Optimization of the mechanical structure of the distribution box

Overview

A method for optimizing the layout of internal stiffened plates of large box structures based on load paths is proposed in this paper.

Key Takeaways

Optimizing a distribution box involves improving stiffener layout, reducing weight, and enhancing mechanical performance while ensuring resistance to environmental loads. Key Principles of Structural Optimization1.

Stiffened-

Plate Layout Optimization Distribution boxes, like other box structures, consist of an outer shell and internal stiffeners. Traditional designs often rely on empirical methods, leading to excessive material use and suboptimal mechanical performance. Modern optimization involves analyzing load paths to determine where stiffeners are most effective.

By decomposing the 3D structure into 2D functional sections and visualizing load paths, designers can place stiffeners along the primary stress trajectories, reducing maximum stress and deformation while lowering overall weight (Gantries example: stress reduced by 14. 9%, deformation by 32. 95%, weight by 14.

4%). 2. Environmental Load Considerations For outdoor distribution boxes, structural optimization must account for wind, snow, and other environmental forces.

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The box should be designed to withstand extreme conditions, such as high wind speeds and snow loads, by adjusting the thickness and dimensions of corner and side columns. Finite element analysis (FEA) can simulate these loads to ensure that maximum stress remains below material limits and that deformation is minimized. 3.

Material and Weight Efficiency Optimizing the mechanical structure also involves selecting appropriate materials and minimizing unnecessary mass. Using high-strength steel or aluminum alloys and optimizing the geometry of the base, body, and top cover can reduce weight without compromising strength. For example, careful sizing of corner and side columns can reduce structural mass by over 12% while maintaining safety margins.

4. Integration of Functional Requirements The internal layout must accommodate electrical components, maintenance access, and insulation distances. Optimization should balance mechanical performance with functional requirements, ensuring that the box can safely house transformers, low- and high-voltage chambers, and auxiliary equipment while maintaining structural integrity.

Recommended Optimization Workflow

Load Analysis: Identify all mechanical and environmental loads acting on the box. Decomposition: Break the 3D structure into functional 2D sections for easier analysis. Load Path Visualization: Map stress trajectories to determine optimal stiffener placement.

FE

A Simulation: Model the structure under combined loads to evaluate stress, deformation, and safety factors. Iterative Design: Adjust stiffener layout, column dimensions, and material selection to minimize weight and maximize performance. Validation: Ensure that the optimized design meets all functional, mechanical, and environmental requirements.

Conclusion

Optimizing a distribution box requires a systematic approach combining load path analysis, material efficiency, and environmental load considerations. By strategically placing stiffeners, refining column dimensions, and using simulation tools, designers can achieve a lighter, stronger, and more durable structure suitable for both indoor and outdoor applications.

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