Faculty of Manufacturing Engineering

NEW HYBRID KENAF FIBRE/EPOXY REINFORCED ALUMINIUM LAMINATE COMPOSITE FOR STRUCTURAL APPLICATION

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NEW HYBRID KENAF FIBRE/EPOXY REINFORCED ALUMINIUM LAMINATE COMPOSITE FOR STRUCTURAL APPLICATION

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DECLARATION

I declare that this thesis entitled “New Hybrid Kenaf Fibre/Epoxy Reinforced Aluminium Laminate Composite for Structural Application” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date :……

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature :…….....

Supervisor Name : Prof. Madya Dr. Mohd Warikh bin Abd. Rashid

Date :…….....

DEDICATION

To my beloved wife, Hazlinda bte Kamarudin, my handsome boys, Muhammad Daniel Haikal and Muhammad Daffy Danish, my cute daughter, Nourish Zara Aleesya and my newborn baby girl, Naura Zhafira Alya. Their source of my inspiration and strength in pursuit of excellence.

To my lovely my mother, father-in law and all families who always pray for our happiness. Also, not forgotten to my deceased father and mother-in law.

Thanks for all support and encouragement toward the end of this journey

ABSTRACT

Fibre metal laminates (FML) technology is an effective way to increase the range of application of kenaf fibre composite in industries and offers some superior mechanical properties. The drawback of kenaf fibre composite is a low strength, high water absorption and the effect of thermal has become a big issue especially for the structural application. Also, lackingof data publish especially in FML technology involving kenaf fibre and increasing environmental concerns cause this study is vital to be explored. The present study is carried out the fabrication of kenaf fibre reinforced aluminium laminatescomposites (KeRALL) for structural application. It includes a comparison of KeRALL fabrication methods, the effect of pre-treatment of kenaf fibers and Al sheets as well as the effect of hygrothermal on KeRALL performance. The methodology was divided into 3 experiments, namely KeRALL fabrication through cold compression (CC) at 27 °C and warm compression (WC) at 80 °C, chemical (kenaf) and mechanical (Al) treatment processes and hygrothermal effects at 30, 60 and 80 °C. Innitially, thermal analysis by DSC showed a better curing degree of epoxy resin in WC as compared to CC. While, dynamic mechanical analysis (DMA) demonstrated that T_g was extended to 100–150 ^oC for CC as compared to 50–100 ^oC for WC. Thermal expansion result showed coefficient of thermal expansion of KeRALL WC almost matched that of Al sheet with only 21% differences. This explained the significant improvement of flexural strength and water resistance in KeRALL WC. It showed the highest flexural strength and lowest water absorption of KeRALL WC, 296.10 MPa and 7.9 %, respectively. Fractographic images illustrated a good interfacial bonding of KeRALL that prepared by WC. For the pre-treatment effect, the flexural test results showed that the KeRALL WC with surface roughened aluminum sheets gave higher values of increment, 283%. However, KeRALL WC with alodine treated aluminum showed the highest impact strength, 37.99 MPa contributed by interfacial delamination as a result of less firm adhesion between Al sheet and composite core. The KeRALL WC also showed improvement in water resistance at less than 9% as compared to the kenaf fibre reinforced composite (KFRC) at about 19%. For hygrothermal effect, KeRALL WC immersed at 30 °C shows the lowest water absorption rate, 4.7%. Mechanical properties of KeRALL shows an overall decreasing trend with the increase of immersion temperature. At 30 °C, 7 % decrement of interlaminar shear stress (ILSS) were recorded, followed by 66 % at 60 °C and 54 % at 80 °C. The significant finding of KeRALL is similar toSiRAL density about 23% increase as well as a high increment of flexural strength about more than 280% compared to kenaf fibre reinforced composite and thus has potential to be commercialized in the structural applications.

ABSTRAK

Teknologi laminat gentian logam (FML) adalah cara yang berkesan untuk meningkatkan pelbagai aplikasi komposit gentian semulajadi dalam sektor industri serta ianya menawarkan sifat mekanikal yang unggul.Kelemahan komposit gentian kenaf adalah berkekuatan rendah, penyerapan air tinggi dan kesan terhadap haba telah menjadi isu besar terutamanya bagi aplikasi struktur. Juga, kekurangan data yang diterbitkan terutamanya dalam teknologi FML yang melibatkan gentian kenaf serta peningkatan kebimbangan alam sekitar menyebabkan kajian ini diterokai. Kajian ini dijalankan terhadap fabrikasi gentian kenaf diperkuat aluminium laminat (KeRALL) bagi aplikasi struktur. Ianya merangkumi perbandingan kaedah fabrikasi KeRALL, kesan pra rawatan gentian kenaf dan lembaran Al serta kesan higroterma terhadap prestasi KeRALL. Metodologi dibahagikan kepada 3 eksperimen iaitu fabrikasi KeRALL melalui pemampatan sejuk (CC) pada suhu 27 °C dan pemampatan panas (WC) pada 80 °C, proses pra rawatan kimia (kenaf) dan mekanikal (Al) dan kesan higroterma pada 30, 60 dan 80 °C. Awalnya, analisis terma DSC menunjukkan tahap pengawetan resin epoksi WC lebih baik berbanding CC. DMA menunjukkan suhu peralihan kekaca, T_g dilanjutkan kepada 100–150 °Cuntuk CC manakala WC kekal pada50–100 °C. Pengembangan terma menunjukkan KeRALL WC hampir menyamai nilai lembaran Al dengan perbezaan 21%. Ini menyebabkan kekuatan lenturan dan rintangan penyerapan air KeRALL WC meningkat dengan ketara. KeRALL WC menunjukkan kekuatan lenturan tertinggi, 296.10 MPa dan penyerapan air terendah, 7.9 %. Imej fraktografi menggambarkan ikatan antara muka yang baik pada KeRALL WC. Bagi kesan pra rawatan,KeRALL WC dengan lembaran aluminium berpermukaan kasar memberikan peratus peningkatan nilai lenturan yang tinggi iaitu 283%. Walau bagaimanapun, aluminium yang dirawat alodine menunjukkan kekuatan hentaman tertinggi, 37.99 MPa yangdisumbangkan oleh penyisihan antara muka akibat kelekatan lemah antara lembaran Al dan teras komposit. Untuk kesan higroterma, KeRALL WC direndam pada 30 °C menunjukkan kadar penyerapan air terendah, 4.7%. Sifat mekanikal KeRALL menunjukkan tren penurunan keseluruhan dengan peningkatan suhu rendaman. Pada suhu 30 °C, tegasan ricih antara laminat (ILSS) merekodkan 7% penurunan, diikuti suhu 60 °C (66 %) dan suhu 80 °C (54%). Penemuan signifikan KeRALL adalah peningkatan yang sama dengan ketumpatan SiRAL kira-kira 23% serta peningkatan kekuatan lenturan yang tinggi, >280% berbanding komposit bertetulang gentian kenaf danberpotensi untuk dikomersialkan dalam aplikasi struktur.

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