Energy Efficiency and Vessel Performance

Christian Schack
Assistant Director, Energy Efficiency, Global Marine

Hamburg
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Outline

- Introduction
- Energy Efficiency Status
- Vessel Efficiency Improvement Strategies
- ABS Support to Vessel Efficiency Improvement
- Vessel Performance
- Conclusions
ABS – Global Marine

Global Marine
EVP Kirsi Tikka

Global Gas
Global Gas Team
- London
- Shanghai
- Houston

Tankers and Bulk Carriers

Container Ships

Operational & Environmental Performance
Operational & Environmental Performance Team
- Houston
- Copenhagen
- Hamburg
- Singapore
- Shanghai
Operational & Environmental Performance

Energy Efficiency
- EEDI Verification
- Specification Review
- Design Benchmarking
- Operational Profile Definition
- Hydrodynamic Design Evaluation
- Hull Form Optimization
- ESD Evaluation & Optimization
- Retrofit Analysis
- Concept Design Evaluation
- Techno-Economic Modeling

Vessel Performance
- Hull & Propeller Added Resistance
- Main Engine Performance
- Auxiliary Performance
- FOC Assessment
- Fleet Benchmarking

Environmental Performance
- Ballast Water Management
- BWMS Selection Assistance
- Vessel General Permit
- Inventory of Hazardous Materials
- Engine Emissions Control
- EGCS Selection Services
- EU Commission - MRV Scheme
Fuel Consumption – Shipping (2012)

Source: IMO 3rd GHG Study-Reduction of GHG Emissions from Ships (2014)
Have Ships Become More Fuel Efficient?

Propulsive Performance Index for AFRAMAX tankers as a function of year of build @ 14 Knots

ABS Propulsion Performance Index: $PPI = \frac{\text{shaft power}}{(\text{DWT} \times \text{speed})}$ – @ same speed

Data from www.SeaWeb.com (ex. IHS Fairplay database)
Possible Strategies to Improve Energy Efficiency

1. Vessel Dimension Selection
   - Choose vessel main dimensions and form parameters for given design constraints to minimize powering requirements without losing containers/cargo space/deadweight

2. Hull Form Optimization
   - Optimize entire hull shape to minimize resistance for the hull over the entire operational profile (incl. bulbous bow, bow section and stern section)

3. Aftship Form Optimization
   - Optimize aftship especially the skeg region to improve propulsion efficiency and minimize the propulsive power
Possible Strategies to Improve Energy Efficiency

4. Propeller / Engine Selection
- Select efficient propeller to minimize power
- Increase diameter, lower RPM
- Energy saving propeller design
- Check matching with possible main engines

5. Possible de-rating of main engine
- Propulsion Losses Minimization
- Rudder bulb
- Twisted rudder
- Thrust fin on rudder
- Propeller boss cap fin

6. Energy Saving Device
- Schneekluth duct with Grothues spoiler
- Pre swirl stator
- Mewis duct
- Vortex generator
Possible Strategies to Improve Energy Efficiency

7. Review and optimization of appendages
   - Design & Alignment of bilge keels
   - Design & Alignment of Thruster grids
   - Position and neutral angle of rudder(s)

8. Waste Heat Recovery System
   - Install waste heat recovery system to utilise waste heat for electrical production

9. Machinery systems
   - Optimize overall configuration (ME, AE, Boiler etc.)
   - Minimize electrical load (VFD’s, LED’s, HVAC optimization etc.)
   - Optimize energy generation (genset layout)
   - Introduce battery solution to harvest excess energy and shave off peak loads (complete auxiliary systems, sub systems (cranes, thruster etc.), etc.)
Implementation of Design

Source: ‘Assessing the implementation of technical energy efficiency measures in shipping’

See also: MEPC 69/INF.8
Possible Savings

Hull Form Changes
For retrofit bulbous bow changes are the most likely as it is do changes to aft ship and main dimensions as retrofits 6-10 % typical savings depending on original design speed, hull constraints and new operational profile

Propeller Change
Evaluate larger diameter propeller / high efficiency propeller and associated main engine matching (possibly de-rated) 2-8 % typical savings depending on base propeller design/engine rpm/changes in operational profile

Adding Rudder Bulb / Twisted Rudder
Evaluate addition of rudder bulb and/or twisted rudder 1-3 % typical savings depending on base propeller design/engine rpm/changes in operational profile
Bulbous Bow Optimization - Retrofit

Before conversion

After conversion

8.4 % Fuel savings over the operational profile
Propulsion: Possible Savings

Generate Pre-swirl in front of propeller
Install a Mewis Duct, Becker Twisted Fin, Schneekluth duct with Grothues spoilers, Pre-swirl stator fins, vortex generators, etc.

Possible savings
4-6 %
3-5%
3-4%

Recover energy aft of the propeller
Optimize rudder position; install propeller boss cap fin, rudder bulb, twister rudder, thrust fin on rudder, etc.

Possible savings
1-2 %
1-2%
1-3%
Techno-Economical Assessment

- **Business case model** with a multi-level approach to enable *stage gate* decision process
- **Tailored to the client** asset, technology, operational profile, investment strategy
- **Minimize CAPEX / OPEX** and retrofit scenario for technology ready designs

### Stage 1
- Asset specific performance data is not available
- **Best and Worst case performance scenario**
- Life Cycle Cost Analysis / Snapshot OPEX
- Decision support for funding further analysis e.g. CFD

### Stage 2
- Asset specific performance data is available
- **Operational profile definition**
- Life Cycle Cost Analysis re-evaluation
- Decision support for “Go / No Go”

### Stage 3
- Sea Trials Performance Assessment
- Life Cycle Cost Analysis re-evaluation
- **Performance Monitoring Program** – Performance Triggers
- Performance Verification Statement – Charter Rate Premium
### Outline Specification Review

**Comments on vessel’s specs on energy efficiency and environmental aspects ONLY**

Prepared by: ABS GCD Operational & Environmental Performance Department

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**Overview**

The review of here below documents has been carried out in order to provide our comments on energy efficiency, performance monitoring and environmental aspects on the vessel’s specification. Our review has extended beyond rules requirements taking under consideration IMO and flag states forthcoming regulations plus those originating from other regulatory bodies like international standards and standard shipbuilding practices aiming to:

- Highlight areas for possible improvement.
- Highlight future or retrospectively appliedIMO requirements.
- Recommend additional certificates or statements that should indicate an advanced feature of the vessel.

**Documents reviewed**

1. OUTLINE SPECIFICATIONS FOR 88,800m3 Very Large Ethane Carrier - DOCUMENT NO.: 88000VLEC-14508-OS-R1 (DATE: 6th July 2015)
2. 88,800 m3 Very Large Ethane Carrier - DOCUMENT No.: 88000VLEC-14508-PP-R1 (DATE: 6th July 2015)

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**Comments on energy efficiency, performance monitoring and environmental aspects on the vessel’s specification:**

<table>
<thead>
<tr>
<th>No.</th>
<th>Spec Section</th>
<th>Subject</th>
<th>ABS Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.2</td>
<td>Energy Efficiency</td>
<td>Model tests results (in as many as possible drafts and speeds) to be submitted including propeller open water and cavitation tests.</td>
</tr>
<tr>
<td>2.</td>
<td>1.2</td>
<td>Energy Efficiency</td>
<td>Besides the speed – main engine power curves from the sea trials the power vs rpm curves to be also submitted. The revised ISO 15516:2015 procedures should be followed for sea trials corrections.</td>
</tr>
<tr>
<td>3.</td>
<td>1.2</td>
<td>Energy Efficiency</td>
<td>The daily fuel consumption and the cruising range are to be submitted. The cruising range should be calculated based on the average observed value for lower calorific value in the range of 40000 KJ/kg.</td>
</tr>
<tr>
<td>4.</td>
<td>1.2</td>
<td>Energy Efficiency</td>
<td>The draft that will be used for the cruising range calculations is to be defined.</td>
</tr>
<tr>
<td>5.</td>
<td>1.2</td>
<td>Energy Efficiency</td>
<td>Fuel tables for ballast, design, and normal draft to be also requested by the company for full range of speeds (including slow steaming).</td>
</tr>
<tr>
<td>6.</td>
<td>1.2</td>
<td>Energy Efficiency</td>
<td>Trim Optimisation study / calculation to be carried out, by model test or CFD, in order to identify the optimum trim at maximum continuous speed.</td>
</tr>
</tbody>
</table>

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- 4-8 pages on energy efficiency & environmental aspects
- Specification Review Database
- Value to client
The Importance of the Operational Profile

- Comparison of the design point condition with a sample profile representative of the actual operation
Operational Profile Analysis

- Operational Profile Analysis based upon:
  - Noon data
  - Auto logged data
  - Prepared based upon planned operation for new operation
  - AIS data based upon a single vessel or a fleet of vessels
Operational Profile Analysis

- Key information for CFD Hull form optimization and Engine Selection
ABS Design Benchmarking Study

Feeder Container Carrier Design Comparative Study

Wan Hai 1,870 TEU Container Carrier proposal by Naikai Zosen

- LOA: 172.10 m
- Design Draft: 9.50 m
- MAN Engine: 1 x MAN-B&W 7S60ME-C8.5
- LBP: 163.00 m
- Scantling Draft: 9.80 m
- NOR: 16,660 kW x 105 RPM
- Build: 28.40 m
- Deadweight: 178 vessels
- DWT: 28.40 m
- Scantling Draft: 9.80 m
- MCR: 16,660 kW x 105 RPM
- Dmld: 14.10 m
- Deadweight: 26,100 mt
- Service Speed: 19.0 knots @ design draft, NOR with 15% SM

To evaluate the subject design against similar contemporary designs, a comparative study has been conducted.

- A representative sample of 653 vessels (including sister vessels) with a TEU range from 1600 to 2,200 has been extracted from the Sea-web (ex-IHS Fairplay) database. The population sample includes both existing vessels and vessels on the order book. The reduced Bangkok MAX database includes 178 vessels (including sister vessels).

Existing Fleet / Orderbook TEU Statistical Distribution

- The distribution highlights three major TEU ranges:
  - Approx. 18% within the 1600-1699 TEU range
  - Approx. 39% within the 1700-1749 TEU range
  - Approx. 18% within the 1800-1900 TEU range

Data Source: Sea-web IHS Fairplay

Speed vs. build year – all vessels 1600 TEU to 2200 TEU

- For the entire population the speed has been reduced over the years, going from around 21-22 knots to less than 19 knots.

DWT versus TEU – Bangkok MAX (< 172.1 m)

- In the Bangkok MAX range the subject vessel has a significantly higher deadweight at design draft than the comparable designs – this might be related to the higher design draft. In the range from 1800-1900 TEU the deadweight is in the range from 21,000-24,000 ton where the proposal has more than 25,500 ton at design draft.

This study answers...

- How is this design compared with historical and contemporary designs?
- Are there any significant deviations in main particulars?

Can be followed by ABS Propulsive Power Index evaluation study
Objective

To compare the efficiency of the given design with a sample of designs of similar characteristics (Dwt, TEU, etc.).

\[
ABS \text{ Propulsion Performance Index} \ (PPI) = \frac{\text{Power}}{\text{Dwt} \times \text{Speed}} = \frac{\text{Energy}}{\text{Transportation Work}}
\]

- At 19 knots, subject vessel Propulsion Performance Index is 8% better than the average ship of the population of comparable container ships.
- Subject vessel is among the 5% most efficient vessels of its category.
# ABS Computational Fluid Dynamics Services

<table>
<thead>
<tr>
<th>Objective</th>
<th>To improve the hull and propulsive efficiency for a given operational profile and thus reduce the vessels fuel consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Initial Hydrodynamic Review</strong></td>
<td>Evaluate quality of the hull form to establish basis for possible improvements</td>
</tr>
<tr>
<td><strong>2. Independent Hull Form Optimization</strong></td>
<td>Parametric hull form modifications to achieve the lowest resistance and fuel oil consumption for a given operational profile</td>
</tr>
<tr>
<td><strong>3. Propeller &amp; Propulsion Review</strong></td>
<td>Evaluate best match for main engine rpm and propeller diameter, and the propeller efficiency behind the hull</td>
</tr>
<tr>
<td><strong>4. Other CFD Services</strong></td>
<td>Energy Saving Device (ESD) Evaluation, Appendages optimization, Optimum trim guidance</td>
</tr>
</tbody>
</table>
ABS - NS Vessel Performance

- Provides visibility into critical performance areas, including environmental compliance, vessel performance and voyage tracking.
- Service delivery through ABS Nautical Systems
- Voyage Performance Manager
- Easily access critical information for voyage planning, performance monitoring and environmental impact to maintain an efficient and compliant operation
- Integrates with vessel’s automation system to facilitate accurate reporting and reduce crew workload
- Optimize future voyages through detailed performance analysis

Key Features:
- Performance KPIs
- Event Based Reporting
The Next Generation Vessel Performance Platform

**Technical Solution**
- Integrated software platform
- Ship to shore replication
- Hull, propeller and main engine data capture

**Onboard**
- Noon and auto-log data collection
- Data validation at source
- Reports and dashboards:
  - Engine reports
  - Performance reports
  - SEEMP

**ABS**
- Performance benchmarking
  - Design profiles
  - Shop tests
  - Sea trial
  - Operational data
- Root cause and predictive analysis
- Pro-active vessel monitoring for event planning

**Onshore**
- Fleet-wide view:
  - Hull & propeller performance
  - Fuel consumption
  - Environmental
  - Charter party compliance
Data & Analysis Results Available in a Web Application
Environmental Reporting

- One-time data collection using manual and auto-logging
- Multiple reporting including Efficiencies, Emissions and Regulatory
  - SEEMP
  - ECA Areas & Fuel Switching
  - MRV Reporting
  - IMO Environmental KPIs
  - Ballast Water Exchange
Conclusions

- ABS can provide support in following areas:
  - **Energy Efficiency**
    - Provide input in the early design stage to ensure an energy efficient vessel
    - Expert advice in design optimization supported by CFD, model tests and related issues
    - Expert advice in design review and optimization for retrofit projects supported by CFD
  - **Vessel Performance**
    - Assistance in data collection and interpretation
    - Nautical Systems (NS) platform including the new Voyage Module
    - Supporting Environmental Compliance