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DFCV Solution of CN VI Heavy Duty Diesel Engine for Commercial Vehicle Applications

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Oct 2019

Wuxi, China

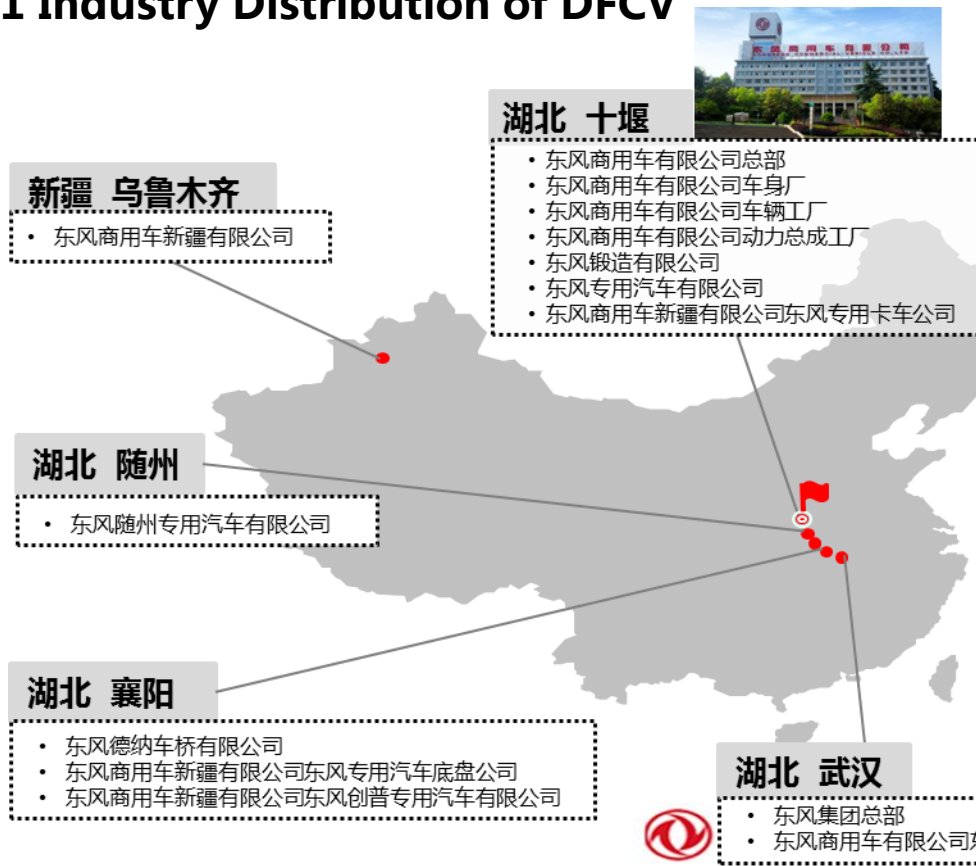


东风商用车技术中心
DONGFENG COMMERCIAL VEHICLE TECHNICAL CENTER

- 1 DFCV Introduction**
- 2 Development Environment and Challenges of HDD Engines in China**
- 3 DFCV Technology Solution of CN VI HDD Engine**
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- 5 DFCV Technology Development Direction of HDD Engine**
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1 DFCV introduction

1.1 Industry Distribution of DFCV



Dongfeng Commercial Vehicle Co., Ltd.

- originated from the Second Automobile Works of China founded in 1969
- Inherited the main business of Dongfeng Brand MD and HD commercial vehicle business
- Over 23,000 employees
- Vehicle sales of 0.17 million, with 13% market share.

Dongfeng Commercial Vehicle Technology Center

- Undertake the research and development work of vehicles and key assemblies for DFCV.

Three Cities and Four Districts

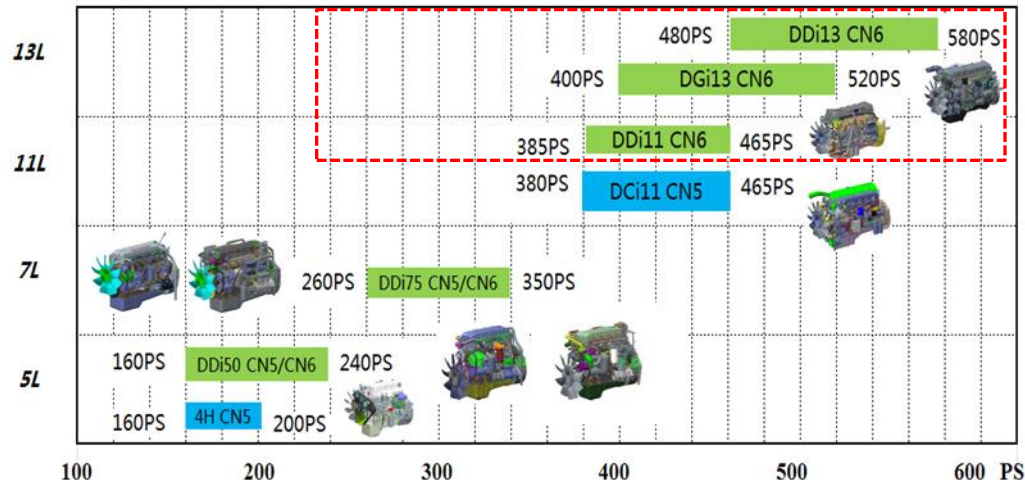


1 DFCV introduction

1.2 DFCV Vehicle and Engine Product Portfolio

□ DFCV vehicle product portfolio: 5 platforms to meet the requirement of different market segments and customers.

Newly developed CN VI engine platform products to meet domestic HD truck market demand.

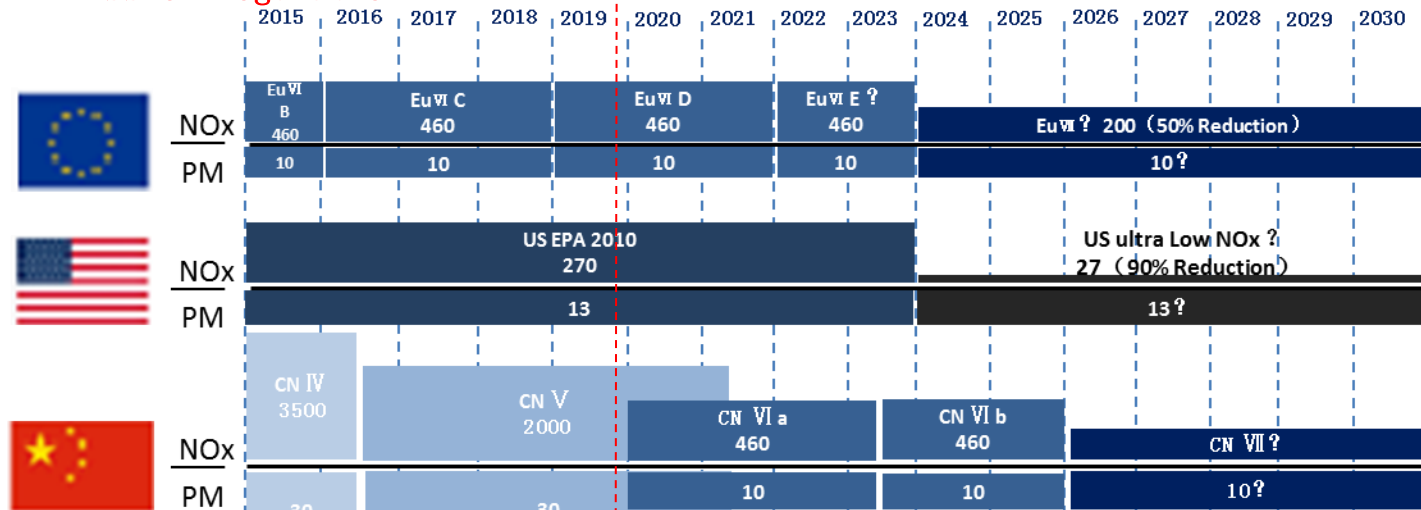


□ DFCV engine product portfolio : displacement from 4.7L to 12.9L, power from 160Ps to 580Ps

2.1 Regulation Environment (1/2)

Emission regulation

Now



Unit: mg/kWh

全国重型柴油车 2021.07 CN VI a

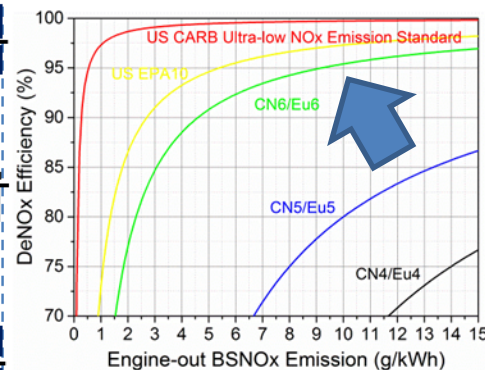
全国城市车辆 2020.07 CN VI a

部分地区柴油车 2019.07 CN VI b



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DONGFENG COMMERCIAL VEHICLE TECHNICAL CENTER

CN VI OBD Challenge

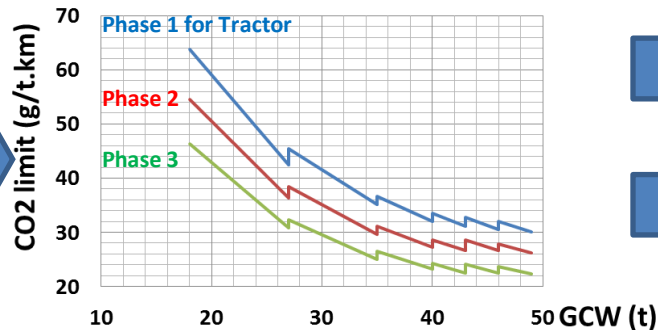
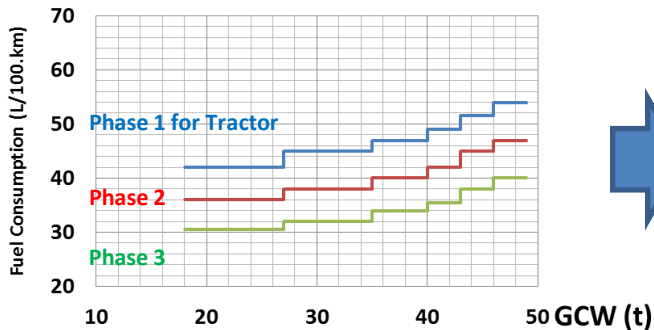
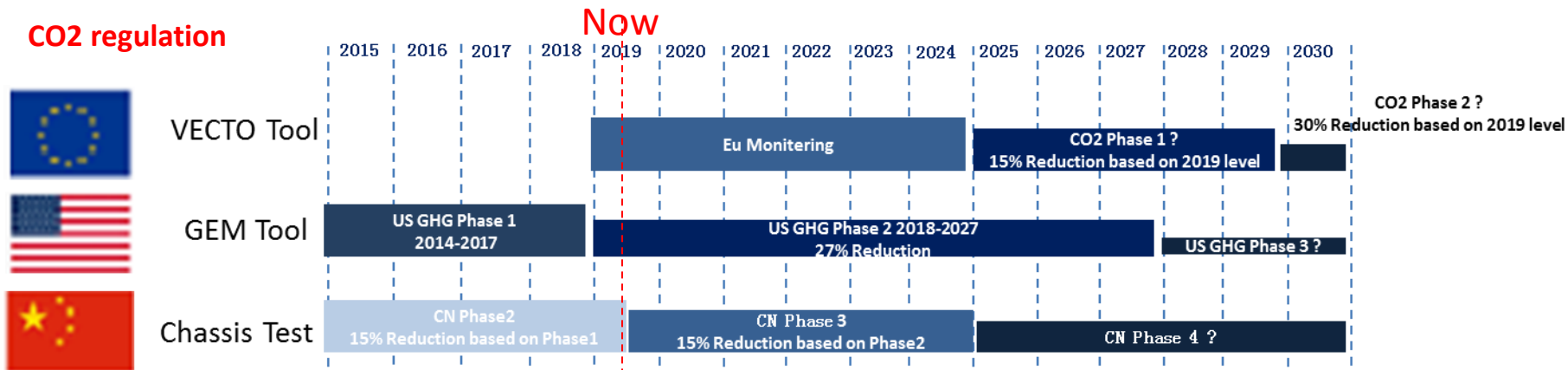


HDD CN5 / **SCR** / 8-12g/kWh / **SCR** 75-85%

HDD CN6 **EGR or SCR only?** / ? g/kWh / **SCR** ?%

2.1 Regulation Environment (2/2)

CO2 regulation



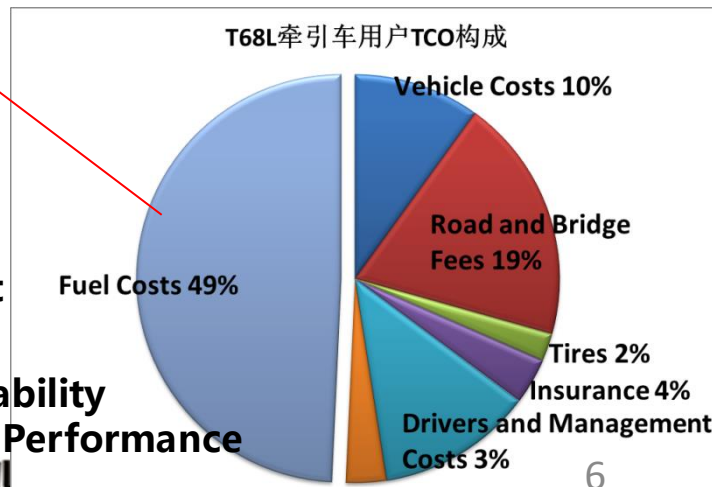
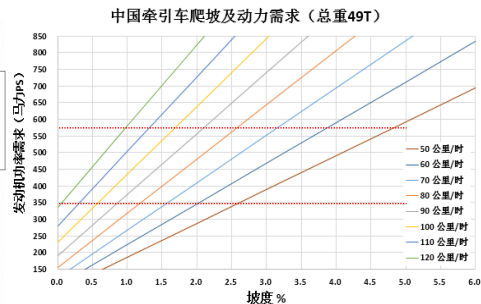
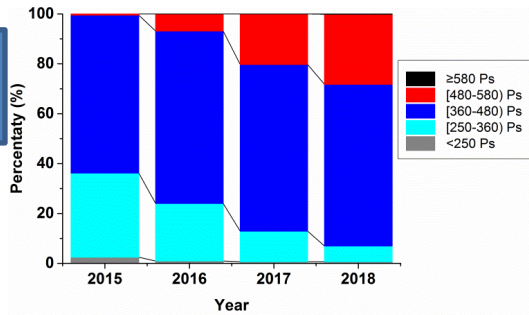
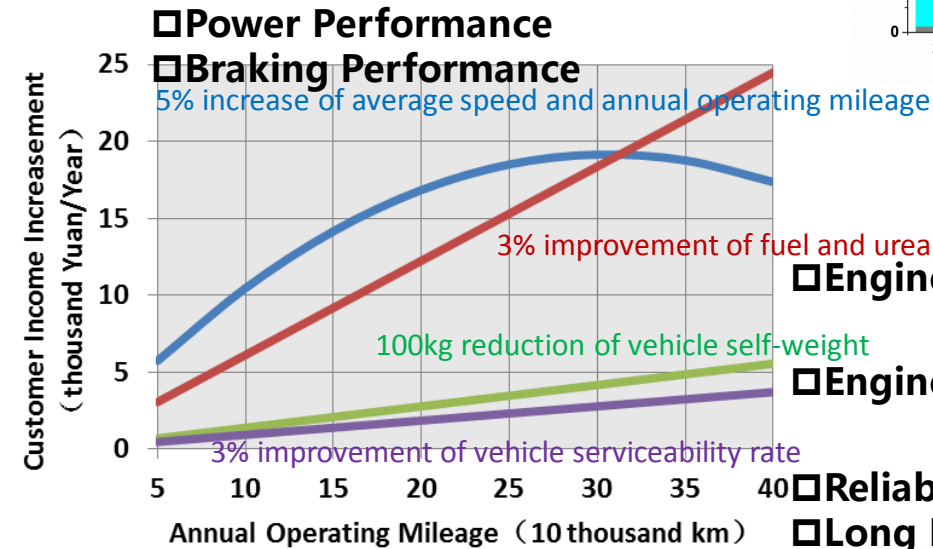
HDD CN5 Phase2 / **43-45%**



HDD CN6 Phase3/ **? %**

2.2 Market and Customer Requirement Environment

How to meet the demand of different market segments and customers?



3 DFCV Technology Solution of CN VI HDD Engine

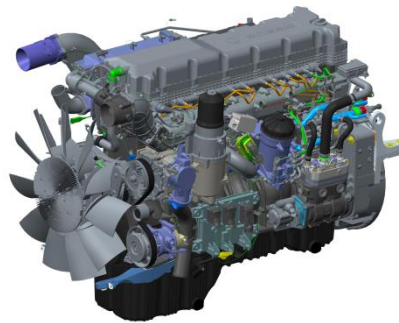
Controllable EGR Technology

High Efficiency and Clean
Combustion Technology

High Robustness Emission
Control Technology



DDi11



DDi13

Engine Lightweight
Technology

High PCP Base Engine
Technology

Long Maintenance Mileage
Technology

Intelligent Thermal
Management Technology

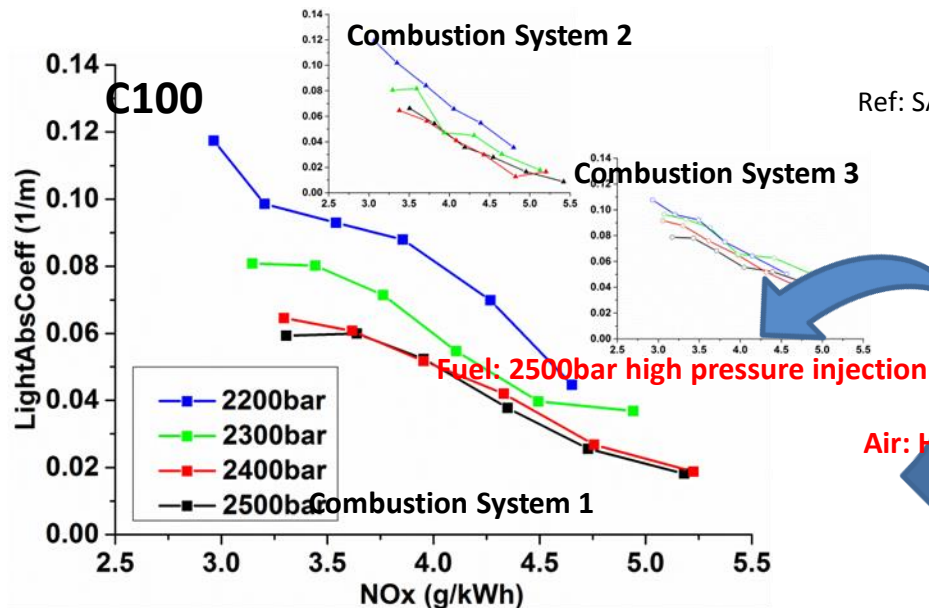
High Performance Engine
Brake Technology

□ In order to cope with the challenges of CN6 HDD engine market, DFCV has developed eight core technologies and two products

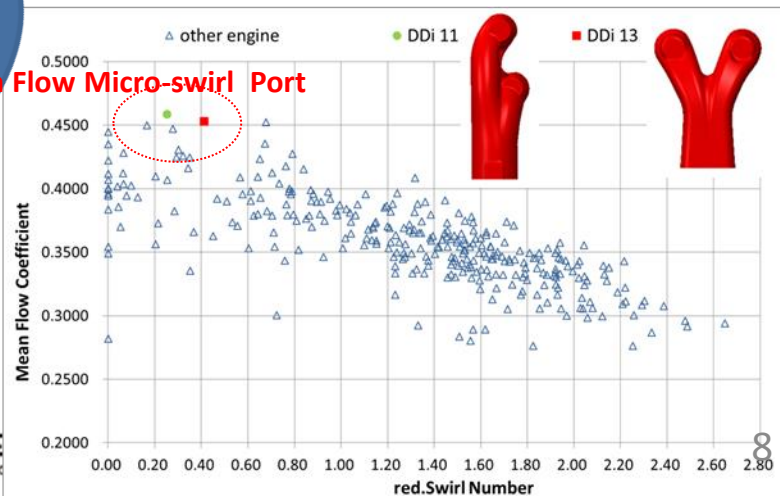
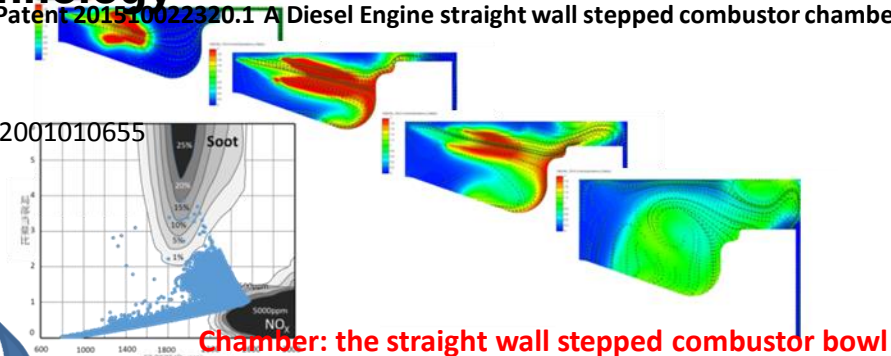
3 DFCV Technology Solution of CN VI HDD Engine

3.1 High Efficiency and Clean Combustion Technology

Patent 201510022320.1 A Diesel Engine straight wall stepped combustor chamber



Ref: SAE2001010655



DFCV HDD engine:

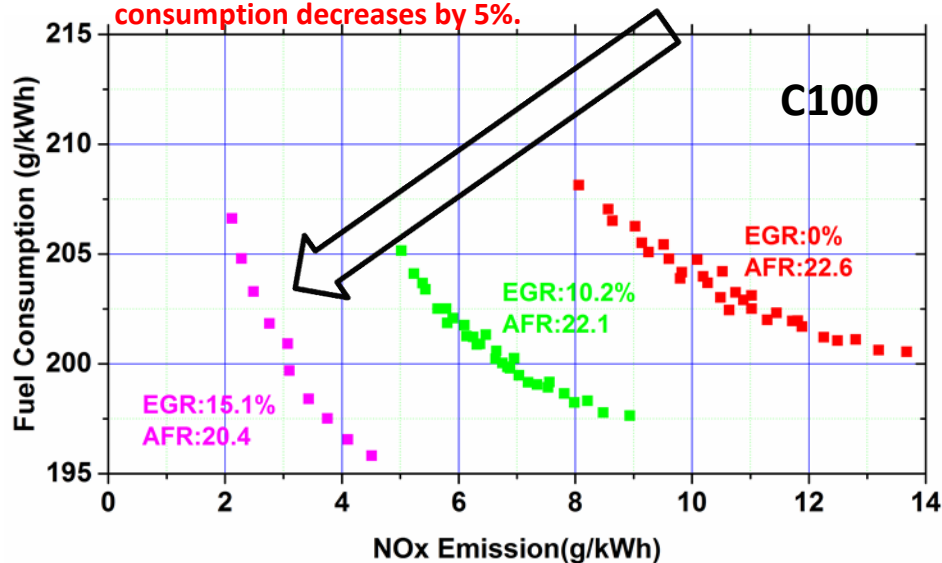
□ Raw PM Emission < 0.02g/kWh

□ Fully passive regeneration at expressway and

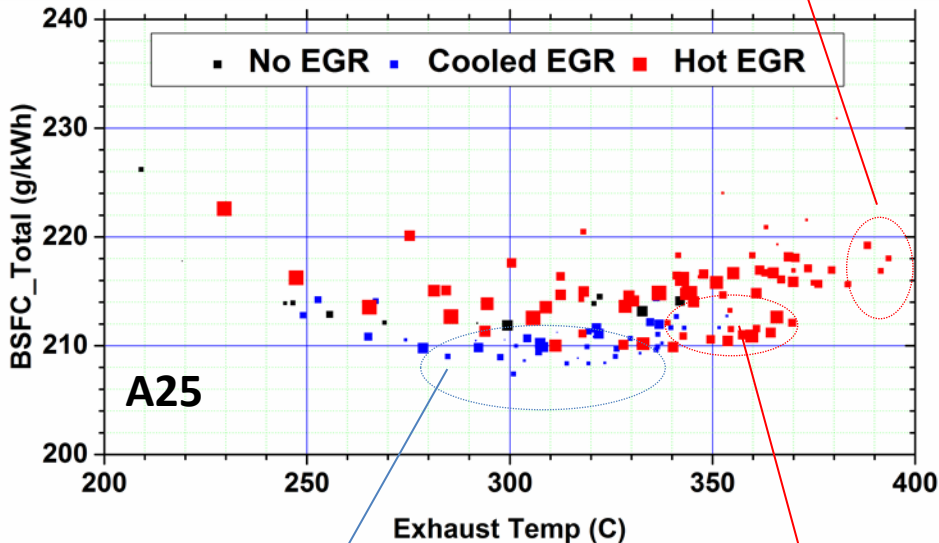
suburban conditions

3.2 Controllable EGR Technology (1/2)

As the EGR rate increases the fuel and urea total consumption decreases by 5%.



Regardless of total consumption, the Hot EGR mode can achieve higher exhaust temp by 50 degrees.



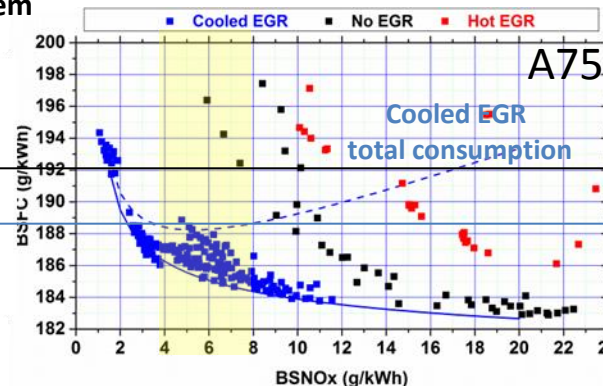
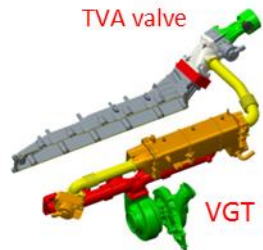
Regardless of engine exhaust temp, the Cooled EGR mode can achieve better total consumption by 2%

Exhaust temp of Hot EGR can be improved by 20 degrees under the same total consumption level

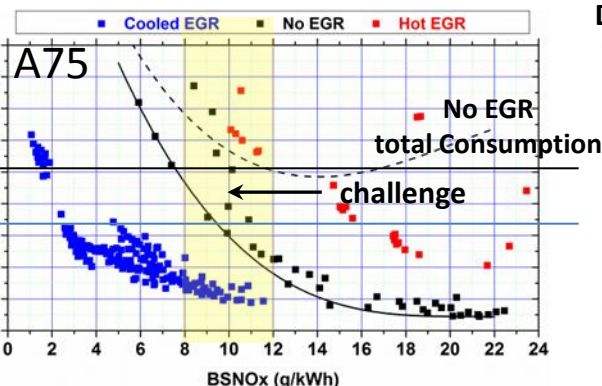
- ❑ Cooled EGR mode can achieve better fuel and urea economy.
- ❑ Hot EGR mode can achieve better exhaust temperature performance.

3.2 Controllable EGR Technology (2/2)

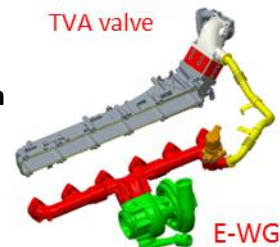
DDi13 Cooled EGR System



2% advantage Cooled EGR vs No EGR, no advantage for Hot EGR

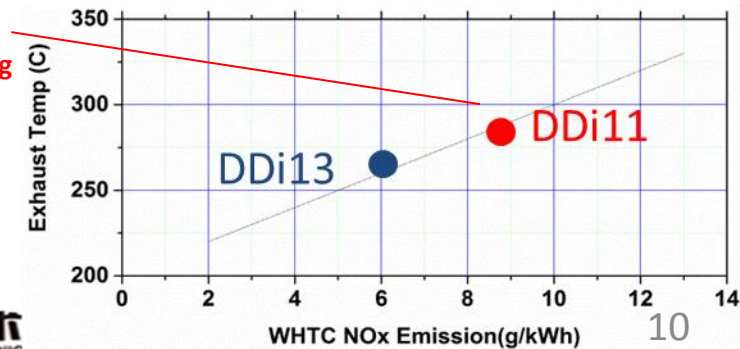


DDi11 Hot EGR System

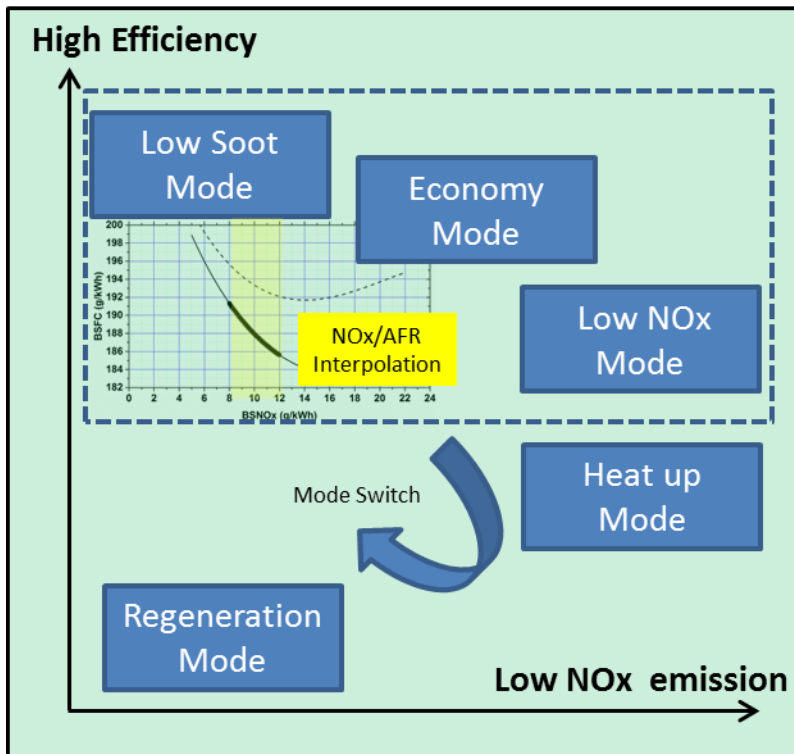


- EGR Closed at medium and high load conditions to improve economy
- EGR Opened at low load conditions to increase engine exhaust temp facilitating aftertreatment conversion efficiency.

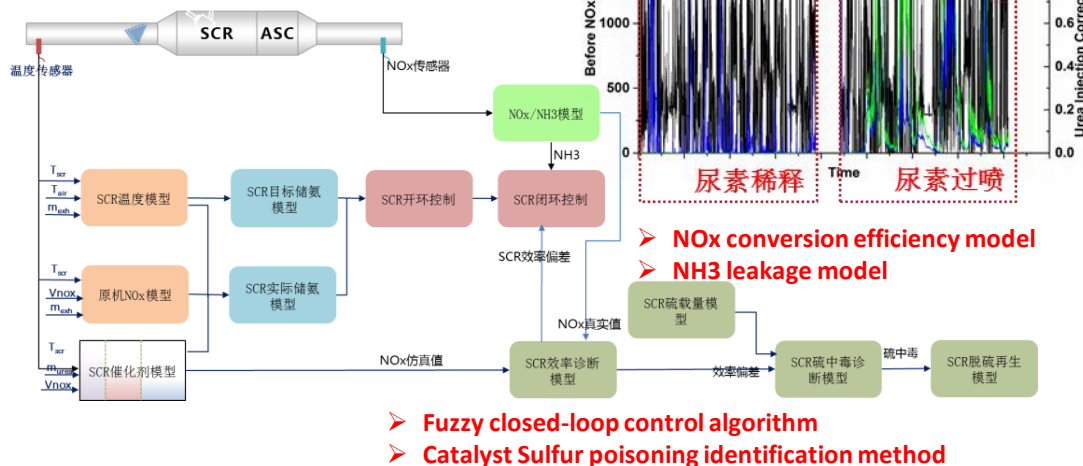
□ Different concept design to meet different feature demand.



3.3 High Robustness Emission Control Technology



- ❑ Engine Multi-mode Operation Technology
- ❑ SCR Closed Loop Control Technology
- ❑ High S Fuel adaptive control Technology



➢ short-term tolerance of 350 ppm high S fuel.

Patents: SCR Sulfur Poisoning and Desulfurization Regeneration Strategy
Based on Sulfur Load and Low SCR Efficiency

3.4 High PCP Base Engine Technology

Different thermal and mechanical load boundaries and durability requirements

DDi13: 240bar, 33kW/L, 1.6 million km

DDi11: 210bar, 31kW/L, 1.2 million km

Patent 201711216908.6 An Engine Cooling System and Its Cooling Method

HCF

HCF Require: DDi13

HCF Require: DDi11

LCF Require: DDi13

LCF Require: DDi11

24 design variables

Within the same concept design there is trade-off relationship between HCF and LCF

□ Different concept design to meet different PCP and durability requirements.

CGI

Counter-current Cooling Strategy

Parallel Valve Layout

DDi13

Grey Iron

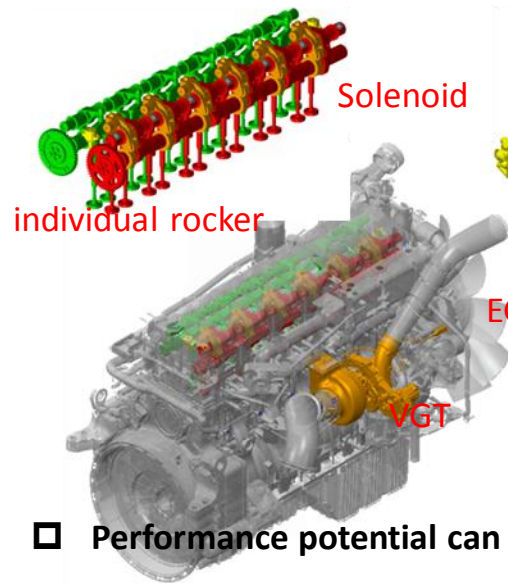
Conventional Cooling Strategy

Inclined Valve Layout

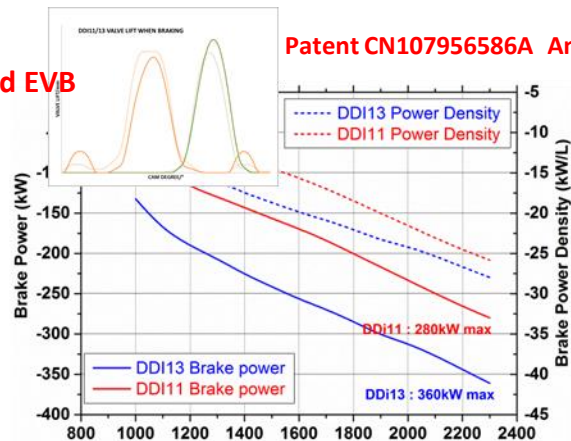
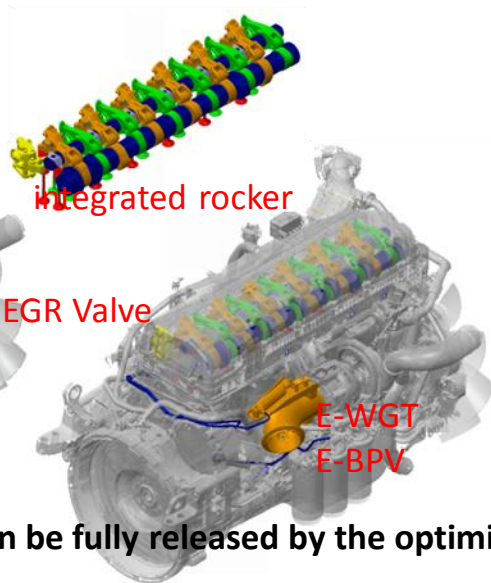
DDi11

3.5 High Performance Engine Braking Technology

DDi13 Electronically Controlled VGT Combined Braking Technology



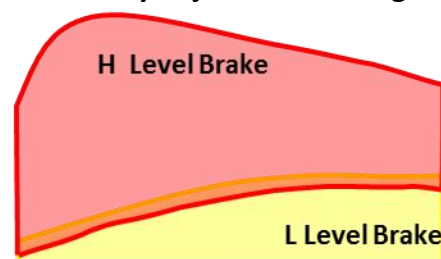
DDi11 Electronically Controlled E-WG and EVB Combined Braking Technology



Patent CN107956586A An Engine Brake Actuator



Continuously adjustable braking



- Performance potential can be fully released by the optimization of valve lift.
- Different air system design to meet the same requirement of Continuously adjustable braking function.

3.6 Intelligent Thermal Management Technology

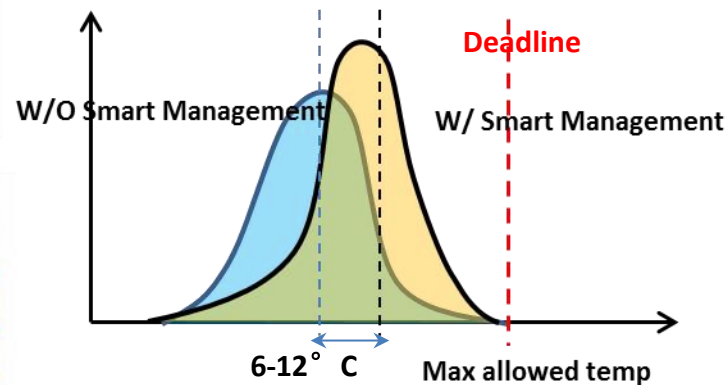
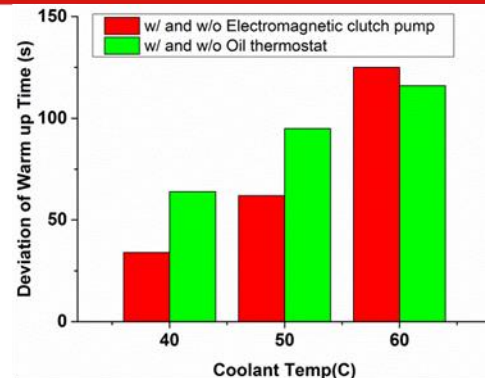
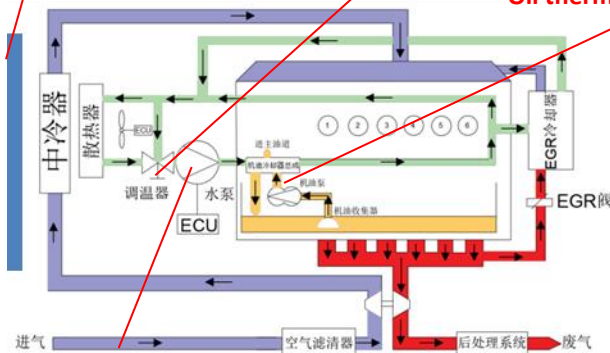
- Vehicle speed
- Ambient temp
- **Coolant temp**
- **Oil temp**
- Engine condition
- Accessory demand

Electronically Controlled Silicone Oil Clutch Fan

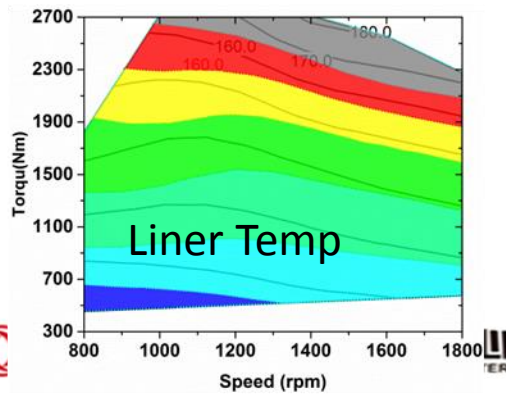
Coolant thermostat

Oil thermostat

Two Stage Electromagnetic clutch pump



- ❑ Warm up time decreased by 1/6.
- ❑ Average coolant and oil temperatures increased by 6-12 degree.
- ❑ Semi-clutch pump drive mode can be used in 90% area of operating conditions.
- ❑ Improvement of vehicle economy by 1.5%

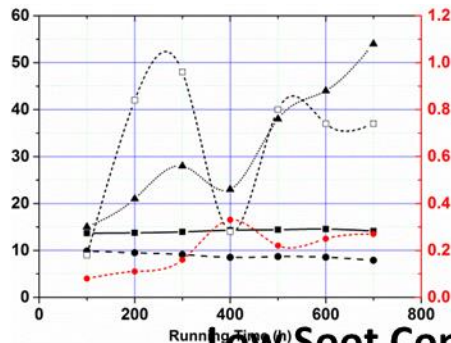


3 DFCV Technology Solution of CN VI HDD Engine

3.7 Long Maintenance Mileage Technology

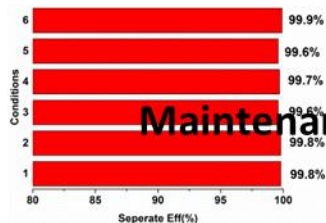
- Exceed API CK-4 and ACEA E6 standards
- Low ash, low sulfur, low phosphorus, high alkali value oil

DFCV-L60 Long-life Oil

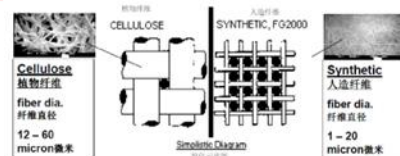


Low Soot Combustion System

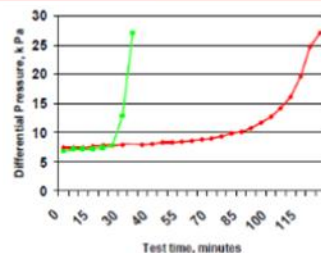
- Oil separation efficiency of OCV > 99.8%
- Oil fuel consumption ratio < 0.05%



Maintenance-free Oil-gas Separator



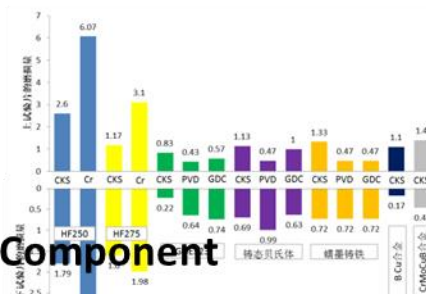
Long-life Oil Filters



- the ash-dissolving ability is improved by 300%

0.15 million km

Low Friction Component



Using PVD piston ring and alloy cylinder liner:

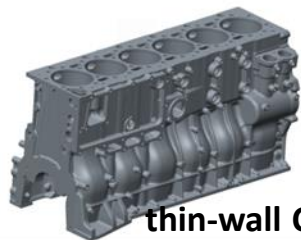
- The friction coefficient decreases by 30%.
- The wear rate decreased by 58%/39%.

Low Oil Consumption PCU System

3.8 Engine Lightweight Technology

laser welding low compression height piston

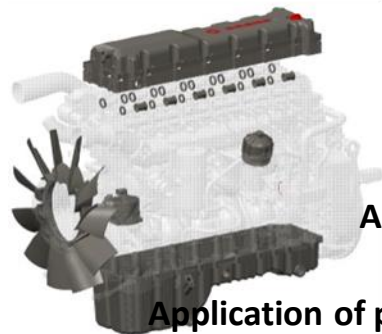
high strength
connecting rod material



thin-wall CGI cylinder head and block



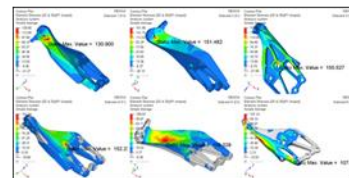
Application of aluminum alloy



Application of plastic



combined camshaft

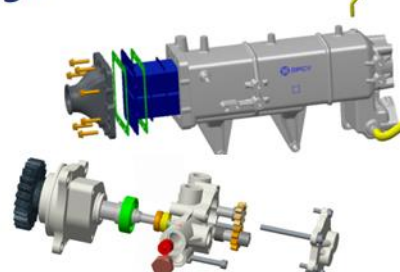


topology and topography optimization



integrated cooling module

integrated EGR cooler



integrated fuel pump unit



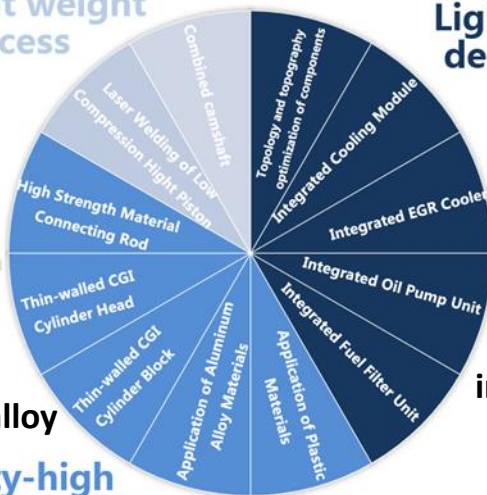
integrated fuel filter unit

16

Light weight
process

Light weight
design

Low density-high
strength materials



4 DFCV Product Solution of CN VI HDD Engine

4.1 DFCV 11L HDD Product



- 35,000 hours bench test
- 1.2 million km vehicle test

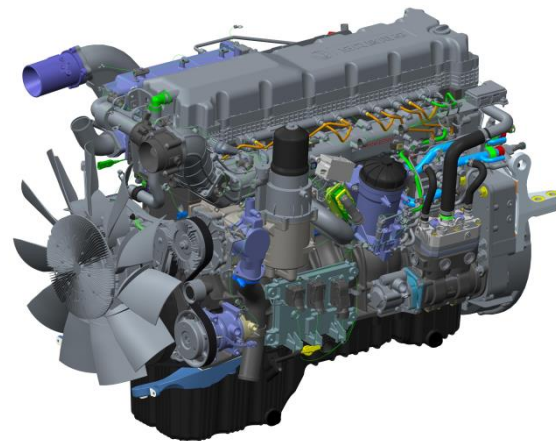
Platform		Unit	DDi11
Emission		-	CNVI b
Technical Solution	Bore × Stroke	mm	123 × 152
	Displacement	L	10.8
	Air System	-	Hot EGR+E-WGT
	Fuel System	-	HPCR 2500bar
	Aftertreatment System	-	DOC+DPF+SCR+ASC
	Designed PCP	-	210bar
Performance	Power	Ps	385 - 465
	Torque	N.m	1935 - 2240
Economy	BSFC	g/ kW.h	186 min
	Urea/Fuel Ratio	-	8%
Durability	B10 life	km	1.2 million
Weight	Dry Weight	kg	965
Braking	Braking Power	kW	280 max
Maintenance	Oil Maintenance Mileage	km	0.1 million max

□DDi11 platform adopts Hot EGR and E-WGT technology considering the comprehensive features of economy, reliability ,cost and weight , to provide customers with reliable value-based power products

4 DFCV Product Solution of CN VI HDD Engine

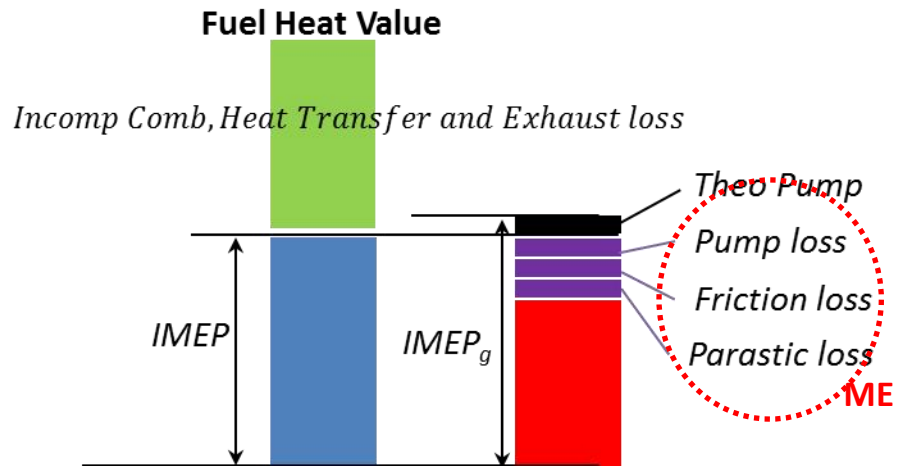
Platform		Unit	DDi13
Emission		-	CNVI b
Technical Solution	Bore×Stroke	mm	131×160
	Displacement	L	12.9
	Air System		Cooled EGR+VGT
	Fuel System		HPCR 2500bar
	Aftertreatment System		DOC+DPF+SCR+ASC
	Base Engine		220bar
Performance	Power	Ps	480 – 580
	Torqu	N.m	2500 – 2700
Economy	BSFC	g/ kW.h	184 min
	Urea/Fuel Ratio	-	5%
Durability	B10 life	km	160万
Weight	Dry Weight	kg	1030
Braking	Braking Power	kW	360 max
Maintenance	Oil Maintenance Mileage	km	15万 max

4.2 DFCV 13L HDD Product



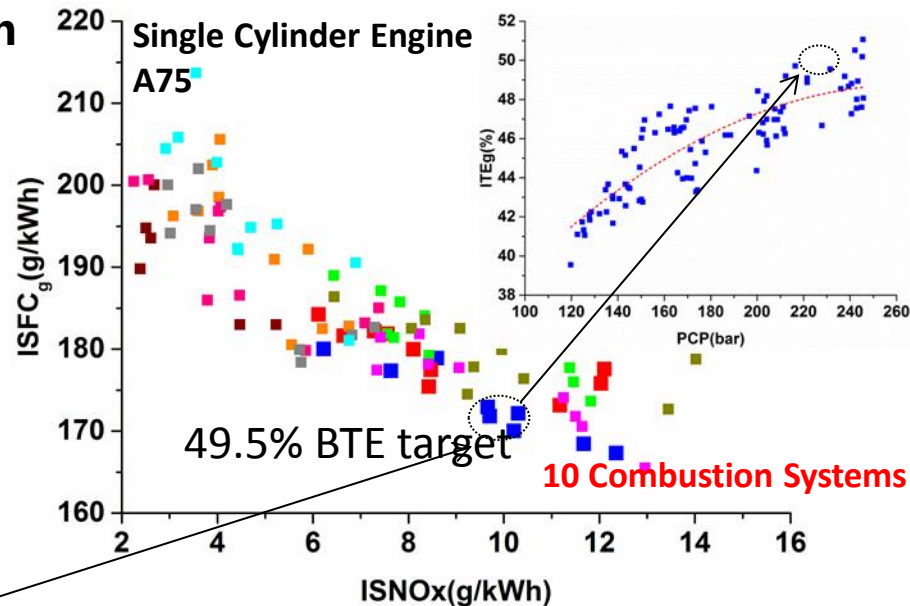
- ❑ DDi13 platform adopts Cooled EGR and VGT technology pursuing the optimization features of economy and power, to provide high-end quality-based products

5.1 Thermal Efficiency Improvement Direction



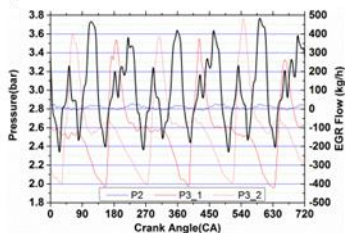
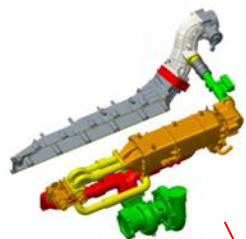
A75 Without Rankine cycle technology

BTE	46%	48%	50%
ITEg	48.3%	49.5%	50.7%
Theo Pump	99.4%	101%	102%
ME	95.7%	96.1%	96.6%
PCP	220bar	250bar	280bar



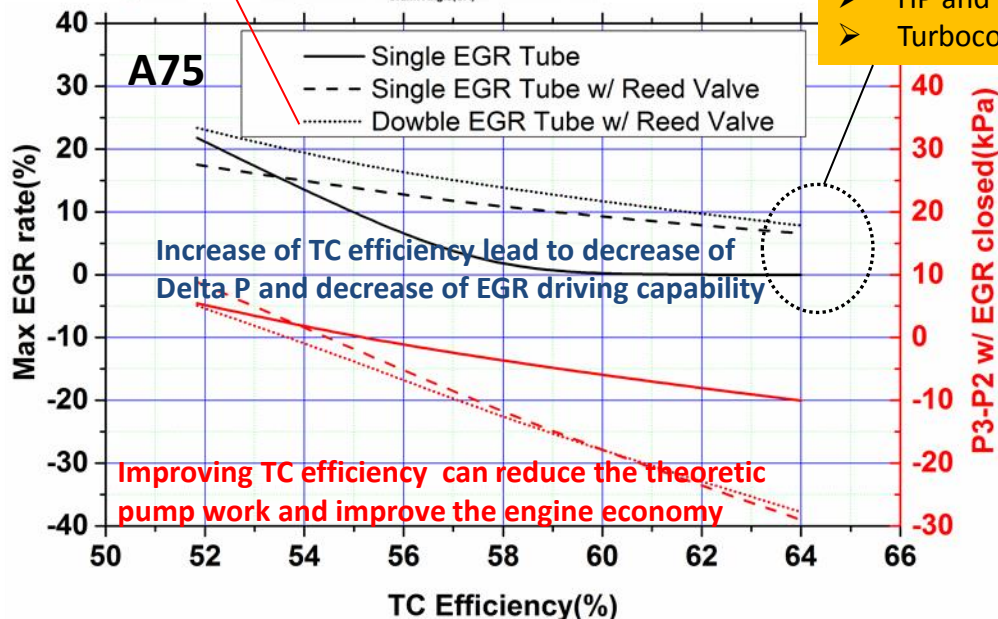
- ITEh increased by 0.4% with PCP increased by 10 bar.
- 49.5% ITEg has been realized in single cylinder engine with NOx emission of 10g/kWh

5.2 High Efficiency Turbocharge System



□ DFCV carried out turbocharge matching work with dual tube EGR system, and realize 101% pump efficiency

- HP and LP EGR?
- Turbocompound?



BTE 48%

BTE 50%

Pump = 102%
TC_Eff 64%
Delta P=-40kPa

Pump = 101%
TC_Eff 58%
Delta P=-22kPa
EGR 15%

BTE 46%

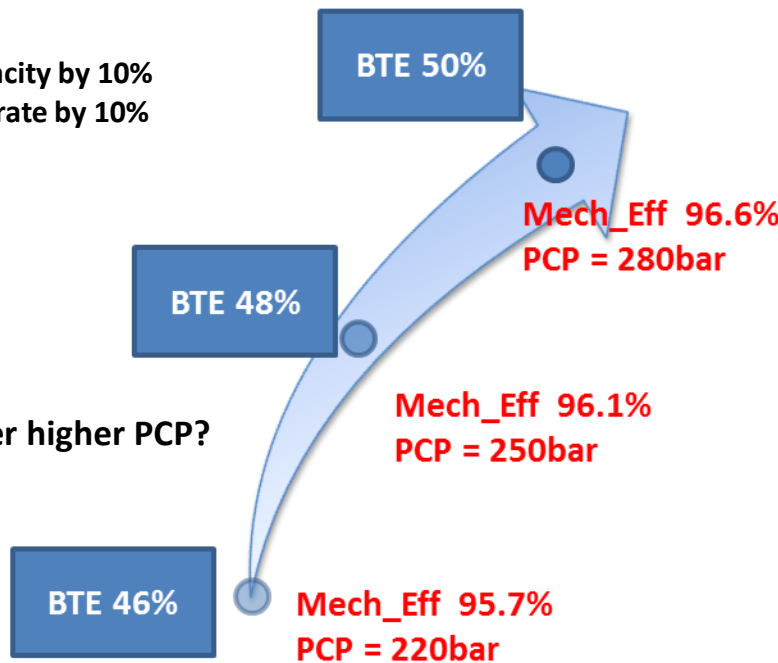
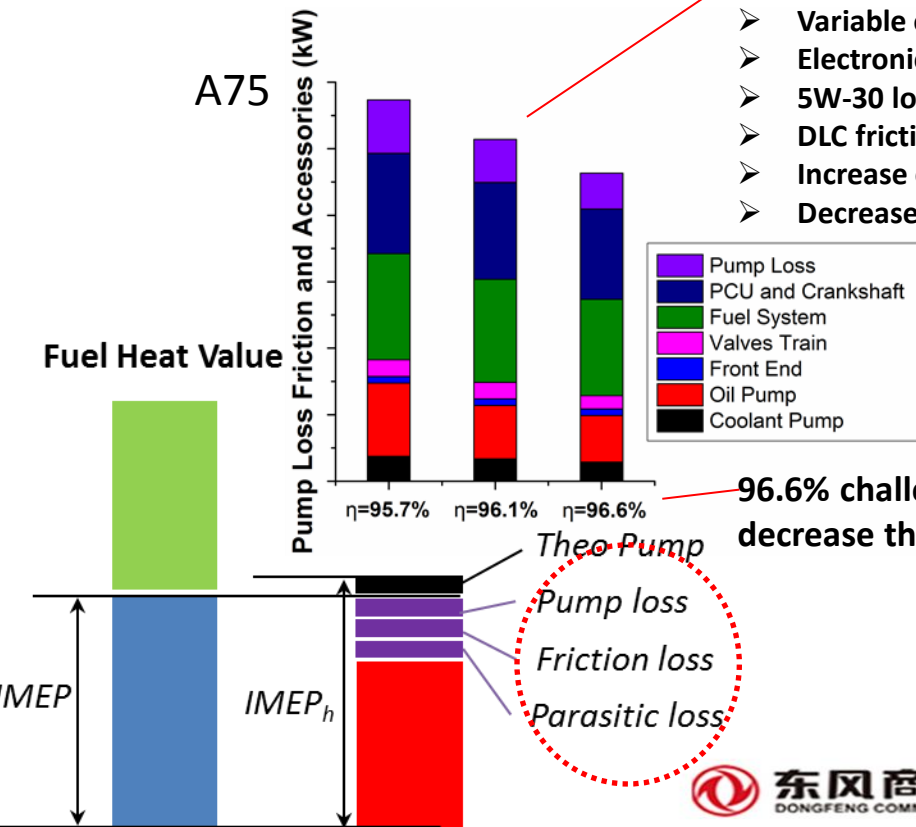
Pump = 99.4%
TC_Eff 53%
Delta P=13kPa
EGR 16%

EGR valve partially opened

5.3 Low Friction Technology

□ DFCV carried out validation work to achieve 96.1% mechanical efficiency target

- Variable oil pump
- Electronically controlled piston cooling nozzle
- 5W-30 low viscosity oil
- DLC friction pair
- Increase of port flow capacity by 10%
- Decrease of coolant flow rate by 10%



- ❑ Regulation iterations and customer demands continue to promote developments of HDD engines in the direction of environmental protection, low carbon, effective and efficient.
- ❑ In order to meet the diversified requirements of different market segments and customers for CN VI Diesel Engine, DFCV developed eight core technologies and two products.
- ❑ DDi11 platform adopts Hot EGR and E-WGT technology considering the comprehensive features of economy, reliability ,cost and weight, to provide customers with reliable value-based power products. DDi13 platform adopts Cooled EGR and VGT technology pursuing the optimization features of economy and power, to provide high-end quality-based products.
- ❑ Aimed at 48% and 50% BTE DFCV defined target decomposition of ITEg, theoretical pump efficiency and mechanical efficiency and engine PCP. Feasibility studies on the first stage of high efficiency combustion system, high efficiency turbocharge system and low friction technology has been carried out.

Thank You For Your Attention