UNIVERSITI PUTRA MALAYSIA

EFFECT OF FIBER ORIENTATION ON TENSILE PROPERTIES OF SHORT GLASS FIBER REINFORCED INJECTION MOLDING POLYPROPYLENE COMPOSITE

ABDUL MALEK YA'ACOB

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By

ABDUL MALEK YA'ACOB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of Requirements for the Degree of Master of Science

May 2004

To my parents…

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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Chairman: Associate Professor Mansor Ahmad, Ph.D.

Institute: Advanced Technology

The objective of this study is to examine the behaviour of composites and to provide an overview of short glass fiber reinforced injection-moulded thermoplastic, SgFRIMT in relation to the fiber orientation direction. In this study, the relationship between the mechanical properties of samples containing longitudinal and transverse direction was studied in terms of the effects of injection speed, fiber concentration and fiber length on the mechanical properties of SgFRIMT. The orientation of fiber distribution in longitudinal and transverse direction was measured according to the gate position and samples taken from identified position were investigated and tested at an angle relative to the fiber direction.

The composite consisting of 5, 10, 15% wt of glass fiber was prepared using single screw extruder model Brabender Plasticoder PL 2000, a compression molding machine and an 80-tonne Toshiba injection molding machine. The tensile properties were evaluated by

Instron testing machine model 4301. The discussion focuses on the effects of fiber concentration, injecting speed and fiber length on tensile properties of a SgFRIMT.

Tensile strength shows a steady decrease with increasing percentage of fiber loadings. In contrast, the tensile modulus increases significantly with an increase in the fiber loadings. At higher fiber concentration, the values of the modulus were higher than those of the unfilled polypropylene. The fiber breakage that occurs during sample preparation reduces the overall tensile strength significantly.

Additional investigation was carried out on the effect of fiber breakage using 6 and 12 mm fiber length, where it was observed that the fiber breakage occurs during compounding stages with approximately 80% reduction in initial fiber length. Observation on the extrudates reveals that poor fiber matrix interaction causes the failure of the prepared samples. The presence of void and the agglomeration inside the samples considerably affects the mechanical properties of the composites. The results indicate that the stiffness and toughness of the SgFRIMT generally are influenced by the addition of glass fibers. In this study the influence of the injection speed was insignificant.

The results of average fiber length agree with the results of other previous studies on SgFRIMT materials, indicating that the fiber length has major influence on the tensile properties of the prepared samples.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PENGHALAAN GENTIAN TERHADAP KELAKUAN KETEGANGAN BAGI KOMPOSIT POLIPROPILENA PENGACUAN SUNTIKAN BERTETULANG GENTIAN KACA PENDEK

Oleh

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Mei 2004

Pengerusi: Profesor Madya Mansor Ahmad, Ph.D.

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Objektif kajian ini adalah untuk menyelidik kelakuan komposit dan juga menyediakan gambaran keseluruhan umum berkenaan dengan komposit plastik haba pengacuan suntikan bertetulang gentian kaca pendek (SgFRIMT) berhubung dengan arah penghalaan gentian. Dalam kajian ini hubungan antara ciri-ciri mekanikal daripada sampel yang mengandungi arah gentian melintang dan membujur dikaji dari segi kesan kelajuan penyuntikan, kepekatan gentian dan panjang gentian kepada ciri-ciri mekanikal komposit plastik haba pengacuanan suntikan bertetulang gentian kaca pendek (SgFRIMT). Taburan penghalaan gentian dari arah melintang dan membujur telah diukur menurut posisi gate dan sample-sampel yang diambil dari posisi yang dikenalpasti telah diselidik dan diuji pada sudut yang berhubung dengan arah gentian.

Komposit yang terdiri daripada 5,10 dan 15% berat gentian telah disediakan menggunakan mesin penyemperitan skru tunggal model Brabendar Plasticoder PL 2000, mesin pengacuan mampatan dan mesin pengacuan suntikan Toshiba 80 ton. Ciri-ciri

ketegangan dinilai menggunakan sebuah mesin penguji Instron model 4301. Perbincangan ini menumpukan kepada kesan kepekatan gentian, kelajuan penyuntikan dan panjang gentian terhadap ciri-ciri ketegangan komposit plastik haba pengacuan suntikan bertetulang gentian kaca pendek (SgFRIMT)

Kekuatan ketegangan menunjukkan penurunan yang stabil dengan peningkatan peratus pengisian gentian. Sebagai perbandingan, pemalar ketegangan meningkat dengan jelasnya dengan peningkatan dalam pengisian gentian. Pada kepekatan gentian yang lebih tinggi nilai pemalar adalah lebih tinggi berbanding polipropilena tidak berpengisi. Pematahan gentian yang berlaku semasa penyediaan sampel dengan jelasnya menurunkan keseluruhan kekuatan ketegangan.

Penyelidikan tambahan telah dijalankan untuk mengkaji kesan pematahan gentian tersebut menggunakan panjang gentian 6 dan 12 mm di mana ianya telah diperhatikan bahawa pematahan gentian berlaku semasa peringkat pencampuran dengan anggaran 80% penurunan dalam panjang asal. Pemerhatian terhadap hasil penyemperitan mendedahkan bahawa interaksi gentian matrik yang lemah menyebabkan kegagalan sampel yang disediakan tersebut. Kehadiran lompang dan timbunan gentian dalam sampel sangat memberi kesan kepada ciri-ciri mekanikal komposit tersebut. Keputusan menunjukkan bahawa kelakuan dan keliatan bagi komposit plastik haba pengacuanan suntikan bertetulang gentian kaca pendek (SgFRIMT) secara umumnya dipengaruhi oleh penambahan gentian kaca. Dalam kajian ini pengaruh kelajuan penyuntikan adalah tidak ketara.

Keputusan purata panjang gentian bersetuju dengan keputusan-keputusan kajian terdahulu yang lain terhadap bahan komposit plastik haba pengacuan suntikan bertetulang gentian kaca pendek (SgFRIMT) yang menunjukan bahawa panjang gentian tersebut mempunyai pengaruh yang lebih besar terhadap ciri-ciri ketegangan bagi sampel yang disediakan.

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LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

a_{11}	First order of orientation tensor
FOD	Fiber orientation distribution
MPI	Molflow Plastics Inside
MFI	Melt Flow Index
PP	Polypropylene
GF	Glass fiber
E-glass	Lime-borosilicate glass, derived from a Pyrex composition. General purpose reinforced plastics applications glass.
S-glass	High strength and high modulus glass to improve stiffness.
A-glass	Soda-lime glass with low thermal constants and poor chemical durability
C-glass	Soda-lime borosilicate glass wit excellent chemical durability.
OPWF	Oil palm wood flour
SgFRIMT	Short glass fiber reinforced injection-moulded thermoplastic
ASTM	American standards testing method
JIS	Japan international standards
f_p	Orientation parameter
σ	Stress
E	Strain
Ø	Fiber plain angle
Nm	Newton meter
%wt	Percent by weight

CHAPTER 1

INTRODUCTION

1.1 Overview

Composites and specifically fiber-reinforced plastics have been used as structural material for a wide range of applications in several fields of technology because of their low overall cost performance and long term durability during services and have a long history of proven performance. Hence the use of composite materials has been widespread for various industries such as aircraft manufacturing, medical and automotive. Composite materials are recognized as the most advanced materials for fabrication. The success of these composite parts in services leads to the increased use of composites in various fields of application because of the advantage of this material to withstand stresses during services. Fiber reinforced composites provide a wide range of properties and behaviors and are stiffer than conventional un-reinforced composites and are superior compared to those of other materials such as steel and aluminum. Generally a composite material is a material that combined two or more materials to form a much stronger structure. Figure 1.1 shows a typical fiber reinforced composites properties.

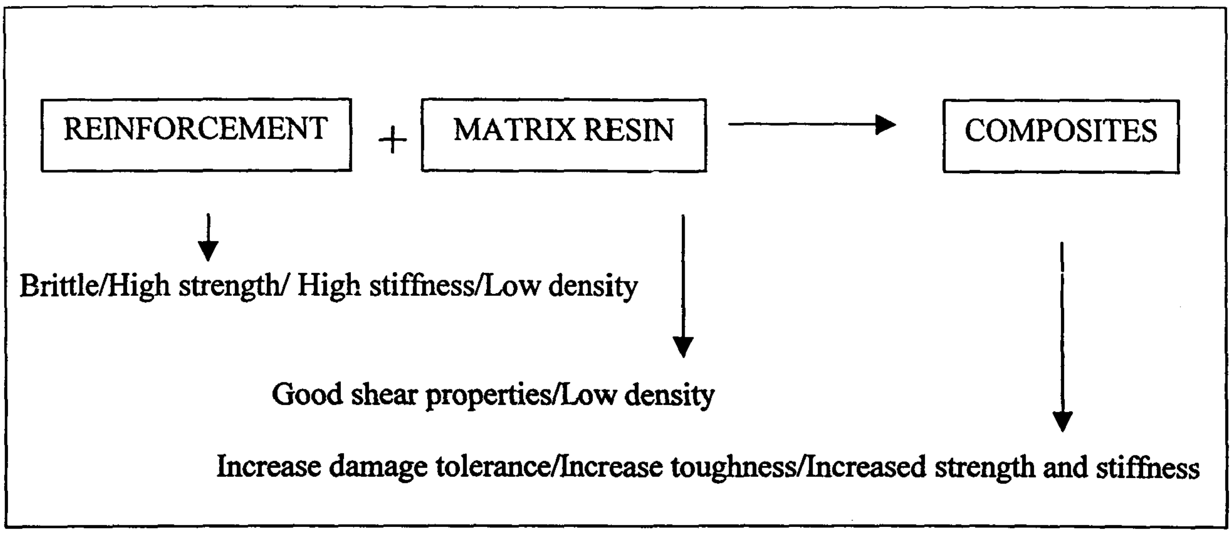

Figure 1.1: General properties of a fiber reinforced plastics

The most known advantage a composites part is the high strength-to-weight ratio. A composites part can be designed as strong as a metal part. Generally composites utilize other advanced material such as metal alloys and are processed to achieve reduced weight, increased strength and improve wear resistance to the part structure.

Several other advantages of a composite structure include;

1. Can be designed to be very flexible.
2. Does not corrode like metal
3. Complex shapes may be molded in a part
4. Composites are very durable.
5. Light weight and more cost effective then the metal counterparts.

The experimental studies of fiber orientation direction are described in this study for an actual specimen prepared by injection molding machine. The concept used in this study followed the work of Edisyams (2002). Generally the purpose of carrying out the experimental study is to predict the effects of fiber orientation for composite samples