INTISARI

Penelitian ini berfokus pada pengembangan manufaktur *metastructure* untuk aplikasi *deployable structure* melalui evaluasi tiga pola origami utama, yaitu Kresling, Miura, dan Yoshimura. Proses dimulai dengan pemodelan parametrik menggunakan Autodesk Inventor dan simulasi numerik Abaqus CAE untuk memprediksi perilaku mekanik serta pola deformasi di bawah beban kompresi. Strategi material yang digunakan adalah penggabungan sifat elastisitas tinggi dari TPU 95A dengan kekakuan material PLA atau PETG CF untuk menciptakan struktur hibrida yang stabil secara struktural.

Proses manufaktur dilakukan menggunakan teknologi *3D Print Fused Deposition Modelling* (FDM) dengan sistem *Dual Extruder* untuk mengintegrasikan dua filamen berbeda dalam satu siklus cetak. Untuk memastikan kualitas integritas material, dilakukan serangkaian karakterisasi yang meliputi analisis gugus kimia melalui *Fourier Transform Infrared Spectroscopy* (FTIR), peninjauan morfologi permukaan menggunakan *Scanning Electron Microscope* (SEM), serta pengujian sifat termal dengan *Differential Scanning Calorimetry* (DSC). Selain itu, akurasi hasil cetak divalidasi dengan membandingkan massa aktual terhadap massa teoritis menggunakan neraca analitik guna mengevaluasi presisi ekstrusi.

Hasil pengujian mekanik berdasarkan standar ASTM menunjukkan bahwa setiap pola origami memiliki keunggulan spesifik: pola Miura menunjukkan sifat *auxetic*, Kresling unggul dalam penyerapan energi melalui fenomena *bistability*, dan Yoshimura memiliki kemampuan adaptasi morfologi yang baik meski kekakuannya paling rendah. Secara keseluruhan, penelitian menyimpulkan bahwa penggabungan material TPU 95A dengan komponen kaku (PLA/PETG CF) terbukti secara signifikan mampu meningkatkan beban puncak serta stabilitas mekanik spesimen dibandingkan hanya menggunakan material tunggal.

Kata kunci: *Metastructure, Deployable Structure,* Kresling, Miura, Yoshimura, Karakterisasi Material, TPU 95A, PLA, PETG CF

ABSTRACT

This research focuses on the development of metastructure manufacturing for deployable structure applications through the evaluation of three main origami patterns, namely Kresling, Miura, and Yoshimura. The process begins with parametric modelling using Autodesk Inventor and Abaqus CAE numerical simulations to predict mechanical behavior as well as deformation patterns under compression loads. The material strategy used is the combination of the high elasticity properties of TPU 95A with the material rigidity of PLA or PETG CF to create a structurally stable hybrid structure.

The manufacturing process is carried out using 3D Print Fused Deposition Modelling (FDM) technology with a Dual Extruder system to integrate two different filaments in one print cycle. To ensure the quality of material integrity, a series of characterizations were carried out which included analysis of chemical groups through Fourier Transform Infrared Spectroscopy (FTIR), review of surface morphology using Scanning Electron Microscope (SEM), and testing of thermal properties with Differential Scanning Calorimetry (DSC). In addition, the accuracy of the print results is validated by comparing the actual mass to the theoretical mass using an analytical balance to evaluate the extrusion precision.

The results of mechanical tests based on ASTM standards show that each origami pattern has specific advantages: the Miura pattern exhibits auxetic properties, Kresling excels in energy absorption through the phenomenon of bistability, and Yoshimura has good morphological adaptability despite its lowest rigidity. Overall, the study concluded that the combination of TPU 95A material with rigid components (PLA/PETG CF) was proven to significantly improve the peak load and mechanical stability of the specimen compared to using a single material.

Keywords: Metastructure, Deployable Structure, Kresling, Miura, Yoshimura, Material Characterization, TPU 95A, PLA, PETG CF