Particulate Emission Characteristic of Two Stroke Marine Diesel Engine
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Introduction

Background
• IMO(International Maritime Organization) restricted discharging ship’s harmful substances to sea by TS/78 MARPOL Convention(International Convention for the prevention of Pollution from ships).
• The Main air pollutants emitted from ships are regulated by ANNEX VI(Reg.12 ~ 19)
  - MEPC of IMO is progressing to adapt regulation to reduce particulate emission(exclusively BC, Black Carbon)
  - IMO approved the definition of Black Carbon for international shipping at 2008 (Annex VI Regulation 14: SOx & PM)

Objectives
• Measurement methods are different depending on the physical properties of the black carbon.
• This study can give an information on data of BC measurement with various methods.

Experiment

• This study is conducting in government project “Quantitative assessment for PM&BC to climate change and development of reduction technology for PM, BC from ships.” by Ministry of Oceans and Fisheries of KOREA.

Experimental Conditions

Test cycle
Cycle: E3 cycle
Power [%] 100 75 50 25
Speed [%] 100 91 80 63
Weighting factor 0.2 0.5 0.75 1.0

Fuel properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density @ 15°C (kg/m³)</td>
<td>ISO 12186</td>
<td>940.2</td>
</tr>
<tr>
<td>Viscosity at 40°C (cP)</td>
<td>ISO 3104</td>
<td>0.882</td>
</tr>
<tr>
<td>Sulfur content (%)</td>
<td>ISO 3730</td>
<td>0.06</td>
</tr>
<tr>
<td>Water content (%)</td>
<td>ASTM D 975</td>
<td>0.05</td>
</tr>
<tr>
<td>LHV (MJ/kg)</td>
<td>ASTM D 2407</td>
<td>41.6</td>
</tr>
</tbody>
</table>

Measurement methods

<table>
<thead>
<tr>
<th>Measurement method</th>
<th>Physical properties of Black Carbon defined by bond et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter smoke number (FSN)</td>
<td>Light absorption, Mass &amp; total number concentration, Soot concentration &amp; FSN, Ejector concentration &amp; FSN</td>
</tr>
<tr>
<td>Photoacoustic Spectrophotometry(BG)</td>
<td>Particle diameter, Mass &amp; total number concentration, Soot concentration &amp; FSN, Ejector concentration &amp; FSN</td>
</tr>
<tr>
<td>Multi Angle Absorption photometry(Lab India)</td>
<td>Particle diameter, Mass &amp; total number concentration, Soot concentration &amp; FSN, Ejector concentration &amp; FSN</td>
</tr>
<tr>
<td>Opacity</td>
<td>Particle diameter, Mass &amp; total number concentration, Soot concentration &amp; FSN, Ejector concentration &amp; FSN</td>
</tr>
</tbody>
</table>

Results

Summary

- Analysis on characteristics of black carbon emission emitted from marine engine is different depending on the measurement methods of black carbon. Also the unit of measurement value vary depending on measurement methods.
- There is need to select the representative measurement method for analysis on characteristics of black carbon emission like CLD method for measuring NOx emission by IMD. To do that IMO gathers data of black carbon measuring results on various ships and engine test bed.
- Before selecting the representative measurement method, there is need to compare to the results with measurement methods and measurement results on any fuels, experimental conditions and engine characteristic(type, purpose and etc.).

Acknowledgments: This study has been funded by the Ministry of Oceans and Fisheries of KOREA. Also this study is conducting in government project “Quantitative assessment for PM&BC to climate change and development of reduction technology for PM, BC from ships.”

Future Work

Further research will be conducted on the performance of engine with various measurement methods and the characteristics of pollutant emission are going to be compared in this study.

Note: Graph and data from various papers and conferences on black carbon and marine diesel engines are used in this study for reference.

- Test number
- 1. This study conducted various measurement methods with measurement results on any fuels, experimental conditions and engine characteristics(type, purpose and etc.).
- 2. The results revealed that particle number concentration with particle size were varied with engine operating conditions.
- 3. The number concentration of nucleation mode particles under low speed and load conditions higher than that under full load condition.
- 4. The mass and total number concentration measured by particle sensor.
- 5. The results revealed that particle mass and total number concentration decreased with decreasing engine speed and load.
- 6. These results revealed that the filter smoke number value was highly dependent on the engine operating conditions for low load.
- 7. A reason for higher smoke formation with low loads that it might be formed in the locally fuel-rich zone downstream of the liquid core of fuel spray, where air ratio is low, and it can be therefore directly related to the engine load or the engine speed.

- Although the magnitude and unit was different. Opacity was nearly similarly with FSN trend.
- In case of opacity is suitable for measuring particulate matter, but there is a limitation in measuring only the Black carbon.

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