Shape Optimization Using *FRIENDSHIP-Framework* and *STAR-CCM+* CAE Test Case with KRISO KCS and MTU 90° Diffuser
Outline

• Introduction
• PART 1 KCS Case
  • Geometry
  • Integration
  • Optimization
• PART 2 90° Diffuser
  • Parametric Model
  • Target
  • Optimized Result
• Conclusion
INTRODUCTION
FRIENDSHIP SYSTEMS

- Founded 2001 in Potsdam/Berlin
- A GL Company, Marine Solution Part since 2009
- Developes and Provides CAE Platform (**FRIENDSHIP-Framework**)
- Supports Technical Issues and Projects
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- Ph.D Student NAOE Technical University Berlin
- Project Manager FRIENDSHIP SYSTEMS
**FRIENDSHIP-Framework**

- CAD
- Integration Interface
- Optimization Engine

FRIENDSHIP-Framework is the CAE platform.
**FRIENDSHIP-Framework CAE Experience**

- CAD
- Coupling Interface
- Optimization Engine

**FRIENDSHIP-Framework the CAE platform**

- FINE/MARINE
- ICEM + CFX
- HydroMax
- Nu_SHALLO
- RAPID
- SHIPFLOW
- In-House Code

- Neptune
- WAVIS
- FreSCO
- POSEIDON
- NAPA
- STAR CCM+

- AUTOMATED MESH GENERATION
- MACRO / JOURNAL
- COMMAND FILE
Selected customers

• DSME
• HHI
• SUNGDONG
• STX
• MOERI
• Pusan National University
• Mokpo National University
• KAIST

Growing Interest from 2010 by Korean Industries and Academic Field
Cooperation between CD-Adapco & FRIENDSHIP SYSTEMS

FRIENDSHIP SYSTEMS POTSDAM

CD-Adapco Nurnberg

STL FILES

IGES

JAVA MACRO

INTEGRATION

OPTIMIZATION

WIN-WIN Cooperation

CD-Adapco team has never used FRIENDSHIP-Framework
FRIENDSHIP SYSTEMS has never used STAR CCM+
Telephone, Email and Done!!!
PART 1 KCS Case
GEOMETRY
Import KCS model in IGES patches

Main Principals

- Lpp 230 M
- B 32.2 M
- D 10.8 M
- Fn 0.26 (24 Knot)

Reference

Desingularization

- Singularity in Stern Valley
- Divide patches
Desingularization

- Extract 4 edge curves
- Create coons patch
- Singularity disappeared
Desingularization

- Singularity in Bulb
- Subdivision
Desingularization

- Singularity in Bulb
- Regularity after Subdivision
Desingularization

- Duplicated IGES Patch
- Cut the corner
Fill Deck Surface

- Produce deck surfaces from the given patches
Water-Tight Trimesh

- Joint the patches with gaps

Tolerance 0.01
Adaptive Tessellation Error 0.01

Tolerance 0.07
Adaptive Tessellation Error 0.01
Water-Tight Trimesh

1_Trimesh

2_Trimesh

2_Trimesh

2_Trimesh

2_Trimesh

Trimesh Hull
Water-tight Trimesh

- Trimesh Deck
- Trimesh Hull
- Trimesh Transom
Hydrostatics for Sctional Area Curve

• Extraction offset groups from IGES surfaces
Hydrostatics for Sactional Area Curve

- SAC as input in Lackenby variation
Lackenby Variation & Design Variables

Dv_dLcb

Dv_fbdyTanBeg

Dv_fbdyTanEnd

Image Trimesh
Export STL

- Export the varied image trimesh as STL format.
- `.exportSTL()` or `.exportColourSTL()`
Integration
Integration

Definition
(Define Input & Output)

Configuration
(Set Input Values)

Computation
(Compute and Read Output)
Integration

- Definition

Integration Editor

- Template files
- Entries
- Input Files
- Result Files

Java Macro

Hull Stl

Deck.Stl

Transom Stl

Result Table (CSV)

Screenshot 1

Screenshot 2

… …
Integration

- Definition

Example: JAVA Macro Integration

- Just import java macro file
Integration

- **Configuration**
  - FRIENDSHIP-Framework
    - Deck.Stl
    - Hull.Stl
    - Transom.Stl
    - Result Table (CSV)
  - STAR CCM+
    - Wave Elevation
    - Wave Center Profile
    - Drag Convergency
    - Streamline

**General**

**Definition**

- Deck
  - `deck.exportColourSTL("kcsdeck.stl")`
- Hull
  - `hull.exportColourSTL("kcs Hull.stl")`
- Transom
  - `transom.exportColourSTL("kcs transom.stl")`

**Result Table**

- Type: automatic

**Screenshot**

- Type: automatic
Integration

- Computation

  - Set argument

  - Set the executable path

  - Argument for POD license
    
    
    ```
    "-power -podkey 98XXX/x3xXX3Xd/91X9XX== -licpath 1999@flex.cd-adapco.com -batch automationScale.java setup.sim"
    ```
Integration

• Computation

Test Computation

• Very small Max. Physical Time (6e-2)
• Check if STAR-CCM+ is integrated.
OPTIMIZATION
Computation Environment in CD-Adapco

- Maximum Physical Time 20.0
- 6 Threads
- Linux

- Duration per Computation About 2 hours
Geometry Scaled

Scaling is implemented in JAVA macro.

Model Scaled in 1/31.6

- Lpp 7.27
- B 1.02
- D 0.34
- Fn 0.26
- Rn 1.4x10^7
Global Search with Sobol

Design variables
- \( Dv_{dLCB} \): [-0.01, 0, 0.01]
- \( Dv_{fbdyTanBeg} \): [-30, 0, 30]
- \( Dv_{fbdyTanEnd} \): [-30, 0, 30]

Objective
- Drag force

Variants number
- 20
Select the best variant

Dv_dLCB = 0.00125
Dv_fbdyTanBeg = -3.75
Dv_fbdyTanEnd = -18.75

Drag original 44.2
Drag selected 43.55 (-1.5%)

Sections at regular stations
PART 2  MTU 90° Diffuser
90° Diffuser
Integration via Case Study

- In collaboration with MTU Friedrichshafen GmbH

- Diffuser: engine component which turns flow of around 1kg/s, direction change of 90°

- Hot exhaust gas at approximately 500°C

- Design study for curved part

- Compare with CFD results of a diffuser which is in service
Parametric Model

- Elbow Shape by Volume Parameter
Target

• Pressure Drop at Bend Exit
• Uniformity Index at Bend Exit
## Optimized Result

<table>
<thead>
<tr>
<th>Objective</th>
<th>Original Model</th>
<th>MTU Trial and Error</th>
<th>Automated Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Drop [mbar] (The Lower The Better)</td>
<td>47</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Uniformity Index (The Higher The Better)</td>
<td>0.51</td>
<td>0.86</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Optimized Result
Conclusion & Outlook

• **Auto-Mesh and JAVA Macro** of STAR-CCM+ is main feature of this CAE process.
• Integration is done in 5 minutes.
• Global search leads designers to the further intuition.
• Enlarge CAE cases between STAR-CCM+ and FRIENDSHIP-Framework
Thank you very much for your attention

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