DME
- in Heavy Duty Diesel Engines

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Volvo Powertrain Corporation
at
EffShip seminar
2010-11-16
Content

- Introduction
  - The drivers for alternative fuels
  - DME features
  - Volvo DME history
- DME technology for heavy duty vehicles
- Conclusions
The drivers for future fuels

- Climate gas emissions
- Depletion of energy sources
- Security of energy supply
- Exhaust emissions
- Urbanization
- ...

HOLISTIC VIEW

+ enablers
- safety
- energy density
- cost
- etc
Emission levels
- overview

PM (g/kWh)

0.15

0.10

0.05

0.01

0.02

0.01

0.005

0.004

0.003

0.002

0.001

NOx (g/kWh)

7.0

5.0

3.5

2.0

0.5

0.25

0.4

0.7

EURO 2 (95/96)

US 04

US 98

US 07

EURO III (00/01)

EURO IV (05/06)

EURO V (08/09)

EURO VI (12/13)

Tier IV-B (14)

Japan pPNLT (09/10)

Japan pNLTT (13?)

US 04

EURO IV (05/06)

EURO V (08/09)

EURO VI (12/13)

Tier IV-B (14)

Japan pPNLT (09/10)

Japan pNLTT (13?)
DME has the highest land use efficiency

- RME
- Ethanol from wheat
- Ethanol from wood
- Synthetic diesel from wood
- Synthetic Diesel - black liquor
- DME / Methanol - wood
- DME / Methanol - black liquor

Source: Volvo

- European conditions

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Relative energy density

<table>
<thead>
<tr>
<th>FUEL</th>
<th>PRESSURE [bar]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Diesel</td>
<td>100</td>
</tr>
<tr>
<td>DME</td>
<td>0.17</td>
</tr>
<tr>
<td>Methane</td>
<td>0.10</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0.03</td>
</tr>
<tr>
<td>LNG (-163°C)</td>
<td>61</td>
</tr>
</tbody>
</table>
DME as energy carrier

- A multi source and multi purpose fuel
- High well to wheel energy efficiency
- High yields of transport work per hectare and year
- Suitable as hydrogen carrier
- Infrastructure and safety similar to LPG
- An ideal fuel for the efficient diesel process
- Potential for ultra low exhaust emissions and reduced noise
- Non toxic and environmentally benign
CO2 neutral transports
... with biomass derived fuels
3 trucks for DME4 in Stockholm 10-09-06

06.30 Göteborg

14.30 Stockholm
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DME handling

- Vehicle filling with DME coded spill free MannTek coupling
- Lubricity and odorant additives mixed in when loading the DME trailer

Additiv bottle + couplings
DME technology for heavy duty trucks

- A modified diesel truck
- Preserved engine efficiency
- Increased transient torque
- Meets regulated emissions with less exhaust after treatment
- Reduced noise

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DME technology for HD trucks

400 bar pump

Piping and filters

Two pumps increase the pressure with ~8bar
DME engine development
- improvements from endurance testing

- DME injector valve seats modified
- Improved material in exhaust valves

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## Features of 3G DME truck

<table>
<thead>
<tr>
<th>Feature</th>
<th>Actual</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base engine</td>
<td>13 litre, 6-cyl</td>
<td></td>
</tr>
<tr>
<td>Fuel supply</td>
<td>Common rail</td>
<td></td>
</tr>
<tr>
<td>Rated power</td>
<td>440 hp</td>
<td></td>
</tr>
<tr>
<td>Emission control</td>
<td>EGR, Ox-cat</td>
<td>No DPF and no SCR system</td>
</tr>
<tr>
<td>Emission level</td>
<td>Euro V EEV</td>
<td>National permit (Very low PM emissions)</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>~ diesel eq.</td>
<td></td>
</tr>
<tr>
<td>Range (40ton)</td>
<td>~ 400 km</td>
<td>~ 800 km with larger tanks for later field test vehicles</td>
</tr>
<tr>
<td>Drive by noise Target 80 dBA</td>
<td>77,6 dBA</td>
<td>Combustion and engine noise are noticeably lower</td>
</tr>
<tr>
<td>Start torque</td>
<td>improved</td>
<td>Low rev torque not limited by smoke emissions</td>
</tr>
</tbody>
</table>

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Combustion chamber optimization

- At low NOx conditions CO is the major emission from a DME fuelled engine
- DME adapted pistons result in significantly lower CO even at same NOx-level
- Larger flame/air interface

Results from Chalmers PhD project "DME in the Diesel process"

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Conclusions

- DME has good fit to the “drivers” for alternative fuels
- DME largely lacks the support from established economic interests
- DME simplifies diesel engine technology at today’s and future emission levels
- DME in diesel process is soon ready to move from advanced engineering to commercial applications
Thank you!