Formula 1 Front Wing
Flow Analysis
Lukas Brink
Front Wing

Generates
- Downforce
- Drag
Analysis

General Numerics Study
Meshing · Boundary Conditions · Schemes · Results

Case Study
Spa Francorchamps · Tailored packages · Results
General Numerics Study
General Numerics Study

Meshing

• Unstructured Grid
• Hexagonal cells
• Variable element size
• Element quality implementation
General Numerics Study

Meshing

Balance accuracy and computation time
General Numerics Study
Meshing

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General Numerics Study

Meshing

3.2M Cells
General Numerics Study
Boundary Conditions

- Velocity Inlet
- Symmetry Wall
- Slip Walls
- Pressure Outlet
- No-Slip Wall (Wing)
- Moving Floor
General Numerics Study
Schemes

• Interpolation: Linear or Cubic
• Integral approximation: Midpoint Rule

• Convection terms discretization: Bounded Upwind
• Gradient terms discretization: CellLimited Least-Squares
• Laplacian terms discretization: Gauss Linear Corrected

• Pressure: GAMG
• U, k, omega: Smooth solver

\[ \int_{t}^{t+\Delta t} \left[ \left( \frac{\partial \phi}{\partial t} \right)_P + \sum_f S_f \cdot (\rho u \phi)_f - \sum_f S_f \cdot (\rho \Gamma \phi \nabla \phi)_f \right] dt = \int_{t}^{t+\Delta t} (S_c V_P + S_p V_P \phi_F) dt \]

• Projection method: SIMPLE

• Turbulence model: K-Omega SST
General Numerics Study

Results - Convergence

Residual

\[ |A\phi^k - b| = |r^k| \]

Solution

Residual = \left[ \frac{|r|}{\text{Normalization factor}} \right] < \text{Tolerance}
General Numerics Study
Results - Convergence

Linear Interpolation

Cubic Interpolation
General Numerics Study
Results – Pressure Visualization
General Numerics Study

Results – Drag Visualization
General Numerics Study

Results – Flow Visualization
General Numerics Study

Results – Flow Visualization
Case Study
Spa Francorchamps

High speed zone
Medium-low speed zone

Medium-high speed zone
Low-speed zone
Case Study
Spa Francorchamps – Tailored Packages

High speed zone

Medium-low speed zone

Medium-high speed zone

Low-speed zone
## Case Study
### Spa Francorchamps – Results

<table>
<thead>
<tr>
<th>Speed Zone</th>
<th>Downforce</th>
<th>Drag</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High speed zone</strong></td>
<td>471 N</td>
<td>108 N</td>
</tr>
<tr>
<td><strong>Medium-high speed zone</strong></td>
<td>670 N</td>
<td>153 N</td>
</tr>
<tr>
<td><strong>Medium-low speed zone</strong></td>
<td>784 N</td>
<td>174 N</td>
</tr>
<tr>
<td><strong>Low-speed zone</strong></td>
<td>850 N</td>
<td>209 N</td>
</tr>
</tbody>
</table>
Thank you