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

*A thesis presented in partial fulfillment of the requirements for the degree of*

**Master of Technology**

in

**Product Development**

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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.

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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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**TABLE OF CONTENTS**

<b>Sl. No</b>		<b>Page</b>
	<b>ABSTRACT.....</b>	i
	<b>ACKNOWLEDGMENTS.....</b>	iii
	<b>TABLE OF CONTENTS.....</b>	v
	<b>LIST OF FIGURES.....</b>	ix
	<b>LIST OF GRAPHS.....</b>	xi
	<b>LIST OF TABLES.....</b>	xii
<b>1</b>	<b>CHAPTER ONE: INTRODUCTION.....</b>	<b>1</b>
1.1	New Product Development.....	1
1.2	Birth and growth of Wood Fibre Reinforced Polymer (WFRP) composites.....	2
1.3	Injection Moulded Radiata Pine Fibre Reinforced Polymer Composites: Properties and Applications.....	5
1.4	Research aim.....	6
1.5	Research objectives.....	6
1.6	Research outcomes.....	6
1.7	Organization of the thesis.....	7
<b>2</b>	<b>CHAPTER TWO: LITERATURE REVIEW.....</b>	<b>9</b>
2.1	Introduction to wood fibre reinforced polymer (WFRP) composites.....	9
2.2	Structure of wood fibre.....	10
2.2.1	Chemical composition.....	11
2.2.2	Organisation of the cell wall.....	12
2.3	Properties of wood fibre.....	13
2.4	Use of Radiata Pine (Pinus Radiata) for this study.....	15
2.5	Feeding of fibre-polymer mixture.....	16
2.6	Influence of the polymer matrix.....	16
2.7	Processing WFRP composites.....	18
2.8	Chemical treatment.....	21

<b>3</b>	<b>CHAPTER THREE: SECTION A –</b>	
	<b>TESTING OF THE COMPOSITE MATERIAL: METHODS...</b>	<b>24</b>
3.1	Introduction.....	24
3.2	Composite material development process.....	24
3.3	Measurement of moisture content in the fibre.....	25
3.4	Mixing of wood fibre and polyethylene powder.....	25
3.5	Injection moulding of test specimens.....	25
3.6	Tensile testing.....	27
3.7	Microscopy.....	28
3.8	Statistical analysis.....	28
3.9	Water absorption.....	28
3.10	Colourability.....	28
	<b>SECTION B –</b>	
	<b>TESTING OF COMPOSITE MATERIAL: RESULTS.....</b>	<b>29</b>
3.11	Effect of addition of wood fibre to virgin plastic.....	29
3.12	Tensile properties of virgin HDPE, MDPE and WFRP composites...	30
3.13	Stress strain curve of the WFRP composite.....	34
3.14	Composite morphology.....	34
3.14.1	Fibre orientation and fracture mechanics.....	35
3.14.1.1	Fibre orientation.....	35
3.14.1.2	Fracture mechanics.....	36
3.14.1.3	Effect of clumping.....	37
3.14.1.4	Effects of melt temperature and fibre content.....	37
3.14.1.5	Effect of fibre length.....	38
3.15	Miscellaneous properties.....	39
3.15.1	Colourability.....	39
3.15.2	Flammability.....	39
3.15.3	Water absorption.....	40
<b>4</b>	<b>CHAPTER FOUR: PRODUCT DEVELOPMENT.....</b>	<b>41</b>
4.1	Introduction.....	41
4.2	Product Development Strategies.....	41
4.3	Process adopted for Fuzzy Front End of New Product Development.....	43



4.4	<b>Idea generation (Iteration 1)</b>	
	Techniques used for identifying opportunities.....	44
4.5	Building foundation insulation and boxing product.....	46
4.6	<b>Opportunity analysis (Iteration 2)</b>	
4.6.1	Measurement of WFRP composite material's thermal resistivity.....	48
4.6.2	Results of the test to determine the R-Value of the composite material.....	50
4.7	<b>Idea analysis (Iteration 1)</b>	
4.7.1	Product concept design: Methods.....	51
4.7.2	Product concept design: Results.....	53
4.7.2.1	Iteration 1.....	53
4.7.2.2	Iteration 2.....	55
4.7.2.3	Iteration 3.....	57
4.7.2.4	Performance analysis as an assembly.....	59
4.8	<b>Idea analysis (Iteration 2) Financial analysis.....</b>	61
4.9	Discussion on the viability of the product.....	62
4.10	<b>Synopsis of the product concept: Concept Description.....</b>	64
4.10.1	Advantages of the product concept.....	64
4.10.2	Areas where more work is required in the development of the product concept.....	65
4.10.3	Marketability of the product concept (projected for 2004).....	65
5	<b>CHAPTER 5: DISCUSSION.....</b>	66
5.1	Critical analysis of the project.....	66
5.1.1	FFE Model for market-driven and technology-driven products.....	66
5.1.2	Development of a new material leading to opportunity identification.....	69
5.1.3	Evaluation of the brainstorming technique to generate 'new' product ideas.....	71
5.1.4	Idea analysis using software simulation.....	71
5.1.5	Financial analysis.....	72

<b>6</b>	<b>CHAPTER 6: CONCLUSION.....</b>	<b>73</b>
6.1	Fuzzy Front End of New Product Development for Technology-driven products.....	73
6.2	WFRP composite material properties.....	74
6.3	Benefits of the foundation product proposed to be manufactured with the material.....	76
6.4	Scope for further development.....	76
	<b>BIBLIOGRAPHY.....</b>	<b>77</b>
	<b>APPENDICES</b>	
A	Tensile test specimen dimensions.....	86
B	Statistical analysis: Results from the SAS software.....	87
C	Derivation of R-Values of WFRP composites at various fibre contents.....	92
D	Calculation of variable pressure exerted by concrete on the product.....	93
E	Financial analysis.....	95

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**LIST OF FIGURES**

<b>Figure</b>	<b>Page</b>
1.1	Flowchart of the WFRP composite development process employed..... 7
2.1	Longitudinal section of an elementary fibril..... 12
2.2	Cell wall model of a softwood tracheid..... 13
3.1	Flowchart of the WFRP composite material development process employed..... 24
3.2	Fibre orientation of the sample (20% fibre content, moulded at 175°C)..... 35
3.3	Fibre orientation of the sample (30% fibre content, moulded at 175°C)..... 35
3.4	Fracture of the sample at 155°C (20% fibre content)..... 36
3.5	Fracture of the sample at 195°C (20% fibre content)..... 37
3.6	Effect of clumping of fibres..... 37
3.7	Fractured region..... 37
3.8	Orientation of fibres (fibre length: > 4mm, 10% fibre content)..... 39
3.9	Fractured region of the sample (fibre length > 4mm, 10% fibre content)..... 39
4.1	Flowchart of the WFRP product development process employed..... 41
4.2	NCD model proposed by Koen <i>et al.</i> (2002) for the FFE stage..... 44
4.3	A method to insulate the building foundation (Harper, 2003)..... 47
4.4	Apparatus to measure the thermal resistance of the WFRP composite material..... 49
4.5	Enlarged view of Inset A in Figure 4.4..... 49
4.6	Boundary conditions for analysing the behaviour of the WFRP foundation insulation product..... 52

4.7	Concept 1 for foundation insulation product.....	53
4.8	Displacement plot for Iteration 1.....	54
4.9	Stress plot for Iteration 1.....	54
4.10	Strain plot for Iteration 1.....	55
4.11	Changes in product for Iteration 2.....	55
4.12	Displacement plot for Iteration.....	56
4.13	Stress plot for Iteration 2.....	56
4.14	Strain plot for Iteration 2.....	57
4.15	Iteration 3 for the proposed product.....	57
4.16	Displacement plot for Iteration 3.....	58
4.17	Stress plot for Iteration 3.....	58
4.18	Strain plot for Iteration 3.....	59
4.19	Complete assembly of the product.....	59
4.20	Displacement plot of the assembly.....	60
4.21	Stress plot of the assembly.....	60
4.22	Strain plot of the assembly.....	61
5.1	FFE model for market-driven product development.....	67
5.2	Proposed TD-FFE model for technology-driven products.....	69

---

**LIST OF GRAPHS**

<b>Graph</b>		<b>Page</b>
3.1	Tensile strength of the WFRP composite with 10% fibre content	31
3.2	Tensile strength of the WFRP composite with 20% fibre content	31
3.3	Tensile strength of the WFRP composite with 30% fibre content	32
3.4	Tensile strength of the WFRP composite with 40% fibre content	32
3.5	Tensile strength of the composite at various fibre fractions and melt temperatures	33
3.6	Stress – strain curve for WFRP composite with 20% fibre fraction, moulded at 155°C and 195°C	34
3.7	Effect of fibre length on tensile strength of the WFRP composite with 10% fibre content	38

---

**LIST OF TABLES**

<b>Table</b>	<b>Page</b>
2.1 Properties of some selected natural fibres and glass fibre.....	14
2.2 Properties of COTENE™ 9048.....	17
3.1 Details of variables for testing of WFRP samples.....	27
3.2 Processing parameters for injection moulding the tensile test samples.....	29
3.3 Densities of the WFRP test samples at various fibre contents and melt temps.....	29
3.4 Tensile properties of HDPE and MDPE.....	30
3.5a Tensile properties of the WFRP composite at 10% and 20% fibre content.....	30
3.5b Tensile properties of the WFRP composite at 30% and 40% fibre content.....	30
3.6 Change in the weight of the composite due to water absorption.....	40
4.1 Results of the brain storming session.....	45
4.2 Temperature gradient measured for WFRP composites at various fibre concentrations.....	51
4.3 Properties assigned to the material of the CAD model to assess its behaviour.....	52
<b>Appendix</b>	
E-1 Building consents issued.....	95
E-2 Cost of assembling one sq. m. of formwork boxing.....	96
E-3 Cost of manufacturing one sq. m. of foundation blocks with the WFRP composite material.....	98
E-4 Scenario analysis.....	105