Recent efforts on the construction of Green Ships in Korea

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KEIT/Korea
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1. Global Environments
2. Green Ship Technologies in Korea
1. Global Environments
IMO Regulations

Regulations discussed in IMO

- Energy Efficiency, NOx, SOx, PM/BC, VOCs, Fuel Quality, Dangerous materials

**EEDI – 에너지 효율화**

EEDI = \( \frac{\text{CO2 factor} \times \text{SFC} \times \text{Engine Power}}{\text{Engine Capacity} \times \text{Engine Speed}} \)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
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<td>30% (2010)</td>
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**NOx**

<table>
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<th>Engine Speed (rpm)</th>
<th>Specific NOx (g/kWh)</th>
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<tr>
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**PM/BC**

**VOCs**

**Fuel Quality & SOx**

- Revised Procedures of MARPOL 73/78
  - Regulation 14 Sulphur Oxides (SOx) and Particulate Matter
  - Regulation 18 Fuel Oil Quality and Availability
IMO Regulations

Attained EEDI

\[ EEDI = \left( \frac{M}{\prod_{j=1}^{n} f_j} \right) \left( \sum_{i=1}^{nM} C_{F_{ME(i)}} SFC_{ME(i)} P_{ME(i)} \right) + P_{AE} C_{FAE} SFC_{AE} + \left( \frac{M}{\prod_{j=1}^{n} f_j} \right) \left( \sum_{i=1}^{nF_{AE}} P_{F_{AE(i)}} \right) - \frac{f_{eff(i)} P_{AEeff(i)}}{\sum_{i=1}^{nF_{AE}}} C_{F_{AE}} SFC_{AE} - \left( \frac{f_{eff(i)} P_{AEeff(i)}}{\sum_{i=1}^{nF_{AE}}} C_{F_{ME}} SFC_{ME} \right) \]

**CO₂ Emissions**

**CO₂ Reductions**

**Transport amount**

\[ f_t \cdot f_e \cdot \text{Capacity} \cdot V_{\text{ref}} \cdot f_w \]

- \( C_F \) (CO₂ Conversion Factor): Coefficient depends on fuel type
- \( SFC \) (Specific Fuel Consumption): Comes from NOx technical File (Parent Engine)
- \( P_{ME} \) (M/E Power): 75%MCR of M/E
- \( P_{AE} \) (A/E Power): Simplified equation or Electric Power Table
- Capacity: DWT (70%DWT for container, GT for passenger)
- \( V_{\text{ref}} \) (ship speed): Speed in calm sea at 75%MCR with full draft
### IMO Regulations

**NOx, SOx, regulations**

*1) North & Baltic Sea (From Jan. 1, 2021, MEPC 70th)*

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**Engine Speed [rpm]**

- Tier I: -15 ~ 20%
- Tier II: -80%
- Tier III: 4.5%

**NOx emission [g/kWh]**

- Tier I: 4.5%
- Tier II: 3.5%
- Tier III: 0.5%
IMO Regulations

- **ECA**

  - Baltic Sea, North Sea: SOx Emission Only (1st Jan. 2015 ~ at present) / IMO NOx Tier III from 1st Jan. 2021
  - **Under Discussion**: Coasts of Mexico, Coasts of Alaska and Great Lakes, Singapore, Hong Kong, Korea, Australia, Black Sea, Mediterranean Sea
1. D-2 = Ballast water treatment systems approved by the Administration
2. IOPP: International Oil Pollution Prevention
3. EIF: Entry Into Force
2. Green Ship Technologies in Korea

- Green Ship has... High efficiency, Low emission, Alternative power

**Energy**
- LNG Fueled Propulsion
- Fuel Cell Hybrid Electricity Generation
- Solar Powered Ship

**Material**
- Non-Corrosive Material
- Environment Friendly Painting Material
- Advanced Anti Fouling Paint
- Ship Recycling Convention Consideration

**Operation**
- Trim Optimization
- Optimum Weather Routing
- Arctic Routing
- Slow Steaming (Eco-Speed)

**Device**
- Shaft Generator
- Pre-Swirl Stator (PSS)
- Ducted PSS
- Rudder Bulb Fin
- Ballast Water Treatment System (BWTS)
- Waste Heat Recovery System (WHRS)
- NOx Reduction Device
- SOx Reduction Device
- Air Cavity System (ACS)
- VOC Reduction Device (Tanker)
- Grey Water Treatment System

**Design**
- Optimized Hull Form Design
- Protective Piping Arrangement
- High Efficiency Propeller Design
- Optimized Main Engine Selection and De-rating
- Enhanced Hull Structure
- Electric Driven Deck Machinery
- Bulbous Bow Optimization

VOC: volatile organic compounds
Energy Efficiency Technology

- Energy Efficiency Improvement technologies
  - Optimum boyage support system
  - Waste Heat Recovery System
  - Optimization of hull design
  - Optimization of propulsion efficiency
  - Optimization of engine system
  - Reduction of friction drag
  - Dual Fuel engine
Energy Efficiency Technology

- Optimized Hull Form Design
- High Efficiency Propeller Design
- Optimized Bulbous Bow Design
- Optimum ME Selection
  - Electronically Control (ME)
  - Low rpm & Longer stroke (G / X type)
  - Optimum Power Setting with Derating
  - Optimum ME Load Tuning (H/ P/ L w/EGB)
## Energy Efficiency Technology

### Energy Saving Devices

<table>
<thead>
<tr>
<th></th>
<th>Duct</th>
<th>Rudder bulb</th>
<th>L.E.-twisted rudder</th>
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<tbody>
<tr>
<td>Picture</td>
<td><img src="image" alt="Duct Picture" /></td>
<td><img src="image" alt="Rudder bulb Picture" /></td>
<td><img src="image" alt="L.E.-twisted rudder Picture" /></td>
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<tr>
<td>Typical gain</td>
<td>up to 5 %</td>
<td>approx. 1 %</td>
<td>1~2 %</td>
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<tr>
<td>Cap Fin</td>
<td><img src="image" alt="Cap Fin Picture" /></td>
<td><img src="image" alt="Pre-Swirl Stator Picture" /></td>
<td><img src="image" alt="DSBow Picture" /></td>
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<tr>
<td>Typical gain</td>
<td>1~2 %</td>
<td>4~5%</td>
<td>(5 ~6 % at Ballast)</td>
</tr>
</tbody>
</table>
Energy Efficiency Technology

- **Drag Reduction by Air Layer**
  [CFD - air bubble distribution around hull surface]
  [Model Test]

- **Low friction paint**

Sources:
- KR
- DSME

- Attachment of marine organism
- TOWING TANK-Test
- Low friction paint

Source: KR
Waste Heat Recovery System (WHRS)

- Change the engine’s waste heat into valuable electric power
- Benefits
  - Lower annual fuel costs
  - Lower running costs for auxiliary engines
  - Lower exhaust emissions: CO\(_2\), NOx, SOx, etc.

Max. 9 % Reduction in Fuel Consumption & CO\(_2\) Emission
Ballast Water Treatment Technology

Ballast Water Treatment System

The organisms in the ballast water are introduced into new habitats. ANS (Aquatic Nuisance Species) can disrupt the food chain and reproductive success of native species.

Source: HHI
Three choices of Air pollution prevention

- **HFO** + Scrubber + SCR (or EGR)
- **MGO** + SCR (or EGR)
- **LNG** Fuelled System

**Abbreviations**

- **HFO**: Heavy Fuel Oil
- **SCR**: Selective Catalytic Reduction
- **EGR**: Exhaust Gas Recirculation
- **MGO**: Marine Gas Oil
- **LNG**: Liquefied Natural Gas
Air Pollution Prevention Technology

- **Nox reduction equipments**
  - SCR (Selective Catalytic Reduction)  
    Source: PANASIA
  - EGR (Exhaust Gas Recirculation)  
    Source: MAN Diesel & Turbo
  - LNG Fuelled Ship  
    Source: DSME

- **SOx reduction equipments**
  - Low Sulphur Fuel  
    Source: GREEN4SEA
  - SOx Scrubber  
    Source: HHI
  - LNG Fuelled Ship  
    Source: DSME
Air Pollution Prevention Technology

- LNG Fuelled propulsion system
  - NOx : 92%, SOx : 100%, CO2 : 23% ↓
Air Pollution Prevention Technology

■ LNG cargo/fuelled tanks

. Major companies in Korea have their own cargo containment systems - KOGAS(KC-1), SHI(KS-S), DSME(SOLIDUS) etc.

. KOGAS applied the KC-1 system to the LNG carrier constructed by SHI

. DSME developed the membrane-type LNG fuelled tank(MCTIB) based on the high manganese steel developed by POSCO and is ready to design to the 180,000DWT ore carrier

KC-1 cargo containment system

MCTIB system
LNG Fuel Gas Supply System

- Each company has its own FGSS system with partial re-liquefacfication system
  - HHI(Hi-GAS), DSME(HiVAR-FGSS), SHI(S-Reli)

- Partial re-liquefaction system has been developed in order to minimize the waste of the excessive boil-off gas.

- Each system is applicable to ME-GI and/or X-DF engine.

Source: DSME
LNG Fuelled ships

- The first LNG fuelled vessel (Econuri) in ASIA
  - L = 38m, B = 8.4 m, DWT = 382 ton
  - Vt = 15 kts, Persons = 57 p
  - Constructed by SHI at 2013
  - Truck to Ship bunkering

Source: Incheon Port Authority
Some LNG fuelled ships

The World’s first LNG Fuelled Aframax Tanker: by HHI

The World’s first ME-GI LNG carrier by DSME

World’s first DP 2 Class LNG Bunkering Vessel by HMD

The World’s first LNG Fuelled Containership by DSME
Thank You