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We hereby declare that we have checked this thesis and our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy

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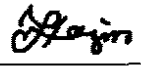
I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



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EFFECT OF LAMINATED PARAMETERS ON MECHANICAL PROPERTIES HYBRID JUTE-RAMIE REINFORCED UNSATURATED POLYESTER COMPOSITE

MOHAMMAD HAZIM BIN MOHAMMAD HAMDAN

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ABSTRAK

Serat semulajadi adalah alternatif yang boleh dipercayai untuk serat sintetik. Penggunaan serat semulajadi sebagai pengukuh adalah penting untuk menjimatkan tenaga, memelihara sumber semula jadi, dan mencapai struktur yang ringan. Malah, pada masa kini penyelidikan mengenai hibridisasi kain tenunan semulajadi masih di peringkat awal. Matlamat kerja semasa adalah untuk menyiasat sifat-sifat mekanik komposit jut-rami dengan resin poliester tak tepu dalam pelbagai jenis parameter seperti saiz lapisan, urutan, dan orientasi kain. Di samping itu, kesan kelembapan berlebihan pada sifat-sifat mekanik untuk komposit jut-rami dengan polyester tak tepu juga disiasat. Bagi tujuan pengulangan eksperimen, sifat-sifat bagi serat tunggal, serat benang and sifat fabrik dianalisis dan direkodkan. Sehubungan dengan itu, untuk menentukan komposisi kimia dan kestabilan terma fabrik jut dan rami, TAPPI 203 OM 02, teknik "Fourier Transform Infra-Red" (FTIR), analisis termogravimetrik dan termogravimetrik terbitan digunakan. Adalah penting untuk mengetahui prestasi mekanikal untuk serat benang tunggal dan kain tenunan dalam arah yang berbeza dari iaitu lekuk and renda. Oleh itu, ujian tarikan serat, ujian sentap, ujian mengoyak dan tusukan digunakan untuk merekod prestasi serat benang dan kain tenunan jut dan rami. Pengimbasan mikroskopik elektron (SEM) digunakan untuk memeriksa struktur patah, kerosakan (pemisahan, retakan matriks, penyingkiran) dan morfologi permukaan komposit. Sampel komposit telah dibuat melalui teknik mampatan tangan dengan hidraulik. Maksimum 4 lapisan saiz pelapik digunakan dengan urutan dan orientasi kain yang berlainan. Empat jenis konfigurasi fabrik itu adalah seperti berikut: 0° lamina, lamina lintang, lamina bersudut, dan quasi-isotropik. Semua sampel komposit mengalami ujian tegangan, ujian lenturan tiga mata dan ujian hentakan mengikut "American Society for Materials Testing" (ASTM). Dalam kes penyerapan air dan pengujian bengkak tebal, bahan komposit dengan 2 dan 3 lapisan direndam dalam air suling selama 30 hari. Hasil dari kajian ini menunjukkan bahawa sifat mekanik UPE dapat dipertingkatkan dengan menggabungkan jut dan rami. Sifat mekanikal untuk komposit hibrid terletak di antara komposit jut tunggal dan komposit rami tunggal. Berdasarkan keputusan telah menunjukkan bahawa kesan susunan urutan susunan dalam ujian lenturan. Sebaliknya, komposit dengan orientasi kain 0° lamina dan lintang didapati signifikan pada ujian tegangan. Secara keseluruhannya, parameter penting untuk sifat tegangan seperti berikut: 1) saiz lapisan 2) orientasi fabrik 3) urutan berlapis. Walau bagaimanapun, bagi lenturan dan kesan corak adalah seperti berikut: 1) saiz lapisan 2) urutan fabrik 3) orientasi kain. Selain itu, permukaan patah komposit tegangan terus dikaji melalui mikroskopik elektron. Menurut imej dari mikrosokopik elektron, dapat disimpulkan bahawa permukaan patah bergantung pada orientasi kain. Komposit dengan orientasi kain lamina bersudut dan quasi-isotropik didapati mempunyai permukaan patah licin yang menunjukkan sifat rapuh. Tambahan pula, perlu diperhatikan bahawa penampilan poros di permukaannya adalah minimum. Keputusan ujian bagi jut tunggal, rami tunggal dan hybrid jut-ramie dibandingkan dengan nilai pengiraan dari model makro-mekanikal seperti peraturan campuran, model Halpin-Tsai, model Hirsch, dan model Cox-Krencel.Sementara itu, satu lagi kajian mendedahkan bahawa sifat-sifat mekanik komposit jut-rami menurun apabila terdedah kepada keadaan lembapan yang berlebihan. Mekanisma pengangkutan air bagi sampel komposit adalah tidak mengikut sifat "fickian". Akhir sekali, kadar penyerapan air didapati meningkat disebabkan oleh saiz lapisan yang lebih tinggi.

ABSTRACT

The natural fibre is an alternative to synthetic fibre. It is key to saving money, conserving natural resources, and providing a lightweight structure. The work on hybridising natural fabrics is still in its infancy. The current research investigates the mechanical properties of reinforced unsaturated polyester resin with various parameter types such as layering size, layering length, and fabric orientation. In the current study, the impact of excessive moisture on mechanical properties for hybrid jute-ramie reinforced UPE composites is also investigated. For experimental purposes, the properties for single fibre, yarn fibre and fabric properties were analysed and registered. The simple 1/1 woven jute and ramie were defined in chemical composition, physical properties and mechanical properties. TAPPI 203 OM 02, Fourier Transform Infra-Red (FTIR) method, thermogravimetric analysis (TGA) and thermogravimetric derivative (DTG) to assess the chemical composition and thermal stability of woven jute and ramie. It is essential to note the mechanical performance for single yarn fibre and woven fabric in a different warp and weft direction. Thus, the multi-fibre-pull-out test, grab test, tearing and puncture test was used to record the performance of yarn fibre and woven fabric of jute and ramie. The scanning electron microscope was employed to examine fractured faces, damage (splitting, matrix cracking, delamination) and composite surface morphology. The composite sample fabricated via hand lay-up and hydraulic compression technique. Maximum 4 layers of layering size were applied with layering sequence and fabric orientation. Four fabric configuration types have been analysed: 0° laminates, cross-ply laminates, angle-ply laminates and quasi-isotropic. According to the American Society for Testing Materials (ASTM), all-composite samples undergo tensile testing, flexural testing, and impact testing according to the American Society for Testing Materials (ASTM). The composite material with 2 and 3 layers immersed in distilled water for about 30 days in the water absorption and thickness swelling testing. The present study indicated that the mechanical properties of UPE could considerably be improved by incorporating different layering sizes of jute and ramie reinforcement. The mechanical properties for hybrid composite lie in between single jute composite and single ramie composite. Based on the results have shown that the effect of stacking sequence dominance in the flexural test. On the other hand, the composite with fabric orientation of 0° laminates and cross-ply found to be significant on the tensile testing. Overall, the vital parameter for tensile properties is the following: 1) layering size 2) fabric orientation 3) layering sequence. Nonetheless, following such pattern are recognised for flexural and impact: 1) layering size 2) layering sequence 3) fabric orientation. Other than that, the tensile composite's fracture surface was further investigated via scanning electron microscopic (SEM). According to the SEM image, it can be concluded that the fracture surface is dependent on fabric orientation. The composites with fabric orientations of angle-ply and quasi-isotropic have a smooth fracture surface. Their presence of micro-void and porous on the surface is minimum. Single jute, single ramie and hybrid jute-ramie were compared with computational models such as rule of mixture, inverse rule of mixture, Halpin-Tsai, Hirsch and Cox- Krencel's. Meanwhile, another study revealed that the hybrid jute-ramie mechanical properties reinforced UPE dropped when exposed to excessive moisture. Mechanism of water transport for the composite sample follow non-fickian behaviour. Finally, the rate of water absorption found to increase due to the higher number of layering sizes.

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