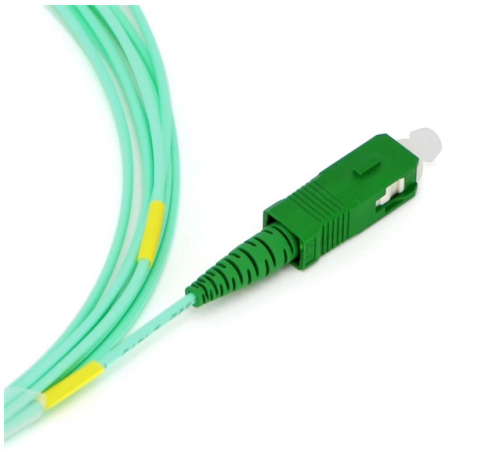
Customization Process for Low-Loss Molded Tapered Beams in Power Systems



Overview

In this paper, an advanced beam-column element is proposed for modeling tapered members with both symmetric and asymmetric variations.

Key Takeaways

The customization of low-loss molded tapered beams involves material selection, geometric optimization, finite element analysis, and vibration testing to ensure minimal electrical and mechanical losses.

Material Selection

Choosing the right material is critical for low-loss performance. Glass fiber-reinforced polymers (GFRP) are commonly used due to their low dielectric constant and high strength-to-weight ratio, which reduces electrical losses and mechanical deformation under load. E-glass is preferred for electrical applications, while S-glass offers higher silica content for enhanced mechanical performance.

The selection process may also consider D-glass for low dielectric applications and A-glass for improved surface finish.

Geometric Design and Tapering

Tapered beams are non-prismatic members with varying cross-sections along their length. The tapering profile—concave, linear, or convex—affects both mechanical stress distribution and modal behavior. Concave tapers can increase modal loss for higher-order modes, which is advantageous for minimizing unwanted vibrations, while convex tapers can reduce nonlinear effects and improve structural stability.

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The beam geometry must be tailored to the specific load conditions and spatial constraints of the power system. Finite Element Analysis (FEA)FEA is used to predict the mechanical and electrical performance of the tapered beam before manufacturing. Advanced beam finite elements can handle non-linear taper, pre-twist, bending, torsion-related warping, and eccentric loads, capturing complex stress fields and large displacements.

Modal analysis identifies natural frequencies and vibration modes, which are critical for minimizing resonance and energy losses in power systems.

Comparing FE

A results with experimental data ensures the design meets vibration and structural standards.

Manufacturing and Testing

Once the optimal material and geometry are determined, the beam is molded or fabricated according to the selected lay-up angles and taper profile. Post-manufacturing, FFT analyzer tests or other vibration measurement techniques are conducted to validate the predicted modal behavior and ensure low-loss performance. Adjustments to lay-up angles or taper geometry may be made iteratively to achieve the desired electrical and mechanical characteristics.

Optimization Considerations

Dielectric properties: Minimize electrical losses by selecting materials with low dielectric constants. Mechanical stiffness: Ensure the beam can withstand operational loads without excessive deflection. Vibration control: Optimize natural frequencies to avoid resonance with system excitations.

Thermal stability: Consider temperature effects on material properties and beam geometry. By integrating material science, geometric design, and computational analysis, the customization process ensures that tapered beams in power systems achieve low-loss, high-efficiency performance while maintaining structural integrity.

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Aisc Steel Design Guide 25 Tapered Beams

It provides a comprehensive understanding of tapered beam theory, design considerations, and practical applications, offering a valuable resource for structural engineers, architects, and students.

Timoshenko-EFEA model for tapered beams and its application

This study develops an enhanced EFEA model for tapered beams based on Timoshenko beam theory (Timoshenko-EFEA), which accounts for both bending and shear effects.

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Application of AISC Design Provisions for Tapered Members

Other standard methods of structural analysis based on either the flexibility or stiffness approach, such as moment distribution, can be readily adapted to tapered frame assemblies (stiffness and carry-over

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Introduction With the aim of optimising material use for improved economy, web-tapered steel beams are frequently utilised within steel structures. In a significant number of instances, a

(PDF) Design of tapered beam-columns

The axial compressive and flexural resistances as well as their interaction of general tapered beam-columns are investigated and proposed.

Bending and buckling of tapered steel beam structures

This paper describes an efficient finite element method of analysing the elastic in-plane bending and out-of-plane buckling of indeterminate beam structures whose members may be

Tapered Beams in MEMS: A Symbolic Modeling

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In this monograph, the authors take a fundamental, physics-based approach to the modeling of tapered beams in MEMS that is based on a rigorous perturbation

Ultimate load direct analysis of tapered web continuous beams

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