

SUMMETH

Sustainable Marine Methanol



Alternative combustion concepts for methanol engines,
Bengt Ramne

SUSTAINABLE SHIPPING - EMISSIONS

1. Optimum energy efficiency – minimize the power required for the service
 - Hull
 - Propeller
 - Systems
 - Operation
2. Generate the power needed with minimum harmful emissions
 - GHG, SO_x, NO_x, PM

HARMFUL EMISSIONS

- CO₂
 - GHG
- SO_x
 - Smog
 - Acid rain
 - Respiratory problems
- NO_x
 - Toxic (NO₂)
 - Smog
 - Acid rain
 - Eutrophication
- Particulate Matter
 - Other toxics stick
 - Cancerogeneous
 - Cardio-vascular impact

Why methanol?

	GHG	SOx	NOx	PM	Cost (delivered)
Fossil diesel (MGO)	Red	Yellow	Red	Red	Green
Synthetic diesel (HVO)	Green	Green	Red	Red	Yellow
Fossil methanol	Red	Green	Green	Green	Green
Fossil methane (LNG)	Red	Green	Green	Green	Green
Bio methanol	Green	Green	Green	Green	Yellow
Bio methane (LBG)	Yellow	Green	Green	Green	Red

IS IT DIFFICULT TO OPERATE AN ENGINE ON METHANOL?

- Methane gas and methanol have similar combustion characteristics
- All combustion concepts that work for gas engines will work for a methanol engine
- All gas engines can be converted to methanol engines

ALTERNATIVE COMBUSTION CONCEPTS FOR METHANOL ENGINES,

- Compression ignited (diffusion combustion)
 - Pilot fuel – Stena Germanica (4-stroke), Mari Jone - Marinevest (2-stroke)
 - Ignition improver Scania 9L MD95
 - DME engines
- Surface ignited
 - Glow plug and direction injection (Caterpillar)
- Spark ignited (premix combustion)
 - SI – PFI
 - SI - DI
- Dual fuel
 - Pilot fuel + Port fuel injection (fumigation)

OTHER ALTERNATIVE COMBUSTION CONCEPTS FOR METHANOL ENGINES (THAT WE WILL NOT WORRY ABOUT TODAY)

➤ HCCI

- Homogeneous charge compression ignition (HCCI)

➤ PPC

- Partially premixed combustion also known as
- partially-premixed compression ignition, PPCI

OUR METHANOL ENGINE JOURNEY – STOP 1

➤ 2010 – EffShip project

➤ Caterpillar



➤ Surface ignited

➤ Glow plug and direction injection

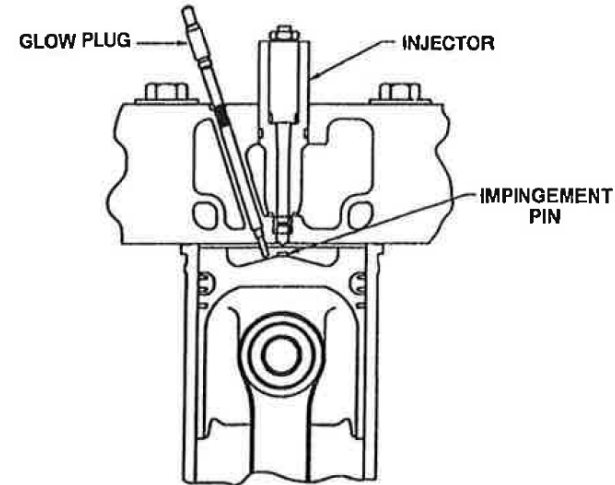
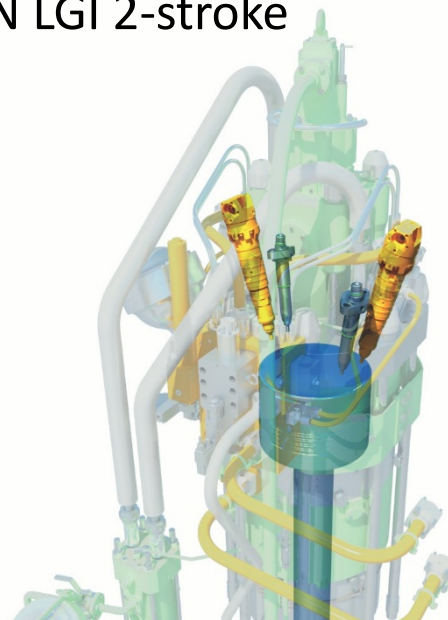
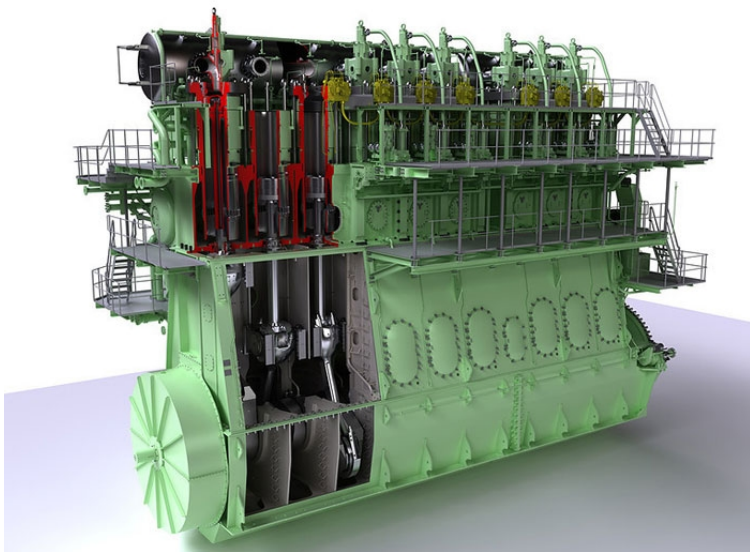


Figure 3: Cross Section of 3406 Methanol Cylinder Head and Combustion Chamber

OUR METHANOL ENGINE JOURNEY, – STOP 2

- 2011 Nordgren project
 - Compression ignited (diffusion combustion) MAN LGI 2-stroke

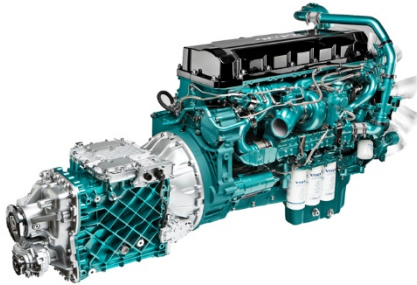
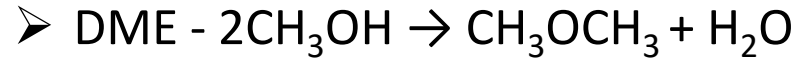


SUMMETH seminar - Alternative combustion concepts for methanol engines - Bengt Ramne

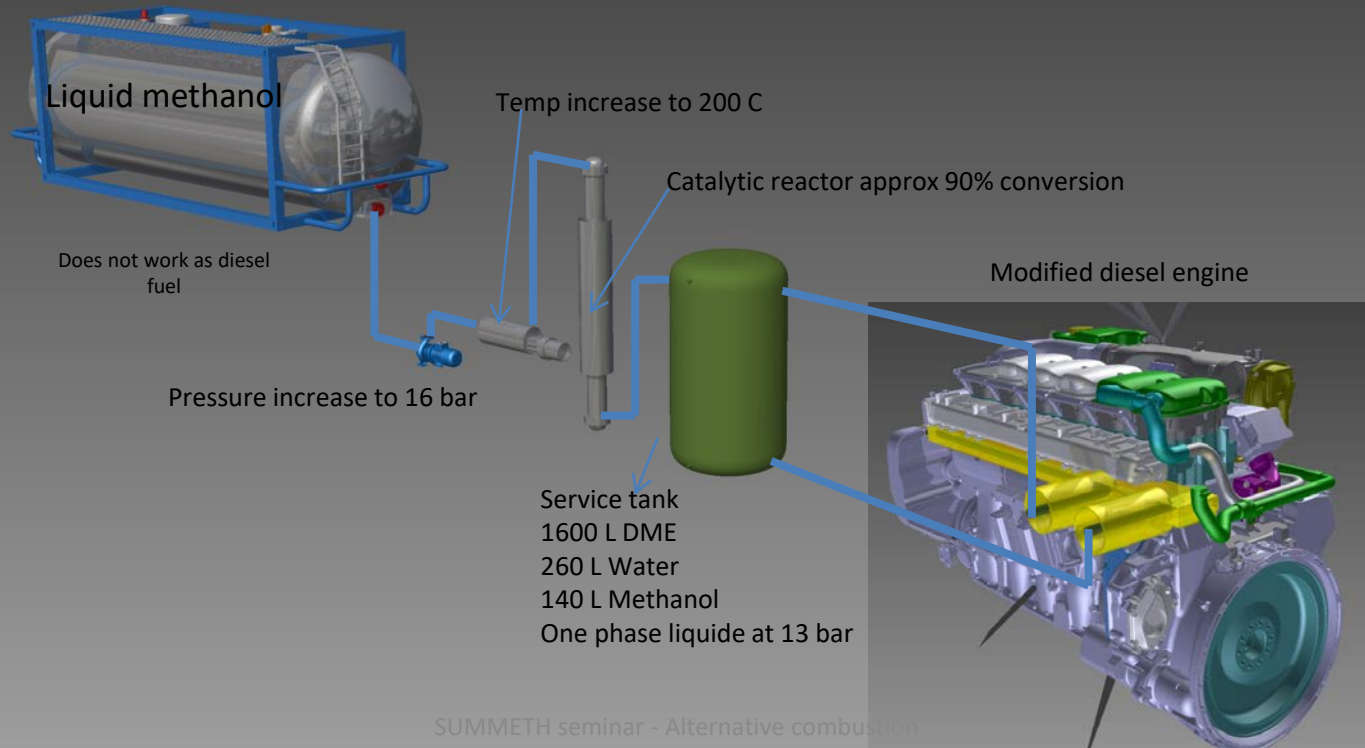
ScandiNAOS AB

OUR METHANOL ENGINE JOURNEY, – STOP 3

➤ 2011 SPIRETH project



➤ OBATE (Haldor Topsö)



SPIRETH - STENA SCANRAIL



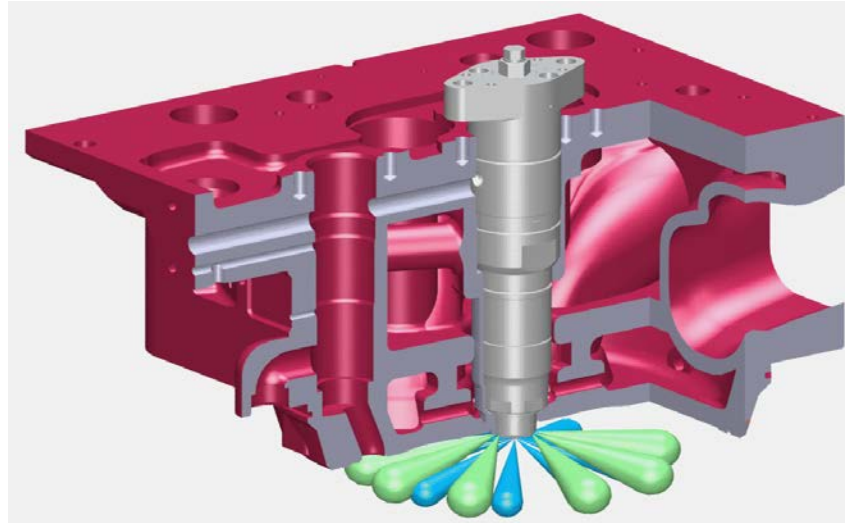
SUMMETH seminar - Alternative combustion
concepts for methanol engines - Bengt
Ramne

ScandiNAOS AB

OUR METHANOL ENGINE JOURNEY, – STOP 4

- 2011 SPIRETH project
 - Compression ignited (diffusion combustion)
 - Lab test Wärtsilä VASA 32 Pilot fuel + methanol

WÄRTSILÄ METHANOL-DIESEL RETROFIT SOLUTION

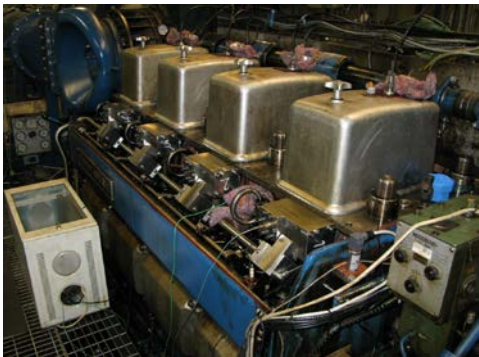


Methanol is combusted according to the diesel process. The methanol is injected close to TDC and ignited by a small amount of pilot fuel - in this case traditional diesel fuel.

The methanol injection pressure is limited to below 650 bar.

So far has the concept only been tested in laboratory environmental .

SUMMARY TEST RESULTS - WÄRTSILÄ MD CONCEPT



Engine: 4L32LNGD
Output: 410kW/Cylinder
Compression ratio: 13.8:1

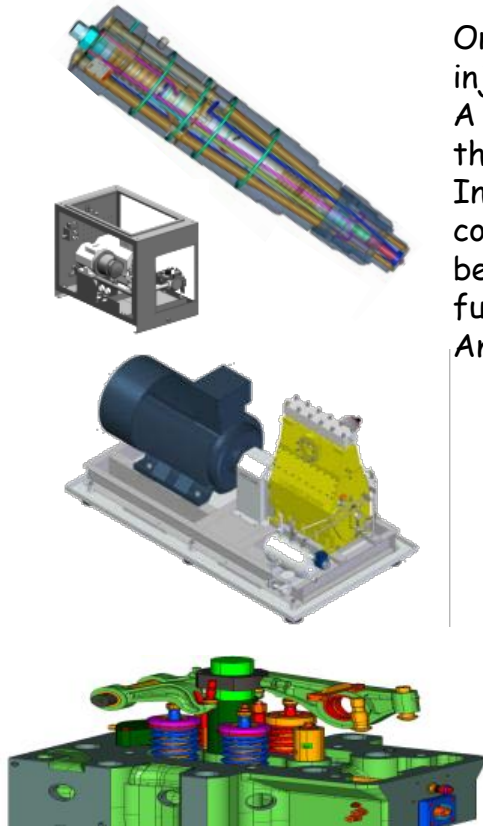
- ☐ **NO_x 3-5 g/kWh (Low Tier II)**
- ☐ **CO acceptable (< 1 g/kWh)**
- ☐ **THC acceptable (< 1 g/kWh)**
- ☐ **Very low PM (FSN ~ 0,1 with HFO as pilot)**
- ☐ **Formaldehyde emissions low ~ below TA-luft**
- ☐ **Efficiency comparable to running on diesel**
- ☐ **No Formic acid detected in exhaust gases**

OUR METHANOL ENGINE JOURNEY, – STOP 5

➤ 2014 Stena Germanica

- Compression ignited (diffusion combustion)
- In situ conversion Wärtsilä Sulzer 6LZ40S Pilot fuel + methanol

Wärtsilä Methanol-Diesel retrofit solution

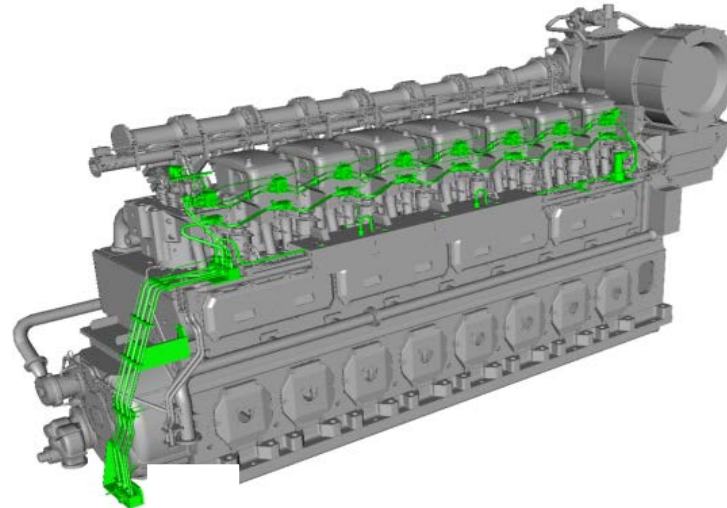


On-engine scope is limited to exchange of cylinder heads, fuel injectors and fuel plungers in existing fuel pumps.

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 injectors.

An ECU will be added to run the engine ensure communication.




WÄRTSILÄ


ScandiNAOS AB

OUR METHANOL ENGINE JOURNEY, – STOP 6

➤ 2016-2017 SUMMETH project

➤ Compression ignited (diffusion combustion)

- Scania 9L MD95 (ignition enhancer) VTT

➤ Spark ignited (premix combustion)

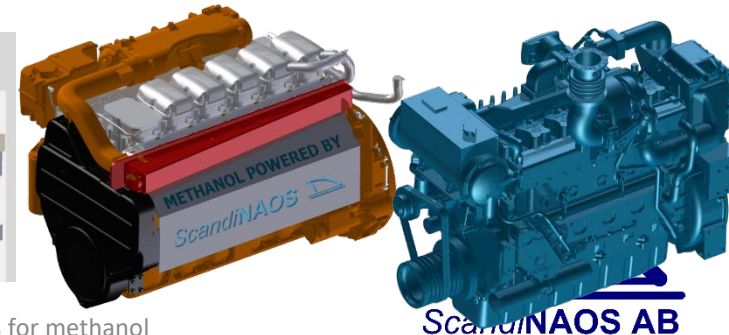
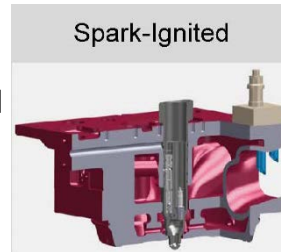
- SI - DI

- Scania 13L (1-cyl) SI-DI LTH

- SI – PFI

- Weichai/FiTEch 12L SI-PFI

- Scania/ScandiNAOS 13L SI-PFI



OUR METHANOL ENGINE JOURNEY, – STOP 7

- 2016-2018 GreenPilot project
 - Spark ignited (premix combustion)
 - SI – PFI
 - Weichai/FiTech 12L SI-PFI
 - Scania/ScandiNAOS 13L SI-PFI
 - Dual fuel
 - Pilot fuel + PFI
 - Scania/ScandiNAOS 13L Dual fuel Pilot fuel + PFI



Even earlier

➤ 1996 California Fuel Methanol Program



- **OEM**

- Ford
- GM
- Chrysler
- Toyota
- Nissan
- Honda
- VW
- Volvo
- Mitsubishi
- Mercedes

- 17,000+ M85 FFVs sold to public without restriction
- Max fuel volume throughput: 7.5 M liters / month
- 10 OEMs involved
- Station deployment: 60+
- 7 oil company branded stations

ALTERNATIVE COMBUSTION CONCEPTS FOR METHANOL ENGINES

➤ Rough comparison

			Fuel flexibility	Single fuel	Fuel upgrade required	Pressure tank required	High efficiency in full load	High efficiency in part load	Requires high pressure methanol fuel pumps	Fulfills NOx tier
Compression ignited	Stena Germanica	Pilot fuel	Yes	No	No	No	Yes	Yes	Yes	II
	Scania	MD95	No	Yes	No	No	Yes	Yes	Yes	II
	Volvo	DME	No	Yes	Yes	Yes	Yes	Yes	Yes	II
Surface ignited	Caterpillar		No	Yes	No	No	Yes	Yes	Yes	II
Spark ignited	Weichai	PFI	No	Yes	No	No	Yes	reduced	No	III
	Scania/SN									
	Scania/LTH	DI	No	Yes	No	No	Yes	reduced	Yes	II
Dual fuel	Scania/SN	Pilot fuel + PFI	Yes	No	No	No	Yes	reduced	No	III

Thank you

