THE VELOCITY IMPACT RESPONSE OF FILLED AND UNFILLED POLYPROPYLENE HONEYCOMB CORE SANDWICH STRUCTURE

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by

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LIST OF ABBREVIATIONS

FRP	Fiber reinforced polymer
PP	Polypropylene
PVC	Polyvinyl chloride
UTM	Universal Testing Machine
ASTM	American Society for Testing and Materials
NDT	Non-Destructive Testing
ss	Sandwich structure
hc	Honeycomb core
ff	Foam filled

LIST OF SYMBOLS

kg	Kilogram
m	Meter
kg/m^3	Density
Mpa	Megapascal
N	Newton
Nm^2	Newton meter square
KHz	Kilo Hertz
mm	Milimeter
g	Gram
ms	Milisecond
min	Minute
E_f	Flexural modulus
P	Force
k	Contact stiffbess
δ	Displacement rate
α	Indentation
E	Young modulus
C	Contact parameter
n	Contact parameter
m	Mass
v	Velocity
t	Time
s	Second

L	Span length
J	Joule

KESAN IMPAK KE ATAS STRUKTUR TERMOPLASTIK TERAS TERAPIT YANG KOSONG DAN TERISI

ABSTRAK

Kajian ini mensasarkan penilaian prestasi termoplastik terapit yang berbeza ketebalan, terisi dan tidak terisi dengan buih poliuretena. Ketumpatan setiap struktur teras terapit direkod sebelum ujian impak hentaman halaju rendah, ujian ketumpatan, ujian lentur, ujian mampatan dan ujian lekuk dilakukan. Ujian imbasan dilakukan ke atas sampel selepas ujian mekanikal dijalankan. Buih poliuretena yang diisi ke dalam sel-sel teras terapit telah meningkatkan ketumpatan teras terapit antara 30 hingga 34 peratus dari ketumpatan asal. Dalam ujian lenturan, kehadiran buih poliuretana telah meningkatkan kadar penyerapan tenaga sebanyak 15 hingga 38 peratus untuk teras berketebalan 30 mm dan 6 hingga 17 peratus untuk teras berketebalan 40 mm. Dari ujian lekuk didapati nilai *n* adalah 1.52 hingga 1.87 untuk teras terapit 30 mm dan 0.33 hingga 1.27 untuk teras terapit 40 mm. Nilai *n* yang diterima untuk komposit adalah 1.5. Nilai kekukuhan *C* bergantung kepada kekuatan kekenyalan plastik buih poliuretena serta sifat lapisan atas dan bawah. Nilai *C* adalah di antara (0.90 hingga 1.56) $x10^6$ N/m^n. Dalam ujian mampatan teras terapit 30 mm dan 40 mm berisi buih poliuretana menunjukkan peningkatan tenaga antara 10 hingga 30 peratus. Manakala dalam ujian impak hentaman halaju rendah teras terapit yang terisi buih poliuretana mampu menyerap lebih tenaga berbanding teras terapit kosong. Kadar kerosakan yang berlaku ke atas permukaan lapisan dipengaruhi oleh kadar penerimaan tenaga semasa berlaku hentakan. Kehadiran buih poliuretana telah membantu menyerap sebahagian tenaga yang dikenakan ke atas teras terapit dan ini menyebabkan kurangnya berlaku kerosakan pada permukaan lapisan atas kulit.

THE VELOCITY IMPACT RESPONSE OF FILLED AND UNFILLED POLYPROPYLENE HONEYCOMB CORE SANDWICH STRUCTURE

ABSTRACT

In this study, the performance of polypropylene honeycomb structure with different thickness, filled and unfilled was investigated. The density of the specimen was measured and subjected to flexural test, indentation test, compression and the low velocity impact test. After each test, the specimen was scanned under ultrasonic C-scan to investigate the effect of energy on the honeycomb panel structure. Introducing reinforced material into honeycomb cell increases the density of the panel structure up to 30 - 34% of initial density. Based on the flexural study, the percentage of energy increment for structure to collapse is around 15 to 38 percent for 30 mm core thickness and 6 to 17 percent for 40 mm core thickness. In indentation test, the *n* value is between 1.52 to 1.87 for 30 mm core thickness and 0.33 to 1.27 for core thickness 40 mm; 1.5 is the value for an acceptant for composite. The stiffness *C* was found to depend on the plastic collapse strength of the polyurethane foam and the properties of the skin. The value is between (0.90 to 1.56) $x10^6$ N/m^n. In compression test, reinforced Polypropylene honeycomb filled sandwich structure has better energy absorption characteristic rather than Polypropylene honeycomb unfilled sandwich structure. In low velocity impact test, the reinforced effect increased the energy absorbtion efficienty about 10 to 30 percentage for both 30 mm and 40 mm core thickness. The damage area for all specimens for the Polypropylene honeycomb unfilled sandwich structure much higher compared to reinforce structure. The reinforced material acted to reduce the stress on the facing skin of the honeycomb structure.

CHAPTER ONE

INTRODUCTION

1.1 Background

In marine engineering, the engineer and the developer are looking for material that has good strength to weight stiffness, costly, easy to handle for structure engineering.

Normally, the honeycomb used is made from aluminum. Others type used are aramide and nomex honeycomb. These types of materials are light, strong, expensive but brittle. In fabricating a structure for intermediate application in some part of interior structure is not significant.

The use of honeycomb design in this field is very effective due to the honeycomb produces the most efficient strength – to – weight and stiffness – to – weight structure attainable and very useful in fabricating lightweight structures.

Polypropylene honeycomb was introduced in 1980 by extrusion process and now are applied in many engineering industries, such as in marine application; internal furniture, automotive; panel for door, roof, energy field; blades, architectural; panels for door, floor and wall for clean room, recreational; canoes, industrial construction; floating roofs and landscaping; gravel.

Polypropylene honeycomb that is made from thermoplastic, has characteristics such as light weight, good ratio of stiffness-strength, vibration and sound dampening, good in absorption of energy, resistant to chemical, corrosion, fungi, moisture and rot and easy to assemble.

Two countermeasures, addition of non-woven polyester tissue and polypropylene film were added and have been taken for a better performance of the polypropylene core. Both sides of the polypropylene honeycomb core surface were laminated with non-woven polyester tissue. The other function of adding the tissue is to create better bonding with other honeycomb panel if necessary. Besides the tissue, polypropylene film was added under the non-woven tissue. The film function is as a barrier to avoid resin goes into the core and at the same time save resin consumption.

The core structure is typically 'sandwiched' between face sheets normally known as ‘skin’. Polyester and hardener are applied to from fiberglass skin. The fiberglass sheets ware attached to the honeycomb core with a bonding adhesive such as polyester mix with suitable hardener or any combination of resin in epoxy systems. This is to ensure homogenous contact of resin between the face sheet and the polypropylene honeycomb core.

Figure 1.1 is a diagram of polypropylene honeycomb panel fabrication and its basic materials; face sheets, adhesive and core structure (reinforce material: polyurethane foam).

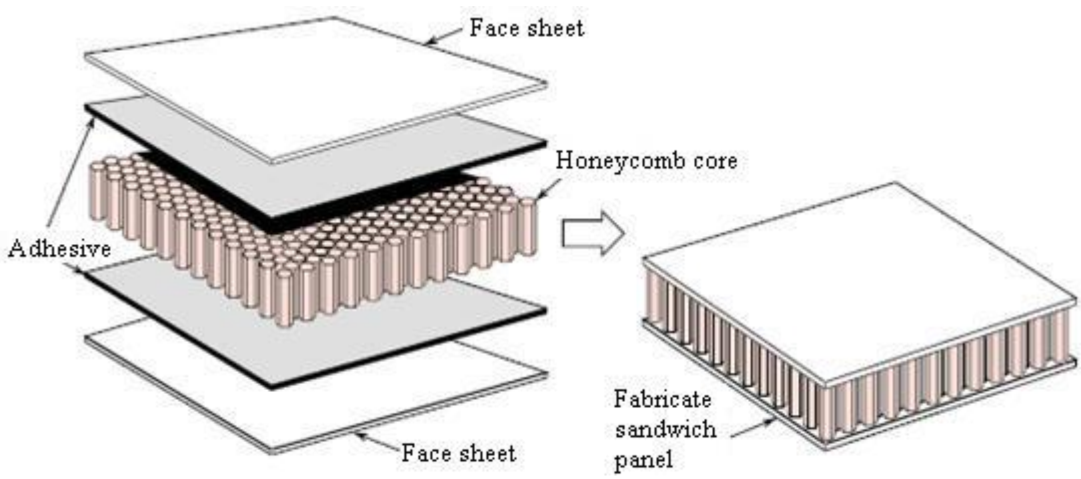

Figure 1.1: A composite sandwich panel
http://www.berlystone.com/js/htmledit/kindeditoren/attached/20150331/20150331194239_65631.jpg (18 May 2015)

In this research, the honeycomb with thickness of 30 mm and 40 mm made of polypropylene materials were suggested as an alternative to be used as a material in construction of simple part in marine interior design. The study has introduced polypropylene honeycomb core and polypropylene honeycomb core reinforce with polyurethane. Polyurethane foam was filled into every core cell for both thicknesses.

These polypropylene honeycomb 30 mm and 40 mm filled and unfilled will be assembled under vacuum bagging technique.

Complete polypropylene honeycomb structure has good elastic and also good stiffness. Reinforce foam into polypropylene core was believed to improve the elastic, stiffness properties and increase the total load receive by honeycomb core structure.

The main reason for using the polypropylene honeycomb is due to its stiffness and light weight. In choosing the core structure five criteria of failure modes when loading are considered. The failure modes are shear core failure, tensile core failure, tensile face yielding, bonding failure between the skin and the core compression face buckling and indentation possibility at the loading points of the faces and core structure.

1.2 Problem Statement

In interior design of small boat, the engineers attempt to find a material with low cost of production with suitable characteristics such as easy to use and handle, as well as appropriate level of stiffness, strength and light. Aluminum honeycomb core is light and strong but expensive and brittle. While aramid fiber honeycomb core is also strong, corrosion resistant but brittle. The advantages of polypropylene are light, corrosion resistant, and elastic and has high stiffness.