

TABLE OF CONTENTS

| | |
|--|------|
| TITLE | i |
| APPROVAL SHEET..... | iii |
| INTELECTUAL PROPERTY STATEMENT FORM | iv |
| PREFACE..... | v |
| TABLE OF CONTENTS | vii |
| LIST OF FIGURES | x |
| LIST OF TABLES | xii |
| LIST OF APPENDIXES | xiii |
| ABSTRACT | xiv |
| 1. CHAPTER 1 INTRODUCTION | 1 |
| 1.1 Background | 1 |
| 1.2 Problem Definition | 4 |
| 1.3 Research Objectives..... | 4 |
| 1.4 Research boundaries | 5 |
| 1.5 Benefits of research | 5 |
| 1.6 Writing systematics..... | 5 |
| 2. CHAPTER 2 LITERATURE REVIEW | 7 |
| 2.1 Sandwich Structure | 7 |
| 2.2 Beetle Forewing Sandwich structure | 7 |
| 2.3 Benchmarking..... | 9 |
| 2.4 Multi-Factor Experimental Design | 12 |
| 2.4.1 Previous Research | 12 |
| 2.4.2 Design Requirements and Functions | 13 |
| 2.4.2.1 Design Requirements | 13 |
| 2.4.2.2 Design Function..... | 14 |
| 2.4.3 Design Parameters | 14 |
| 2.4.4 Finite Element Analysis (FEA) | 15 |

| | | |
|---------|---|----|
| 2.4.4.1 | Stress-Strain Curve | 16 |
| 2.4.4.2 | Deformation | 18 |
| 2.4.4.3 | Flexural Strength..... | 19 |
| 2.4.4.4 | Energy Absorption..... | 19 |
| 2.4.4.5 | Material Properties..... | 19 |
| 2.4.5 | Bending Test..... | 20 |
| 2.4.6 | Grey Relational Analysis..... | 21 |
| 2.4.7 | Normality Test..... | 22 |
| 2.4.8 | Kruskal-Wallis Test..... | 23 |
| 3. | CHAPTER 3 RESEARCH METHODOLOGY..... | 24 |
| 3.1 | Conceptual Model..... | 24 |
| 3.2 | Systematic Problem Solving | 25 |
| 3.2.1 | Stage of Identification and Introduction | 26 |
| 3.2.2 | Stage of Collecting and Processing Data..... | 27 |
| 3.2.3 | Multi-Factor Experimental Design Method | 28 |
| 3.2.4 | Stage of Analysis and Conclusion | 32 |
| 4. | CHAPTER 4 DATA COLLECTION AND PROCESSING | 33 |
| 4.1 | Multi-factor Experimental Design Method..... | 33 |
| 4.1.1 | Factor and Level Selection | 33 |
| 4.1.2 | Design Factors and Multi Experimental Factor Combination..... | 35 |
| 4.1.2.1 | Design Factors | 36 |
| 4.1.2.2 | Multi Experimental Factor Combination | 38 |
| 4.1.3 | Bending Set-up dan Static Structural Simulation..... | 40 |
| 4.1.3.1 | Bending Set-up | 40 |
| 4.1.3.2 | Static Structural Simulation | 41 |
| 4.1.3.3 | Implementation of Experiments..... | 46 |
| 4.1.4 | Grey Relational Analysis..... | 51 |

| | |
|---|----|
| 4.1.5 Statistic Test | 56 |
| 4.1.5.1 Normality Test | 57 |
| 4.1.5.2 Determine the Levelling and Combination of Factors..... | 58 |
| 4.1.5.3 Kruskal-Wallis Test | 60 |
| 4.2 Selected Design Concepts..... | 62 |
| 5. CHAPTER 5 ANALYSIS..... | 64 |
| 5.1 Analysis of the Multi-factor Design Method | 64 |
| 5.2 3D Model Analysis Based on Static Structural Simulation..... | 64 |
| 5.3 Analysis of Kruskal-Wallis Test..... | 66 |
| 5.4 Analysis Selected Design from Existing Honeycomb Sandwich Structure | 67 |
| 6. CHAPTER 6 CONCLUSION AND SUGGESTION | 70 |
| 6.1 Conclusion | 70 |
| 6.2 Suggestion..... | 71 |
| BIBLIOGRAPHY | 72 |
| APPENDIX 1 | 77 |
| APPENDIX 2 | 78 |
| APPENDIX 3 | 87 |