Advancing ship design technology – getting better designs faster

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Agenda

• Climate change and Main drivers for more efficient designs

• Known engineering solutions - Potential gains when optimized

• MDX - Some industry case studies

• Automated design exploration process and tools – example of testing new idea

• Ship scale CFD – New initiative

• The final message
Discover Better Designs, *Faster*

What size and shape of hull?

How easy is it for you to answer these questions with your simulations today?

Would it help if this process was simpler and faster?

- **STAR-CCM+:** Advanced Toolset for automated MDX
  - Improved product performance
  - Better understanding of design and sensitivities
  - Lower risk of product issues
  - Most effective leverage of investment in modelling and simulation

**MDXploration**
Multidisciplinary Design eXploration
Main drivers

• Shipping is essentially a commodity business
  – Companies generally don't care too much who is shipping goods as long as they arrive in one piece
  – From owner’s perspective: look for min CAPEX, maximize profits through charter rates
  – Subject to boom and bust cycles (long lead time to build a ship so demand and supply are not in sync)

• Political – international and national pressure post COP21

• Social responsibility (environmental friendliness, sustainability)

• Economic – failing to align practices with expectations will result in risk to business

• IMO regulations for emissions and environment:
  – EEDI - covering most ship types (Effective January 2015) the level tightened incrementally every 5 years
  – NOx Tier III (Effective from 1st January 2016 for ECAs)
  – SOx – 0.10% ECA limit (1st January 2015)
  – IMO guidelines for reducing underwater noise from commercial ships
The range of expected increase in GHG emissions in the shipping sector up until 2050 if no further action is taken.

To achieve the 2 or 1.5 degree scenario, international shipping emissions must peak in 2020 and then start to decline sharply.
GHG emissions from Shipping – current status

The range of expected increase in GHG emissions in the shipping sector up until 2050 if no further action is taken.

Gap 1: Already known technical, operational and structural means, enabling
- 50% reduction for vessels delivered in 2030
- 70% reduction for vessels delivered in 2050

Gap 2: Break-through technologies to be made commercial beyond 2020

Source: Momentum – A Platform for Innovation – DNV Study 2009
Achieving required efficiency

• The first step is optimised design for efficient performance
  – Keep FOC at minimum

• Secondary measures for increasing efficiency and emissions controls:
  – Scrubbers, SCR, EGR
  – Low sulphur/better quality fuels
  – Hull coatings
  – Energy recovery
  – Operational measures (keep FOC at minimum)
    • Weather routing
    • Trim optimisation
    • Slow steaming
    • Regular maintenance
### Efficiency Improvement Measures


#### Methods best suited for new buildings

- Efficiency of scale
- Optimum main dimensions
- Lightweight construction
- Reduce ballast
- Interceptor trim planes
- Ducktail waterline extension
- Shaft line arrangement
- Skeg shape/trailing edge
- Minimising resistance of hull openings
- Air lubrication
- Tailoring the concept for the operation

#### Measures that can be retrofitted to an existing vessel
Potential efficiency gains

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<th>Rudder Bulb</th>
<th>Kappel</th>
<th>PBCF</th>
<th>AHT Nozzle</th>
<th>Mewis duct</th>
<th>Pre swirl fins</th>
<th>Efficiency rudders</th>
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Source: MAN Diesel & Turbo – EEDI Energy Efficiency Design Index
Where to optimize?

- Traditional contract: for just one condition (1 speed/draught)

- But a typical vessel has multiple loading conditions and sails at multiple operating speeds

- So why not take into account the whole operating envelope?
Solution – Design for entire operational envelope

- Move away from single design point....

- Performance optimisation - apply ‘design weighting’ for each speed/draught combination
MDX with EHP and HEEDS for basic hull design

FRIENDSHIP Framework

STAR-CCM+

Change design variables

Responses

MDXploration
Multidisciplinary Design eXploration
EHP – for reliable process automation
**Challenge:**
- 2S Main Engine instead of 4S and Higher service speed
- Compliance with latest MARPOL and Tier III for emissions
- Higher ice class
- Compliance with new Ballast water treatment system regulation

**Solution:**
- Use STAR-CCM+ for hydrodynamic optimisation taking structural and regulatory requirements as constraints in order to improve and secure key performance indicators

**Impact:**
- Significant wave-resistance reduction through modifications to the bulbous bow
- Improvement of nominal wake fraction value and distribution through hull lines optimisation
• **Challenge:**
  • VS 485 PSV: A successful design, 20 units in operation
  • VS 485 PSV: ‘Vestland Cygnus’ built but could not be delivered – order was cancelled
  • What to do with built vessel and no buyer?

• **Solution:**
  • Convert PSV into windfarm support vessel
  • Utilise large number of sea trials data to validate STAR-CCM+ CFD model for PSV at ship scale
  • Carry out hull shape optimization to mitigate effect of sponsons

• **Impact:**
  • Noticeable reduction in power at higher speeds and minimal negative impact at lower speeds
  • Satisfied customer – positive feedback received
  • Removal of potentially large financial loss
**Challenge:**
- Recover rotational energy with a propeller cap fins system
- Optimize for efficiency and reduce energy losses

**Solution:**
- Use STAR-CCM+ 3D CAD to design and parametrise initial fin geometry
- Combine Optimate+ with STAR-CCM+ to analyse performance of over 2000 designs

**Impact:**
- 1.17% efficiency gain
- Torque 0.5% lower; Thrust 0.72% higher
- Maximum turbulent kinetic energy in the domain is 5.2% lower
- Rotational hub vortex energy recovery
• Challenge:
  • Optimize Becker Mewis Duct® geometry (fin orientation and duct cross-section) for each individual hull form to maximize efficiency
  • Guarantee fuel savings of at least 4.5% or money back

• Solution:
  • Use STAR-CCM+ to carry out careful tuning of over 40 design parameters
  • Apply automated process for intensive design exploration to meet performance targets

• Impact:
  • Fuel savings of $’00s thousands per year - return on investment typically within a year of installation
  • Over 1,000 of the devices installed since the product was launched in 2008
Evaluating new ideas – aerodynamic drag reduction

Objective:
- Reduce fuel consumption
- Improve deckhouse design - introduced fairings and alter other appendages

Example study
- 95,000 DWT bulk carrier
- Head Wind speed: 0-25 [kts]

Courtesy of Lloyd’s Register
Evaluating new ideas – aerodynamic drag reduction

- Predicted reduction in wind drag up to 34%
- New design agreed with 20% reduction
- Reduction in estimated fuel use of up to 2.5% at 14kn ship speed and 22kn head wind

Courtesy of Lloyd's Register
Evaluating new ideas – aerodynamic drag reduction

Courtesy of Lloyd’s Register
Test novel ideas – what if we harness air slipstream?

Introduce and optimize ‘wind turbine’ within high-speed air flow
Methodology

~400 m
Introduce and optimize ‘wind turbine’ within high-speed air flow
The **Overset** Methodology allows superimposing arbitrary number of meshes over each another. The grids are allowed to overlap and flow field information is transmitted from one grid to another.
Test novel ideas

Introduce and optimize ‘wind turbine’ within high-speed air flow
It Works! – Reduces total drag and generates usable power
Marine Scrubber design exploration study

Best Design:
- Pressure drop: **137 Pa**
- \( \text{SO}_2 \) out: 0.0113 kg/s
- Footprint: **13.56 m}^2**

Base-line Design:
- Pressure drop: **7113 Pa**
- \( \text{SO}_2 \) out: 0.0152 kg/s
- Footprint: **15.75 m}^2**

This scenario represents changing a known good design to meet new Environmental and operating standards while still achieving a minimal footprint.
Ship scale CFD – New initiative

Call for Participation: Workshop on Ship scale Hydrodynamics

Workshop objectives:
- Raise the level of confidence for ship scale Computational Fluid Dynamics (CFD) modelling in the Marine industry
- Develop an extensive database of CFD results contributing to best practice for ship scale Marine CFD
- Provide a forum for researchers and commercial practitioners of Marine CFD to network and develop ideas for future collaborative work

Dates
- 25 October 2016 – deadline for results submission
- 25 November 2016 – workshop

Venue
Lloyd’s Register Global Technology Centre, Southampton

Further details
Email to Dmitriy Ponkratov (Dmitriy.Ponkratov@lr.org)
Event to be published on LR website in May

Lloyd’s Register & University of Southampton
Discover Better Designs, *Faster* - the final message

- **Design process within Marine industry is changing**
- **Climate change introduces new, extremely powerful drivers**
  - New ships will require step change in efficiency and reduction in emissions – we need new ideas
  - MDX is the only way forward to meet these requirements
  - MDX is also a perfect fit to ‘Full scale, real operating conditions’
- **STAR-CCM+: Advanced Toolset for automated MDX**
  - Improved product performance
  - Better understanding of design and sensitivities
  - Lower risk of product issues
  - Most effective leverage of investment in modelling and simulation

What size and shape of hull?

...because a **greener** future is a better future