EMBRAER CONTRIBUTION TO THE 2ND AIAA GEOMETRY AND MESH GENERATION WORKSHOP

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Embraer S/A
Outline

Introduction

Geometry generation

Mesh generation

Conclusions
INTRODUCTION
Many practical problems we are concerned on robust grid generation for a generic and complex geometry:

- High quality elements grid
- Control over the grid

OPAM-1 (Case 3) comes as an opportunity to develop automatic grid generation methodology for a simple yet representative geometry.

Main Goal → Develop the capability of accurately calculating drag increments from slight changes in geometry → Optimization

Robust geometry generation tool (Parameterized Geometry)

Automatic (no human decisions or interaction) and consistent grid generation process
GEOMETRY GENERATION
GEOMETRY GENERATION: GEOMETRIC MODULES

Parametric input file

- Geometric modules
  - W
  - B
  - P
  - N
  - V
  - H

IGES/Tecplot

Output formats

Parametric Aircraft Model
Design Parameters

- Design parameters to Control Points ($P_{i,j}$)
- Control Points to Parametric Surface (NURBS)

\[
S(u, v) = \frac{\sum_{i=0}^{n} \sum_{j=0}^{m} N_i (u) N_j (v) w_{i,j} P_{i,j}}{\sum_{i=0}^{n} \sum_{j=0}^{m} N_i (u) N_j (v) w_{i,j}}
\]
Two main steps required from design parameters to final geometry;

1. Control points definition (+ weights and knot vectors);
2. Surface generation by NURBS formulation;

These steps are automatically evaluated inside the geometric modules;

The modules export the final geometry into an IGES file (*Entity 128)*;
Geometry generation: The Process

Design problem

Parameterization

Sketch

Parameters definition

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Wing Construction Notes

- Constructed as a "ruled" surface between 3 NACA 4-series airfoils that are parallel to the aircraft centerline.
  - "root" is in centerline plane
  - "break" is at $y = \text{wing:break} \times \text{semispan}$
  - "tip" is at $y = \text{semispan}$
- Standard NACA 4-series definition is used (which results in a blunt trailing edge), with $p = 0.40$ (see next slide)
- Airfoils are rotated about the leading edge by the indicated setting angle (measured from the horizontal)
- Wing is moved to place the root leading edge at the specified $(x_{root}, 0, z_{root})$

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>wing:area</td>
<td>4240</td>
<td># area</td>
</tr>
<tr>
<td>wing:aspect</td>
<td>9.00</td>
<td># aspect ratio</td>
</tr>
<tr>
<td>wing:tapec</td>
<td>0.48</td>
<td># inboard taper ratio</td>
</tr>
<tr>
<td>wing:tapeco</td>
<td>0.23</td>
<td># outboard taper ratio</td>
</tr>
<tr>
<td>wing:sweep</td>
<td>36.0</td>
<td># leading edge sweep</td>
</tr>
<tr>
<td>wing:dihedral</td>
<td>7.0</td>
<td># dihedral</td>
</tr>
<tr>
<td>wing:break</td>
<td>0.37</td>
<td># inboard/outboard</td>
</tr>
<tr>
<td>wing:alphan</td>
<td>-3.0</td>
<td># setting angle at root</td>
</tr>
<tr>
<td>wing:thickr</td>
<td>0.15</td>
<td># thickness ratio at root</td>
</tr>
<tr>
<td>wing:camberr</td>
<td>0.04</td>
<td># camber ratio at root</td>
</tr>
<tr>
<td>wing:alphanb</td>
<td>-3.0</td>
<td># setting angle at break</td>
</tr>
<tr>
<td>wing:thickrb</td>
<td>0.15</td>
<td># thickness ratio at break</td>
</tr>
<tr>
<td>wing:camberb</td>
<td>0.04</td>
<td># camber ratio at break</td>
</tr>
<tr>
<td>wing:alphan</td>
<td>-8.0</td>
<td># setting angle at tip</td>
</tr>
<tr>
<td>wing:thickc</td>
<td>0.08</td>
<td># thickness ratio at tip</td>
</tr>
<tr>
<td>wing:cambert</td>
<td>0.04</td>
<td># camber ratio at tip</td>
</tr>
<tr>
<td>wing:xroot</td>
<td>54.0</td>
<td># xloc at root LE</td>
</tr>
<tr>
<td>wing:zroot</td>
<td>-5.0</td>
<td># zloc at root LE</td>
</tr>
</tbody>
</table>
Geometry generation: The Process

- Design problem
- Sketch
- Parameterization
- Parameters definition
- Pseudo algorithm
- CAGD operations
- Programming language
- Geometric module

In-house computer program written in C language
(Developed for each aerodynamic component)
Geometry Generation: Geometries

Case 3A

Case 3B

Case 3C

Case 3D

“Generated automatically and virtually instantaneously by running an in-house computer program written in C language”
MESH GENERATION
Mesh Generation: Basic Steps

- ICEMCFD .tcl script for multiblock structured grid (quality and connectivity) - GMA
  - Library of dedicated geometry and bunching functions that considerably expedites programming multiblock grids
- Robust geometry generation module: Smooth, watertight, no missing parts
- Geometry with small number of patches
- Identify and name each of the components generated on the geometry creation tool
- Devise versatile and clean block cutting (avoid unnecessary splits and ogrids)
- Case 3E excluded
- High quality structured grid
- Fast grid generation (~ 2 min / grid)
- Fast search for a good "first grid"
Figure: Complete model
Figure: Complete model - Blocking
Figure: Complete model - Pylon nacelle set
Figure: Complete model - Grid
Figure: Wing
Figure: Complete model - Nose
Figure: Complete model - Wing LE
Figure: Complete model - HT and VT
Figure: Wing Pylon Nacelle - from above 1
Figure: Wing Pylon Nacelle - from above 2
Figure: Wing Pylon Nacelle - from bellow
Figure: Nacelle TE
CONCLUSIONS
Conclusions

- Automatic, fast and consistent multiblock grid generation tool
- CFD runs shows that the process is very accurate when calculating drag increments
- 7 weeks to program the mesh generation script
- Geometric Tool is available to help generating new geometries
- Important to emphasize that Geometric Generation and Mesh Generation go hand in hand to produce an automatic grid generation process, and are essential steps before performing any shape optimization process.
THANK YOU

(OBRIGADO!)