MATERIAL SELECTION OF NATURAL FIBER METAL LAMINATE FOR AUTOMOTIVE BODY PANEL

NURUL FARZLINA BINTI RUSLAN

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DECLARATION

I declare that this project report entitled "Material Selection of Natural Fibre Metal Laminate For Automotive Body Panel" is the result of my own work except as cited in the references

Signature: ……...

Name: ……..

Date: ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature: ....

Supervisor's Name: ……...

Date: …………………………………………………

DEDICATION

This research are dedicated to my beloved parents, Ruslan and Zulfida, for their unconditionally love, support and my strength for success.

ABSTRACT

Nowadays, most of scientist and manufacturer are looking for lightweight materials to reduce fuel consumption and gas emission to surrounding from vehicles. In order to solve the problems, the lightweight of alternative material from natural fiber are greatly treasured by scientist and manufacturer. This is because natural fibres are lightweight material, cheaper and the sources mostly available. Therefore, the research is about material selection of natural fibre and matrix of automotive body panel for FML. The objective for this project is to select best material of natural fiber and matrix for FML. The method involved in material selection is CES Edupack software and Pugh method analysis. There are has five stage of CES Edupack which is problem statement, objective function, objective constraint, screening, and ranking of the materials. In order to eliminate material that not satisfies in this project, the material are sort out according to material limitation stage and attribution of properties against another properties. The limitation stage are applied for natural fibre material selection which is non-toxic material, durability of water, and biodegradable material while no limitation stage for matrix. Besides that, the constraints involve in scanning and ranking step in CES Edupack software 2013 is attribution of Young's modulus, yield strength, density, price, and performance index line in order to determine the stiffness, strength, lightweight at reasonable cost. The result proposed by CES Edupack software for natural fibre is kenaf fiber, jute fiber, and ramie fiber. While, material candidates for matrix is PP (homopolymer, high flow), PP (homopolymer, low flow), PP (homopolymer, darified/nudeated), PS (heat resistant), and PLA (unfilled). In order to get best material, the candidate materials for natural fiber and matrix are compared by using Pugh method for justification. The materials are compared by using symbol indicator based on objective function to the project and current material as the datum.The datum for natural fiber is steel while the datum for matrix is epoxy. Therefore, the analysis shows that kenaf fibre and PP (homopolymer, darified/nudeated) are selected as best candidates for natural fiber reinforcement FML and fulfil the objective constraint in this study which is lightweight material, minimize cost, and maximize the performance.

ABSTRAK

Kini, kebanyakkan saintis dan pengeluar mencari bahan yang ringan untuk mengurangkan penggunaan bahan api dan pembebasan gas yang dilepaskan terhadap persekitaran melalui kenderaan. Untuk menyelesaikan masalah tersebut, serat semulajadi menjadi bahan alternatif yang ringan amat dicari oleh saintis dan pengeluar. Hal ini kerana, serat semulajadi mempunyai berat yang ringan, murah, dan mudah didapati. Jadi, projek ini adalah berkenaan pemilihan bahan serat semulajadi dan matriks untuk panel badan automotif untuk serat logam lamina. Objektif projek ini adalah untuk memilih bahan terbaik daripada serat semulajadi dan matrik untuk serat logam lamina. Kaedah yang digunakan untuk pemilihan bahan adalah perisian CES Edupack dan analisis kaedah Pugh. Terdapat lima peringkat untuk menggunakan perisian CES Edupack iaitu kenal pasti masalah, fungsi objektif, objektif rintangan, penapisan, dan turutan bahan. Untuk menggasingkan bahan yang tidak menepati objektif projek ini, bahan akan diasingkan menggunakan peringkat kekangan dan penggunaan sifat bahan tersebut untuk melawan sifatnya yang lain. Peringkat had kekangan diaplikasikan untuk pencarian serat semulajadi sahaja tidak untuk matrik iaitu bahan tidak bertosik, ketahanan terhadap air, dan biodegrasi. Selain itu, kekangan yang terlibat dalam peringkat penapisan dan turutan bahan ialah penglibatan, modulus Young, kekuatan alah, ketumpatan, dan harga untuk menentukan kekukuhan, kekuatan,keringanan bahan pada kos yang berpatutan. Keputusan yang dicadangkan oleh perisian CES Edupack untuk serat semulajadi ialah serat kenaf, serat jute, dan serat rami. Manakala, calon bahan untuk matrik ialah PP (homopolimer, aliran yang tinggi), PP (homopolimer, aliran rendah), PP (homopolimer, darified/nudeated), PS (haba menentang), and PLA (tidak dipenuhi).Untuk mendapatkan bahan terbaik, calon bahan serat semulajadi dan matriks di bandingkan dengan menggunakan kaedah Pugh untuk penentuan. Bahan tersebut akan di bandingkan menggunakan symbol penunjuk berdasarkan fungsi objektif projek dan bahan semasa sebagai datum. Datum yang digunakan untuk serat semulajadi ialah keluli, manakala matriks adalah datum epoxy. Jadi, analysis menunjukkan serat kenaf dan PP (homopolimer, darified/nudeated) terpilih sebagai calon terbaik untuk serat semulajadi dan matriks panel badan automotif untuk serat logam lamina dan memenuhi kekangan projek iaitu bahan yang ringan, kos yang rendah, dan tinggi prestasi.

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
CES	Cambridge Education Selector
EXPROM	Evaluation
FML	Fibre Metal Laminate
MCDM	Multi-Criteria Decision Making
MYR	Malaysia ringgit
PROMETHEE II	Preference Ranking Organisation Method for Enrichment
PET	Polyethylene Terephthalate
PLA	Polylactide
PP	Polypropylene
PS	Polystyrene
PSI	Preference Selection Index
QFD	Quality Function Deployment
TOPSIS	To Ideal Solution
UV	Ultra Violet
VIKOR	VIsekriterijumsko KOmpromisno Rangiranje
WDM	Weighted Decision Matrix

LIST OF SYMBOLS

°C	Celsius
ρ	Density
σ	Yield strength
E	Young Modulus

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Recent developments in the field of automotive industries have led to a renewed interest in lightweight materials for reducing environmental impact such as greenhouse gas emission in the transportation sector (Poulikidou et al. 2015). To encounter the greenhouse gas problems, the automotive industries seek the solutions to improve the performance either to reduce weight of the vehicle or to redesign selected part. Optimization of the structure are by replacing the current materials with alternative materials that have a lightweight characteristic such as magnesium alloys, aluminium alloys, carbon fiber and polymer composites (Mustafa et al., 2014). The lightweight materials also offered a great potential to increase the efficiency of the vehicle to accelerate from less energy compared to heavy object. Regarding this matters, lightweight materials development are also considering the safety retaining, affordability, and environment friendly as essential priority approach (Kopp et al. 2012).

According to Alkbir et al. (2016), natural fiber reinforced composite became attention from scientist and manufacturers because they are biodegradable, environmental friendly, lightweight, inexpensive, exhibit interesting physical and mechanical properties (high specific stiffness, low density, and relatively flexibility, and good strength. Thus, natural fiber reinforced composite are considered to be excellent material in automotive production industries. There are several type of natural fiber commonly used in automotive industries such as jute, flax, hemp, sisal, ramie, and kenaf. The composite material has been used widely for interior and exterior body part of car. Besides that, composite component also used these materials as trim parts in dashboard, door panel, parcel shelves, seat cushions, backrest and cabin linings (Alkbir et al., 2016). Materials expert from various automakers estimate that an all advanced composite auto-body could be 50% - 60% lighter than a current similarly size steel auto-body as compared with 40% - 55% mass reduction for an aluminium auto-body and 25% - 30% mass reduction for an aluminium steel auto-body (Koronis et al., 2013). An auto-body could be lighter with addition of natural fibers in composite because these less dense than the synthetic types.

Sandwich structures are composed of two thin stiff materials as skin bonded to a thick lightweight material as a core in the structure. It shows that the structure will have the a high bending stiffness properties with overall low density (Tan and Akil, 2012). In his study, natural fibers are commonly used in automotive industries as alternative materials to succeed the same structural performance as conventional materials with less weight. Metal composite systems such as fiber metal laminates (FML) are based on layers of fiber-reinforced composite materials and metal due to its superior impact and fatigue properties compared to conventional material systems. The FML base of thermoplastic matrices which is polypropylene FML shows the good impact resistance for both high and low impact of velocity. It was known as impact response of sandwich structure depending on both of skin and core materials used. The impact responses are influence by core thickness and effect of core thickness varied with the facesheet materials (Tan and Akil, 2012).

Cambridge Engineering Selector (CES) Edupack software is one of Ashby method in order to select the materials. The CES Edupack software contains more than 3000 database regarding the materials properties and the process properties including the fundamental of science and selection of design requirement. The interactions in material selection, function of the part, and manufacturing process are related but not independent to each other as in Figure 1.1 (Ashby et al., 2007).

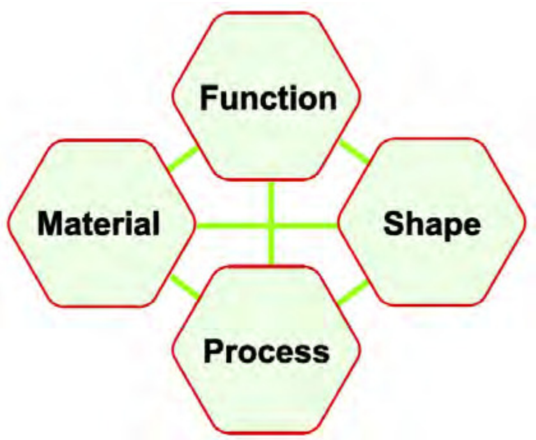

Figure 1.1: The material selections are not independent to the function, manufacturing process, and shape (Ashby et al., 2007)

1.2 PROBLEM STATEMENT

The increasing numbers of vehicle on the road contribute to the greenhouse gas emissions and environment impact. The combustion of car was affected by the weight of the vehicle. The scientist and manufacturer have found out the solution to achieve customer requirement regarding environmental friendly user by suggested to use alternative materials as replacement which is natural fiber composite because the source of the material are available, has lightweight criteria, reducing the cost of production, and high performance. The objectives in this study are to select natural fiber reinforcement, and matrix of composite. The purpose of the selection of alternative materials is to replace the core of metal composite lamination between two thin aluminium skins according FML by using natural fiber reinforcement stacked together with polymer matrix. The material selection will be conducted by using Cambridge Engineering Selector (CES) Edupack software 2013.

1.3 OBJECTIVES

The objectives of this project as follow:

i. To determine the best natural fiber reinforced composite for fiber metal laminate.
ii. To determine the best matrix of fiber reinforcement composite for fiber metal laminate.

1.4 SCOPE OF STUDY

The scopes of this project as follow:

i. The part of car covered in this project is automotive body panel.
ii. The lamination alternative core material selections are among natural fiber composite and thermoplastic matrix materials.
iii. The skin of metal laminate is aluminium.
iv. Material selection was analysis by using CES Edupack Material Software.
v. The selection will go through Pugh method to fulfil criteria and constrain in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is an important element in research paper which provides information on previous studies regards to the research topic. The aims of literature review are to define the scope of problem and relate the study to previous studies, compare and contrast different authors' opinions on an issue.

2.2 NATURAL FIBER REINFORCEMENT COMPOSITE

There are two phases in the composite material which is continues and discontinues phase. The discontinued phase are referred as fiber while continues phase are referred as matrix. The composite material consists of one or more discontinues phase that are embedded in continues phase to become reinforcing material that have stronger and harder material characterisation (Chandramohan and Marimuthu, 2011). Fiber reinforcement composite are categorized into natural fiber and synthetic fiber as shown in Figure 2.1.

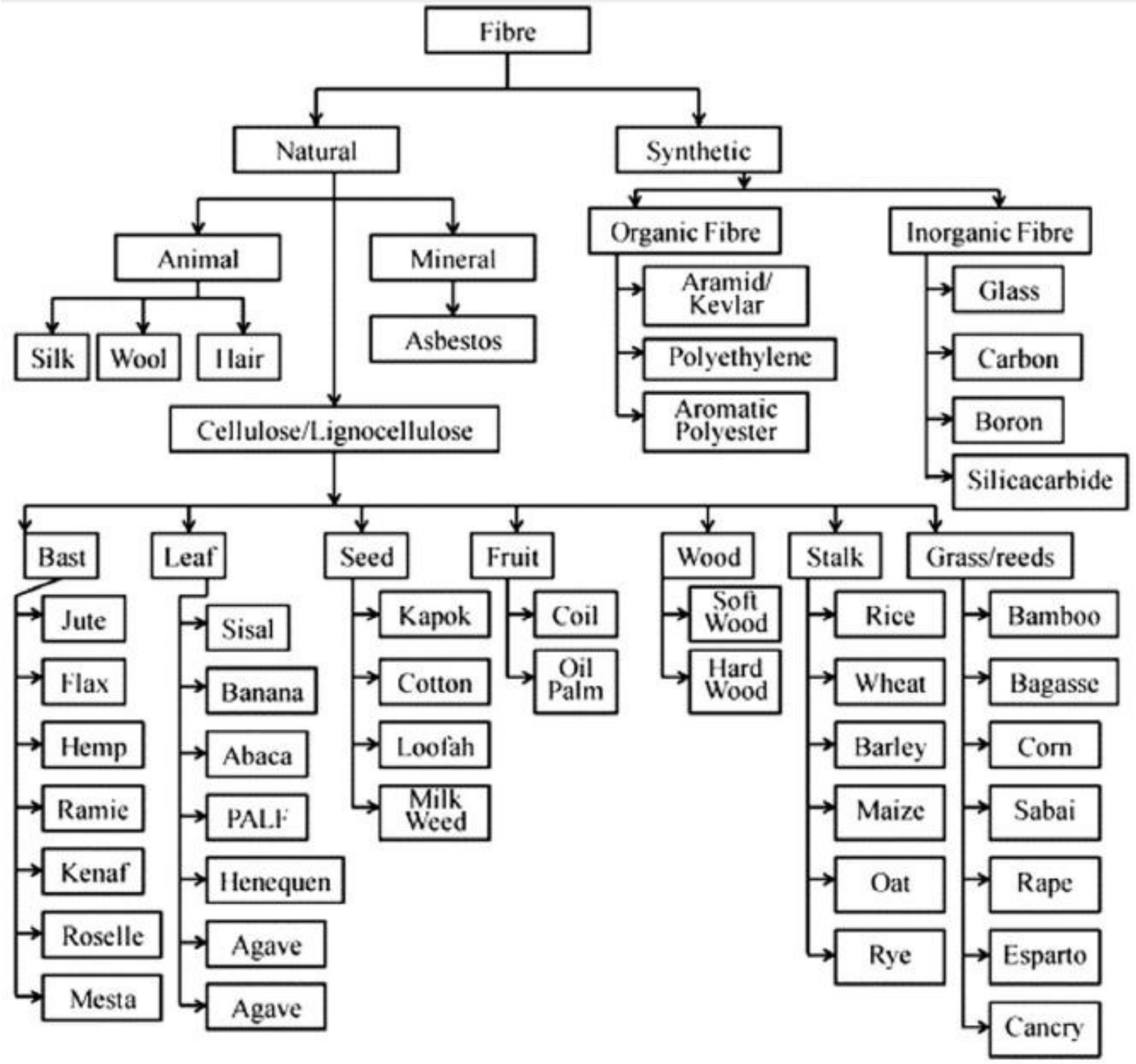

Figure 2.1: Classifications of natural and synthetic fiber (Alkbir et al. 2016)

Lately, the interests of natural fiber reinforcement composite are rapidly increased either in industrial application and research studies due to renewable sources, biodegradable, recyclable and cheap materials. The comparison between natural fibers and synthetic fibers in technical and environmental aspect are shown in Table 2.1. Even though natural fiber has a moderate mechanical properties compared to synthetic fiber but it has a high moisture sensitivity (Sanjay et al., 2016) .

Table 2.1: Comparison of natural fibers and synthetic fibers (Sanjay et al., 2016)

Aspect	Property	Natural fibers	Synthetic fibers
Technical	Mechanical properties	Moderate	High
	Moisture sensitivity	High	Low
	Thermal sensitivity	High	Low
Environmental	Resource	Infinite	Limited
	Production	Low	High
	Recyclability	Good	Moderate

Nowadays, cellulose fibers are commonly used in the industry especially in automotive industries in order to reduce weight, costing and have a better performance. The advantages and disadvantages of natural fiber are listed in Table 2.2. According to Monteiro et al. (2011) on his previous studies regarding natural lignocellulosic fibers, most of automotive parts nowadays are replacing the synthetic fiber with natural lignocellulosic reinforcement polymer composite such as in the Mercedes Benz sedan shown in Figure 2.2. This is because the smallest diameter of lignocellulos fiber obtained high tensile strength (Monteiro et al. 2011). The common applications of natural fiber reinforcement are listed in Table 2.3.

Figure 2.2: Automotive body part made of natural fiber (Monteiro et al., 2011)

Table 2.2: Advantages and disadvantages of natural fiber (Alkbir et al. 2016)

Advantage	Disadvantage
Low specific weight results in a higher specific strength and stiffness than glass	Lower strength especially impact strength
Renewable resources, production requires little energy and low CO_2 emissions	Variable quality, influenced by weather
Production with low investment at low cost	Poor moisture resistance, which causes swelling of the fibers
Friendly processing, no tools and no skin irritation	Restricted maximum processing temperature
High electrical resistance	Lower durability
Good thermal and acoustic insulation properties	Poor fire resistance
Biodegradable	Poor fiber/matrix adhesion
Thermal recycling is possible	Price fluctuations to harvest results or agricultural policies

Table 2.3: Common application natural fiber material in industry (Ho et al. 2012)

Potential application	Example
Automotive	Door, panels, seat back, headliners, dash boards, car door, transport pallets, trunk liners, decking, rear parcel shelves, spare tyre covers, interior trim, spare-wheel pan, trim bin
Aircraft	Interior panelling
Construction	Railing, bridge, siding profiles
Household products and furniture	Table, chair, fencing elements, door panels, interior panelling, window frames, door frame profiles, food tray, partition.
Electric and electronic	Mobile cases, laptop cases
Sports and leisure item	Sport and leisure item: tennis racket, bicycle, frames, snowboard.

In order to overview mechanical performance of natural fibers, Koronis et al. (2013) in his studied regarding the automotive application state that the properties of several natural fiber and bar graph of mechanical performance of specific strength and specific stiffness in Table 2.4 and Figure 2.3 respectively. From the observation on Figure 2.3, E-glass has highest specific strength but outperform in specific stiffness by kenaf, hemp, and ramie. Thus, the material selections of natural fiber need to be identified by screening in order to achieve adequate specific strength and specific stiffness.

Table 2.4: Properties of several natural fibers and E-glass (Koronis et al. 2013)

Fibers	**Density (g/cm^3)**	**Diameter (mm)**	**Tensile Strength (MPa)**	**Young Modulus (GPa)**	**Elongation at brake (%)**
Flax	1.50	40-600	345-1500	27-39	2.70-3.20
Hemp	1.47	25-250	550-900	38-70	1.60-4.00
Jute	1.30-1.49	25-250	393-800	13-26.50	1.16-1.50
Kenaf	1.50-1.60	2.60-4.00	350-930	40-53	1.60
Ramie	1.50-1.60	0.049	400-938	61.40-128	1.20-3.80
Sisal	1.45	50-200	468-700	9.40-22	3-7
Curaua	1.40	7-10	500-1100	11.80-30	3.70-4.30
Abaca	1.50	10-30	430-813	31.10-33.60	2.90
E-glass	2.55	15-25	2000-3500	70-73	2.50-3.70