DEVELOPMENT OF SHORT CARBON FIBRE REINFORCED POLYPROPYLENE COMPOSITE FOR CAR BONNET

By

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

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October 2006

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Faculty : Engineering

Carbon fiber reinforced thermoplastics are increasingly used for high performance composites, particularly for the automotive industry. This study focuses on the development of short carbon fiber reinforced polypropylene (SCF/PP) for use as car bonnet in replacement for steel. The scope of work includes formulation of the composites, evaluation of mechanical, thermal and morphological properties as well as comparative performance to that of steel. The composites were prepared by melt blending using chopped fibers of 5 sizes;0.5 mm, 1 mm, 2 mm, 5 mm and 10 mm respectively for fiber loading of 1, 2, 3, 4, 5, 6 and 7% weight fraction. Sheets of 1 mm and 3 mm thickness were compression moulded to be used for further testing. The sheets were tested for mechanical properties such as density (ASTM D792), tensile strength (ASTM D638), flexural strength (ASTM D790), Rockwell hardness (ASTM D785) and Izod impact values (ASTM D256). The effects of fiber length on thermal properties of the composites were evaluated using thermogravimetric (TGA) and dynamic mechanical analysis (DMA). TGA was used to evaluate composite decomposition and stability whilst DMA was utilized to evaluate parameters such as the glass transition temperature, T_g, storage modulus, E', loss modulus, E" and tan δ.

The morphology of failure was observed using scanning electron microscopy (SEM). The performance of the composites was compared to the current material in use (mild steel) for mechanical and thermal properties. The mechanical properties of the composites were enhanced with increase in weight fraction as well as fiber size. The SEM micrograph of fractured surfaces showed that there was good fiber-matrix adhesion for composites with longer fibers which resulted in improvement of mechanical properties of composite. The TGA results showed that thermal stability of SCF/PP composites increased with increment of carbon fiber length. DMA results showed that storage and loss modulus of SCF/PP composites improved with incorporation of 5 and 10 mm length but for 1 and 2 mm length, no considerable change was observed. The T_g of composites with 5 and 10 mm length increased compare to unfilled PP. The performances of the composites were compared to the standard steel material applied and were found to be a viable replacement option. The composite showing the optimum properties within the investigation was one with 7% fiber content and 10 mm length.

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

PEMBANGUNAN KOMPOSIT GENTIAN KARBON PENDEK BERTETULANG POLIPROPENA UNTUK BONET KERETA

Oleh

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Thermoplastik bertetulang gentian karbon digunakan semakin banyak untuk pencapaian komposit berprestasi tinggi, terutamanya di dalam industri automatif . Kajian ini bertumpukan pembentukan komposit polipropena (SCF/PP) bertetulang gentian karbon pendek untuk digunakan sebagai bonet kereta untuk mengganti keluli. Kerja-kerja yang terlibat merangkumi formulasi komposit, penilaian sifat-sifat mekanik, terma dan morfologi dan prestasi perbandingannya dengan keluli. Komposit-komposit tersebut disediakan melalui pencairan menggunakan alat campuran yang menggunakan potongan gentian karbon dalam lima saiz iaitu; 0.5 mm, 1 mm, 2 mm, 5 mm dan 10 mm masing-masing bagi muatan fiber dengan nisbah berat 1, 2, 3, 4, 5, 6 dan 7 %. Kepingan setebal 1 mm dan 3 mm diacu mampat untuk ujian seterusnya. Kepingan-kepingan tersebut diuji bagi sifat-sifat mekanik seperti ketumpatan (ASTM D792), kekuatan ketegangan (ASTM D638), kekuatan lenturan (ASTM D790), kekerasan Rockwell (ASTM D785) dan nilai-nilai hentaman Izod (ASTM D256). Kesan panjang gentian atas sifat-sifat terma komposit dinilai dengan mengguna analysis gravitian terma (TGA) dan analisis dinamik mekanik (DMA). TGA digunakan untuk menilai penguraian dan stabiliti komposit sementara

DMA digunakan untuk menilai parameter-parameter seperti suhu alihan kaca, Tg, modulus simpanan, E', modulus kehilangan, E" dan tan δ. Morfologi kegagalan dicerap dengan mengguna scanning electron microscopy (SEM). Prestasi komposit-komposit tersebut dibandingkan kepada bahan semasa yang digunakan (keluli terkisar) untuk sifat-sifat mekanik dan terma. Sifat-sifat mekanik komposit ditingkatkan dengan peningkatan nisbah berat dan saiz gentian. Mikrograf permukaan patah SEM menunjukkan yang terdapat rekatan fiber-matrik yang baik bagi komposit-komposit dengan gentian yang panjang yang menyebabkan peningkatan sifat-sifat mekanik komposit. Keputusan TGA menunjukkan yang stabiliti terma SCF/PP komposit-komposit meningkat dengan peningkatan panjang gentian karbon. Keputusan DMA menunjukkan yang modulus simpanan dan kehilangan komposit-komposit SCF/PP meningkat dengan penambahan panjang 5 dan 10 mm tetapi bagi panjang 1 dan 2 mm, tiada perubahan jelas diperhatikan. Tg komposit-komposit dengan panjang 5 dan 10 mm meningkat berbanding dengan PP yang tidak bertetulang. Prestasi komposit-komposit dibandingkan dengan bahan kenaan keluli piawai dan pilihan pengganti boleh jaya dijumpa. Komposit yang menunjukkan sifat-sifat optima dalam penyiasatan ialah yang mempunyai kandungan gentian 7 % dan panjang 10 mm.

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I certify that an Examination Committee has met on 17th October 2006 to conduct the final examination of Fateme Rezaei on her Master of Science thesis entitled "Development of Short Carbon Fibre Reinforced Polypropylene Composite for Car Bonnet" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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FATEME REZAEI

Date: 7 November 2006

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