The International Symposium on Energy

The Progress of Methanol for IC engines in China

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Beijing, Oct.30, 2019

Outline

- **Background**
  - **Methanol vehicle development in China**
- **Technology of Methanol on Engines**
- **Characteristic of DMCC**
- **Key Parts for Methanol**
- **Methanol Production in China**

Development of methanol vehicles in China

The Ministry of Industry and Information Technology (MIIT) in China started an methanol vehicles pilot program in 2012

- 10 cities located in Shaanxi (陕西）, Shanxi （山西）, Gansu, Guizhou and Shanghai
- 1024 vehicles including passenger cars, MPV, heavy-duty trucks, etc.
- 23 vehicle models
- Total running distances longer than 184 million km
- Consumed methanol: 24000 tons

甲醇汽车公告车辆和制造企业辆一览表

序号	单位名称	车型种类	型 号	工信部公告号	公告日期
1	陕汽集团公司	自卸车	SX3317	第243批	2012年12月18日
2	上海华普汽车公司	甲醇轿车	SMA7151K05M	第240批	2012年9月19日
3	上海华普汽车公司	甲醇轿车	SMA7181K04M	第240批	2012年9月19日
4	陕西通家汽车股份有限公司	厢式运输车	STJ5023X	第244批	2013年1月18日
5	陕西通家汽车股份有限公司	多用途乘用车	STJ6404	第244批	2013年1月18日
6	郑州宇通客车股份有限公司	城市客车	ZK6100	第246批	2013年3月19日
7	浙江豪情汽车制造有限公司	甲醇轿车	JL7152K13M	第247批	2013年4月10日
8	浙江豪情汽车制造有限公司	甲醇轿车	JL7182K04M	第247批	2013年4月10日
9	山西省成功汽车制造有限公司	多用途乘用车	SCH6400	第251批	2013年8月16日
10	浙江豪情汽车制造有限公司	甲醇轿车	JL7152K16M	第264批	2014年9月17日
11	浙江豪情汽车制造有限公司	甲醇轿车	JL7182K05M	第264批	2014年9月17日
12	中国重汽集团济南卡车股份有限公司	甲醇/柴油双燃料自卸汽车	ZZ3257N 3847D 1M	第267批	2014年12月23日
13	中国重汽集团济南卡车股份有限公司	甲醇/柴油双燃料自卸汽车	ZZ3317N 4667D 1M	第267批	2014年12月23日
14	中国重汽集团济南卡车股份有限公司	甲醇/柴油双燃料牵引汽车	ZZ4257N 3247D 1BM	第267批	2014年12月23日
15	中国重汽集团济南卡车股份有限公司	甲醇/柴油双燃料牵引汽车	ZZ4257N 3247D 1HM	第267批	2014年12月23日
16	浙江吉利汽车有限公司	甲醇轿车	MR7152L30M	第274批	2015年7月9日
17	浙江吉利汽车有限公司	甲醇轿车	MR7182L12M	第274批	2015年7月9日
18	浙江豪情汽车制造有限公司	甲醇轿车	JL7152L01M	第275批	2015年8月12日
19	浙江豪情汽车制造有限公司	甲醇轿车	JL7182L01M	第275批	2015年8月12日
20	浙江豪情汽车制造有限公司	甲醇轿车	HQ7182L01M	第276批	2015年9月15日
21	浙江豪情汽车制造有限公司	甲醇轿车	HQ7182L02M	第279批	2015年12月9日
22	浙江豪情汽车制造有限公司	甲醇轿车	JL7152L02M	第279批	2015年12月9日
23	浙江豪情汽车制造有限公司	甲醇轿车	JL7182L02M	第282批	2016年4月1日

Development of methanol passenger cars

Geely Motors has developed M100 methanol passenger cars at different grade to meet various kinds of requirements from customers. Some models join in the program initiated by the MIIT.

Vehicles tested in different ambient such as high temp., high plateau and coldest area as well



Vehicle reliability test


Vehicle emission measurement

Gui Yang

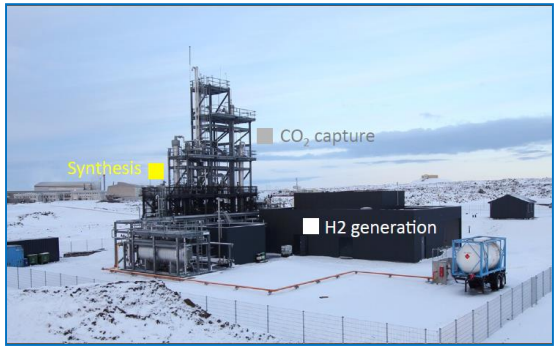
Xi`an

Those vehicles joined in pilot program and still are run in several regions

Currently, 8124 Taxi cars running with methanol in Xi`an, Shaanxi province, and 9699 cars in Guiyang, Guizhou province.

Geely cars exported to the Iceland in Europe

- **The methanol passenger cars produced by Geely Motors has been imported to Iceland in Europe and started to trial running since the year of 2015, which were fueled with the methanol produced from CO2 manufactured by the company CRI (Carbon Recycling International).**



HD Trucks Running with Pure Methanol

- **Truck for heavy duty use developed by Geely has entered in market April.26th, 2019**
- **The displacement of engine is 12.54L， power output 460PS.**

Methanol practiced in CI engines

- The HD trucks equipped with DMCC（Diesel/Methanol Compound Combustion） system joined in the pilot program initiated by the MIIT since April,2014
- 5 HD trucks ran more 2 years and were verified by Shaanxi province and the MIIT respectively in the July, 2017.

Two assembly lines for HD trucks in China

C.S. Cheung, Z.H. Zhang, T.L. Chan, **Chunde Yao**, Investigation on the Effect of Port-Injected Methanol on the Performance and Emissions of a Diesel at Different Engine Speeds, **Energy and Fuel**, **2009**, *23* (11), pp 5684–5694ble)

Methanol applied in vehicles with CI engines

- More than 160 HD trucks equipped with DMCC have undergone to operate for several years in 12 provinces and cities
- Based on the data obtained from field tests, the average ratio of methanol substituted for diesel was more than 30% and the rate of methanol to replace one litter of diesel fuel is just less than 1.5 litter of methanol.

Chunde Yao, *, C.S. Cheung, Chuanhui Cheng, and Yinshan Wang, "Reduction of Smoke and NO*x* from Diesel Engines using Diesel/Methanol Compound Combustion System", [J] **Energy and fuels**, 2007,21, 686-691

Practical examples for vehicle with CI engine

45 trucks running in phosphorus mine, Guizhou province showed that fuel economy improved by 15%.

3 trucks running in coal mine, Xinjiang province. The rate of methanol substituted for diesel 38%, the ratio of methanol to replace diesel at 1.3 within the range of diesel substitution.

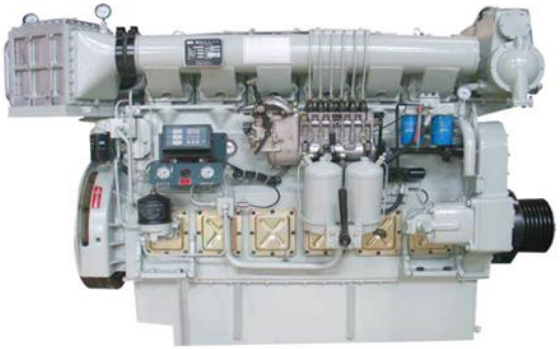
2 loaders working in Tianjin harbor. The rate of operation was increased 10-20%.

Lijiang Wei, Chunde Yao, Quangang Wang, Wang Pan, Guopeng Han， Combustion and emission characteristics of a turbocharged diesel engine using high premixed ratio of methanol and diesel fuel， Fuel

Test of methanol as a marine fuel

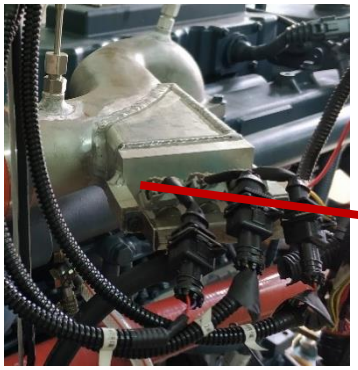
In 2017, the Ministry of Agriculture led the work of using methanol instead of diesel in ships. Tianjin University and Weichai were commissioned to carry out bench tests. The mooring test and fishing boat operation test will be carried out in Nantong in the first half of 2018. The project is supported by the Methanex Group, the largest methanol company in the world.
At present, the Weichai bench has been completed, preliminary performance and emission tests have been completed, and methanol-substituted diesel has shown obvious economic and environmental benefits.

Marine diesel engine methanol transformation

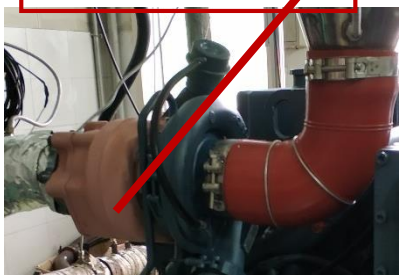


Type	Inline, four-stroke, direct injection, exhaust gas turbocharged intercooler
Number of cylinders	6
Cylinder diameter（mm）	170
Piston stroke（mm）	200
Compression ratio	14.5
Continuous speed（r/min）	1500
Continuous power（kW）	450
Mean effective pressure（MPa）	1.454
Fuel consumption rate（g/kW·h）	196

High-speed ship machine methanol transformation

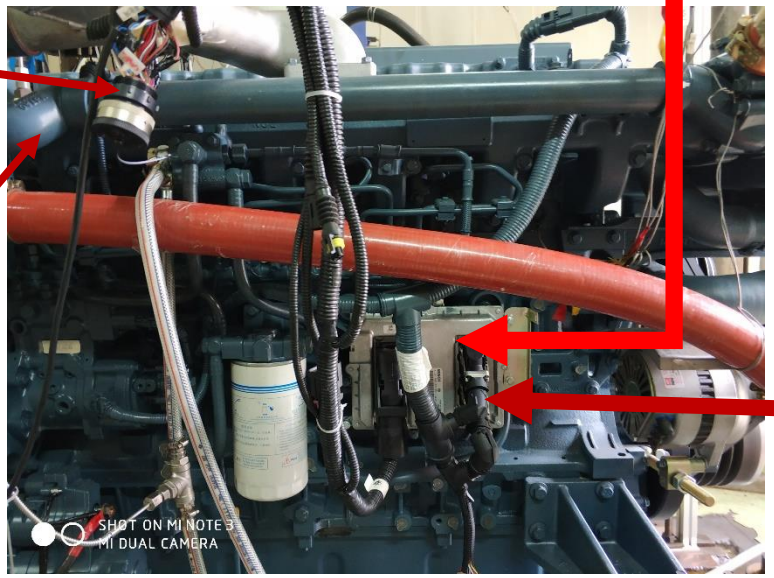


Methanol injector



Supercharger

2 ECUs work together by CAN bus communication



Methanol ECU

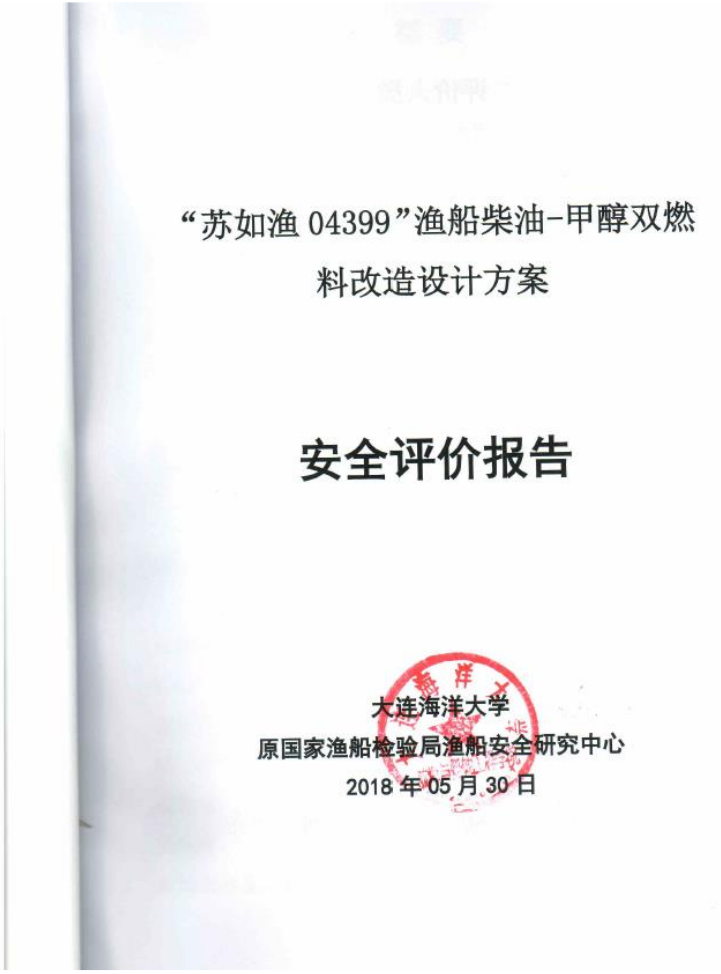
Master computer

A methanol injection and control system is installed on the supercharged intercooled and electronically controlled high pressure common rail engine, which is calibrated and calculated by the main control computer to operate according to the diesel-methanol combined combustion mode. A methanol injection and control system is installed on the supercharged intercooled and electronically controlled high pressure common rail engine, which is calibrated and calculated by the main control computer to operate according to the diesel-methanol combined combustion mode.

First Methanol Vessel Launched in China

Zhong Shan, China- On 23rd of July, a launching ceremony of the first Chinese methanol vessel developed by Jiang Long Shipbuilding Co. Ltd was held.
The vessel is a 49m long and 1,000 DWT dry bulk vessel powered by Yu Chai engine which has Diesel Methanol Compound Combustion technology provided by Tianjin University.

Completed the preliminary safety assessment report


“苏如渔 04399”渔船柴油-甲醇双燃料改造设计方案

安全评价报告

大连海洋大学
原国家渔船检验局渔船安全研究中心
2018 年 05 月 30 日

Conclusions and recommendations of the assessment:

1. The “Suruyu 04399” fishing boat methanol-diesel dual-fuel power retrofit program basically meets the relevant requirements of the competent authority;
2. The risks in the design can be avoided by modifying the design and risk control during the construction process;
3. The technical transformation of fishing vessel DMCC can improve the technology and equipment level of China's fishing vessels, optimize the emission standards of fishing vessels, and help to achieve the strategic goal of “energy saving and emission reduction” for fishing vessels, with good social and economic benefits.

Mooring test for real ship application of methanol fuel

Engine: Weichai 6160, 184kW/1000 rpm. Engine power remains unchanged
The smoke reduction averaged over 60%, 500 rpm decreased by 73.07%, 700 r/min decreased by 54.07%
Fuel economy was improved by 17.3%, methanol replaced diesel by 27.6%, and methanol equivalent to equivalent diesel was 1.1.

DMCC system applied to locomotive engine

The assembly has 4 methanol injectors on it, which can provide methanol to meet the demand of engine power output. Methanol injector kit installed on intake manifold in detail.

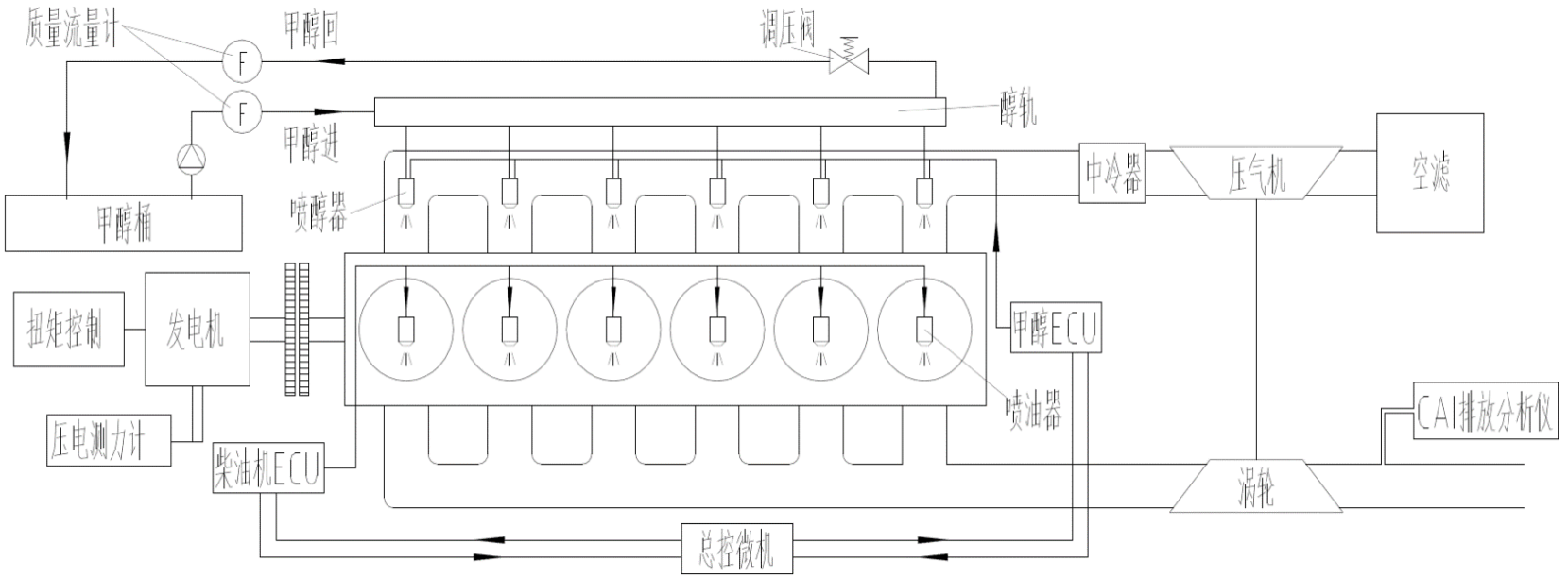
Technical Specifications of the test engine:

4 stroke, Inline,6 cylinders, Turbo-charged; Model: R280ZC

Power output: 1774kW@1000r/min; Compression ratio: 13:1

BMEP: 1.91 MPa;

Methanol system installed on an engine



The engine has two electronic control systems, one for baseline engine, the other for methanol. They can communicate with each other through CAN.

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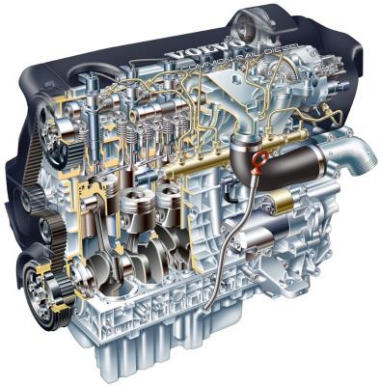
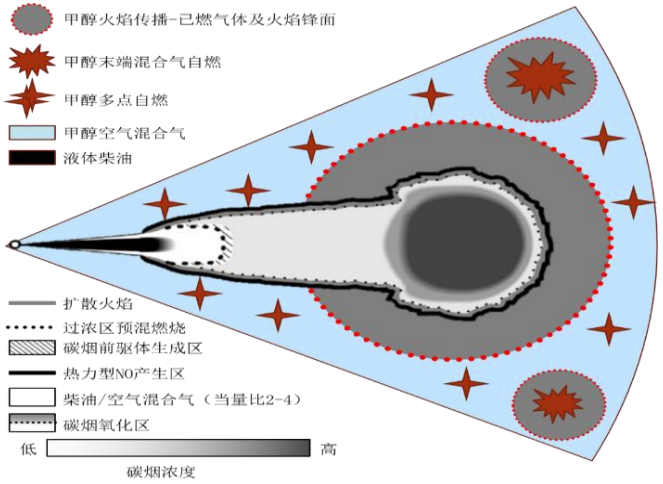
Gasoline/Diesel Methanol dual fuel engine

SI engine：starting with pure gasoline, then switch to methanol after the engine is fully warmed up.

CI engine：starting with pure diesel, then switch to diesel/methanol dual fuel running after the engine is fully warmed up.



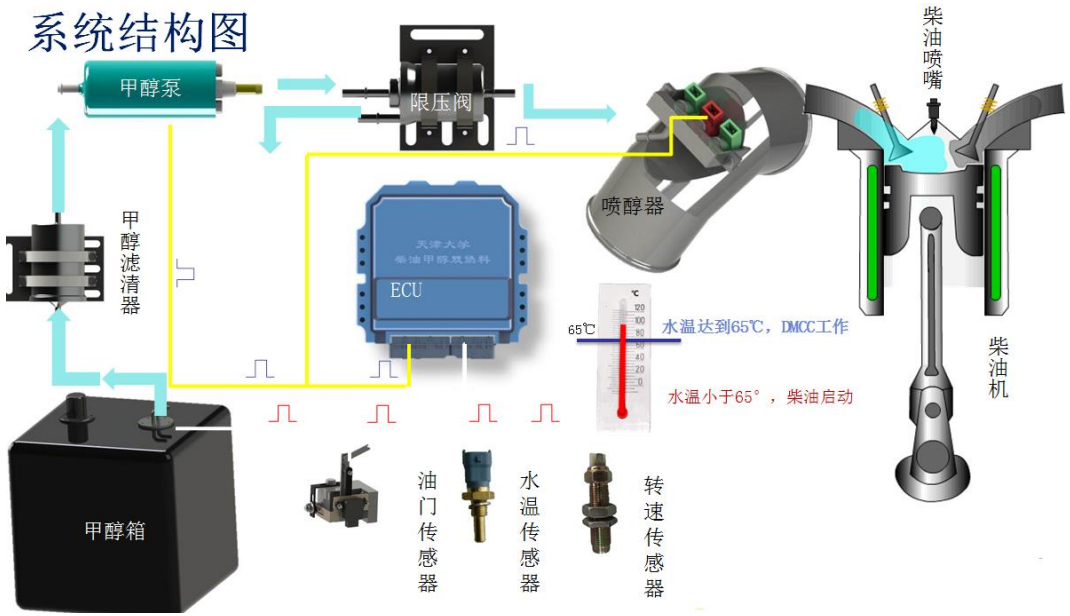


- Two fuel system.
- Three Way Catalyst.
- Recalibration.

- Two fuel system.
- DOC+DPF.
- Recalibration.

Diesel and methanol combined combustion technology and its working characteristics

Fuel properties	Methanol/ ethanol	Diesel	Gasoline
Autoignition temperature℃	450	~205	415℃~530℃
Cetane number	< 5	>45	< 5



Three difficulties in methanol compression ignition:
High Autoignition temp
Poor evaporability
Not miscible with diesel

Diesel methanol combined combustion technology（DMCC）

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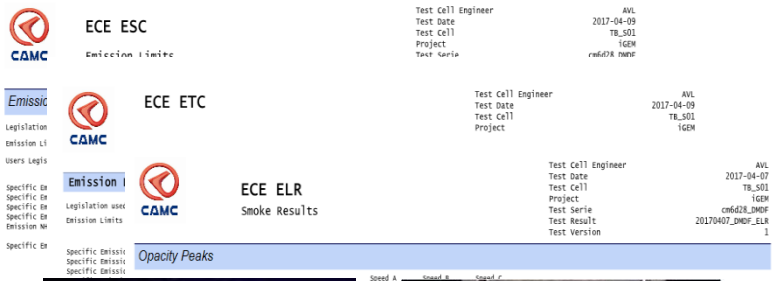
DMCC: China V without NOx aftertreatment

Technical routine :
DMCC+EGR+DOC+CDPF

	Emission Items	HC	CO	NOX	PM
ESC	Limits	0.46	1.5	2.0	0.02
	DMCC	0.007	0	1.7	0.004
ETC	Limits	0.55	4.0	2.0	0.03
	DMCC	0	0	1.8	0.003
ELR	Load response	Limits		DMCC	
	Soot	0.5		0.037	

ESC: HC 1.5%, CO 0 %, NOx 85%, PM 20%
ETC: HC 0 %, CO 0 %, NOx 90 %, PM 10 %
ELR: 7.4%

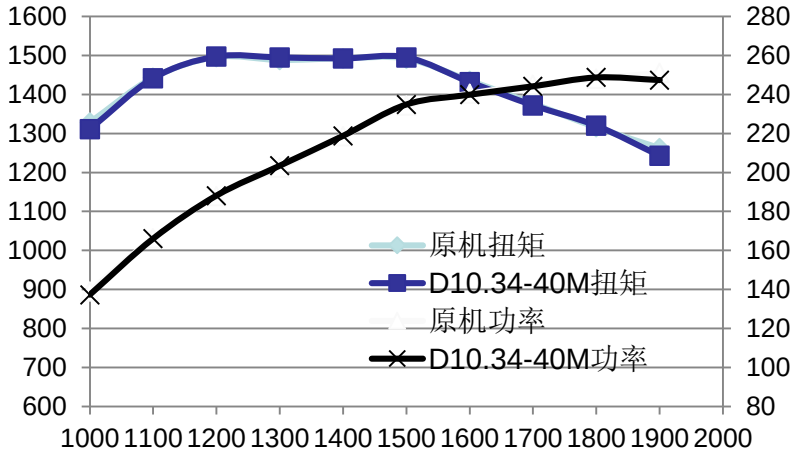


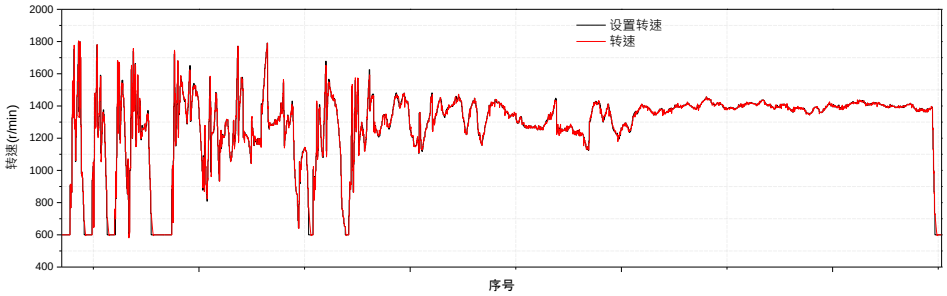
DOC **CDPF**

DOC+CDPF

Peng Geng, Chunde Yao, Lijiang Wei, Junheng Liu, Quangang Wang, Wang Pan, Jianyun Wang, Reduction of PM emissions from a heavy-duty diesel engine with diesel/methanol dual fuel, Fuel 123 (2014) 1–11

DMCC: full power output





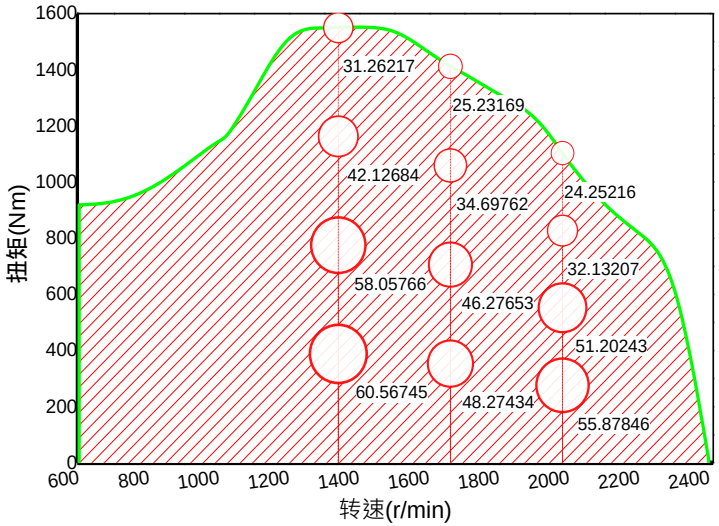
Engine response performance
-acceleration is better than baseline

Methanol quickly burns to secure the acceleration of vehicle

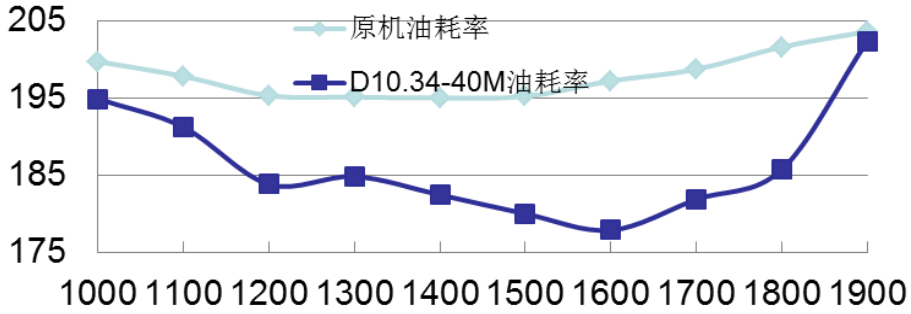
Dual fuels burn more fuel than those of single one per unit time

Junheng Liu, Anren Yao, Chunde Yao, Effects of injection timing on performance and emissions of a HD diesel engine with DMCC. Fuel 134 (2014) 107–113

DMCC: engine thermal efficiency improvement



Methanol substituted for diesel >50%



10L diesel engine for HD vehicle

Maxi. ratio of methanol substituted for diesel	Average ratio methanol substituted for diesel
45.6%	32.7%

Brake thermal efficiency increased by 8.7%, the maximum value increased from 43.4% of baseline engine to 47.6% of the DMCC engine.

Junheng Liu, Anren Yao, Chunde Yao, Effects of diesel injection pressure on the performance and emissions of a HD common-rail diesel engine fueled with diesel/methanol dual fuel, Fuel 140 (15 January, 2015) ,Pages 192–200, DOI: 10.1016/j.fuel.2014.09.109

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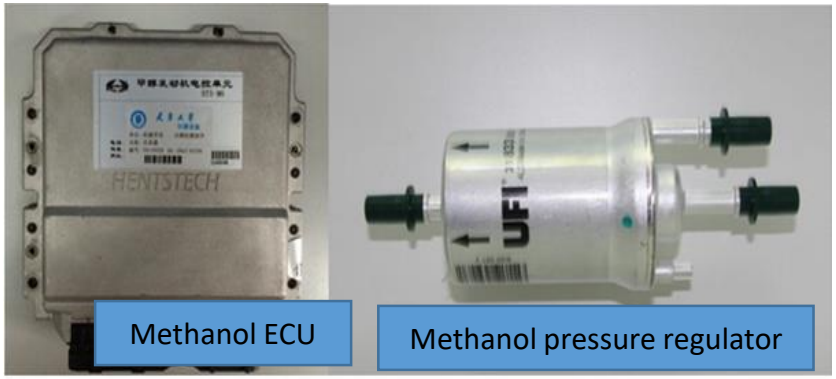
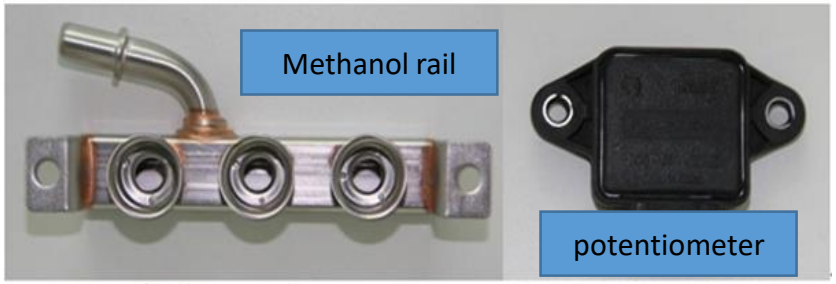
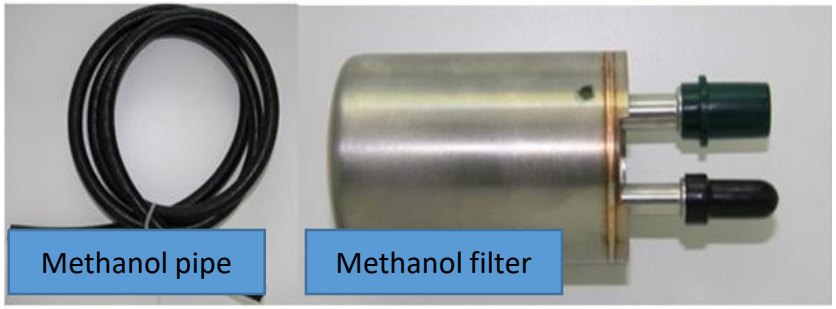
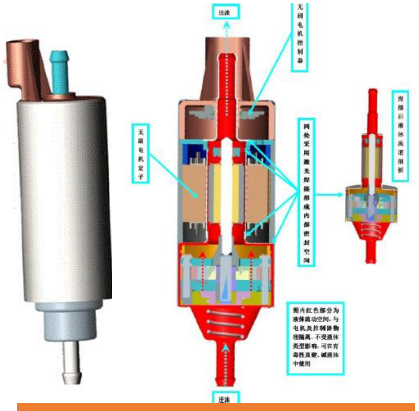
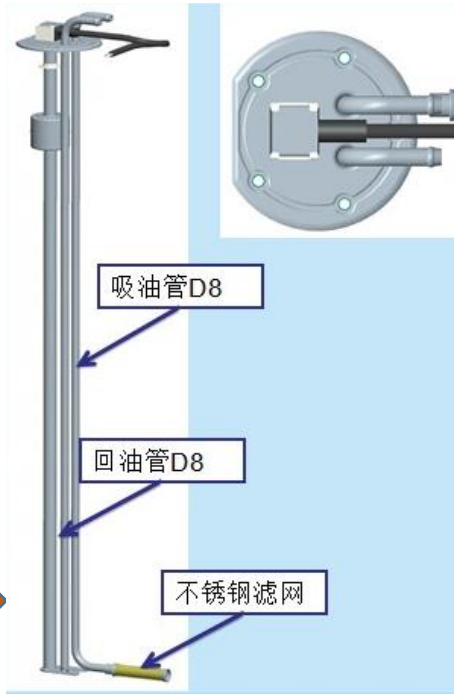
Component developed with anti-methanol corrosion









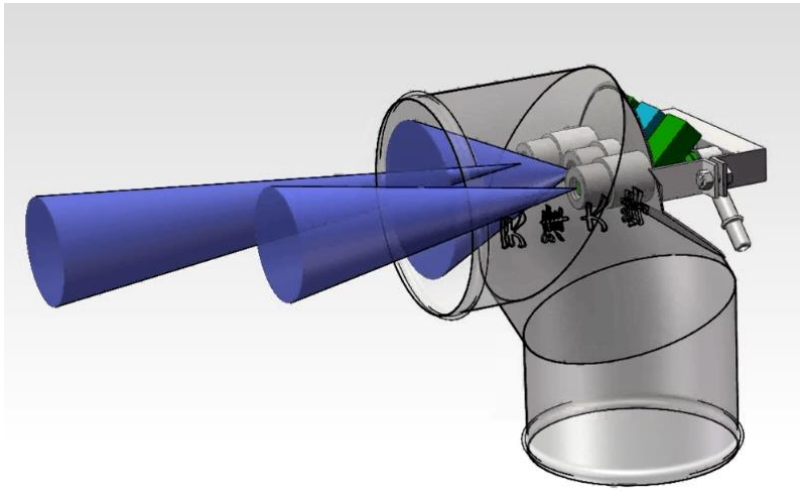


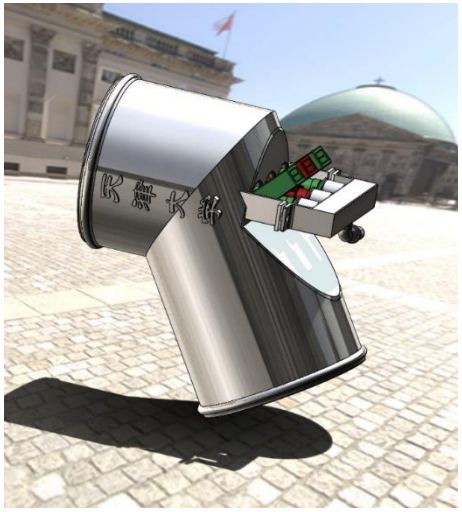

Methanol injector


Methanol cluster

ZL 2012 2 0579003.1, ZL 2012 2 0581363.5, ZL 201320894154.0

Developed various of methanol injectors





ZL 2012 2 0535175.4, ZL 2012 3 0535162.7, ZL 2012 3 0535330.2

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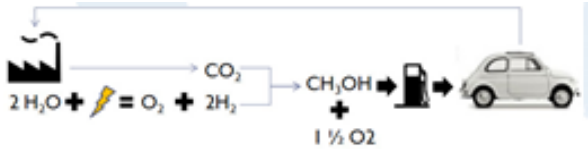
Methanol industry in China

CRI(Carbon Recycling International) starts to produce methanol converted from CO2 with hydrogen, annual productive volume 4000 tons, in 2011.

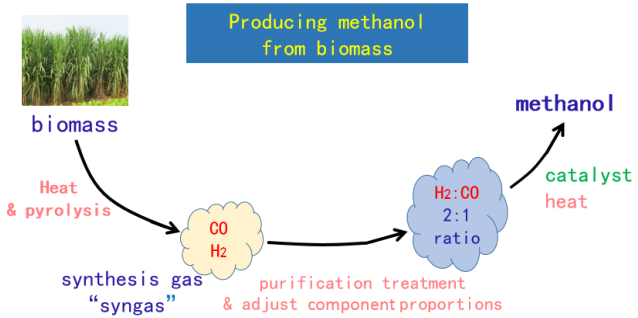
Geely Motor group cooperated with CRI in 2016, and planned to use the technology to produce methanol in China also.

China is the largest methanol production country in the world, its productive capacity 87,59 Million tons, methanol production 66.39 Million tons in 2018.

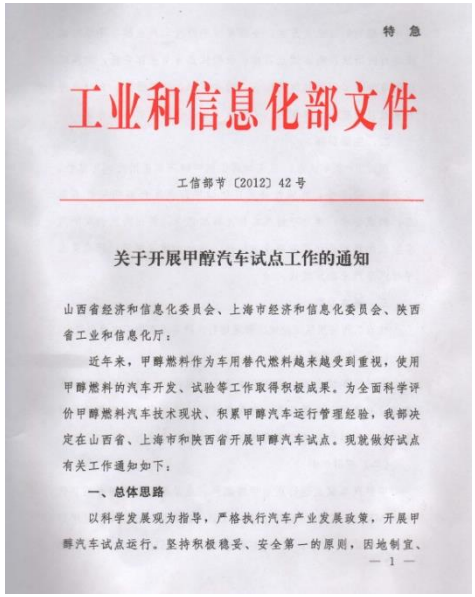
More than 70% methanol is produced from coal, the rest from coal-gas and natural gas respectively. There are more 200 plants to produce methanol distributed in the whole country except Beijing, Tibet and several regions.



Carbon balance cycle



Methanol as fuel promoted by the government



特 急

工业和信息化部文件

工信部节〔2012〕42号

关于开展甲醇汽车试点工作的通知

山西省经济和信息化委员会、上海市经济和信息化委员会、陕西省工业和信息化厅：

近年来，甲醇燃料作为车用替代燃料越来越受到重视，使用甲醇燃料的汽车开发、试验等工作取得积极成果。为全面科学评价甲醇燃料汽车技术现状，积累甲醇汽车运行管理经验，我部决定在山西省、上海市和陕西省开展甲醇汽车试点。现就做好试点有关工作通知如下：

一、总体思路

以科学发展观为指导，严格执行汽车产业发展政策，开展甲醇汽车试点运行。坚持积极稳妥、安全第一的原则，因地制宜、

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中华人民共和国国务院办公厅
政府信息公开专栏

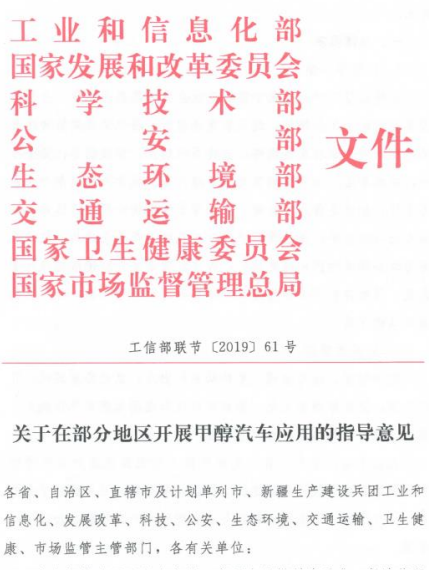
索 引 号：000014349/2013-00025　　主题分类：国土资源、监察\其他
发布机构：国务院办公厅　　发文日期：2013年02月06日
名　　称：国务院办公厅关于加强内燃机工业节能减排的意见
文　　号：国办发〔2013〕12号　　主 题 词：

国务院办公厅关于加强内燃机工业
节 能 减 排 的 意 见

国办发〔2013〕12号

各省、自治区、直辖市人民政府，国务院各部委、各直属机构：

内燃机是交通运输、工程机械、农业机械、渔业船舶、国防装备的主导动力设备，内燃机工业是重要的基础产业。经过多年发展，我国内燃机工业取得了长足进步，内燃机产品节能减排等技术水平有了很大提高，我国已成为全球内燃机生产和使用大国。但与国际先进水平相比，我国内燃机产品在节能环保指标上仍有较大差距，关键核心技术欠缺，节能减排标准体系不健全，高能耗、高排放、低性能内燃机产品仍在广泛使用，内燃机工业节能减排的潜力巨大。为加强内燃机工业节能减排，促进节约石油资源和改善空气质量，经国务院同



工业和信息化部
国家发展和改革委员会
科学技术部
公安部
生态环境部
交通运输部
国家卫生健康委员会
国家市场监督管理总局
文件

工信部联节〔2019〕61号

关于在部分地区开展甲醇汽车应用的指导意见

各省、自治区、直辖市及计划单列市、新疆生产建设兵团工业和信息化、发展改革、科技、公安、生态环境、交通运输、卫生健康、市场监管主管部门，各有关单位：

The pilot program started in several regions in China by MIIT (Ministry of Industrial and Information Technology)

Methanol as alternative fuel for heavy duty diesel engine was promoted by the State office of China in February, 2013

<To promote methanol vehicles utility in part regions in China> promulgated by MIIT and the other 7 ministries in March, 2019

Summary

Methanol as transportation fuel has been applied in various fields in China. The test results show that it is very friendly to environment and easy for delivery, and is able to provide power output as we want. We believe that methanol will play an important role in energy utility in future.

Thank you for your listening!

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