HPC in Automotive and Appliance Industry
Especially in CAE field

WanHo Jeon
CEDIC Co., Ltd.
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- Applications of CFD Analysis Techniques in Automotive/Appliance Product Design
- More than design issue : Reliability test

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1. Introduction of CEDIC Co., Ltd.

- CEDIC Co., Ltd. (Concurrent Engineering Design using Intelligent CAE)
- Foundation: Feb. 2005
- Staff: 40 Persons
- Address: 12F Ace High-end Tower III Geumcheon-gu, Seoul,
- Business Field
  - Developing engineering S/W
  - Engineering consulting – Analysis, Design
  - Engineering consulting in Japan (CEDIC Japan branch)
- Technologies
  - Development of S/W and engineering solutions
    - FlowNoise (Dipole and Quadrupole)
    - FDS (Fan Design System)
    - Data Analysis, CDS (CAE Design System)
  - Vehicle design using CAE
  - Optimized green energy (wind, water, solar power etc.) efficiency
  - Heat management technology in electronic components
1. Introduction of CEDIC Co., Ltd.
1. Introduction of CEDIC Co., Ltd.

Axial fan

Centrifugal Fan

Cross flow fan
## 2. Current HPC Usage in Korean Industry

- Current number of cpus and usage of HPC by major companies (Mechanical CAE field)

<table>
<thead>
<tr>
<th>Company</th>
<th>Number of CPU retention (in Mechanical field)</th>
<th>Major Fields of HPC in mechanical field (%)</th>
<th>Total rate of usage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyundai Motors Company</td>
<td>5,000</td>
<td>CFD 25, Structure 20, NVH 15, Crash 25, ETC 15</td>
<td>60</td>
</tr>
<tr>
<td>Samsung Electronics (Home Appliance)</td>
<td>1,000</td>
<td>CFD 20, Structure 50, NVH 15, Crash - , ETC 15</td>
<td>80</td>
</tr>
<tr>
<td>Samsung Advanced Institute of Tech.</td>
<td>3,500</td>
<td>CFD 10, Structure 60, NVH 10, Crash - , ETC 20</td>
<td>30</td>
</tr>
<tr>
<td>LG Electronics</td>
<td>1,000</td>
<td>CFD 10, Structure 50, NVH 10, Crash - , ETC 30</td>
<td>60</td>
</tr>
<tr>
<td>Hyundai Heavy Industry</td>
<td>3,000</td>
<td>CFD 20, Structure 20, NVH 20, Crash - , ETC 40</td>
<td>40</td>
</tr>
</tbody>
</table>

- Needs of HPC are gradually increasing since 2000.
  - Performance, Optimize, Replace proto-type test
- The usage of HPC have rapidly increased since 2010.
  - Use real CAD data. Replace Reliability test
3. Major Analysis Issues

**Automotive application > Aerodynamics**
Aerodynamic design / Drag coefficient analysis / Aero-acoustic analysis
3. Major Analysis Issues

- Temperature uniformity
- Flow distribution of duct
- Fan performance, Noise
- Icing inside refrigerator
- Local cooling
- Optimize duct system

- Layout optimize
- Fan performance, Noise
- Compact system
- Heat problem

- Fan performance, Noise
- Cooling time minimize
- Local Targeting of air
- Dew condensation
- New duct system design
- Room analysis
4. Applications of CFD Analysis Techniques in Automotive Product Designing

- Concept design stage: Predict the performance of the vehicle using CAD can help the designer.
- Development stage: CAE can be used in parallel with actual test. CAE can substitute the test in some particular fields.

Major companies in automobiles, electronics, and heavy industries are currently applying “designing process using CFD/CAE” for reduction of time and cost for development.
4. Applications of CFD Analysis Techniques in Automotive Product Designing

[ Aero-acoustics application ]

- The noise of vehicle connection area
  - By changing the height of step

The height of step (+1.5, -0.5, -2.5[mm])
4. Applications of CFD Analysis Techniques in Automotive Product Designing

[ Aero-acoustics application ]

- **Mesh structure**
  - Sample: CASE1(+1.5[mm])

Minimum mesh size: 0.1[mm]~
4. Applications of CFD Analysis Techniques in Automotive Product Designing

[ Aero-acoustics application ]

- **Vorticity field (movie)**
  - CASE1(+1.5[mm])
4. Applications of CFD Analysis Techniques in Automotive Product Designing

[Aero-acoustics application]

- Pressure fluctuation (movie)
  - CASE1(+1.5:mm)

\[ \Delta p = p - p_{ave} \quad p_{ave} = \frac{1}{T} \int_{t'}^{t'+T} p(t) dt \]
4. Applications of CFD Analysis Techniques in Automotive Product Designing

[ Aero-acoustics application ]

- Analysis of the noise characteristics of Ahmed body model (Experimental Data offered by HMC, 2013)

[ Comparison of Peak frequency and SPL with variable velocities ]

[ computational grids and boundary conditions]
4. Applications of CFD Analysis Techniques in Automotive Product Designing

[ Water Tunnel Test ]

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Development of Water Level Predicting Method around the Air Intake Duct by using Multivariate Analysis

Jun Yamamura
Toyota Motor Corporation
Hisaaki Sugiyma, Tetsuya Akino
Toyota Technical Development Corporation

ABSTRACT

This paper describes a water level prediction method for the air intake duct using multivariate analysis. When a vehicle runs on a submerged proving ground, in some cases the water level around the air intake duct rises. Although the rise in water level can be measured experimentally in actual vehicles, the design factors that determine the water level are not fully understood.

The first step in understanding the factors for determining the water level on front-engine and front-drive (FF) type vehicles is to establish a water level prediction technique. This is accomplished by the

At Toyota, actual driving tests conducted on courses simulating submerged conditions. However, the physical factors that determine the actual water level remained unclear. Also, design modifications intended to reduce the water level often conflicted with the radiator's cooling capacity. Satisfying both points requires repeated evaluations, meaning that much time must be spent to ensure an adequate level of performance.

Submerged proving ground

Air intake duct
Water level
Rising
Radiator
5. CFD Analysis in designing appliances

Virtual Fan Tester
5. CFD Analysis in designing appliances

◎ CFD analysis should be one of the tool for “Product developing Process”

Making about 100 of sample (mock-up):
- takes several months and high cost
- Noise reduction study relies solely on engineering experience

Shape configuration using each companies’ design tool
No information about noise reduction

Sample: 100 EA
Facility: needs several billion won
It takes several month for measure

Concept Design
(Digital Products)

Make PT or CAE Process

Meet the Requirement

Test for confirm

More than 3 times shorten the developing process and cost
5. CFD Analysis in designing appliances

- Sweat test for air-conditioner

At a restaurant

Dew drops

vapor

foods

Wet air in summer

Dew drops

bed
5. CFD Analysis in designing appliances

- A test for reliability specification(KS C 9306) is performed after prototype development of an air-conditioner.
- If the prototype model fails at the sweat test, it requires total modification of the product which takes lots of cost and time.
- A technology for verification of dew condensation is required at the development planning step.
5. CFD Analysis in designing appliances

- Sweat test for air-conditioners

- CAE Boundary Condition

Test Room Modeling (Psychrometric Chamber)
5. CFD Analysis in designing appliances

- Sweat test for air-conditioners

Test room
5. CFD Analysis in designing appliances

- Sweat test for air-conditioners

Comparison of the surface temperature

Measure  Numerical results
5. CFD Analysis in designing appliances

- Sweat test for air-conditioners

Standard type air-conditioner

✔ CFD : SC/Tetra
✔ Test : IR Camera, PIV
6. Future: Automated Analysis System

Problem of Young Engineers

- Companies worry about “Technology drain” (leaving of Design Engineers from manufacturing floor was one of the causes).
- Many students don’t study the “Engineering”. They want to be a lawyer, doctor and government employee.

What is Thinking CAE?

- Light CAE for design engineers by automation process
- Linked knowledge base database
- The know-how and knowledge can be packed with software and transferred to younger people.
- Design engineers can easily use CAE with design parameter and understand the cause-and-effect relationships.
6. Automated Analysis System

What is our strategy to success in worldwide

China, India, etc.
- Securing vehicle design and technology by reverse engineering
- Expanding fund for targeting worldwide market
- Introducing design technique using CAE
- Improving competitiveness of price with low labor cost

GM, Ford, Toyota, etc.
- Collecting data from experiment, analysis, etc.
- Fast designing of a vehicle using database
- Constructing automated process of CAE analysis to replace actual testing

Choice of Korean Industries
- Fast designing of a vehicle using database and automated CAE analysis
- Increasing competitiveness by prior occupation of technology
- Ensuring competitive price by reducing designing and producing
6. Automated Analysis System

Architecture of Automation + Database

- DO (CAE Design System)
- eCustomizer
- Database
- ePredict
- eAutomation
- Analysis Model
- Mesh
- B.C.
- Result
- Report
- Model DB
- B.C. DB
- Result DB
- Report DB
- Data Mining
- Analysis Database
- Data mining
- Knowledge Discovery
- Multiple Regression Analysis
- Genetic Algorithms
- Neural Network algorithms
- eManage
6. Automated Analysis System

DDD (Data Driven Design)

- Concept design
- Detail design
- Design optimization
- Output of design data
- Analysis results
- ePredict module
- eAutomation module
- Database system
- Master GUI
6. Automated Analysis System

• Data Driven Design
  - Making a Database with previous + New data (requires HPC for many CFD calculation)
  - Data mining method: using Genetic Algorithm

Design parameter

Analysis and Measured data
(Automation)

Update every year with new data
6. Automated Analysis System

The optimized design & analysis system of Torque converter (TDOS, 2006)

- **Workflow of TDOS**
- **DOE Setup**
- **BPG for blade profile**
- **Report of TDOS**
- **Optimized results**

**Development of the Integrated Process for Torque Converter Design and Analysis**

Kyoung Song, Kyuroop Kim, Jaein Park, JaeChang Kook and JongSun Oh
Hyundai-Kia Motor Company
JangHyung Cho
CEDIC
MuSang Kim
Engineous Korea

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2008-01-0785

2008-01-01785

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6. Automated Analysis System

Web based fan design and analysis system – Automation

Client

Step 1

Select whether CAD modeling or not

Set pre-processing option

Input design parameter for CAD modeling

Set solving option

Select CAD file of previous models
6. Automated Analysis System

Web based fan design and analysis system - Automation
Thank You!