Optimisation of composite laminate stacking sequences

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CDT conference
16 April 2019

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Design of blended composite laminates

Aims

- Discrete design variables

- High non-linear and non-convex objective and constraints functions

- Many design variables

- Discrete design variables

- Discrepancy in the multi-level optimisation

Difficulties

Lightweight structures

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Optimisation of composite laminate stacking sequences
Novel optimiser to design the plies’ fibre orientations

Optimisation of composite laminate stacking sequences

Target lamination parameters
Boundary of the lamination parameter design space

[45, 90, -45, ?, ..., ?]
Design of a benchmark 18-panel structure

<table>
<thead>
<tr>
<th>24 in.</th>
<th>18 in.</th>
<th>20 in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_x = -700$</td>
<td>$N_y = -400$</td>
<td>$N_x = -375$ $N_y = -360$</td>
</tr>
<tr>
<td>$N_x = -1100$</td>
<td>$N_y = -600$</td>
<td>$N_x = -900$ $N_y = -400$</td>
</tr>
<tr>
<td>$N_x = -375$</td>
<td>$N_y = -525$</td>
<td>$N_x = -400$ $N_y = -320$</td>
</tr>
</tbody>
</table>

Load intensities in lbf/in (x 1751.1 for N/m)

- Weight: 28.8 kg
- Execution time: 10 min

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Conclusion and future work

- Multi-level optimisation to account for load redistribution

1 - stiffness and thickness optimisation

Interaction between the levels of optimisation

2 - stacking sequence design
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Novel technique to design blended structures

Sub-division of the optimisation problem
Design of a benchmark 18-panel structure

Load intensities in lbf/in (x 1751.1 for N/m)

<table>
<thead>
<tr>
<th>Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial thickness distribution from individual panel optimisations</td>
<td>Weight similar than in the literature</td>
</tr>
<tr>
<td>Multi-panel structure optimisation</td>
<td>Design obtained less than an hour</td>
</tr>
<tr>
<td>Addition of a ply to the most critical panel if the buckling constraints are not all satisfied</td>
<td>Many laminate design guidelines can be considered: symmetry, balance, contiguity, disorientation, 10% rule, ply drop spacing and stacking</td>
</tr>
</tbody>
</table>

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Design of composite laminates

Objective

• Highly non-convex objective function

• Discrete design variables

• Many design variables

• Many design and manufacturing guidelines

For single-panel optimisation with a fixed number of plies

$M^N = \text{Number of possible stacking sequences}$

$N = \text{Number of plies}$

Lightweight structures

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