INTISARI

Teknologi *Stereolithography* (SLA) mampu menghasilkan produk dengan presisi tinggi, namun material resin fotopolimer murni umumnya bersifat getas, sehingga membatasi aplikasinya pada komponen struktural. Penelitian ini bertujuan untuk memodifikasi matriks resin dengan menambahkan aditif *Silicone Rubber* (SR) RTV 48 guna meningkatkan ketangguhan material. Selain modifikasi matriks, penelitian ini juga bertujuan untuk menganalisis pengaruh penambahan lapisan penguat (*reinforcement*) serat hibrida *Kevlar-Carbon* (0, 1, dan 2 layer) terhadap sifat mekanik seperti kekuatan tarik, kekuatan lentur, kekerasan, serta distorsi geometri spesimen.

Metode penelitian diawali dengan pencampuran resin Anycubic Standard V2 dengan variasi kadar SR (0% hingga 20%) menggunakan bantuan pelarut Hexane untuk menjaga homogenitas campuran. Proses pengadukan dilakukan secara mekanis menggunakan *planetary centrifugal mixer* sebelum spesimen dicetak menggunakan printer SLA sesuai standar ASTM D638 Tipe V dan ASTM D790. Pengujian mekanik dilakukan untuk mendapatkan data kekuatan tarik, lentur, dan kekerasan Shore D. Selain itu, dilakukan analisis morfologi dengan mikroskop digital dan pengukuran kelengkungan (*curvature*) menggunakan perangkat lunak Fiji ImageJ. Hasil eksperimen kemudian divalidasi melalui simulasi numerik menggunakan *Finite Element Analysis* (Abaqus).

Hasil penelitian menunjukkan bahwa penambahan *Silicone Rubber* menurunkan kekuatan tarik, kekuatan lentur, dan kekerasan secara linear, namun meningkatkan daktilitas secara optimal pada konsentrasi 10% SR. Distorsi geometri ditemukan meningkat seiring bertambahnya kadar SR akibat fenomena *shrinkage mismatch* internal. Di sisi lain, integrasi serat hibrida *Kevlar-Carbon* pada matriks 10% SR berhasil meningkatkan kekuatan tarik secara drastis hingga mencapai 30,55 MPa pada variasi 2 layer dan memicu lonjakan regangan melalui mekanisme *fiber bridging*. Kekuatan lentur optimal dicapai pada penambahan 1 layer serat. Validasi melalui Abaqus menunjukkan akurasi tinggi dengan rata-rata galat hanya sekitar 2%, yang membuktikan reliabilitas model numerik dalam memprediksi perilaku mekanik komposit tersebut.

Kata kunci: *Stereolithography* (SLA), Komposit Hibrida, *Kevlar-Carbon Fiber*, *Silicone Rubber*, Sifat Mekanik, Abaqus.

ABSTRACT

Stereolithography (SLA) technology is capable of producing products with high precision, yet pure resin materials are generally brittle, thus limiting their application in structural components. This research aims to modify the Anycubic Standard V2 resin matrix with Silicone Rubber (SR) RTV 48 additive to enhance material toughness. The primary focus of the study is to analyze the influence of SR addition and hybrid Kevlar-Carbon fiber reinforcement layers (0, 1, and 2 layers) on the tensile strength, flexural strength, hardness, and geometric distortion of the specimens.

The research method begins with resin mixing and varying SR content (0%–20%) using Hexane as a solvent to maintain homogeneity. The mixing process was conducted mechanically using a planetary centrifugal mixer before specimens were printed using an SLA printer according to ASTM D638 Type V and ASTM D790 standards. Mechanical testing was performed to obtain material strength data, while geometric distortion analysis utilized Fiji ImageJ software. All experimental results were then validated through numerical simulation using Finite Element Analysis (Abaqus).

The research results indicate that the addition of SR linearly decreases tensile strength, flexural strength, and hardness, but optimally increases ductility at a 10% Silicone Rubber concentration. Geometric distortion was found to increase as SR content increased due to the internal shrinkage mismatch phenomenon. The integration of hybrid fibers into the 10% Silicone Rubber matrix successfully increased the tensile strength drastically to 30.55 MPa for the 2-layer variation through the fiber bridging mechanism. Optimal flexural strength was achieved with the addition of 1 fiber layer. Abaqus validation proved the reliability of the numerical model with an average error of only approximately 2%.

Keywords: Stereolithography (SLA), Hybrid Composites, Kevlar-Carbon, Silicone Rubber, Mechanical Properties, Abaqus.