the same time promote recycling is of primary importance. In this study, we aim at the development of Wood fibre-reinforced thermoPlastic Composites (WPC) as replacement of plywood as floor material of ship containers. WPC is a lighter and friendlier to the precious rainforests material replacement. This shift to WPCs as container floors has the dual positive effect of significantly reducing the freight of containers as well as eliminating the use of natural resources. This radically contributes to the environmental cost and paves the way towards circular economy. WPC were developed using double-screw extrusion, consisting of recycled waste wood fibres reinforcing recycled polyethylene (PE). Following the tight international shipping standards for container flooring with respect to mechanical and hygrothermal performance, high quality lightweight recycled WCPs were developed. WPC blends of HDPE matrix reinforced with 30%, 40% and 50%wt wood fibre flour, were fabricated and subjected to 3 point-bending mechanical testing. It was found that the studied WPCs reveal acceptable mechanical properties and can qualify as candidate replacements of plywood timber flooring in ship containers.

2. Experimental

2.1. Manufacturing

WPC were produced by a simple mixture of wood powder with thermoplastic polymers (Fig. 1). Before the mixing process, all raw materials were dried out in an oven at 60^{o}C for 24hrs to remove moisture absorbed by the environment. Then, wood powder and the polymer matrix were mechanically mixed in their dry state (Fig. 2).

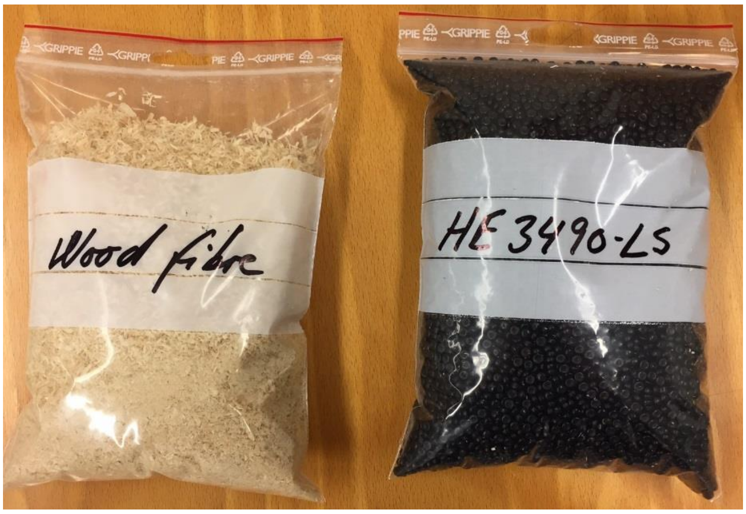

Figure 1. Raw materials employed for the production of WPC.

Figure 2. Compound after mechanical mixing.

This mixture of Fig. 2 was then heated and placed within the extruder for extrusion into different profile shapes.

2.2. Mechanical testing

Three-point bending was employed to assess the mechanical performance of the developed WPC according to the ISO 178. Three-point bending was performed on a Zwick Z2.5 testing machine. All mechanical testing was conducted at room temperature conditions. Five standard specimens were fabricated and tested for each wood powder fraction (30%, 40% and 50%wt). Dogbone samples were prepared according to ISO A1 in dimensions of 50x28x305 mm.

3. Results and discussion

Fig. 3 displays the flexural strength whereas Fig. 4 the flexural modulus of the fabricated WPCs, for the 3 different wood-powder volume fractions. As can be seen, flexural strength exhibits an increasing tendency with wood powder content increase from 30%wt to 50%wt. However, Fig. 4 demonstrates that flexural modulus increases significantly with the increase in wood powder content.

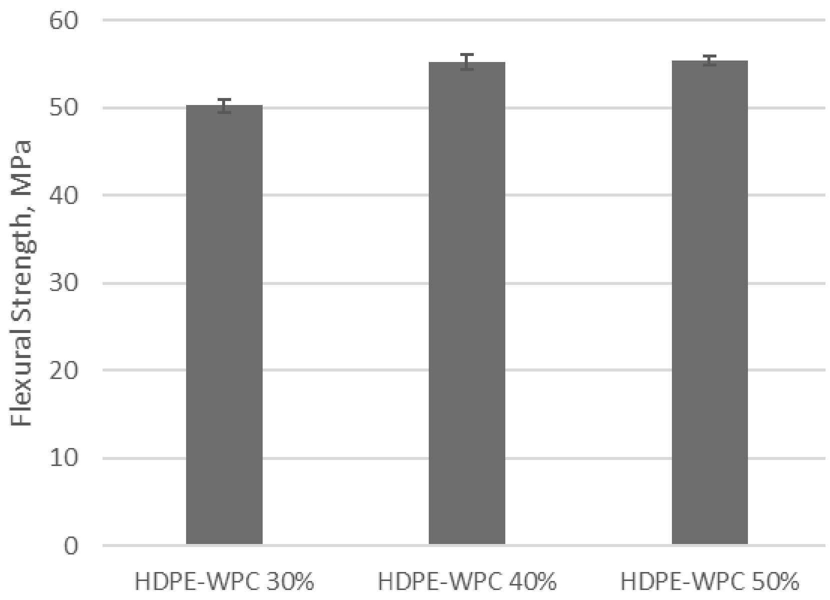

Figure 3. Flexural strength of the tested WPCs.

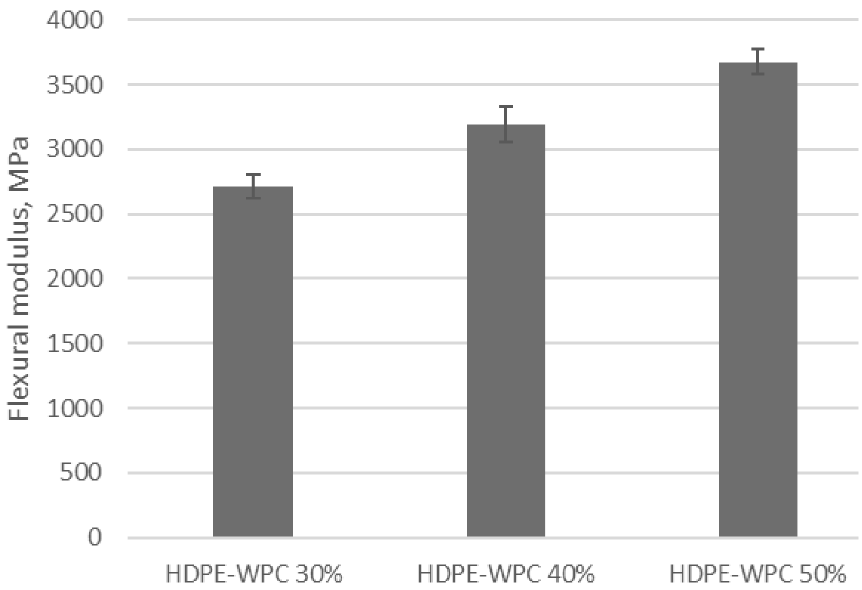

Figure 4. Flexural modulus of tested WPCs.

In order for the developed WPCs to qualify as a floor panel material for ship containers, they have to surpass the threshold of 65.9 MPa in flexural strength (according to the IICL TB 001 Performance standard for Structural Container Floor Panels) which is 10% higher that the WPC modified with 50%wt wood powder. This implies the fact that based on mechanical performance, the proposed WPCs are a promising sustainable material solution for the replacement of rainforest plywood in ship containers.

4. Conclusions

This study investigated the development of Wood Plastic Composites for potential replacement of plywood as ship containers floor material. WPCs were developed using double-screw extrusion, consisting of recycled waste wood fibres reinforcing recycled polyethylene (PE) matrix. WPC blends of HDPE matrix reinforced with 30%, 40% and 50%wt wood fibre flour, were fabricated and subjected to 3 point-bending mechanical testing. It was found that the studied WPCs reveal mechanical performance adequate to qualify as replacements of plywood timber flooring in ship containers. This replacement contributes to containers freight reduction (less CO_2), minimization of the use of fossil fuels and recycling, radically contributing to climate change measures for future circular economy.

Acknowledgments

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