流体解析（CFD）活用によるターボファンの最適化検討

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要旨

弊社の簡単な説明を行い、欧州、アジア向けコンパクト天カセ用（ミニ四方向天井カセット）ターボファンを開発した際のCFD適用事例を紹介する。
Optimization of the turbofan by Computational Fluid Dynamics (CFD)

Mechanism Research & Development Center
Base Technology Development Group
Keiko Kanagawa
<table>
<thead>
<tr>
<th>Category</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic</td>
<td><img src="image1.png" alt="Image of domestic products" /></td>
</tr>
<tr>
<td>Business</td>
<td><img src="image2.png" alt="Image of business products" /></td>
</tr>
<tr>
<td>For Building</td>
<td><img src="image3.png" alt="Image of building products" /></td>
</tr>
<tr>
<td>Exhaust Fan</td>
<td><img src="image4.png" alt="Image of exhaust fan" /></td>
</tr>
<tr>
<td>Train</td>
<td><img src="image5.png" alt="Image of train products" /></td>
</tr>
<tr>
<td>CC</td>
<td><img src="image6.png" alt="Image of CC products" /></td>
</tr>
<tr>
<td>Compressor IPDU</td>
<td><img src="image7.png" alt="Image of compressor IPDU" /></td>
</tr>
</tbody>
</table>
# Commodity Field (For Foreign Countries)

<table>
<thead>
<tr>
<th>Domestic</th>
<th>Daiselka (Single split)</th>
<th>Inverter Multi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td><img src="image1" alt="Image of Daiselka (Single split)" /></td>
<td><img src="image2" alt="Image of Inverter Multi" /></td>
</tr>
<tr>
<td>For Building</td>
<td><img src="image3" alt="Image of Toshiba DI Series for Economy and Ecology" /></td>
<td><img src="image4" alt="Image of Brilliant debut of Super Modular Multi System" /></td>
</tr>
</tbody>
</table>

_Toshiba DI Series for Economy and Ecology_
Purpose

To develop a low noise turbofan for high performance compact cassette type indoor unit.

Problem of these days
- the shortness of development period
- reduction of staff
- reduction of development costs
- difficulty of make prototype

CFD situation of these days
- calculation time of a turbofan is comparatively short.
- Noise analysis can also be performed if it is a qualitative comparison.

Development Items are studied by CFD.
Improvement of development efficiency

Former

The determination of specify
0-th prototype
Examination
1-st prototype
Examination...

The n-th prototype
Examination

n = 20~30

Proposal

The determination of specify
The final confirmation trial
Examination
The final re-confirmation trial
Examination

3 months

6 months

New fan is developed within limited time and few prototype.
Development of a new turbofan

**Target:**

1. Contribution to development:
   - Air volume, Noise
2. Development improving in efficiency:
   - 70% reduction of the prototypes.

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1. The check of whether the current fan can examine
2. Extraction of the examination item from the current fan
3. Optimization of a new fan
4. The examination of specify
The existing turbofan examines.

1. Comparison with CFD and Experiment

2. Similarity Rule

Examination is advanced with the current turbofan.
1. Examination of blades number

Relative velocity contour figure near the blades

<table>
<thead>
<tr>
<th>Blades number</th>
<th>8 blades</th>
<th>7 blades</th>
<th>6 blades</th>
<th>5 blades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative velocity contour figure</td>
<td><img src="image1.png" alt="Relative Velocity Contour Figure" /></td>
<td><img src="image2.png" alt="Relative Velocity Contour Figure" /></td>
<td><img src="image3.png" alt="Relative Velocity Contour Figure" /></td>
<td><img src="image4.png" alt="Relative Velocity Contour Figure" /></td>
</tr>
</tbody>
</table>

Seven blades is the optimal.
(New fan has a large boss by motor standardization.)
1. Blades form and mounting angle examination

From the factor effect figure, the optimal combination is decided.
A. The maximum camber size
B. The maximum camber position
C. The maximum thickness size
D. The maximum thickness position

Optimization model result

<table>
<thead>
<tr>
<th>The mounting angle</th>
<th>50 degrees</th>
<th>45 degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flows separation (Isosurface, such as 2 or less etc. m/s)</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
</tr>
</tbody>
</table>

Flows separation is decreasing.
The conclusion of a new turbofan

1. CFD was used for the primary design and the target was achieved.

<table>
<thead>
<tr>
<th></th>
<th>Improvement</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blades number</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Blade shape</td>
<td><img src="image1" alt="Improved Blade Shape" /></td>
<td><img src="image2" alt="Present Blade Shape" /></td>
</tr>
</tbody>
</table>
Conclusion

Reduction of the prototype number (shortening of a development period)

Reducing the prototype number to 15%.

- It was connected to commercial production by seven prototypes.
  (Two changes of design are from manufacture and three changes are blade figure.)
- The 0th prototype becomes specify near the goal