Gust Load Alleviation on Aircraft Wings

Proposal for Master Thesis
in Aerospace or Mechanical Engineering

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Enquadramento

- MEMec - Área de especialização: Produção
- MEAer - Área de especialização: Aeronaves

Objectives

When an aircraft is hit by an upward gust (short blast of wind), its wing load is momentarily increased, thus increasing the bending moment on the wing. By making a careful structural design, such bending effect should also result in a twist such that the angle-of-attack is reduced, thus reducing the wing load. This coupled effect mitigates the gust effect that could otherwise lead to a catastrophic structural failure.

The objective of this proposal is to study a passive gust alleviation solution for single- and twin-isle commercial aircraft wings, based on intentional bend-twist effect of the main wing structural element, here considered as a composite wing box. The solution should include the optimal composite layup (laminate fiber orientation) such that a prescribed stress is never exceeded.

Description

To meet the goals proposed, the work should be composed of the following main tasks:

- Bibliography Review
  Literature research about beam theory, in particular bending-twist coupling, laminate composites and basic review of aerodynamics.
  Estimated time: 4 weeks.

- Problem Definition
  Detailed definition of the problem, including mathematical formulation, gust scenarios, wing internal structures, laminate composite parameters and material properties.
  Estimated time: 3 weeks.

- Aerodynamic Analysis Model
  Selection or development of the aerodynamic model and corresponding numerical implementation. Validation with available experimental data.
  Estimated time: 4 weeks.

- Structural Analysis Model
  Selection or development of the structural model and corresponding numerical implementation. Validation with available experimental data.
  Estimated time: 4 weeks.
• Bend-Twist Coupling
  Study of the effect of the composite laminate layup on the the bend-twist coupling, ranging from adverse coupling (divergence: gust increases angle-of-attack) to beneficial coupling (stability: gust decreases angle-of-attack).
  Estimated time: 6 weeks.

• Aero-Structural Analysis
  Simulation of two representative subsonic aircraft wings (Airbus 320 and Airbus 330), with and without bend-twist coupling.
  Estimated time: 4 weeks.

• Tailored Wing Design
  Using the coupled analysis, study the optimum layup of the composite structures that lead to minimum weight and maximum gust alleviation for a large aircraft wing.
  Estimated time: 6 weeks.

• Thesis Write-up
  Write-up of the dissertation thesis and corresponding oral presentation support material. The different technical topics covered should be described in detail, and a rigorous presentation is expected, both in visual and verbal terms, in a document logically structured.
  Estimated time: 5 weeks.

Requirements

The work proposed requires knowledge covered in the following courses:

• Material Mechanics
• Solid Mechanics
• Computational Mechanics
• Computational Fluid Dynamics
• Optimization and Decision

The list mentioned is only illustrative of the scientific content of the work to be executed, it does not represent mandatory requirements. As such, the student that shows interest in this proposal is advised to previously discuss it with the supervisor.

Calendar

The work will be developed during 6 months, in accordance to the active MSc program. During this period, the student is expected to meet weekly with the supervisor to report the status of progress and discuss ideas or doubts.
The student will have freedom to manage the time in the way that suits him best but a calendar will be suggested to accomplish the tasks described above.

<table>
<thead>
<tr>
<th>Table I: Proposed Calendar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thesis Write-up</td>
</tr>
<tr>
<td>Tailored Wing Design</td>
</tr>
<tr>
<td>Aero-Structural Analysis</td>
</tr>
<tr>
<td>Beam-Twist Coupling</td>
</tr>
<tr>
<td>Structural Analysis Model</td>
</tr>
<tr>
<td>Aerodynamic Analysis</td>
</tr>
<tr>
<td>Problem Definition</td>
</tr>
<tr>
<td>Bibliography Review</td>
</tr>
</tbody>
</table>

- Month 1
- Month 2
- Month 3
- Month 4
- Month 5
- Month 6

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