MECHANICAL BEHAVIOR OF FDM 3D PRINTED COCONUT WOOD-FILLED PLA

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DOCTOR OF PHILOSOPHY

UNIVERSITI MALAYSIA PAHANG

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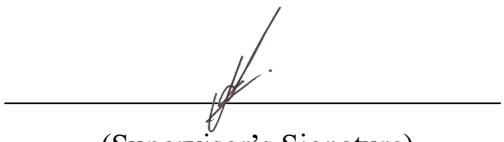

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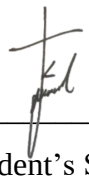

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ABSTRAK

Fused Deposition Modeling (FDM) ialah kaedah pembuatan aditif (AM) yang penting, dan ia merupakan proses pencetakan 3D yang murah untuk membuat bahan termoplastik dan komposit. Teknologi FDM telah memainkan peranan penting kepada industri pembuatan kerana kapasitinya untuk mencipta bahagian yang rumit sambil turut menyediakan dimensi yang tepat. Zarah kayu digunakan secara meluas dalam sektor bioperubatan. Walau bagaimanapun, terdapat maklumat terhad mengenai sifat mekanikal kayu tulen. Sehingga hari ini, kayu kelapa terkenal dengan bahan mesra alam, biodegradasi, rintangan haba dan rintangan kakisan. Oleh itu, tujuan penyelidikan ini adalah untuk mencirikan sifat fizikal dan kimia PLA, kayu kelapa (Ct.W), dan komposit PLA/ Ct.W tersuai. Kemudian siasat sifat mekanikal spesimen PLA dan PLA/Ct.W mengikut piawaian ASTM. Sebagai contoh, ujian tegangan mengikuti ASTM D638 Jenis 1, ujian mampatan mengikuti ASTM D695, ujian lenturan berikutan ASTM D790, dan terakhir ujian impak berikutan ASTM D256. Spesimen ujian telah disediakan dengan peratusan isian yang berbeza (25%, 50%, 75%) dan corak isian (Rectilinear, honeycomb, grid, concentric, dan octagram spiral) dengan menggunakan teknik FDM pada PLA kayu kelapa. Selepas itu, sifat mekanikal PLA dan PLA/Ct.W ditentukan selepas ujian tegangan, lenturan, mampatan dan hentaman. Selepas eksperimen, keputusan kemudiannya dianalisis dengan menggunakan model regresi (RSM) untuk mengenal pasti parameter yang dioptimumkan yang memberi kesan ketara ke atas sifat mekanikal. Model matematik sifat mekanikal juga dicipta menggunakan RSM yang boleh digunakan untuk meramalkan sifat mekanikal yang dikehendaki dengan peratusan isian dan corak isian yang berbeza-beza. Morfologi serbuk kelapa memaparkan mikrozarah sfera dan saiz serbuk kelapa berjulat antara 1.78 µm. kepada 3.88 µm. Kumpulan FTIR menunjukkan serbuk kayu kelapa mempunyai jalur karboksil yang meregang pada 1240 dan 1034 cm^{-1} menunjukkan ikatan interlayer yang mencukupi antara PLA dan Ct.W Keputusan eksperimen menunjukkan corak isian concentric dan peratusan isian 75% mencapai sifat maksimum dalam tegangan. ujian dan ujian lenturan. Untuk ujian mampatan, corak isian grid dan peratusan isian 75% memberikan sifat mampatan maksimum. Akhir sekali, untuk ujian impak, corak isian honeycomb dan spesimen peratusan isian 75% menunjukkan sifat impak yang paling tinggi. Secara keseluruhannya, corak isian lingkaran octagram menunjukkan sifat paling lemah antara semua corak isian. Juga menggunakan RSM persamaan regresi dicipta untuk mencapai sifat maksimum menggunakan komposit PLA/Ct.W. Sebagai cadangan, menggunakan agen ikatan untuk meningkatkan ikatan bahan kayu PLA dan Kelapa serta mengurangkan saiz zarah kayu kelapa akan membantu untuk meningkatkan kualiti produk. Selain itu, parameter seperti ketebalan lapisan, jurang udara, dan sudut raster juga boleh diubah dengan peratusan isian dan corak isian untuk mengenal pasti kesan terperinci parameter pencetakan pada sifat mekanikal spesimen yang dicetak untuk peningkatan kekuatan PLA/ Spesimen atau produk FDM berasaskan Ct.W. Selain itu, penyelidikan semasa menyumbang matlamat pembangunan mampan (SDGs) nombor-8 Kerja yang baik dan pertumbuhan ekonomi dan nombor-12 Penggunaan dan pengeluaran yang bertanggungjawab.

ABSTRACT

Fused Deposition Modeling (FDM) is a crucial additive manufacturing (AM) method, and it is an inexpensive 3D printing process for making thermoplastic and composite materials. The FDM technology has made significant contributions to the manufacturing industry because of its capacity to create complicated parts while also providing exact dimensions. Wood particles are widely used in the biomedical sector. On the other hand, little is known about the mechanical characteristics of pure wood. Coconut wood has a long history of being valued for its environmentally beneficial, biodegradable, thermal, and corrosion-resistant properties. Consequently, this study's goal is to characterize the physical and chemical properties of Polylactic acid (PLA), Coconut wood (Ct.W), and customized PLA/ Ct.W composite. The mechanical properties of PLA and PLA/Ct.W specimens were next investigated in accordance with ASTM standards. For example, tensile testing following ASTM D638 Type 1, compression testing following ASTM D695, bending testing following ASTM D790, and lastly, impact testing following ASTM D256. Using the FDM process on PLA made from coconut wood, testing specimens were created with various infill percentages (25%, 50%, and 75%) and infill patterns (rectilinear, honeycomb, grid, concentric, and octagram spiral). Next, the mechanical properties of PLA and PLA/Ct.W was determined after tensile, bending, compression, and impact testing. The response surface methodology (RSM) is then used to further examine the experiment's data in order to pinpoint the optimal parameter that has the greatest impact on the mechanical properties. RSM was also utilised to construct mathematical models of the mechanical properties that may be used to forecast desired mechanical properties with different infill percentages and infill patterns. The response surface methodology (RSM) is then used to examine the experiment's data further to pinpoint the optimal parameter that impacts the mechanical properties most. The morphology of coconut powder displays spherical microparticles, and the size of the coconut powder ranges between 1.78 µm. to 3.88 µm. FTIR group shows that the coconut wood powder had a carboxyl band stretching at 1240 and 1034 cm^{-1} showing an adequate interlayer bonding between the PLA and Ct.W. According to the experimental findings, a concentric infill pattern and a 75% infill percentage produced the best results in both bending and tensile tests. Grid infill patterns with 75% infill rates provide the best compression properties for testing. Lastly, for the impact testing, the honeycomb infill pattern and 75% infill percentage of specimen has the highest impact properties. Overall, the octagram spiral infill pattern shows the weakest properties among all the infill patterns. Also, using the RSM, the regression equations were created to achieve the maximum properties using the PLA/Ct.W composite. As a recommendation, using bonding agents to increase the bonding of the PLA and Coconut wood materials and reduce the particle size of the coconut wood will help enhance the quality of the product. To determine the precise impact of printing parameters on the mechanical property of printed specimens and to improve the strength of PLA/Ct.W based FDM specimens and products in the future, parameters like layer thickness, air gap, and raster angle can also be changed along with infill percentage and infill pattern. Also, the present research contributes Sustainable development goals (SDGs) number-8 Decent work and economic growth and number-12 Responsible consumption and production.

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