제품 개발 프로세스 효율화 방안

(Simulation based Design)

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Altair SimSolid™

2018년 12월 11일 오후 1시
스타트업 캠퍼스 1층 컨퍼런스홀
AGENDA

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II. Simulation Based Development 6

III. Democratizing CAE 11

IV. Topology Optimization 17

V. Summary 26
Product Development Process

**Planning**

1. Generate Product Idea
2. Evaluate Product Idea
3. Agree on Product Idea
   - Consensus

**Concept Design**

Hardware #1

4. Define Product Concepts
5. Delineate Product Concepts
6. Freeze Product Concept
   - Model Freeze
   - Product Target

**Detail Design**

Hardware #2

7. Design Product
8. Produce Product
9. Validate Product
   - Validation Approval

**Manufacturing Check**

Hardware #3

10. Launch Clinic
11. Validate Pilot Product
12. Confirm Mass Production
   - Mass Production (Job 1)

How to
- increase Efficiency
- improve Quality
- reduce Time & Cost

Overall Process

Design Idea Efficient Evaluation - Efficient Decision Making

Courtesy of ITI

Multi Physics Analysis and Optimization Lab
Strategy for Improving Development Process

**Upfront Engineering**: Evaluation in early stage of Development Process

$$Design\ Change\ Cost = \Sigma N(\text{phase}) \times C(\text{Phase})$$

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<tr>
<th>Development Phase</th>
<th>Resolution Cost per Problem [C(p)]</th>
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<td>Concept Design</td>
<td>10 X</td>
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<tr>
<td>Detail Design</td>
<td>100 X</td>
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<tr>
<td>Prototyping</td>
<td>1000 X</td>
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<tr>
<td>Evaluation</td>
<td>10000 X</td>
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<td>Production Ramp-Up</td>
<td>20000+ X</td>
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For most OEM’s the process focuses on activities between “Conventional” and “Digital” after detailed design.
Digital Development (VPD, Virtual Product Development)

Digital Development Tools
CAx (Computer Aided x)

- CAS
- CAM
- DPA / DFA

‘DESIGN’

- CAE
- CAD

‘EVALUATION’

PLM
MANAGEMENT

Practice
Upfront Engineering
&
Concurrent Engineering

Digital Development: Prototyping & Manufacturing

CAS Presentation / CAD Template / CAE Automation - Process Integration / Knowledge Base Eng. / Communication

Digital Factory

Automotive Engineering
**Automotive Development Methodology Shift**

**Hardware based Development**
- DESIGN
- BUILD Prototype
- TEST
- Trial & Error

**Simulation based Development**
- SIMULATION
- OPTIMIZATION
  - Minimize Design Change
  - Less Hardware Stages

시뮬레이션개발 → 시험확인

시험개발 by Design-Build-Test Iterations
Digital Development in Automotive Industry

**Digital Car Project, 1997 – 50% shorter development cycle (60 → 30 mon.)**

- Increase Parallelization of Design Tasks
- Elimination of some design iterations
- Quicker Completion of the remaining design iteration

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**Reduce Development Time (44 → 20 mon.) by CAE based development** & Platform Technology
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Role of CAE in Automotive Development

CAE Benefit: Efficiency / Completeness / Easiness
CAE Purpose: Quality Design / Efficient Development

Efficiency
- Proto Test
  - 1st Test
  - ~2 Months
  - ¥ 100,000,000
- CAE
  - 1st Simulation
  - ~2 Weeks
  - ¥ 0
  - 2nd Simulation
  - 1-2 Days
  - ¥ 0

1 day turn around

Complete Info

Easy to Understand
- Pass? / Fail?
- How to Improve?

Best CAE for communication: ‘As it is simulation’

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CAE Role Evolution: Evaluation Tool → Design Tool

**CAE 1st Stage (~ late 90s)**
- After Design Release
- Failure Analysis
- Improvement

**CAE 2nd Stage (~ late 2000s)**
- Before Design Release
- Design Evaluation
- Improvement

**CAE 3rd Stage (mid 2010s ~)**
- Before Detail Design
- Concept Evaluation
- Optimization

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**Role Change:**

- **After Design Release** → **Before Release** → **Concept Optimization**

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**Prototype Evaluation**

**Design Review**

**Concept Design**

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**Role Change:**

**After Design Release** → **Before Release** → **Concept Optimization**

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**Pedestrian Protection**

~170 Head Impact Points on Hood & Windshield Glass

8 weeks → 1.5 weeks
Automotive Development Process Integration

Concept Development (Test Car Stage)

- Package / Layout
- Concept Design
- Pre Evaluation (Simulation)
- Design Release
- Prototype Build
- Post Evaluation (Test)

Product (Detail) Development (Proto Car Stage)

- Detail Design
- Pre Evaluation (Simulation)
- Design Release
- Prototype Build
- Post Evaluation (Test)

* 각 Hardware 단계에서 '설계-선형평가-설계출도-후행평가' 과정 반복
CAE Role in each Stage of Development Process

**Conceptual Design Phase**
- Topology Optimization Method (위상 최적화 기법)
- Shape Modeling (형상 모델링)

**Conceptual Design Phase**
- Routine Job Development Automation
  - Design Information Input - Modeling - Analysis (PLM)
- Design Information Input - Modeling - Analysis (자동화)

**Verification Phase**
- Routine Job Development Automation
  - Design Information Input - Modeling - Analysis (PLM)
- Design Information Input - Modeling - Analysis (자동화)

**Verification Phase**
- Experimentation-correlation
  - Experiment Result Detailed Analysis

**Verification Phase**
- Experiment-Design correlation
- Experiment Result and Code Assessment

**Verification Phase**
- Experiment-Design correlation
- Experiment Result and Code Assessment

- Example: Pedestrian Protection Analysis Automation
  - 48 impacts - 165 to 170 targets
  - 170 targets - Design Time: 8 weeks to 2 weeks

- Example: Enhanced Concept Design
  - All Drawings
  - Design Collaboration Period
  - Fast Verification and Design Improvement

- Example: Compliance
  - Design-Experiment correlation
  - Experiment Result and Code Assessment
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Democratizing CAE

- Raised issue on rapidly increasing CAE demand at NAFEMS 2013
- Resource limit to meet demand (not enough CAE engineers)
- Proposed ‘Democratizing CAE’ at NAFEMS 2015
- Allow Design engineers perform CAE evaluation in Design Process

**NAFEMS** : National Agency for Finite Element Methods & Standards

Democratizing CAE

- Expert Knowledge Capture & Reuse
- Usability
- Accessibility
Democratizing CAE (for Designer)

**FOA (First Order Analysis)**

Concept Study: Intuitive 1-D Analysis Tool (Toyota)

**CAD Tool base Analysis**

Full FEA
Easy to use for Designers w/o CAE skill
Limit: Single Part, Linear Analysis

Currently Available Tools: Inspire / DesignSight
CAE Process

**Pre-Processing (Modeling)**

- Meshing
- Property Assignment
- Material Assignment
- Assembly
- Boundary Condition
- Loading Condition

**Solving**

- Solver Selection
- Parameter Set Up
- Output Set Up

**Post-Processing**

- Result Analysis
- CAE / Test Correlation
- Engineering Judgment
- Design Recommendation

Equivalent to Test Car Build

Equivalent to Test

Test / Design Engineer Function

Optimization
Meshless Methods

Smoothed Particle Hydrodynamics
Democratizing CAE (for Designer & CAE Engineer)

Assembly or System level Nonlinear Analysis
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“Optimization is the Design Goal & CAE Purpose”

- **Sensitivity**, 민감도 (for Linear Problem)
- **DoE** (Design of Experiment), 실험계획법
- **Shape Optimization**, 형상최적화
- **Topology Optimization**, 위상최적화

- **MDO** (Multi-Disciplinary Optimization), 다 분야 최적설계
- **MOO** (Multi-Objective Optimization), 다 목적함수 최적설계
- **RBDO** (Reliability Based Design Optimization), 신뢰성 기반 최적설계

✓ **PIDO** (Process Integration & Design Optimization)
"Easy to use for non expert in optimization"  
(somewhat ‘As it is’ concept)

Design variable: Mass or Stiffness of *Meshed Element*

< Typical Problem >
Objective: Minimize Weight or Maximize Performance
Design Variable: Elements’ Mass
Constraints: Design Space
Topology Optimization

- Powerful Tool for Optimal Concept Design
- Easy to use even without CAE or Optimization Expert Knowledge
- Architects can get design concept
Topology Optimization by Students - AOC

> 대학생 최적화 경진대회 사례 – 자전거 Brake Arm 최적화

 INITIAL DESIGN

Max. Stress : 136.6 MPa
Volume : 39,370 mm$^3$

TOPOLOGY OPTIMIZATION

Max. Stress : 109 MPa (20% ↓)
Volume : 32,350 mm$^3$ (18% ↓)

DESIGN DOMAIN

REDESIGN

(*) '08 알테어 대학생 최적화 경진대회 작품 참조)
Panel Bead Pattern 최적화 (Topology for NVH)

インテンプル로어

TOPOGRAPHY (비드패턴최적화)

색적함수 : 변형에너지 최소

제한조건 : 판넬 떨림 억제를 위한 판넬강성 확보

설계변수 : 판넬 비드패턴

경계조건 : 전후스트럿 고정
하중 : 인템플로어 압력 부과

물결무늬 비드

설계초기안

설계반영안

인템플로어 판넬강성 190% 향상
: 0.85→1.4t 효과 (1.3Kg 절감효과)
위상 최적화 기법을 활용한 전단부 언더커버 리브 형상 최적화

Beyond engineer’s intuition
Learning from Nature → Getting close to Nature?
Optimization Case in Automotive Industry – Topology

- Topology Optimization (위상최적화)

- Body Design Concept
- Wheel Styling Concept
- Floor Panel Bead Pattern
- Hood Inner Structure

Steel
Aluminum

head impact
Strength
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Summary

- Simulation Based Development
  
  **Hardware based Development**
  
  DESIGN → BUILD Prototype → TEST
  
  Trial & Error
  
  시험개발 by Design–Build–Test Iterations

- Simulation based Development
  
  시뮬레이션개발 → 시험확인
  
  - Minimize Design Change
  - Less Hardware Stages

- Democratizing CAE

- Topology Optimization
Simulation based Development Process

- **Conceptual Design Stage**
  - Topology Optimization
  - Morphing Modeling

- **Design Verification Stage**
  - Routine Job Development Automation
  - Design Information Input - Modeling - Analysis (PLM) Automation

- **Verification Test Stage**
  - Test Result Detailed Analysis

- **Quality Assurance and Time Reduction**

Minimize Design Change
Less Hardware Test Stage
Improve Quality & Reduce Time

170 Test Cases Reduced - Analysis Time: 8 weeks → 2 weeks

KU

Multi Physics Analysis and Optimization Lab
TO GET THROUGH THE HARDEST JOURNEY WE NEED TO TAKE ONLY ONE STEP AT A TIME, BUT WE MUST KEEP ON STEPPING.

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