ABSTRAK

IMPLEMENTASI PENDEKATAN *VALUE ENGINEERING* DAN *FUZZY-BASED* TAGUCHI UNTUK MENGOPTIMALKAN PARAMETER PROSES FABRIKASI FILAMEN 3D PRINTING BERBAHAN DAUR ULANG BOTOL PET

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Limbah botol plastik polyethylene terephthalate (PET) merupakan permasalahan lingkungan yang signifikan, termasuk di Indonesia, karena sebagian besar belum terkelola secara optimal. Salah satu pendekatan yang menjanjikan untuk meningkatkan nilai tambah limbah PET adalah pemanfaatannya sebagai filamen 3D printing recycled PET (rPET) melalui proses additive manufacturing. Namun, proses fabrikasi filamen rPET masih menghadapi berbagai tantangan, seperti ketidakstabilan diameter, densitas yang tidak seragam, serta efisiensi waktu pultrusi akibat degradasi material selama proses daur ulang. Oleh karena itu, diperlukan metode optimasi proses yang mampu menangani karakteristik multirespon dan ketidakpastian data secara sistematis. Penelitian ini bertujuan untuk mengoptimasi parameter proses fabrikasi filamen rPET melalui integrasi framework Value Engineering (VE) dan metode Design of Experiment (DOE) berbasis Fuzzy-Taguchi. Parameter proses yang dianalisis meliputi suhu, kecepatan pultrusi, dan lebar strip, sedangkan respon yang dievaluasi adalah waktu pultrusi, diameter, dan densitas filamen. Metode Taguchi digunakan untuk merancang eksperimen secara efisien, sementara logika fuzzy diterapkan untuk menggabungkan beberapa respon kualitas ke dalam satu nilai fuzzy score performa fabrikasi. Analisis statistik lanjutan dilakukan menggunakan Analysis of Variance (ANOVA). Hasil penelitian menunjukkan bahwa kombinasi parameter optimal diperoleh pada suhu 210 °C, kecepatan pultrusi 9, dan lebar strip 0.8 dengan nilai *fuzzy score* tertinggi sebesar 0.87139. Hasil ANOVA menunjukkan bahwa faktor suhu memberikan kontribusi terbesar terhadap performa fabrikasi sebesar 55.27%. Integrasi VE dan Fuzzy-Based Taguchi terbukti mampu memberikan pendekatan optimasi yang terarah, efisien, dan aplikatif dalam meningkatkan konsistensi serta nilai tambah filamen rPET.

Kata kunci: filamen rPET, Value Engineering, Taguchi, Fuzzy-Based Taguchi, additive manufacturing.

ABSTRACT

IMPLEMENTATION OF VALUE ENGINEERING AND FUZZY-BASED TAGUCHI APPROACH TO OPTIMIZE PROCESS PARAMETERS IN THE FABRICATION OF 3D PRINTING FILAMENTS FROM RECYCLED PET BOTTLES

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Plastic waste from polyethylene terephthalate (PET) bottles remains a significant environmental issue, particularly in Indonesia, where most PET waste is not properly managed. One promising approach to increasing the value of PET waste is its utilization as recycled PET (rPET) filament for additive manufacturing applications. However, the fabrication process of rPET filament still faces several challenges, including dimensional instability, non-uniform density, and inefficiency in pultrusion time due to material degradation during recycling. Therefore, an optimization approach capable of handling multi-response characteristics and data uncertainty is required. This study aims to optimize the rPET filament fabrication process by integrating the Value Engineering (VE) framework with a Fuzzy-Based Taguchi Design of Experiment (DOE) method. The process parameters investigated include temperature, pultrusion speed, and strip width, while the evaluated responses consist of pultrusion time, filament diameter, and density. The Taguchi method was employed to design experiments efficiently, whereas fuzzy logic was applied to transform multiple quality responses into a single fabrication performance fuzzy score. Further statistical evaluation was conducted using Analysis of Variance (ANOVA). The results indicate that the optimal parameter combination was achieved at a temperature of 210 °C, a pultrusion speed of 9, and a strip width of 0.8, yielding the highest fuzzy score of 0.87139. ANOVA results reveal that temperature is the most influential factor, contributing 55.27% to the variation in fabrication performance. The integration of Value Engineering and Fuzzy-Based Taguchi provides a structured, efficient, and robust optimization framework for improving the consistency and value-added performance of rPET filament fabrication.

Keywords: rPET filament, Value Engineering, Taguchi, Fuzzy-Based Taguchi, additive manufacturing.