Altair HyperWorks
Driving the Product Development Process of Turbomachines

1. Dresdner-Probabilistik-Workshop

Altair Engineering GmbH
Dr. Dominik Schlotz
Director Business Development
Dresden, 09.10.2008
AGENDA

- Company Overview

- HyperWorks – A Platform for Innovation
  - HyperWorks Overview
  - Altair HyperWorks Morphing Technology
  - Design Studies with solver-neutral Software Altair HyperStudy

- HyperWorks Applications

- Summary

- Q&A
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Altair – Global CAE Supplier

- Founded 1985 in Detroit, USA
- ~1400 Colleagues
- 30 Offices worldwide
- More than 3,500 Customers

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## Industry Verticals

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<th>Heavy Equipment</th>
<th>Government / Defense</th>
<th>Life Sciences/ Earth Sciences</th>
<th>Consumer Goods / Oil &amp; Gas</th>
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*Over 3,500 Customers in Various Industries*
Altair Technology Groups

Altair Engineering

Technology to analyze, optimize and visualize information for decision makers in business and engineering
Computer-aided engineering software suite for product design and manufacturing

- Market leader for modeling, visualization and optimization of complex mechanical systems
- A Platform for Innovation - Powerful, open and easy to program design environment for mechanical engineers in all industries
Grid computing technology that maximizes the ROI of enterprise IT assets

- Market share leader with over 30,000 deployments worldwide
- **PBS Professional** and **OpenPBS**
- Proven scalability and reliability on the largest and most complex data centers
- Mature Eco-System partner network ensures seamless integration and ease of deployment
- *It’s EveryWare!* - Manages heterogeneous mix of Unix, Linux and Windows systems
The shortest distance between concept and reality

High value and innovative product design, process mapping
and automation consulting services
Exhibiting Strong Software Growth
Europe 2007: +50%

Total revenue 2007: ~140 M USD
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Altair HyperWorks - Overview

Modeling & Visualization
- Finite Element
  - HyperMesh/HyperCrash
- Multi-Body Dynamics
  - MotionView
- Visualization
  - HyperView

Analysis
- Finite Elements
  - RADIOSS
- Multi-Body Dynamics
  - MotionSolve

Optimization
- Concept & Design
  - OptiStruct
- Multi-Disciplinary
  - HyperStudy

Manufacturing
- Sheet Metal
  - HyperForm
- Extrusions
  - HyperXtrude
- Forging
  - Altair Forging
- Molding
  - Altair Molding
- Fr. Stir Welding
  - Altair Friction Stir Welding

CAE Data Management
Altair Data Manager

Process Automation
Altair Process Manager
Open Architecture for Better Integration into Enterprise PLM Architectures

HyperWorks - Enterprise Simulation Framework

HyperWorks - Unified CAE Data Structure

- CATIA
- UG
- Pro/E
- IGES
- STEP
- Adams
- Abaqus
- Ansys
- Deform
- Dyna
- Fluent
- Madymo
- Moldflow
- Nastran
- Permas
- PamCrash
- Radioss
- Simpack
- StarCD

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Efficient Preprocessing

- **HyperMesh**
  - Geometry cleanup, automated or manual
  - Meshing and assembly for rapid FE model development
  - Advanced Hex-meshing
  - State-of-the-art solver interfaces

- **BatchMesher**
  - Automated “Batch” Meshing and Assembly
  - Performs geometry cleanup and auto-meshing (in a “batch” mode) for CAD files
  - Operates on shell meshes
  - Significantly reduce model cleanup and meshing time
Morphing Technology

- HyperMorph (embedded in HyperMesh)

What is morphing?
Derive from metamorphose, transformation
Morphing Existing Models to New Designs

- **Description**
  - Rapidly change geometry of existing FE model interactively or parametrically
  - Adapt existing FE models to new design data

- **Benefits**
  - Dramatic reduction in modeling time
  - Enables rapid “What If?” studies

- **Application Examples in Gas Turbine Industry**
  - “System Level Morphing” - HyperMorph is used to perform morphing of an engine model to allow rapid assessment of bearing and seal location/configuration
  - “Component Morphing” – Turbine blades morphed to “in-operation” shape

Example for cyclic morphing
**Rapid Evaluation of “Concessions”**

- **Description**
  - Rapidly assess the usability of out-of-spec high value components
  - FE model is morphed to the “as manufactured” geometry, loads and boundary conditions are retained
  - Assessment usability made within the one week deadline
  - Components on which this has been used include turbine blades and engine casings

- **Benefits**
  - Significant cost savings by using high value components that were usually scrapped
  - Just one of the concessions saved by this manufacturer more than covers the price of a HyperWorks license for HyperMesh
HyperView

- Engineering analysis of test data and simulation results
- Report templates
  - Rapid post-processing of design iterations
  - Automated report generation
  - Publish to HTML and MS/Office
- Results mapping from one analysis to a successive analysis
- Test data correlation and advanced data analysis
- Comprehensive support of virtually all commercial solvers, including ANSYS, NASTRAN and LS-DYNA
- Readers for “in-house” codes can be created

Results overlay
Process Automation and Data Management

- Altair Process Manager
  - Process management and authoring environment to capture best practices for design processes
  - Enables integration of diverse applications (from CAD, to in-house applications, to HyperWorks) in organized work flows

- Altair Data Manager
  - Product performance data management and decision support driven by already established engineering processes
  - Manage engineering work-in-process data in the context of existing PDM system
Altair’s Vision

Today...

Altair...

Optimization is Driver in CAE Driven Design Process
Optimization & Design Studies

... generic study tool for arbitrary solvers, includes DOE and Stochastics

... with integrated FEA solver
Performing Design Studies

- Altair HyperStudy
Design Studies with Altair HyperStudy

- Solver Neutral
- Direct parameterization: Automatic transfer of modal parameters from e.g. HyperMesh/HyperMorph
- Integrated with HyperWorks thru HyperMesh, MotionView and direct solver interfaces
- Multi-Solver Study: sequential or parallel
- Integration of grid computing software PBS professional

Model

Variant

Simulation

Results

Study Engine

Creation

Job Management

Extraction

Study Results
- Optimal Parameters
- Sensitivities
- Model Robustness
- ...

Concept Design Optimization Design (CAD) Virtual Test (CAE) Build Test Optimization
Process Flow in HyperStudy

Setup

DOE

Approximation

Optimization

Stochastic

Process Definition

Study Definition

Process Flow
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**Objective**

Minimize stresses and strains at the root of turbine blade where it attaches to the disc to improve fatigue life

**Software Tools**

- FE Model development – HyperMesh
- Solver – ANSYS
- Shape variable definition – HyperMorph
- Optimization setup – HyperStudy
- Optimization – HyperStudy

**Cyclic symmetry boundary conditions**

**Two cases – 8500 rpm & 4000 rpm**
Shape Optimization of a Turbine Blade Root

- Shape variables definition with HyperMorph
Shape Optimization of a Turbine Blade Root

- Elastic-Plastic Analysis Optimization Results (8500 RPM)

**Baseline Design**
Max SEQV = 768 MPa
Max Strain = 0.00808

**Optimized Design**
Max SEQV = 746 MPa
Max Strain = 0.00603

25% reduction in strain

Baseline Shape
Optimized Shape

Leads to significant improvement in fatigue life

25% reduction in strain
Engine Compressor Blade Optimization

- **Challenge**
  - Increase pressure ratio of radial compressor through optimized blade design

- **Solution**
  - CFD optimization using HyperStudy
  - Shape optimization with morphing
  - Objective: maximize pressure relation between inlet and outlet

- **Results**
  - 5.6% increase in pressure ratio, which leads to better fuel efficiency and higher engine power

"Including HyperWorks and CFD in the design process cuts development time and enables us to perform automated design and optimization studies."

Dr. Mario Dittmann, MTU Friedrichshafen GmbH
Optimization and Reliability Analysis of a Mars Lander

ESA Aurora Exploration Program Launch in 2011 or 2013

New Lander Design Concept
  - Vented airbag, coming to rest on 2nd bounce
  - Traditional concepts come to rest after 10 to 20 bounces

Failure modes
  - Roll-over (payload overturns),
  - Dive-through (payload impacts rock)
  - Rupture (fabric tears)

Full scale terrestrial testing expensive/difficult: Therefore virtual design approach
Optimization and Reliability Analysis of a Mars Lander
Reliability Study: Range of Conditions

Only rock impact load case considered
Controlled/Uncontrolled conditions

- Wind speed (Weibull)
- Rock Height (Exponential)
- Lander pitch attitude (+/- 20 deg)
- Lander pitch rate (+/- 30 deg/s)
Results

Design Variable Change

- Vortex Area: 60%
- Airbag Diameter: 38%
- Airbag Height: 16%
- Inflation Pressure: 25%

Optimized Responses

- Maximum Material Stress: 44%
- Rock Impact: 93%
- Payload Acceleration: 93%

Successful Landing Rate: 17%
Optimization and Reliability Analysis of a Mars Lander
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Summary

- Deep Knowledge of CAE Design Processes
  - CAE Process Automation / Integration
  - How to Best Exploit CAE Software and Methods
  - Provide Mentoring and Best Practices – Comfortable with Technology Transfer

- HyperWorks, Integrated Suite of CAE Tools to Drive Product Innovation
  - HyperMesh: Highly Advanced Preprocessor Increasing your Efficiency
  - BatchMesher: Fully Automated Geometry Cleanup and Shell Meshing
  - HyperMorph: Allowing Rapid Design Changes Resulting in Dramatic Cost Savings
  - HyperStudy: DOE, Multi-disciplinary Optimization and Stochastic Simulation Engine

- Altair is a Reliable Business Partner – Exhibiting Strong Growth
  - Flexible HyperWorks Licensing Concept Reducing Software Costs
  - Passing on Business Benefits to Customer, e.g. HyperWorks Enabled Partner Program
Thank You For Your Attention!

Another Morphing Example

- Q&A