UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Influence of Processing Methods and Fiber Size on Rheological Properties of Hybrid Composite

Report submitted in accordance with partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Engineering Materials)

By

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: INFLUENCE OF PROCESSING METHODS AND FIBER SIZE ON RHEOLOGICAL PROPERTIES OF HYBRID COMPOSITE

SESI PENGAJIAN : 2007/2008

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I hereby declare that this report entitled "Influence of Processing Methods and Fiber Size on Rheological Properties of Hybrid Composite" is the result of my own research except as cited in the references.

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APPROVAL

This report submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Engineering Materials). The members of the supervisory committee are as follow:

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ABSTRACT

This report is based on the study on the influence of processing methods and fiber size on the rheological properties of hybrid glass/carbon composite. The objective of this study is to investigate the effect of different processing methods, fiber size and processing parameter specifically temperature on the rheological properties of the hybrid composite. Besides that, another aim is to analyze the relationship of the processing methods, fiber size and temperature on the rheological-morphological properties of the hybrid composite. E-glass in both short fiber and powder form as well as charcoal in powder form was incorporated into polypropylene (PP) to form hybrid composite in the study. Processing methods refers to the different mixing techniques used to prepare the hybrid composite mixture prior to rheological measurements while fiber size refers to the reinforcements in particulate form and short fiber with the fiber length of less than 1 mm. Temperature effect was monitored during the rheological measurement. The rheological properties of the hybrid composite were studied using a capillary rheometer. After conducting rheological measurements, the morphology of the hybrid composite for both longitudinal and transverse directions in flow direction was observed under the Scanning Electron Microscope (SEM). Results showed that viscosity decreased while flow rate and shear rate increased with temperature and also in the hybrid composites that employed the processing method of 2+1 as well as those composites utilizing completely particulate reinforcements. All composite system also exhibited the pseudoplastic behaviour based on the rheological measurement results. This was further supported by the good orientation and alignment as well as uniform distribution of the reinforcements in the PP matrix. Thus, hybrid composite which employed the combinations of 2+1 Powder exhibited superior rheological properties compared to the other combinations.

ABSTRAK

Laporan ini adalah berdasarkan kajian tentang kesan kaedah pemprosesan dan saiz gentian ke atas sifat reologi hibrid komposit kaca/karbon. Objektif kajian ini adalah untuk menyelidik kesan daripada kaedah pemprosesan, saiz gentian dan parameter pemprosesan khususnya suhu yang berlainan ke atas sifat reologi hibrid komposit tersebut. Selain itu, objektif lain termasuk menganalisis hubungan antara kaedah pemprosesan, saiz gentian dan suhu ke atas sifat reologi-morfologi hibrid komposit tersebut. Kaca-E dalam bentuk gentian pendek dan serbuk serta arang dalam bentuk serbuk telah ditambah ke dalam polipropilina (PP) untuk membentuk hibrid komposit dalam kajian ini. Kaedah pemprosesan merujuk kepada kepelbagaian teknik pencampuran yang digunakan dalam penyediaan campuran hibrid komposit sebelum pengujian reologi dijalankan. Sementara itu, saiz gentian merujuk kepada penetulang dalam bentuk partikel dan gentian pendek di mana panjang gentian yang digunakan adalah kurang daripada 1 mm. Sifat reologi hibrid komposit dikaji dengan menggunakan reometer kapilari rerambut. Selepas menjalankan kajian pengujian reologi, morfologi hibrid komposit untuk kedua-dua pandangan merentas aliran bahan dan mengikut aliran bahan telah dikaji dengan menggunakan teknik kemikroskopan elektron imbasan. Keputusan menunjukkan kelikatan berkurang manakala kadar alir dan kadar ricih bertambah dengan penambahan suhu serta hibrid komposit yang mengamalkan kaedah pemprosesan jenis 2+1 dan hibrid komposit yang terdiri daripada penetulang jenis zarah. Semua sistem komposit memamerkan kelakuan pseudoplastik berpandukan keputusan ujian reologi yang dijalankan. Keadaan ini disokong dengan orientasi dan susunan serta taburan penetulang yang baik dan sekata dalam matriks PP. Oleh sebab itu, hibrid komposit yang terdiri daripada kombinasi 2+1 Powder memamerkan sifat reologi yang baik berbanding kombinasi yang lain.

DEDICATION

For my beloved mother and father.

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τ	-	Interfacial shear strength or the matrix shear strength
μm	-	Micron or Micrometer
π	-	Pi
$\hat{\sigma}_{Tf}$	-	Tensile stress in fiber
Δt	-	Time Taken from S_1 to S_2 or Time Taken for D_r
%	-	Percentage
&	-	And
=	-	Equal
°C	-	Degree Celsius
$°C^{-1}$	-	Reciprocal of Degree Celsius
1/T	-	Reciprocal of Temperature
2+1	-	2+1 Processing Method
3	-	3 Processing Method
A	-	Pre-exponential factor or Prefactor
A_r	-	Cross Sectional Area
$CaCO_3$	-	Calcium Carbonate
cm^2	-	Centimeter Square
cm^3	-	Centimeter Cube
CMC	-	Ceramic-Matrix Composite
cmHg	-	Centimeter Mercury
D	-	Diameter of fiber
D	-	Diameter of Orifice
D_r	-	Distance
$d\gamma_s/dt$	-	Shear Rate
E	-	Activation Energy
E_a	-	Activation Energy
et al.	-	Et Alia (And Others)

g	-	Gram
GPa	-	Giga Pascal
HDPE	-	High Density Polyethylene
HFP 20	-	Hybrid Glass/LCP Fibers Reinforced Untougnened Nylon Composite with 20 wt% LCP
HFRT 20	-	Hybrid Glass/LCP Fibers Reinforced Tougnened Nylon Composite with 20 wt% LCP
K	-	Constant
k	-	Rate constant of chemical reaction
K^{-1}	-	Reciprocal of Kelvin
kg	-	Kilogram
kgf	-	Kilogram Force
kJ	-	Kilo Joule
kV	-	Kilo Volt
l_c	-	Critical Fiber Length
L	-	Die Length
LCP	-	Liquid Crystalline Polymer
LFRT 20	-	20 wt% LCP Fibers Reinforced Toughened Nylon Composite
log	-	Logarithm of 10
M	-	Malaysia
min	-	Minute
mm	-	Millimiter
MMC	-	Metal-Matrix Composite
mol	-	mol
n	-	Flow Index
O_2	-	Oxygen
P	-	Pressure
Pa	-	Pascal
PA	-	Polyamide
PDMS	-	Polydimethylsiloxane
PE	-	Polyethylene