Injection Moulded Radiata Pine Fibre Reinforced Polymer Composites: Properties and Applications

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ABSTRACT

New Product Development (NPD) is important for an organization's growth, profitability and competitiveness. The product being developed depends on an organization's unique context and could either be market-driven or technology-driven. Technology-driven product development begins with a new proprietary technology, and the firm then identifies products where the technology can be applied. Models like Technology Stage-Gate™ have been suggested for developing new technology-driven products. But this process has the drawback of isolating the technology development process from the product development process.

The present project began with the observation that New Zealand had an enormous amount of Pine wood fibre resource at her disposal, and there was growing research and use of wood fibre reinforced polymer composites worldwide for applications like automotive interior components, decking, furniture, and so on. Development of commercial products with this material was limited to thermoforming, extrusion, and compression moulding process. Although there was limited research initiated into injection moulding of pine wood fibre reinforced polymer composites, there was no documentation of the effect of varying the melt temperature on the mechanical properties of the material. There was also no documentation, either of commercial injection moulded products that have been manufactured with this material, or of the process that could be employed to develop commercial products with the new material.

This led to the broad research aim of identifying a commercial product idea that could be manufactured by injection moulding the composite material that was developed using wood fibre and medium density polyethylene powder (rotational moulding grade) and to document the process adopted to achieve this. Some of the objectives were to document the properties of the composite material that was developed without either pelletising, or modifying the properties of the wood fibre by chemical means. The effect of change in fibre content, melt temperature and fibre length were studied. The fibre content ranged from 10% to 40% (in steps of 10%), and the experiments were conducted at four melt temperatures (155° to 215°C, in steps of 20°C), and for two fibre lengths (up to 4mm, and between 4mm and 8mm). The results of the experiments were statistically analysed using the 'Analysis of Variance' method, for their significance.

Abstract

A new development model, "Technology Driven - Fuzzy Front End" (TD-FFE), was used to manage the "fuzzy" stage of developing the new material, identifying new product ideas, and analysing the product concepts. The model is discussed in detail. *Brainstorming* technique was adopted to identify new product ideas for the material.

The effect of the increase in fibre content on the tensile properties of the composite material was found to be more significant, compared to the effect of melt temperature. The interaction between fibre content and melt temperature on the tensile properties of the composite material was also found to be significant. The results of testing the composite material indicated that addition of wood fibre to the polymer increased the viscosity of the polymer melt. The density of the composite was found to increase with increase in fibre content (up to 40%). The tensile properties of the material increased steadily with increase in fibre content up to 30%, after which it decreased. The maximum ultimate tensile strength was found to be about 20MPa (when moulded at 175°C).

The brainstorming technique was *not* found to be very suitable for the current project as the number of *new* product ideas identified were very limited since there were constraints on the material and manufacturing method to be used. Nevertheless, the method identified a *building foundation insulation and boxing product.* The performance of the product was simulated using COSMOS software and from the results of the static stress analysis, it was concluded that the composite material had the required tensile strength to withstand the pressure exerted by wet concrete. A broad analysis to determine the financial viability of the product was also conducted. It was found that it was cheaper to manufacture the new product than assemble the formwork boxing in the traditional method. It offered additional benefits like improving the insulation of the house, and the feel (or appearance) of the foundation, and also could reduce the construction time of the foundation.

It is hence recommended that the product concept be investigated in greater detail by conducting consumer and market research to determine its commercial feasibility, and take it through to production and into the market.

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