KARAKTERISTIK KETAHANAN *IMPACT* MATERIAL *HYBRID COMPOSITE* DENGAN MATRIKS *EPOXY*

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ABSTRAK

Penelitian ini bertujuan untuk menganalisis karakteristik ketahanan *impact* material *hybrid composite* dengan matriks *epoxy* melalui pendekatan eksperimental dan numerik. Material komposit disusun dari kombinasi beberapa jenis serat dalam bentuk laminasi untuk meningkatkan performa mekanik terhadap beban dinamis. Pengujian eksperimental dilakukan menggunakan metode uji *impact* Charpy untuk menentukan kemampuan penyerapan energi, serta analisis morfologi patahan menggunakan *Scanning Electron Microscope* (SEM) guna mengidentifikasi mekanisme kegagalan. Selain itu, analisis numerik direncanakan menggunakan metode *Finite Element Analysis* (FEA) untuk mendukung pemahaman distribusi tegangan dan perilaku material saat pembebanan *impact*. Hasil pengujian menunjukkan bahwa nilai energi serap sangat dipengaruhi oleh konfigurasi laminasi dan interaksi antar material penyusun. Analisis SEM mengungkapkan bahwa mekanisme kegagalan yang dominan meliputi retak matriks, delaminasi antar lapisan, penarikan serat, dan patah serat, di mana mekanisme *fiber pull-out* dan delaminasi berkontribusi terhadap peningkatan ketangguhan melalui penyerapan energi tambahan sebelum kegagalan total. Dengan demikian, ketahanan *impact hybrid composite* ditentukan oleh struktur laminasi, kualitas ikatan antarmuka, serta kombinasi material penyusun, sementara analisis numerik diharapkan dapat memberikan validasi dan pemahaman yang lebih komprehensif terhadap perilaku mekanik material tersebut.

Kata kunci: *hybrid composite*, *impact*, Charpy, SEM, FEA, ketangguhan, mekanisme kegagalan

CHARACTERIZATION OF IMPACT RESISTANCE IN HYBRID COMPOSITE MATERIALS WITH EPOXY MATRIX

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ABSTRACT

This study aims to analyze the impact resistance characteristics of hybrid composite materials with an epoxy matrix through both experimental and numerical approaches. The composite materials are composed of a combination of different fibers arranged in a laminated structure to enhance mechanical performance under dynamic loading conditions. Experimental testing was conducted using the Charpy impact method to evaluate energy absorption capability, followed by fracture surface analysis using Scanning Electron Microscopy (SEM) to identify the dominant failure mechanisms. In addition, numerical analysis using the Finite Element Analysis (FEA) method is intended to support the understanding of stress distribution and material behavior under impact loading. The results indicate that the absorbed impact energy is significantly influenced by the laminate configuration and the interaction between constituent materials. SEM observations reveal that the dominant failure mechanisms include matrix cracking, interlaminar delamination, fiber pull-out, and fiber breakage, where fiber pull-out and delamination contribute to improved toughness through additional energy absorption prior to complete failure. Therefore, the impact resistance of hybrid composites is governed by laminate structure, interfacial bonding quality, and material combination, while numerical analysis is expected to provide validation and a more comprehensive understanding of the material's mechanical behavior.

Keywords: *hybrid composite, impact, Charpy, SEM, FEA, toughness, failure mechanisms*