NUMERICAL INVESTIGATION OF STRESS REDISTRIBUTION IN AIRCRAFT ENGINE PYLON USING GEOMETRY-BASED STRUCTURAL OPTIMIZATION

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ABSTRACT

In aircraft engine pylon design, the engine–wing junction represents one of the most critical structural regions due to combined aerodynamic, inertial, and vibratory loads. High stress concentrations in this area may significantly reduce structural durability and fatigue life, often leading to conservative weight penalties in traditional designs. This study presents a geometry-based structural optimization approach aimed at reducing stress concentration in the engine pylon without increasing mass or altering material properties.

A baseline pylon configuration was first developed to represent a conventional engine mounting architecture. Subsequently, a modified pylon geometry was introduced while maintaining identical boundary conditions, material properties, and loading scenarios. Structural analyses were performed using the finite element method, with aerodynamic loads derived from numerical flow simulations applied consistently to both configurations. Stress and strain distributions were evaluated under multiple operational conditions, including open- and closed-slat wing configurations.

Results demonstrate that the proposed geometry leads to a significant redistribution of stresses, effectively reducing peak stress values and producing a more uniform load transfer path through the pylon structure. Maximum von Mises stress and average stress levels were substantially reduced in critical attachment regions, while elastic strain levels were also notably decreased. These improvements were consistently observed across different operational configurations, indicating robust structural performance. The findings highlight the effectiveness of geometry-driven structural refinement as a lightweight and practical strategy for improving engine pylon performance and provide a solid foundation for future studies on fatigue life and aeroelastic behavior.

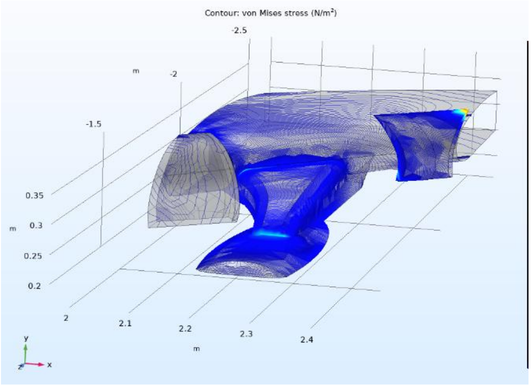

Fig. 1: Stress contours for open-slot pylons, illustrating stress concentration regions (original pylon)

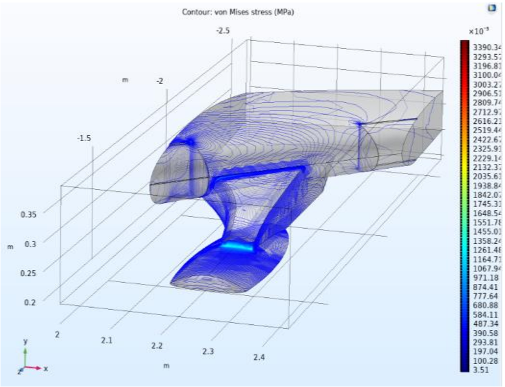

Fig. 2: Stress contours for close-slot pylons, illustrating stress concentration regions (original pylon)

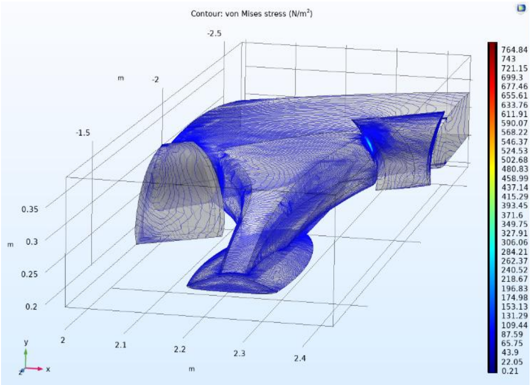

Fig. 3: Stress contours for open-slot pylons, illustrating stress concentration regions (modified pylon)

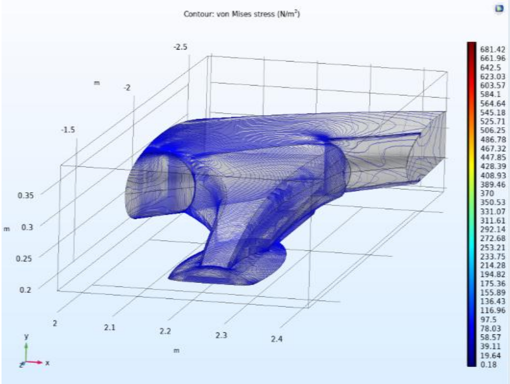

Fig. 4: Stress contours for close-slot pylons, illustrating stress concentration regions (modified pylon)

Strain Analysis

The strain analysis evaluates elastic deformation in the engine mount for both open and closed-slot configurations. The study utilizes strain contour visualization to determine the impact of design modifications. Results indicate that the proposed mount reduces strain intensity around critical attachment regions. The reduction in stress concentration directly translates into lower strain values, minimizing misalignment forces during propulsion. For the closed-slot configuration, the improvement significantly enhances the mount's ability to withstand operational loads. The mathematical approach for strain assessment follows the same principles as the stress analysis, using surface integration to compute average and peak strain values. The findings suggest that reducing strain concentrations improves structural performance, particularly under aerodynamic loads. The optimized mount design reduces unwanted elastic deformations, leading to better alignment and improved overall aircraft performance.

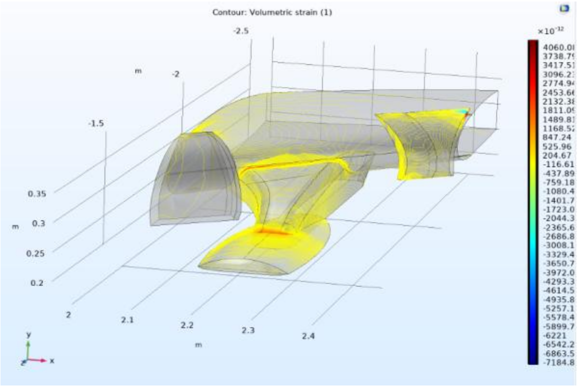

Fig. 5: Strain distributions for open-slot pylons, showing deformation trends (original pylon)

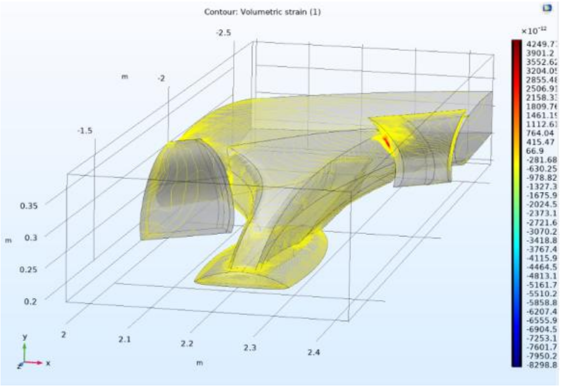

Fig. 6: Strain distributions for open-slot pylons, showing deformation trends (modified pylon)

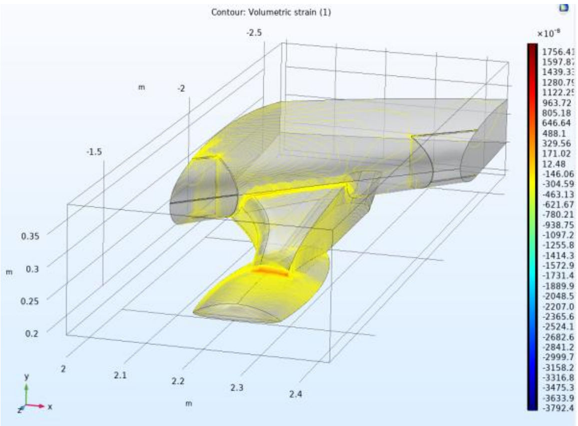

Fig. 7: Strain distributions for closed-slot pylons, verifying structural enhancements (original pylon)

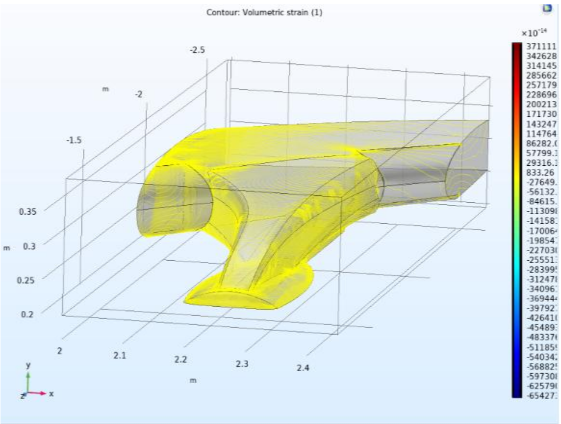

Fig. 8: Strain distributions for closed-slot pylons, verifying structural enhancements (modified pylon)