.Mechanical Behavior and Failure Analysis of Advanced Composite Materials for Lightweight Structural Applications

Abstract:

Introduction:

Kenaf fiber reinforced polymer composite is becoming a popular choice for lightweight structural applications because it's affordable, eco-friendly, and offers a good strength-to-weight balance. This study looks at how a rectangular structural component made of kenaf fiber composite behaves under mechanical loading, particularly how it responds in terms of stress, strain, deformation, and eventual failure. The goal is to first find a structural configuration that performs well under loading, and then explore how different kenaf composite ply arrangements affect fracture behavior once that configuration is finalized.

Methods :

Finite element analysis is used to investigate the structural response, deformation, and damage of the component, starting with optimization of the structural configuration itself. Once a suitable geometry is finalized, kenaf fiber composite material is introduced using ANSYS ACP (Pre), with different ply arrangements and fiber orientations tested to find the configuration that gives the best structural output. Fracture behavior is then assessed based on critical stress and deformation criteria to understand crack initiation and progression across the tested layups.

Results :

As the applied load increases, stress and strain are expected to rise steadily until a critical point is reached, where cracks are likely to begin near regions of highest bending stress. Ply arrangements closer to 0° are expected to perform stiffer with less deflection, while layups involving more 45° orientation are expected to distribute stress more evenly, potentially delaying crack initiation and lowering peak stress by around 10 to 15 percent compared to less favorable layups. The critical fracture load across configurations is expected to fall somewhere around 70 to 80 percent of the

theoretical elastic limit, showing that failure tends to begin before the material reaches its full theoretical capacity.

Conclusion :

The study aims to identify which structural configuration and kenaf composite ply arrangement offers the best combination of strength and fracture resistance, contributing to more informed, sustainable choices in lightweight structural design.