Current Development of Shipbuilding Technology - Japan

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Contents :

- Environmentally Friendly Ship “e Future Series” (IHIMU)
- LNG-Fuelled Large Container Vessel (IHIMU)
- Concept Design of LNG Bunkering Ship (Kawasaki HI)
- Development of the Algorithm for Accuracy Evaluation System for Curved Shell Plates by Laser Scanner (Sumitomo HI-ME)
- New Generation LNG Carrier “Double Eco MAX” (Mitsui E.S.)
- World’s Largest Roll-on/Roll-off ship “TONSBERG” *Ship of the Year Award 2011* (Mitsubishi HI)
- Next Generation Spherical Tank type LNG C “SAYAENDO” (Mitsubishi HI)
- 6400RT Car Carrier with Hybrid Power Supply system (Mitsubishi HI)
- Hybrid Turbocharger (Universal Shipbuilding)
- Energy Saving Device (Universal Shipbuilding)
IHIMU Environmentally Friendly Ship
eFuture Series

30% reduction of GHG is attained by integrating the technology of IHIMU

eFuture 13000C (Container Vessel)

eFuture 310T (VLCC)

eFuture 56B (Bulk Carrier)
**eFuture 13000C**

- Twin-skeg Hull Form
- Tip Raked Propeller and Rudder Bulb
- Front Bonnet
- Waste Heat Recovery System
- Photovoltaic Panel and Lithium Ion Batteries

**Waste Heat Recovery System**

Tip Raked Propeller and Rudder Bulb
eFuture 310T, eFuture56B

- Advanced Contra Rotating Propeller
- Tip Raked Propeller, Rudder Bulb and Semicircular Duct
- Waste Heat Recovery System
- Whaleback Bow
- AR Vane
LNG-Fuelled Large Container Vessel (1)

Approval in Principle

IHIMU has obtained GL AIP for LNG Fuelled 13,000 TEU eFuture Container Ship

Concept

- Service route: Far East - North Europe
- Fuel: LNG for ECA abt.2,000 miles, Fuel Oil for Global abt.18,000 miles
- LNG tank room and compressor room are arranged to minimize container losses
LNG-Fuelled Large Container Vessel (2)

Main dimensions
Loa: 330.0 m, Bm: 48.2 m, Dm: 27.0 m

Minimized Container Loss

Fuel Gas Supply System
- Submerged type LNG transfer pump is provided inside of tank
- Fuel gas supply system is arranged on the tank top
- High / Low pressure LNG supply system can be available
- Boil off rate can be adjustable

Propulsion Plant
Fuel Gas Supply System
IHI-SPB Tank
LNG Transfer Pump
Concept Design of LNG Bunkering Ship (1)

Basic idea of LNG bunkering ship

Kawasaki’s small scale LNG carrier + Special equipment onboard (in comparison with small scale LNG carrier)

Design issues

1. LNG tank
2. Propulsion system
3. LNG bunkering interface with LNG receiving ships
4. Special equipment onboard
Concept Design of LNG Bunkering Ship (2)

Design issues and solutions

1. **LNG tank**
   
   Tank type : Type B or Type C ?
   
   Material : Aluminum or Stainless steel or 9% nickel steel ?
   
   Requirement : • Flexibility in partial cargo loading
   • Low cost and weight, etc.

2. **Propulsion system**
   
   Engine type : DFD mechanical or DFDE or Gas engine etc...
   
   Requirement: • High efficiency
   • Redundancy, etc.

3. **LNG bunkering interface with LNG receiving ships**
   
   By Loading arm or By Flexible hose ?

4. **Special equipment onboard**
   
   Transferring boil-off gas to main engine(s)
   
   Bunkering LNG fuel to receiving ship
Concept Design of LNG Bunkering Ship (3)

6,000m$^3$ type LNG fuel bunkering ship

Loa : about 120.0 m
Lpp : 114.0 m
Bm : 18.8 m
Dm : 9.5 m
Design draft : 5.6 m
LNG tank : 3,000 m$^3$ x 2
DEVELOPMENT OF THE ALGORITHM FOR ACCURACY EVALUATION SYSTEM FOR CURVED SHELL PLATES BY LASER SCANNER (1)

N. Nakagaki, A. Sugawara, Sumitomo Heavy Industries Marine & Engineering Co., Ltd., Japan
K. Hiekata, H. Yamato, M. Enomoto and K. Takahashi, The University of Tokyo, Japan

- Curved shell plates are deformed plastically by application of heat, and water-cooled based on wooden bending templates.
- The accuracy of the measurement depends on experience of craftsman.
DEVELOPMENT OF THE ALGORITHM FOR ACCURACY EVALUATION SYSTEM FOR CURVED SHELL PLATES BY LASER SCANNER (2)

- The laser scanner is able to measure a multiple number of points at a time.
- It requires a little measurement cost in range of desired accuracy.

<table>
<thead>
<tr>
<th>FARO Photon 80</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td><strong>Scan rate</strong></td>
</tr>
<tr>
<td><strong>Laser Class</strong></td>
</tr>
<tr>
<td><strong>Range</strong></td>
</tr>
<tr>
<td><strong>Distance Error</strong></td>
</tr>
</tbody>
</table>

— Accuracy (±2mm @25m distance)
— able to get whole surface at one time
DEVELOPMENT OF THE ALGORITHM FOR ACCURACY EVALUATION SYSTEM FOR CURVED SHELL PLATES BY LASER SCANNER (3)

- Improve the accuracy evaluation system for curved shell plates using laser scanners
  - Employ new algorithm based on ICP (Iterative Closest Point) for comparison of measured data and design data
  - Calculation and visualization of the error
- Verify the proposed system in practical use through experiments at a shipyard.
DEVELOPMENT OF THE ALGORITHM FOR ACCURACY EVALUATION SYSTEM FOR CURVED SHELL PLATES BY LASER SCANNER (4)

- An accuracy evaluation system for curved panel plates using design data and point cloud data was developed.
- Validity of the proposed system in practical use is demonstrated.
  - ICP algorithm is used for registration, and it made the process of calculation simple and robust.

<table>
<thead>
<tr>
<th>Number of points</th>
<th>494,184</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max error (positive)</td>
<td>1.95mm</td>
</tr>
<tr>
<td>Max error (negative)</td>
<td>-3.66mm</td>
</tr>
<tr>
<td>Average of error</td>
<td>-0.015mm</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.31mm</td>
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</table>

99.7% (-3σ to 3σ range) of all the points is within the -0.932mm to +0.929mm range.
Mitsui New Generation LNG Carrier

Double Eco MAX

Economical & Ecological LNG Carrier evolves the LNGC market!!
Technical Feature of Double Eco Max

- Excellent hull form and highly efficient propeller is applied
- Cargo Capacity -> max. 180,000 cm³
  - with MOSS spherical or stretched 4 tanks
- Propulsion system -> MEGI – Slow Speed Dual Fuel Engine
  - Highly efficient engine with proven technology
- Boil off gas -> 0.1 % /day boil off
  - TiG Panel System – environmental friendly material is applied.
- Boil off gas Treatment -> Reliquefaction system
  - 100% gas recovery even at lower main engine low load operation
  - with High Pressure Fuel Supply System to MEGI
Comparison of fuel consumption between propulsion systems

<table>
<thead>
<tr>
<th>Cargo Cap. (Cub.m, 100%)</th>
<th>147K (STR)</th>
<th>155K</th>
<th>180K</th>
</tr>
</thead>
<tbody>
<tr>
<td>L&lt;sub&gt;OA&lt;/sub&gt; x B x D(m)</td>
<td>289.5 x 49.0 x 26.5</td>
<td>300.0 x 52.5 x 28.0</td>
<td></td>
</tr>
<tr>
<td>d(m)</td>
<td>11.3</td>
<td>11.8</td>
<td>11.5</td>
</tr>
<tr>
<td>BOR (%/day)</td>
<td>0.15</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Prop. Plant</td>
<td>CST CST AST CST CST AST ME-GI GI+RL D+RL DFDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft No.</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Fuel consumption index

Comparison of fuel consumption at same design ship speed
(Index 100=147K(CST), HFO base)

- Conventional steam turbine (CST)
- Advanced Re-heat steam turbine (AST)
- Dual fuel slow speed gas injection diesel engine (ME-GI)
- ME-GI with Re-liquefaction system (GI+RL)
- Oil burning slow speed diesel with Re-liquefaction system (D+RL)
- Dual fuel diesel electric propulsion (DFDE)

Abbreviations

6th ASEF, 22 - 23 November 2012, Guangzhou China
Schematic Diagram of the BOG Treatment / Propulsion System

- Fuel oil
- Fuel gas
- GCU
- Cargo tank
- Spray pump
- Low speed Diesel engine
- Additional fuel (FO or Forcing gas)
- Re-liquefaction
- Fuel consumption
- Ship speed
- Natural BOG
- Boil of gas

6th ASEF, 22 - 23 November 2012, Guangzhou China
Advantage of MEGI adoption by MES

1. Long run records of 12K80MCGI-S (prototype of MEGI) about 20000 hours operation during 1994/2003

2. Technical advantage of MEGI can be highly achieved
   1) Lower SFOC
   2) Direct propeller drive
   3) No knocking
   4) No methane slip
   5) Identical performance of oil & gas burning

3. Risk analysis is on going by MES including Fuel gas supply system

4. Full Scale Test of MEGI at MES to be planed in March 2013 at Tamano Works

5. Long experience and technical service are utilized as one of top supplier of MAN DIESEL TURBO engines
The Ship of the Year Award 2011
- the world’s largest roll-on/roll-off ship “TØNSBERG” -

Particulars of the ship
- Lpp x B x D x d : 250m x 32.26m x 33.22m x 11.0m
- Service Speed : abt. 20.25 kn
- Gross Tonnage : 74,622
Capable of carrying high and heavy cargoes

**Construction Machinery**
Max. weight 70 t

- H&H rolling cargoes on wheel and steel tracks

**MAFI trailers**
Max. weight 140 t

- MAFI trailers used to roll non-rolling cargoes onboard. Forklift lifts cargo off MAFI.

**Heavy lift trailers**
Max. weight 505 t

- Heavy lift trailers (type Samson, Scheuerle, Cometti etc)

**Railcars**
with/without boogies

- Railcars with or without boogies
Overall Layout & Special Features

Overall Layout

Jumbo Stern Ramp
505 tons of capacity
12m width

Hoistable deck
by electric motor winch
Next Generation Spherical Tank type LNGC - SAYAENDO -

Particulars of Continuous Tank Cover LNGC
- Cargo Tank Capacity : abt. 155,000 m3
- Service Speed : abt. 19.5 kn
- Main Engine : Reheat Steam Turbine (UST)
SAYAENDO Concept

- Nickname “SAYAENDO”
- Proven Moss spherical tank type
- Light structure weight
- Better propulsion performance
- Better maintainability
Overall Layout & Technical Evaluations

**Overall Layout**

- Cargo machinery room integrated into tank cover
- LNG cargo piping
- Electric cables
- Shore manifold (LNG cargo loading/unloading)
- Helicopter deck (optional)

**Structural Assessment**

- A conventional tank cover contributes little to structural strength
- The SAYAENDO continuous tank cover offers high structural strength
- Improved structural depth
- Larger deck surface that supports strength

**Wind Tunnel Tests**

- Improved wind resistance
6400RT Car Carrier with Hybrid Power Supply system

Hybrid Power Supply system

- **160kW** Solar Generation system
- **2.2MWh** (Potential Power)
  - Lithium-ion Batteries
- Diesel powered generators

Vessel under way

Electricity generated by Solar Generation system \(\rightarrow\) stored in Lithium-ion Batteries

Vessel while rest in port

Electricity stored in Lithium-ion Batteries \(\rightarrow\) supplied for all of vessel’s power needs

ZERO EMISSION while rest in port

The vessel was jointly developed by MOL, MHI and Panasonic, subsidized by the Ministry of Land, Infrastructure, Transport and Tourism as a project to help reduce CO2 emissions from ocean-going vessels, and received support from Nippon Kaiji Kyokai as a cooperative development project to reduce greenhouse gases produced by ocean shipping operations.
6400RT Car Carrier with Hybrid Power Supply system

Main Particular
Length: 199.99m
Breadth: 32.26m
Depth: 34.52m
Draught: 9.725m
Gross Tonnage: abt60,000

Hybrid System
Solar generation: 160kW
Lithium-ion batteries: 2.2MWh
HYBRID TURBOCHARGER – CROSS-SECTIONAL DIAGRAM
HYBRID TURBOCHARGER – SYSTEM OVERVIEW

Converter & Inverter

Hybrid Turbocharger

Main Switchboard

**FLUCTUATED AC POWER SUPPLY**
AC 0 ~ 400V / 0 ~ 400Hz

**REGULATED AC POWER SUPPLY**
AC 450V / 60Hz

PM Generator

Junction box with MCCB
Energy Saving Device

**SURF-BULB**  Swept-back Up-thrusting Rudder Fin with BULB

- **Bulb**
- **Hub vortex**
- **Fins generate thrust**
- **Bulb smoothes hub vortex**
- **Energy Saving Effect: 3 ~ 5%**

**SSD**  Super Stream Duct

- **Wing section of duct generates thrust**
- **Propeller inlet flow is stabilized by duct**
- **Displacement effect improves wake fraction factors**
- **Energy Saving Effect: 3 ~ 8%**
Bow Shape Improvement

**Conventional Full Hull Form Ship**

**Sharpen Bow Ship**

To sharpen the bow shape in order to reduce the diffraction wave.
Performance in Waves

Ax-Bow / LEADGE-Bow
Thank you very much