The latest technologies of J-ENG’s UE Engine, toward higher efficiency

October 11 2019
Japan Engine Corporation
Hideo Okamura
CONTENTS

1 Overview of Japan Engine Corporation and UE engine
2 Development concept
3 Principle structure and advantages
4 Conclusion
Company profile

MITSUBISHI HEAVY INDUSTRIES
- Research & Development

MITSUBISHI HEAVY INDUSTRIES MARINE MACHINERY & EQUIPMENT (MHI-MME)
- Marine Engine Division
  - New engine development
  - License business
- Marine Machinery Division
  - MET Turbochargers
  - Boiler & Turbine
  - Propeller

Support by cutting edge technology

KOBE DIESEL
- Production design
- Manufacturing
- After-sales service

Japan Engine Corporation
- Research & Development
- New engine development
- License business
- Manufacturing
- Production design
- After-sales service
Naming rule

Example: 6 UEC 42 LSH - Eco - D 3 - EGR

- **Tier III technology:**
  - (blank): Tier II
  - EGR: Low Pressure EGR
  - SCR: Low Pressure SCR

- **Version number:**
  - 1: Standard version
  - 2: Low-SFOC version
  - 3: Extra Low-SFOC version (UEC50LSH-Eco)

- **BMEP number:**
  - A: 20bar
  - B: 21bar
  - C: 22bar or 22.5bar
  - D: 24bar (blank): less than 20bar

- **Eco:** Electronically controlled engine
  - (blank): Camshaft controlled engine

- **Development code:** LSI, LSE, LSH, LSJ (MGO mono-fuel engine)

- **Bore size in cm:**

- **Brand name:**
  - Uniflow scavenging
  - Exhaust gas turbocharged
  - Crosshead type

- **Number of cylinders:**

---

**Low pressure EGR system**

**Low pressure SCR system**
Developing history of UE engine

Development technologies accumulated over 60 years

Eco: Electronically controlled engine

© 2019 Japan Engine Corporation
UE Engine  Production Records of LSII / LSE / LSH

As of Aug, 2019

<table>
<thead>
<tr>
<th>Engine type</th>
<th>Ordered</th>
<th>Delivered</th>
<th>1st set in service</th>
</tr>
</thead>
<tbody>
<tr>
<td>85 LSC</td>
<td>7</td>
<td>7</td>
<td>1993.12</td>
</tr>
<tr>
<td>85 LSII</td>
<td>50</td>
<td>50</td>
<td>1992.7</td>
</tr>
<tr>
<td>75 LSII</td>
<td>20</td>
<td>20</td>
<td>1988.4</td>
</tr>
<tr>
<td>60 LSII</td>
<td>201</td>
<td>201</td>
<td>1995.8</td>
</tr>
<tr>
<td>50 LSII</td>
<td>243</td>
<td>243</td>
<td>1994.2</td>
</tr>
<tr>
<td>43 LSII</td>
<td>26</td>
<td>26</td>
<td>2004.6</td>
</tr>
<tr>
<td>37 LSII</td>
<td>19</td>
<td>19</td>
<td>2000.9</td>
</tr>
<tr>
<td>33 LSII</td>
<td>139</td>
<td>124</td>
<td>1994.6</td>
</tr>
<tr>
<td>80 LSE</td>
<td>2</td>
<td>2</td>
<td>2013.6</td>
</tr>
<tr>
<td>68 LSE</td>
<td>15</td>
<td>15</td>
<td>2003.5</td>
</tr>
<tr>
<td>60 LSE</td>
<td>35</td>
<td>32</td>
<td>2008.6</td>
</tr>
<tr>
<td>52 LSE</td>
<td>30</td>
<td>30</td>
<td>2001.9</td>
</tr>
<tr>
<td>50 LSE</td>
<td>18</td>
<td>18</td>
<td>2007.2</td>
</tr>
<tr>
<td>45 LSE</td>
<td>262</td>
<td>251</td>
<td>2008.12</td>
</tr>
<tr>
<td>35 LSE</td>
<td>14</td>
<td>7</td>
<td>2014.6</td>
</tr>
<tr>
<td>33 LSE</td>
<td>34</td>
<td>29</td>
<td>2014.12</td>
</tr>
<tr>
<td>50 LSH</td>
<td>41</td>
<td>21</td>
<td>2015.8</td>
</tr>
<tr>
<td>Total</td>
<td>1156</td>
<td>1095</td>
<td>-</td>
</tr>
</tbody>
</table>

**UEC42LSH is the successor of UEC45LSE, and developed by using proven UEC50LSH technologies.**
CONTENTS

1. Overview of Japan Engine Corporation and UE engine
2. Development concept
3. Principle structure and advantages
4. Conclusion
UEC42LSH-Eco  Development concept

- “UEC42LSH” is a successor to UEC45LSE engine, which is the UE’s best seller engine ordered over 260 sets so far.

- Based on comprehensive market research, the optimal rating is set for Handysize BC, Small CT, etc. for the domestic and overseas shipyards. Especially for Handysize BC’s rating field, 6UEC42LSH, which has an advantage in terms of vibration, can be applied comparing to 5cyl. (50cm bore) engine.

- UEC42LSH-Eco-D3 can achieve the lowest SFOC in the world.

- Long time slow steaming can be easily operated. (Continuous operation is possible down to 20% load without any load up)

- Compact engine size and weight.

- Promote the digitalization in future.

- MGO mono-fuel engine “UEC42LSJ” also joins in the UE’s lineup.
UEC42LSH-Eco Rating Field

- Best rating field for Handysize BC
- Best rating field for Small CT
# UEC42LSH-Eco Main Particulars

<table>
<thead>
<tr>
<th>Model</th>
<th>6UEC42LSH-Eco-D3</th>
<th>6UEC45LSE-Eco-B2</th>
<th>5UEC50LSH-Eco-C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore</td>
<td>[ mm ]</td>
<td>420</td>
<td>450</td>
</tr>
<tr>
<td>Stroke</td>
<td>[ mm ]</td>
<td>1,930</td>
<td>1,930</td>
</tr>
<tr>
<td>Stroke/Bore</td>
<td>—</td>
<td>4.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Output</td>
<td>[ kW ]</td>
<td>7,560</td>
<td>8,280</td>
</tr>
<tr>
<td>Engine speed</td>
<td>[ rpm ]</td>
<td>118</td>
<td>128</td>
</tr>
<tr>
<td>Pme</td>
<td>[ bar ]</td>
<td>24.0</td>
<td>21.1</td>
</tr>
<tr>
<td>Piston speed</td>
<td>[ m/s ]</td>
<td>7.6</td>
<td>8.2</td>
</tr>
<tr>
<td>SFOC @100%Load</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier2 Mode</td>
<td>[ g/kWh ]</td>
<td>164</td>
<td>169</td>
</tr>
<tr>
<td></td>
<td>(LP-EGR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier3 Mode</td>
<td>[ g/kWh ]</td>
<td>165.6 (LP-EGR)</td>
<td>170.7 (LP-EGR)</td>
</tr>
</tbody>
</table>

The lowest SFOC engine in the world
Comparison rating point: 5,430kW x 105rpm (Tier II Mode)

6UEC42LSH-Eco-D3 can achieve much lower fuel oil consumption.
## UEC42LSH-Eco Comparison of Dimensions

<table>
<thead>
<tr>
<th>Model</th>
<th>6UEC42LSH-Eco-D3</th>
<th>6UEC45LSE-Eco-B2</th>
<th>5UEC50LSH-Eco-C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine length</td>
<td>5,646 (Lcc760)</td>
<td>5,894 (Lcc792)</td>
<td>5,560 (Lcc870)</td>
</tr>
<tr>
<td>(Catalogue figure)</td>
<td>-4.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piston overhaul</td>
<td>8,850 (St1930)</td>
<td>8,860 (St1930)</td>
<td>10,050 (St2300)</td>
</tr>
<tr>
<td>[ mm ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crank shaft center</td>
<td>1,000</td>
<td>1,000</td>
<td>1,190</td>
</tr>
<tr>
<td>[ mm ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedplate width</td>
<td>2,800</td>
<td>3,000</td>
<td>3,350</td>
</tr>
<tr>
<td>[ mm ]</td>
<td>-6.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (without EGR)</td>
<td>170</td>
<td>187</td>
<td>194</td>
</tr>
<tr>
<td>[ ton ]</td>
<td>-9.1%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Compact engine size and weight**

© 2019 Japan Engine Corporation
UEC42LSH-Eco  Comparison of Dimensions

UEC42LSH can achieve downsizing from UEC45LSE

© 2019 Japan Engine Corporation
## CONTENTS

1. Overview of Japan Engine Corporation and UE engine
2. Development concept
3. Principle structure and advantages
4. Conclusion
UEC42LSH-Eco  Principle structure and advantages

**Design process**
- Utilization of MBD (Model Based Development)

**Conceptual Design**
- Functional Design
- Layout Design
- Structural Design
- Manufacturing Design

Development technologies accumulated over 60 years.

**Performance evaluation**

Utilizing advanced CAE based on the latest technologies

- 3D CAD/CAE
- Advanced design using analysis simulation.
**Main structure**
- Compact size, light weight, less deformation

**Cylinder jacket**
- High stiffness by appropriate configuration and material change (applying FCD)
  ⇒ Higher reliability (Piston running behavior)

**Bedplate & column**
- High stiffness by single separate wall ⇒ Higher reliability
- Reduce deformation of column sliding plate by appropriate configuration
  ⇒ Higher reliability (Piston running behavior)

**Tie rod**
- High stiffness by twin stay tie bolt with low alloy steel
- Reduce deformation of main bearing girder
  ⇒ Higher reliability

- Stiffness and weight of these structures are optimized by FEM and EHL analysis.
**UEC42LSH-Eco  Principle structure and advantages**

**Moving parts**
- Compact size, light weight

**Crosshead**
- Lower mechanical loss due to high rigidity and appropriate surface press. of guide shoe
  ⇒ Higher reliability, Lower FOC

**Crosshead bearing**
- Lower oil film press. by applying pocket type without center oil groove, Higher fatigue strength by aluminum metal
  ⇒ Higher reliability, Compact size

**Main bearing & crankpin bearing**
- Higher fatigue strength by aluminum metal
  ⇒ High reliability, Compact size

- Achieve **lower fuel oil consumption** by optimization of moving parts weight and reduction of mechanical loss.
UEC42LSH-Eco  Principle structure and advantages

Combustion chamber
- Reduction of thermal load, thermal stress

Nimonic Exh. valve
High heat resistant alloy, Nimonic or DSA760 as standard

Piston
- Bore cooling type and high top land.
  Lower temperature by increase cooling capacity
  Reduce influence by combustion gas

Cylinder liner
- Liner temp. control by insulation band and loop cooling
- Lower mechanical loss by plateau honing
  ⇒ Better slow steaming operation, Lower FOC

Cylinder lubricating system
- Appropriate lubricating by A-ECL*

The strength and heat condition of combustion chamber are analyzed by FEM and Thermal analysis.

FEM model

Thermal analysis

*N-A-ECL : Advanced Electronically Controlled Lubricating system
UEC42LSH-Eco Principle structure and advantages

Eco system
- Development by J-ENG own technologies = “No Black Box”

Cylinder control unit
- Accumulating block
- Fuel injection pump
- Exhaust valve lower part
- Solenoid valve unit
  - Solenoid valve
  - Valve plate
  - Main valve

Control unit
- Engine control unit (ECU)
- Power distribution unit (PWD)
- Local control unit (LCB)
- Multi IO unit (MIO)
- Driver unit (DRV)

Electric driven pump (for hyd. oil)

Solenoid valve

Engine driven pump (for hyd. oil)

FO. side: 2 Solenoid valves

© 2019 Japan Engine Corporation
Eco system

Fuel injection rate control

Concept of fuel injection mode

[Control mechanism]

- Fuel injection rate is controlled by differences of main valve's lift and opening timing
- Main valve’s opening timing is controlled by each S/V

Controlled fuel injection rate contributes to improve the trade-off relationship of NOx emission and FOC.
UEC42LSH-Eco  Principle structure and advantages

Exhaust Gas and Scavenge System

CFD analysis

CFD: Computational Fluid Dynamics

Achieve **lower fuel oil consumption** thanks to reduction of pressure loss by optimization for scavenging air and exhaust gas passage.

CFD analysis for scavenging passage
Application of “JUMP” technology

Concept of JUMP

J-ENG Unique Marine Power

Solution to three environmental issues of NOx, SOx, EEDI(CO2) simultaneously

- Insert water in fuel injection valve during standstill period of injection at each cycle
- Fuel and water can be injected by layers according to actuation of fuel pump

UEC-LSJ
- Environmental impact reduction engine

Schematic diagram of water injection system
Environmental impact reduction engine “UEC-LSJ”

Technical features of “UEC-LSJ”

Realize low FOC meeting with NOx regulations by comprehensive UE engine technology and mixture of existing technology

- Ultimate low FOC
  - Combustion tuning to prioritize low FOC
- Reduction of NOx
  - Application of water injection system
- Compliance with Tier3 LP-EGR or LP-SCR

<table>
<thead>
<tr>
<th>Original (Tier2)</th>
<th>FOC 100</th>
<th>NOx 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSJ engine (Tier2)</td>
<td>FOC 95</td>
<td>NOx 100</td>
</tr>
<tr>
<td>LSJ engine (Tier3)</td>
<td>FOC 96</td>
<td>NOx 24</td>
</tr>
</tbody>
</table>

Tier2 Limit

Tier3 Limit
CONTENTS

1. Overview of Japan Engine Corporation and UE engine
2. Development concept
3. Principle structure and advantages
4. Conclusion
The latest type of UE engine, **UEC42LSH-Eco**, is being developed to meet worldwide needs and will contribute to ship owners, ship operators and shipyards to cut operating costs and installation cost.

**UEC42LSH-Eco** is being designed on the basis of well-proven conventional UE engines and with further improvements.

Experiences of excellent operating condition of in-service engine will be fed back to new buildings.

**UEC42LSH-Eco** is ready for complying with IMO-NOx Tier III regulation.

The first “**UEC42LSH-Eco**” will be manufactured in December 2020 and tested and launched soon.
Thank you

Contact:
Hideo Okamura
Japan Engine Corporation
1-1, Wadasaki-Cho 1-Chome, Hyogo-ku, Kobe
Hyogo Pref., 652-8585, Japan
Hideo.okamura@j-eng.co.jp
https://www.j-eng.co.jp/