METHANOL AS FUEL

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Pusher → SEAC Regulation
Methanol ....the fourth alternative?
Total fuel consumption in ECAs

- The North Sea and Baltic ECAs account for approximately 27 million tonnes (IMO 2009), approximately 9% of total bunker fuel used in the maritime industry, more than half of the bunker fuel consumed in Europe.

- North America accounts for approximately 10 million tonnes which makes a total of 37, maybe 40 million tonnes (DNV study shipping 2020 assumed 45).

- 10 million becomes 16.5 in 2020 (EPA estimates) and considering similar growth rates we get to a 60/70 million tonnes by 2020 (still roughly 10% of global bunker fuel consumption). North American ECAs will represent an estimated oil consumption of around 20 million tonnes (0.35 mb/d) of fuel by 2020 (EPA, 2009).

- 8000 vessels affected by ECA regulation

Source: Prof. Dr. Michele Acciaro, Kühne Logistics University, Hamburg, Germany
Methanol is used as a fuel already today
Methanol is used as a fuel already today
Methanol price

Global Methanol Pricing Comparison

USD per metric ton


- Methanol US Contract Index, Avg Realized Price FOB USGC USD/metric ton
- Methanol US Spot FOB USGC USD/metric ton
- Methanol West Europe Contract (T2), Avg Realized Price FOB Rotterdam USD/metric ton
- Methanol West Europe Spot (T2) FOB Rotterdam USD/metric ton
- Methanol NEA/SEA MMSA Contract NTR Weighted Region Avg. USD/metric ton
Fuel availability: Methanol Infrastructure Advantage

- Extensive existing terminal infrastructure + modest cost to build new terminal capacity; ability to use existing fuel infrastructure

- Terminal locations are representative based on available information and is not a complete list
- Source: Methanex
Historic development of Methanol as motor fuel

Alcohols were actually tried in engines in the early days by both Otto as well as Diesel............

- The development of the market for methanol as a motor fuel worldwide started with the shortage of motor fuels during the First World War.

- Likewise, the use of methanol has received attention primarily during periods when shortage of conventional fuels have been on the agenda.

- Two such periods besides First World War were the second War and first oil crisis during the 70´s.

- The current only major market for methanol as motor fuel is China
# Methanol as fuel compared to LFO

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Methanol</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (kg/l)</td>
<td>0.79</td>
<td>0.85</td>
</tr>
<tr>
<td>Boiling point (°C)</td>
<td>65</td>
<td>150-370</td>
</tr>
<tr>
<td>Flash point (°C)</td>
<td>11</td>
<td>min. 60</td>
</tr>
<tr>
<td>Auto ignition (°C)</td>
<td>464</td>
<td>240</td>
</tr>
<tr>
<td>Viscosity cSt at 20°C</td>
<td>~ 0.6</td>
<td>~ 13.5</td>
</tr>
<tr>
<td>Octane RON/MON</td>
<td>109/89</td>
<td>-</td>
</tr>
<tr>
<td>Cetane No.</td>
<td>3</td>
<td>45-55</td>
</tr>
<tr>
<td>LHV (MJ/kg)</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>LHV (MJ/l)</td>
<td>16</td>
<td>36</td>
</tr>
<tr>
<td>Flammability Limits, Vol%</td>
<td>7-36</td>
<td>1-6</td>
</tr>
<tr>
<td>Flame Speed (cm/s)</td>
<td>52</td>
<td>37</td>
</tr>
<tr>
<td>Heat of Evaporation (kJ/kg)</td>
<td>1178</td>
<td>233</td>
</tr>
<tr>
<td>Stoichiometric Air-Fuel Ratio</td>
<td>6.4</td>
<td>14.7</td>
</tr>
<tr>
<td>Adiabatic flame temp. (°C)</td>
<td>1910</td>
<td>2100</td>
</tr>
</tbody>
</table>

**MeOH**

- Top 3 Safety Aspects
  - "invisible flame"
  - Corrosive
  - Toxic

**Performance Aspect**
- LHV less than half of LFO
- Heat of Evaporation
Possible Methanol Concepts for IC Engines

- Surface Ignition
- Fumigation
- Mixing Concept (Emulsion)
- Ignition Improvers
- Pilot fuel assisted Diesel Combustion
- Premixed Combustion with Spark Plug or Pilot Fuel Ignition
Conclusions from using methanol in the diesel process

- Engine output and efficiency equal to the diesel engine
- Significant reduced NOx and PM compared to diesel
- Life time of major components will be similar or better than the diesel engine
- No change in oil change intervals are expected

Sources: SAE 902160 paper, EPA-460/3-023 August 1981
Wärtsilä Methanol-Diesel retrofit solution

- Methanol is combusted according to the diesel process.
Wärtsilä Methanol-Diesel retrofit solution

- On-engine scope is limited to exchange of cylinder heads, fuel injectors and fuel plungers in existing fuel pumps.
- A common rail system for methanol injection will be added on the engine.
- In addition to the Engine related conversion includes the conversion kit a stand-alone high pressure methanol pump with belonging oil unit for supply of sealing oil and control oil to the fuel - beside an update of the automation system.
The additional piping on the engine allows not only supply of methanol to the cylinders, but also oil to seal the high pressure methanol injector as well as controlling opening/closing of the injector.

Methanol high pressure piping are designed as purge able double walled piping for maximum safety.
On engine modifications
Injector Integration in Cylinder Head

The modified cylinder heads allow Methanol supply just above the inlet of the Diesel supply.

Exhaust valves are modified to resist excess wear since the exhaust gases combustion methanol consist less lubricating particulates.
Methanol-Diesel test engine at VTT, Wärtsilä Vasa 4L32LNGD
Tests on Methanol – Initial testing of Wärtsilä MD concept

**Engine: Wärtsilä Vasa 32**

- Optimal heat release
- Lower Exhaust Temperature
- Reduced NOx
- CO, THC acceptable (< 1 g/kWh)
- Formaldehyde emissions low ~ much below TA-luft
- No Formic acid detected in exhaust gases
- Same efficiency as diesel
Methanol-Diesel Test Engine in Trieste - Sulzer Z40S-MD
Tests on Methanol – Recent testing of Wärtsilä Sulzer Z40S-MD

Repeated tests on Sulzer Z40S-MD show same trends as the pre-tests on Wärtsilä Vasa 32:

→ Reduced NOx / PM
→ Reduced exhaust temperature
→ Same (or better) efficiency
EU (TEN-T) funded ‘Spirit’ project

- Explore a technology enabling methanol conversions
- Total project budget ~ 22 million €
- Project time frame 2013 to end 2015
- Partners: Stena AB, Stena Oil, Wärtsilä, Port of Kiel, Port of Gothenburg
Stena Germanica, Gothenburg - Kiel

45,000 Cars
45,000 Lorries
Lifted from the road every year
Stena Germanica – Conversion Scope

- Engines converted for methanol combustion
- Double walled fuel pipes
- Ballast tank converted to methanol fuel tank
- Pump room
- Transfer pump room
Methanol Potential - what is missing?
Thank You

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