Influence of Advanced Technology for Thermal Management on SUV

Great Wall Engine R&D center

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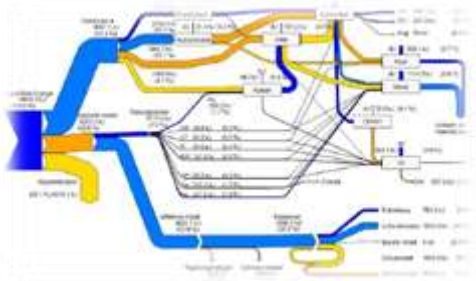
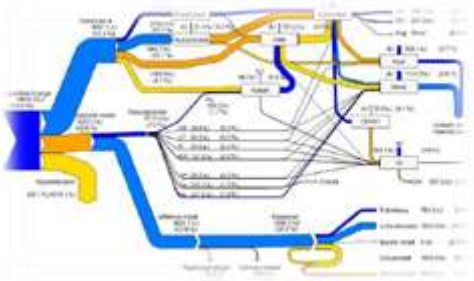


- Introduction
- Background
- Model description
- Calibration
- Results
- Summary



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Introduction

China's largest SUV and pickup manufacturer

Haval and Great Wall brands

products range of SUV, passenger car and pickup

Introduction

2010-2014

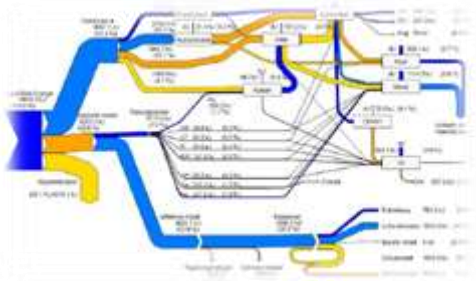
2014

2010

2011

2012

2013



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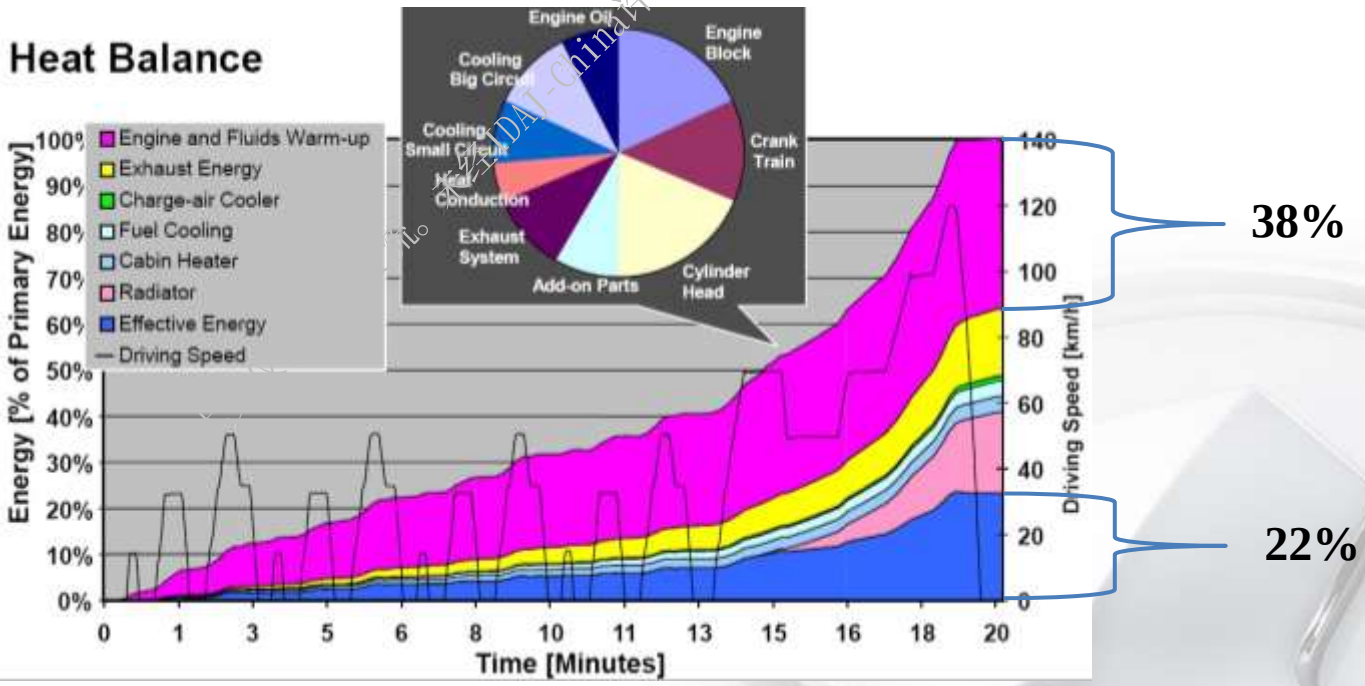
Background

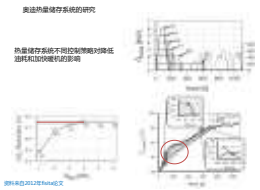
- Reducing fuel consumption is a major challenge in vehicle development.
- Lower warm up time is beneficial for friction reduction and passenger comfort in cold-start.
- More and more advanced technology were developed for vehicle thermal management.



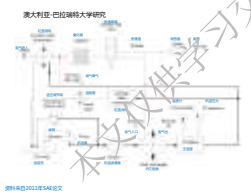
Background

Thermal management technology

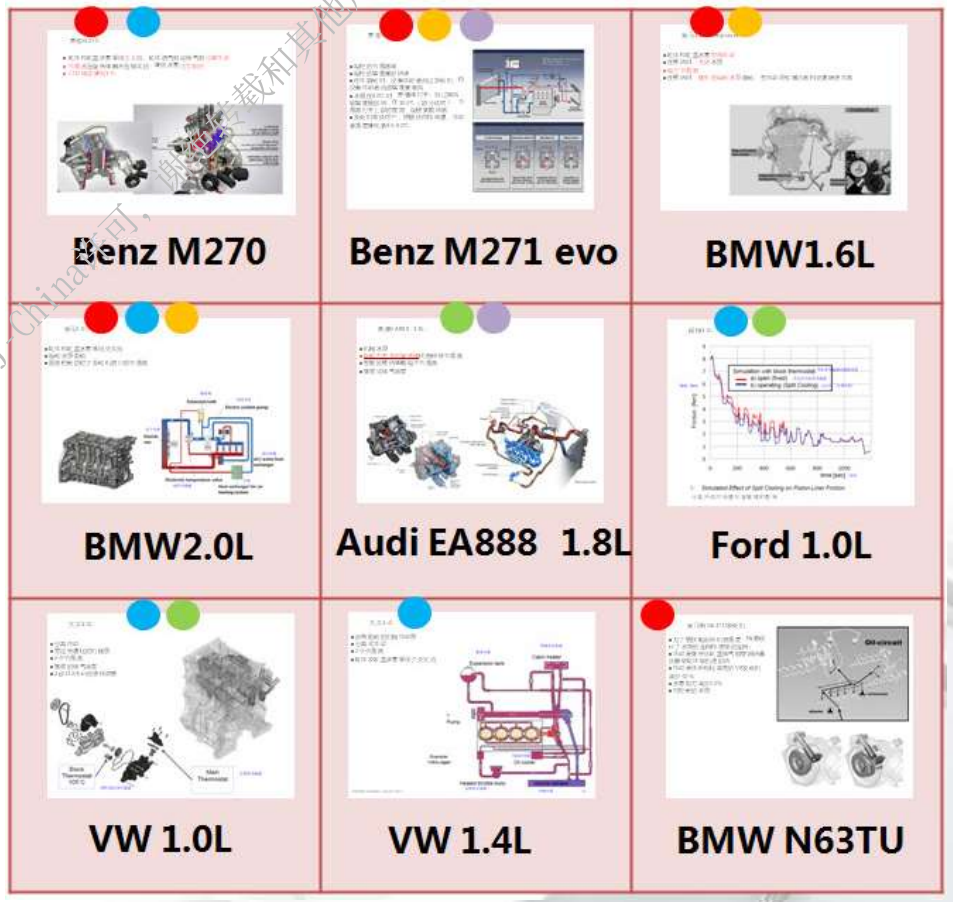
- Control Pump
- Split Cooling Jacket
- Map Control Thermostat
- Integrative exhaust manifold
- Thermal management module
- Heat Storage System
- Heat Exchanger

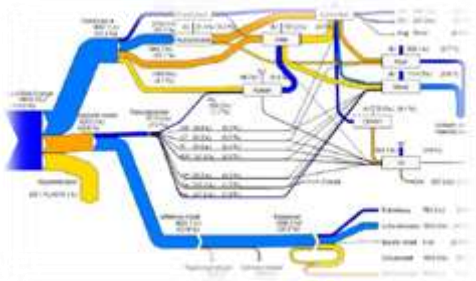


Heat storage system



Heat exchanger





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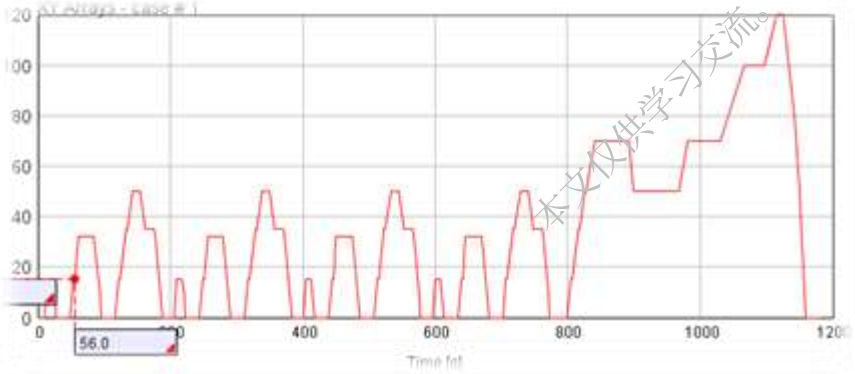
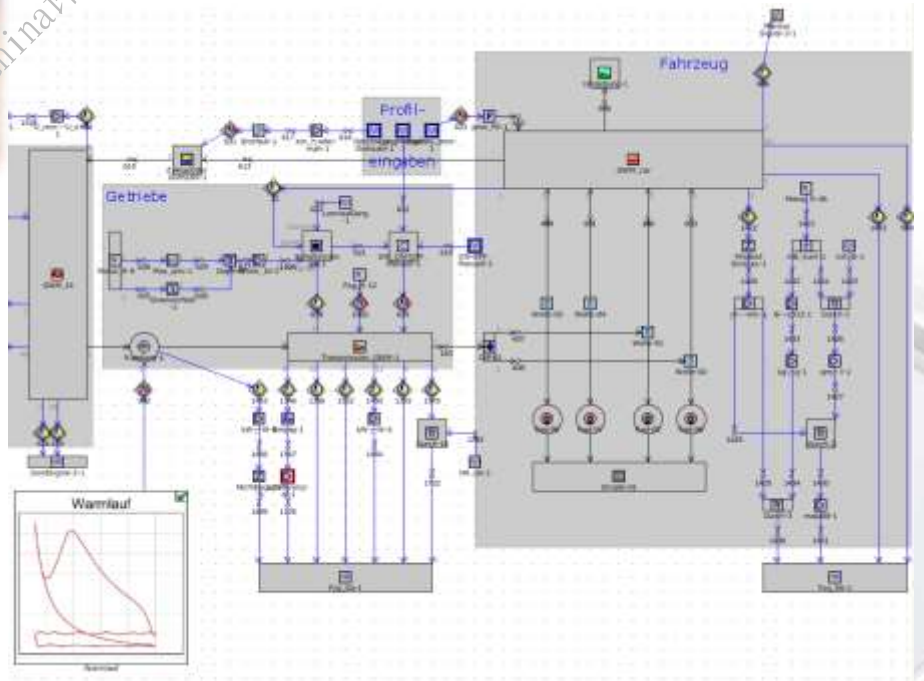
Model description

Vehicle Model

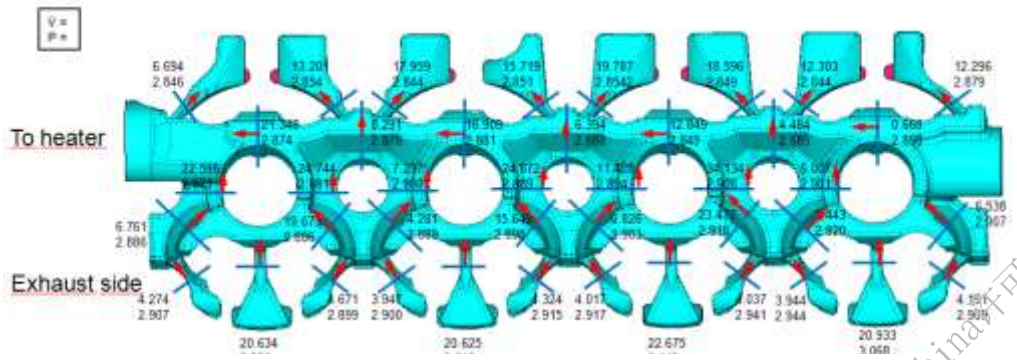
Vehicle model and Driving cycle



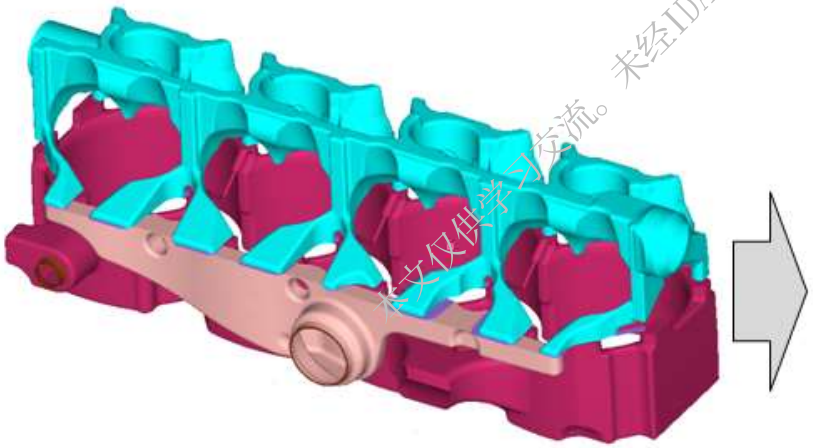


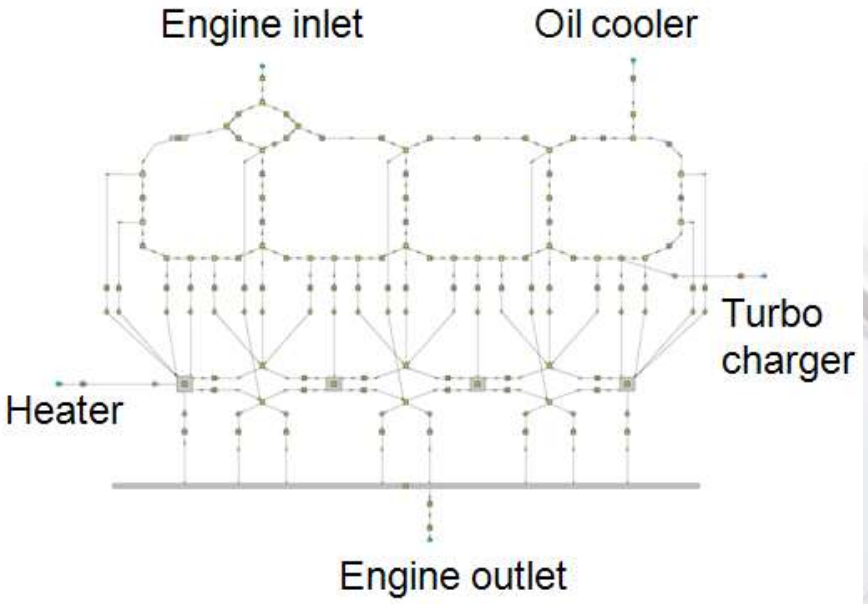
Model description

Water Jacket



CFD results for water jacket 1D model calibration





Model description

FE Heat Transfer

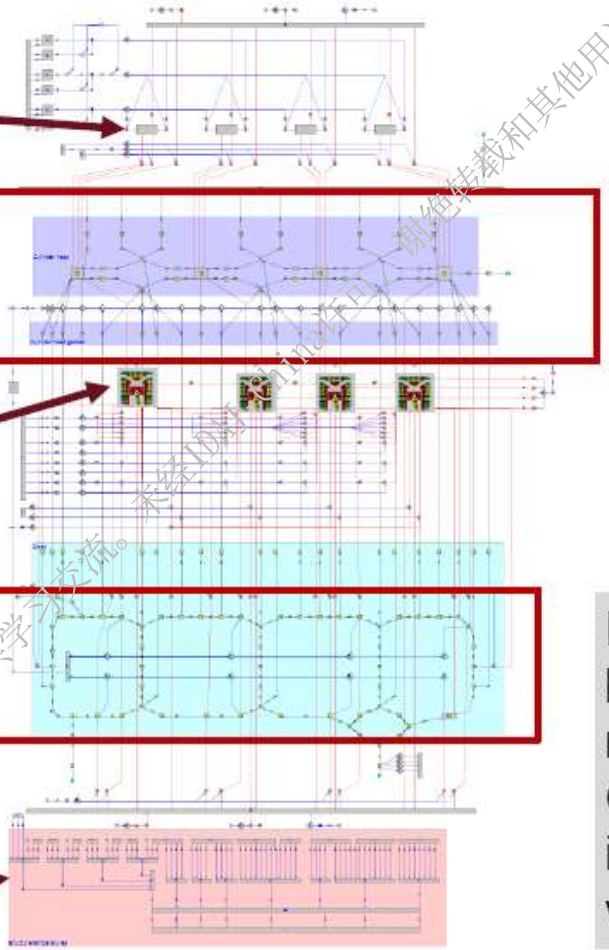
Simplified 3D FE Model of exhaust ports

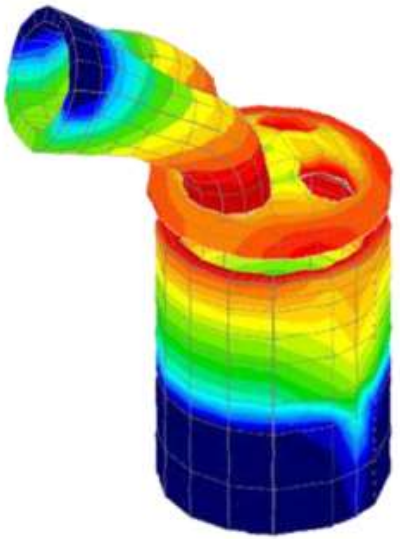
Simplified cylinder head water jacket

3D FE Model of combustion chamber

Simplified engine block water jacket

Local temperatures

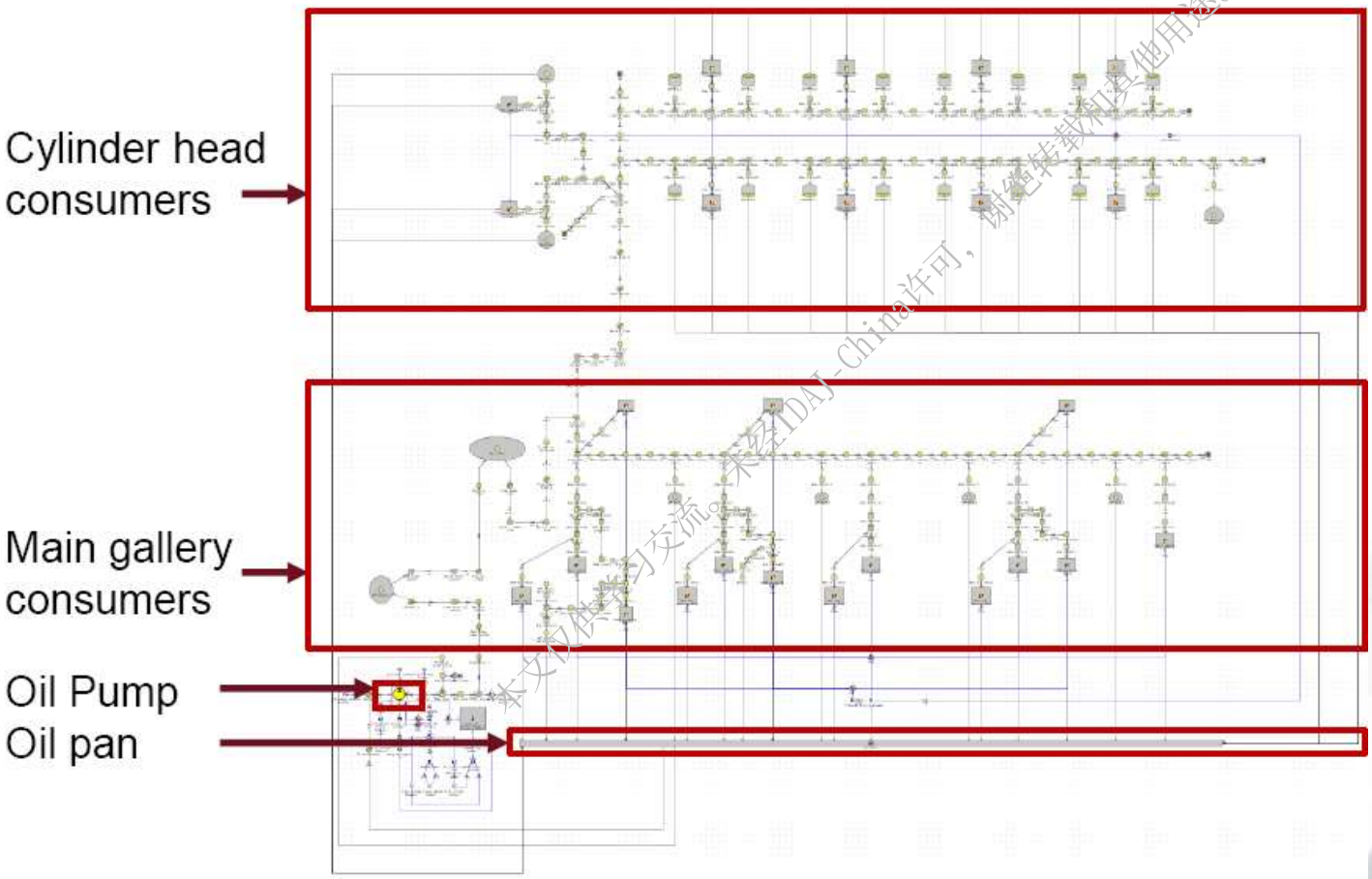




Internal cooling circuit has been built up according to most recent CAD data. GEM 3D was used to implement water jacket volumes.

Model description

Lubrication System

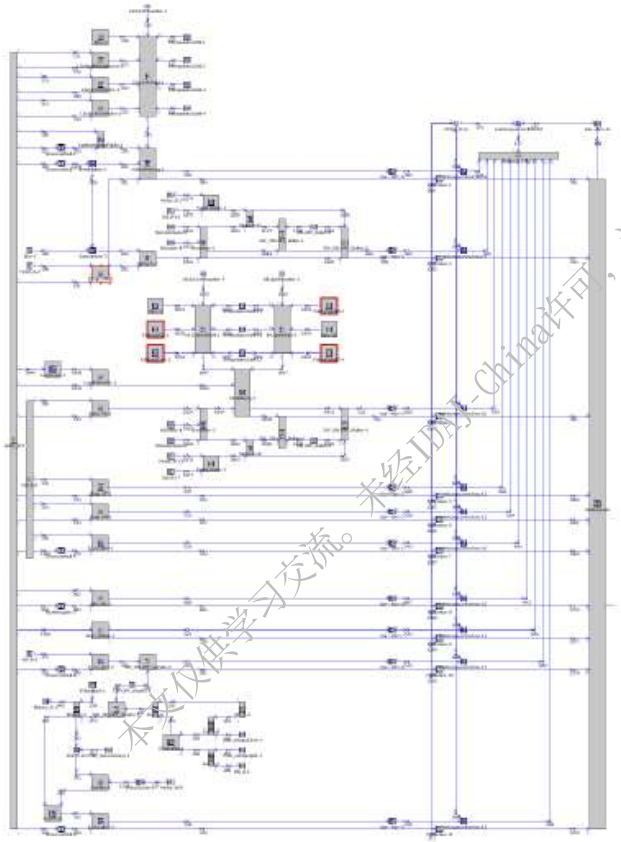


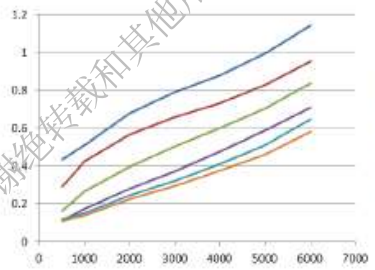
Model description

Friction of Engine

Engine friction (e.g.):

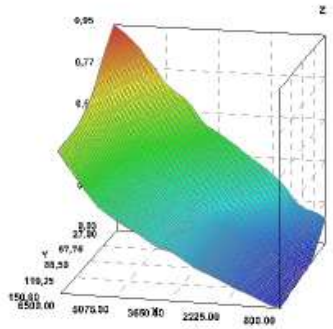
- piston
- con rod
- crank shaft
- mass balancing system
- generator
- acc. drive
- valve train
- water pump
- oil pump





Estimated friction map

Interpolation/Extrapolation

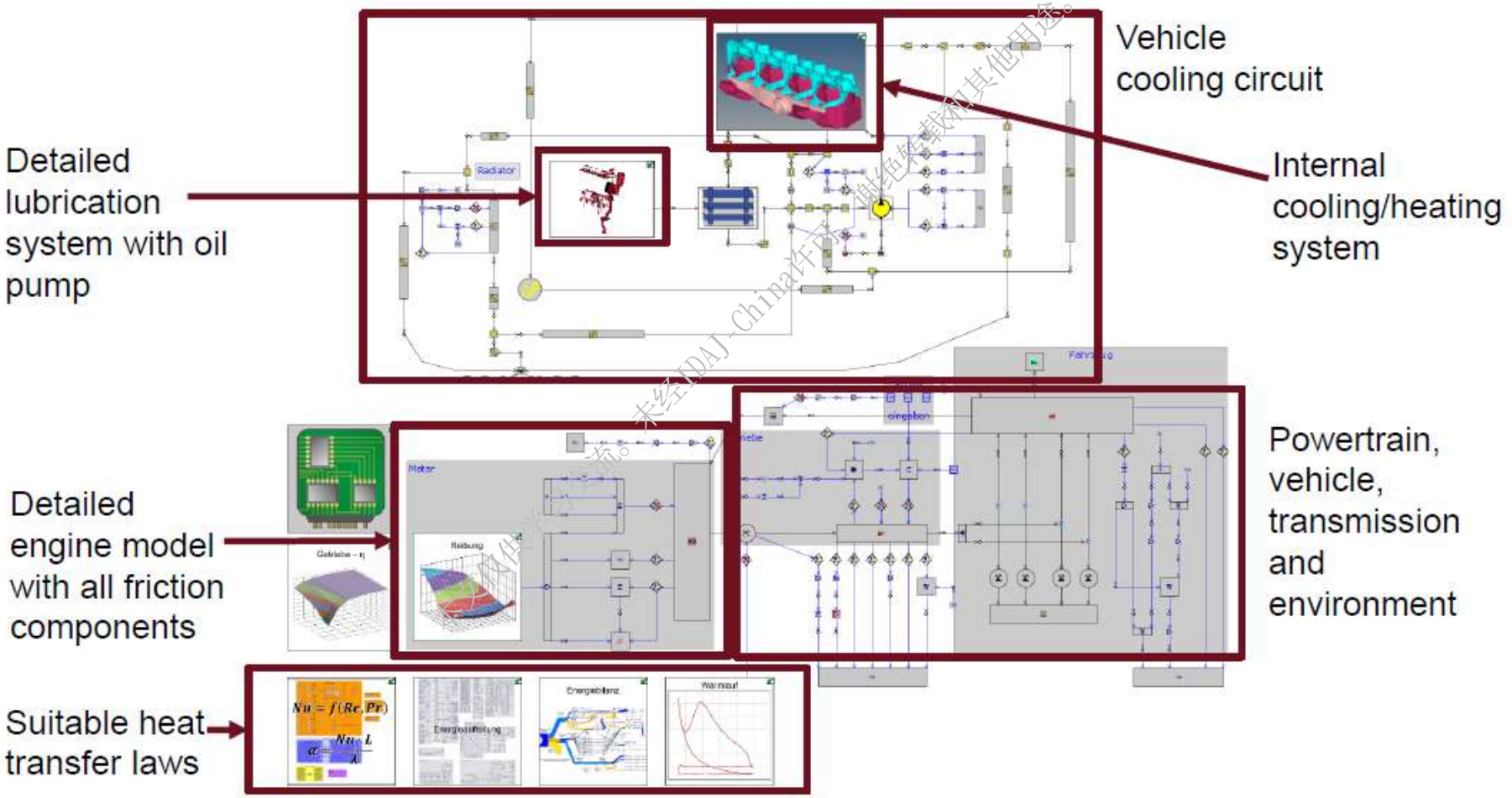


Extended map

Friction maps have been interpolated and extrapolated.

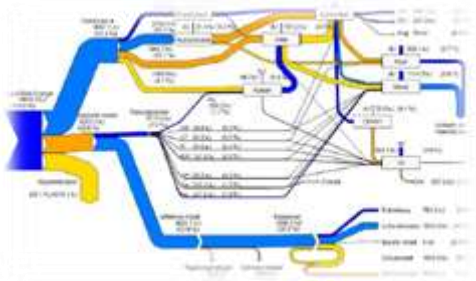
Model description

The Whole Model



Model description

- 2 tests
- 18 components
- 201 parameters in input list



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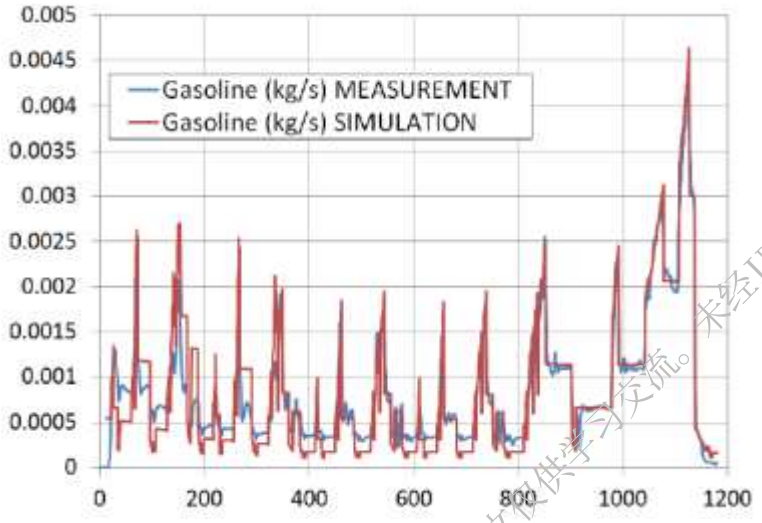
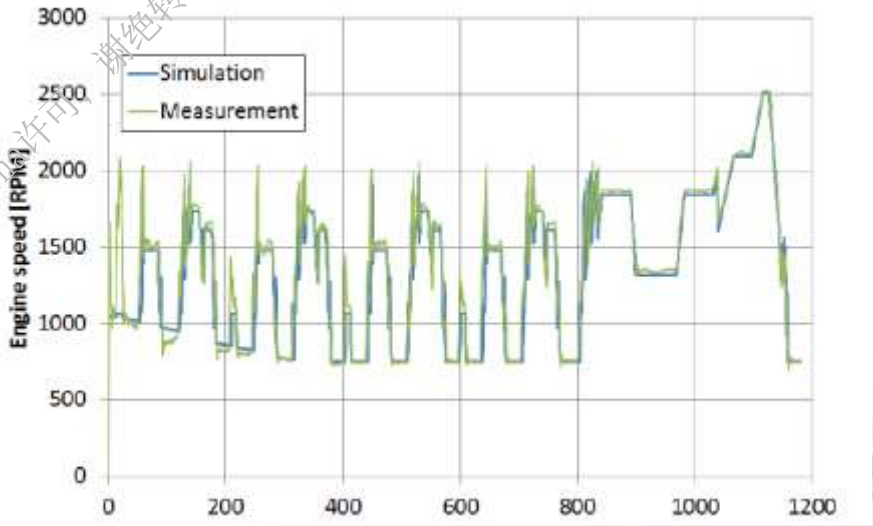
Calibration

- Following measurement data was used for model calibration:
  - Fuel consumption measurement during NEDC
  - Engine speed during NEDC
  - Water temperature during NEDC
  - Oil temperatures during NEDC

Calibration

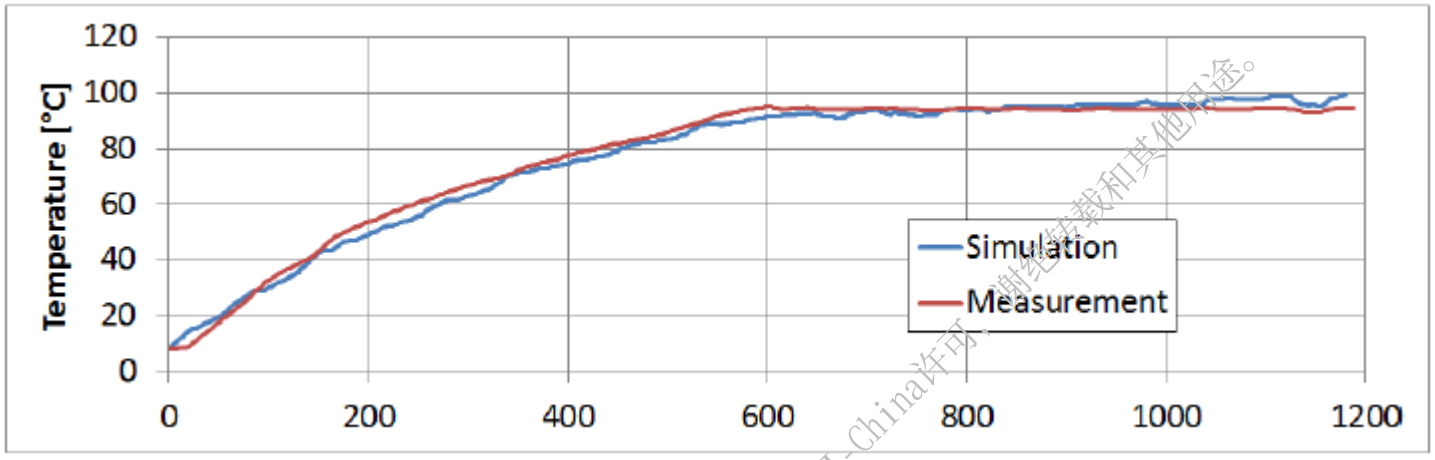


Fuel consumption during NEDC



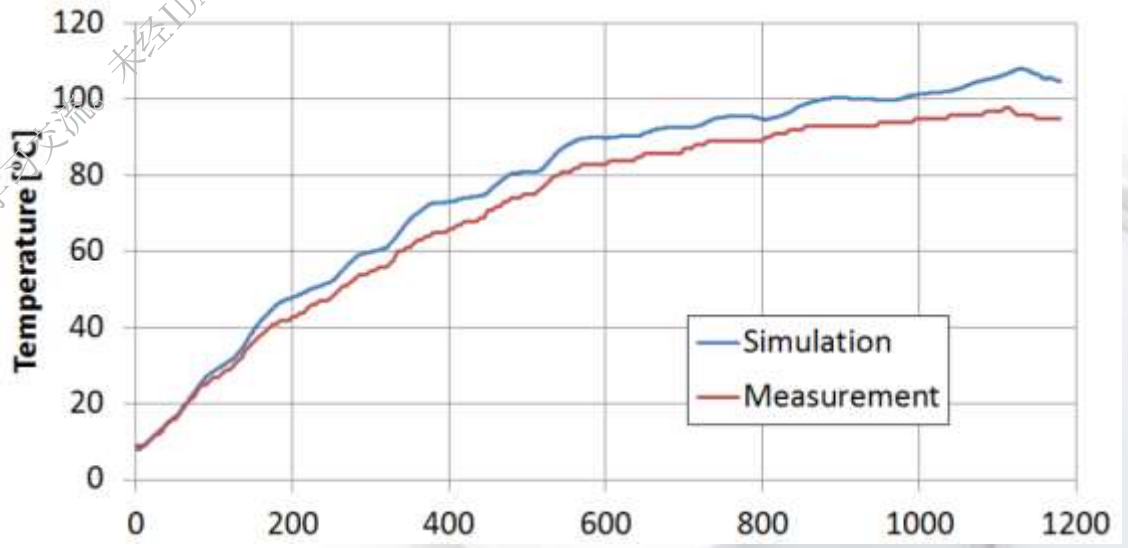
Engine speed during NEDC

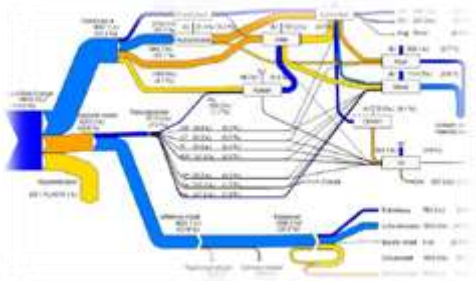
Calibration



Water temperature during NEDC

Oil temperature during NEDC





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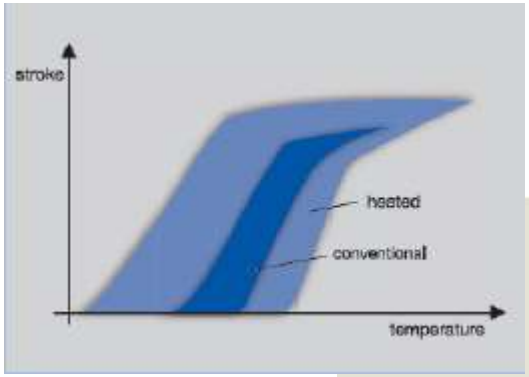
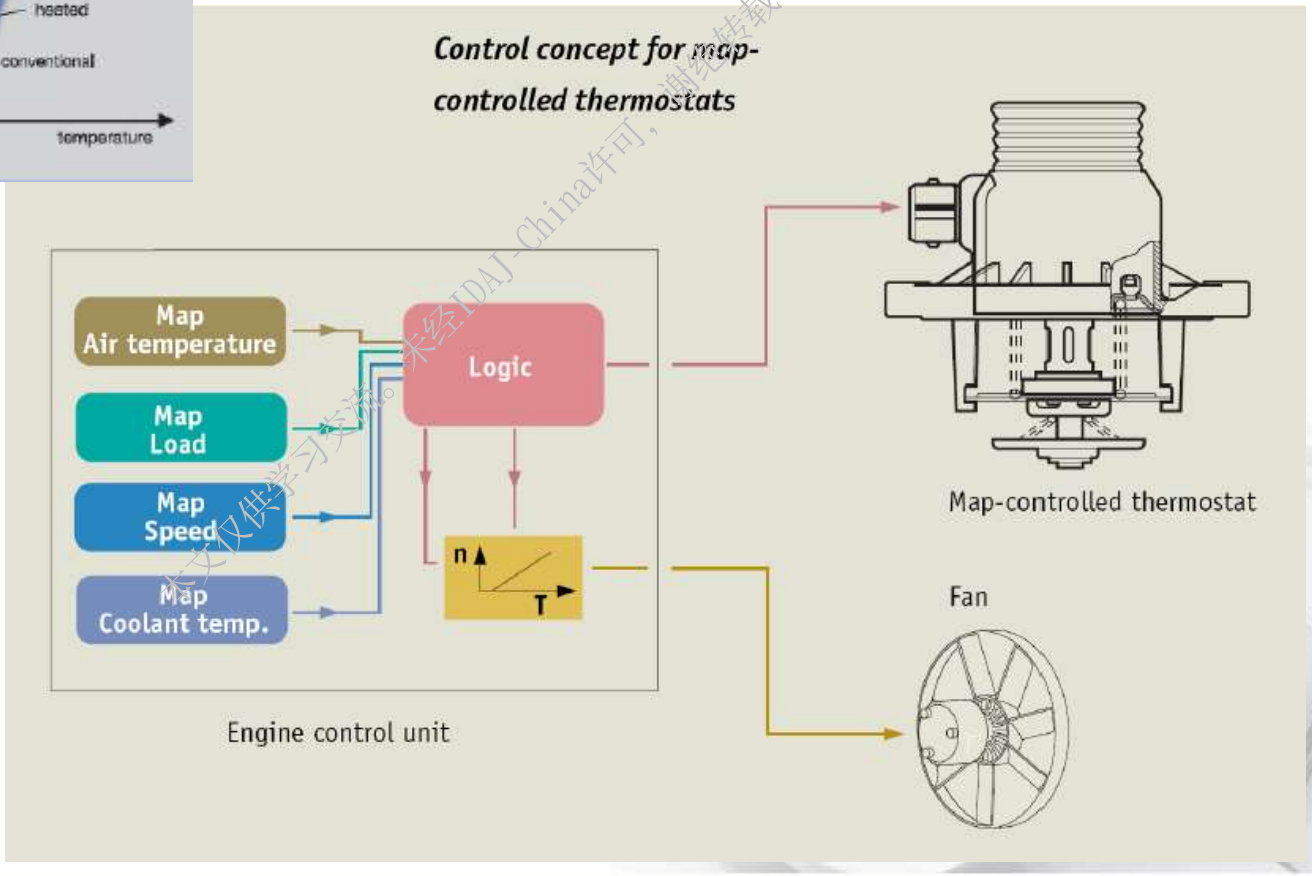
Results

Thermal management task	Boundary conditions
1) Variable oil pump	- Standard NEDC - Modified NEDC (T_start = -20°C)
2) Map controlled main thermostat	- Standard NEDC - Modified NEDC (T_start = -20°C)
3) Electric water pump	- Standard NEDC - Modified NEDC (T_start = -20°C)
4) Split Cooling	- Standard NEDC - Modified NEDC (T_start = -20°C)
5) Split Cooling + electric water pump	- Standard NEDC - Modified NEDC (T_start = -20°C)

Results

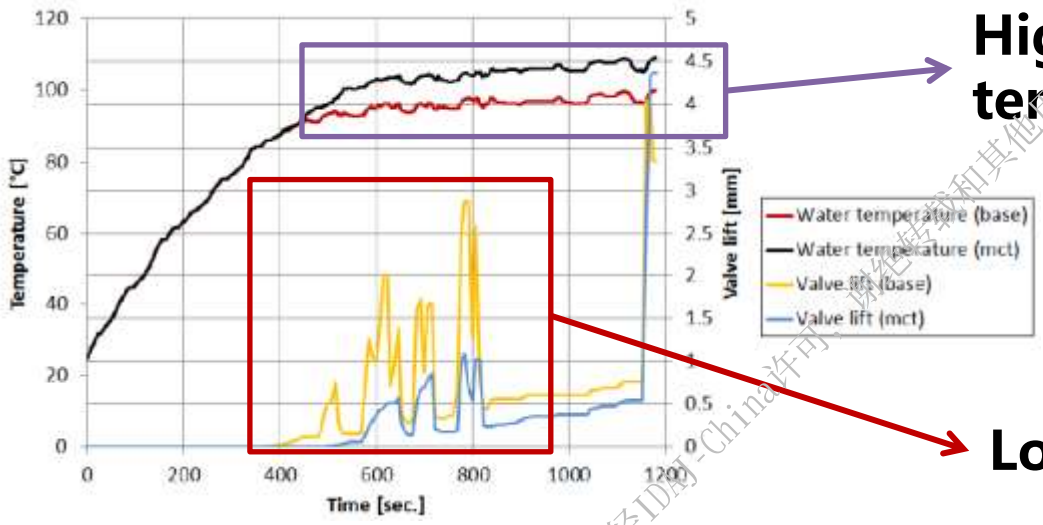
Map controlled thermostat





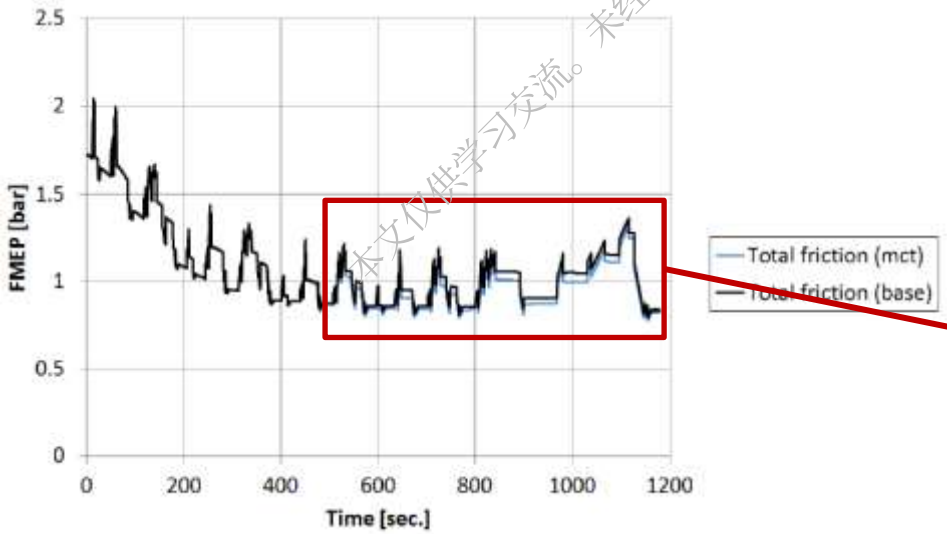
Results

Map controlled thermostat



Higher opening temperature

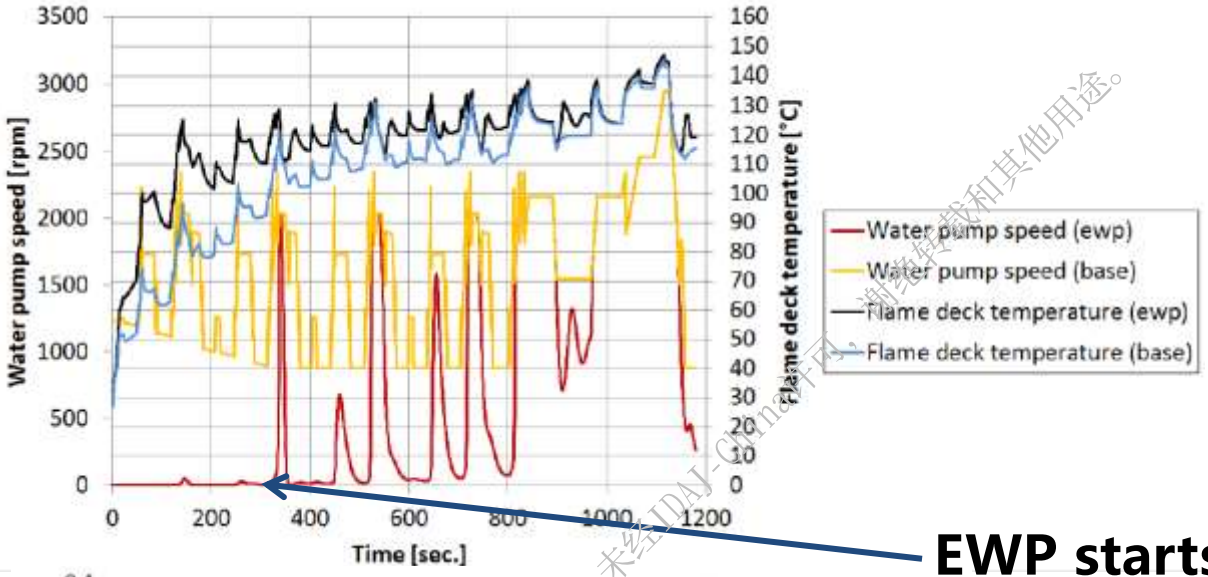
Lower valve lift



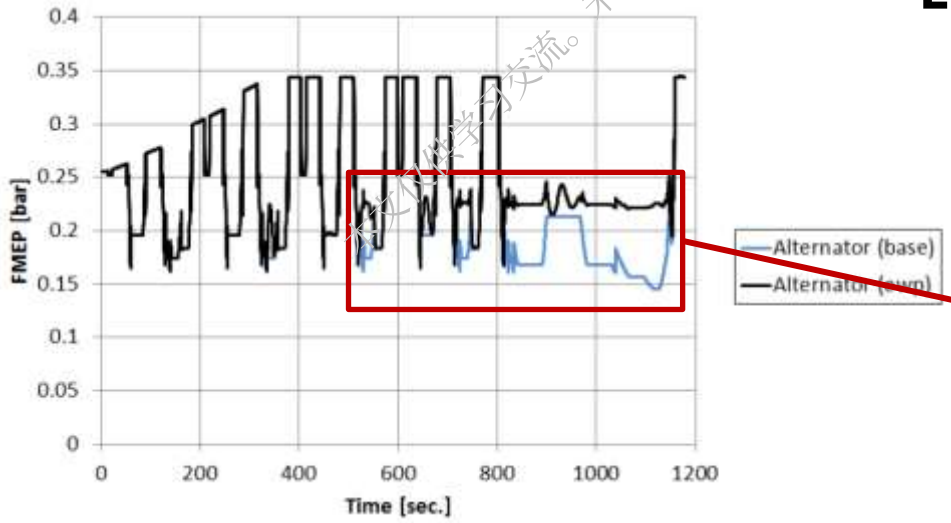
Reduced friction

Results

Electric water pump



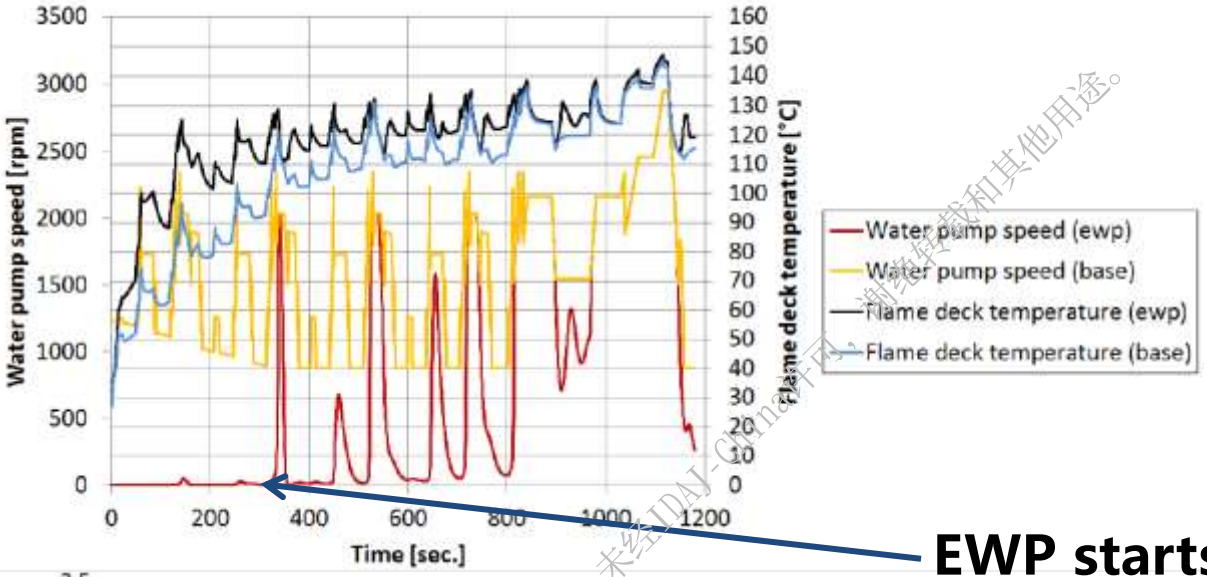
EWP starts to rotate



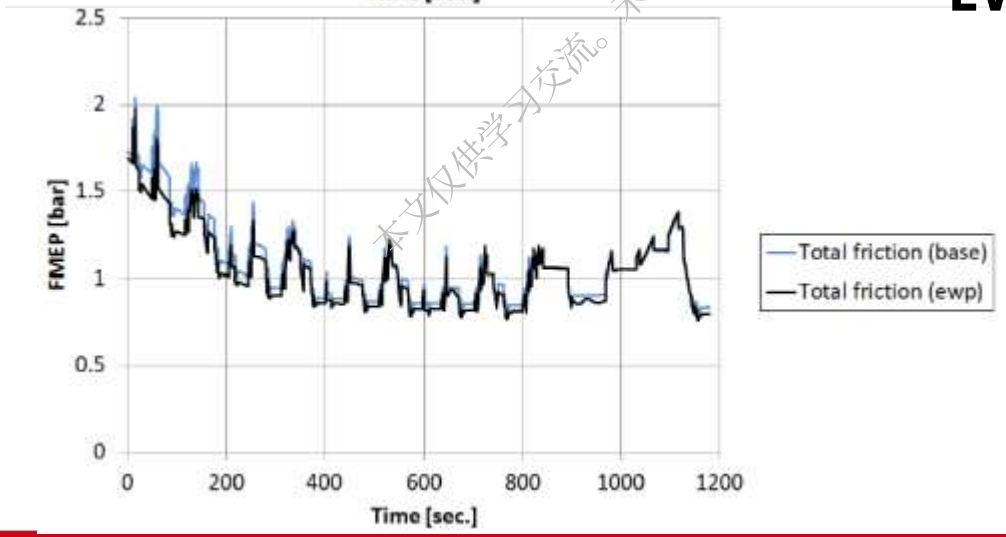
Difference of alternators for EWP and base

Results

Electric water pump



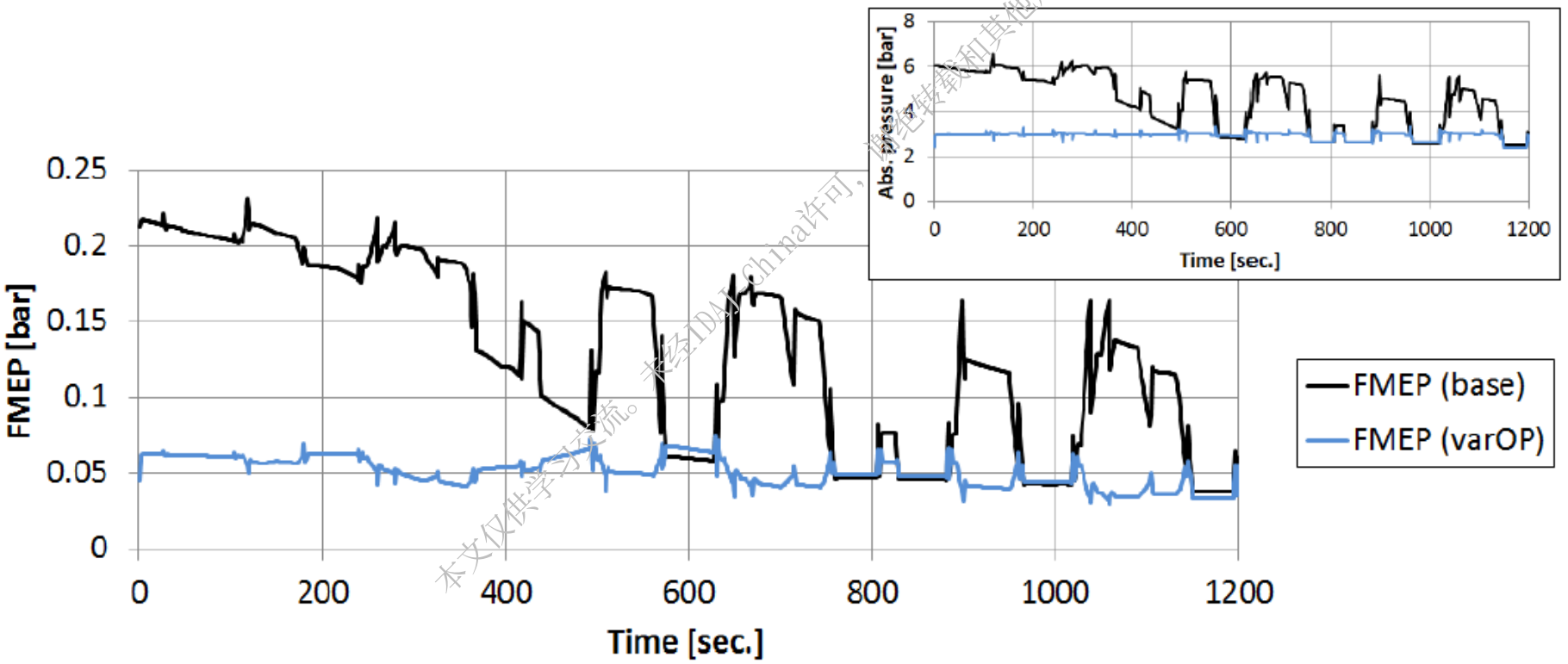
EWP starts to rotate



Total friction is in sum approx. 4% lower using electric water pump.

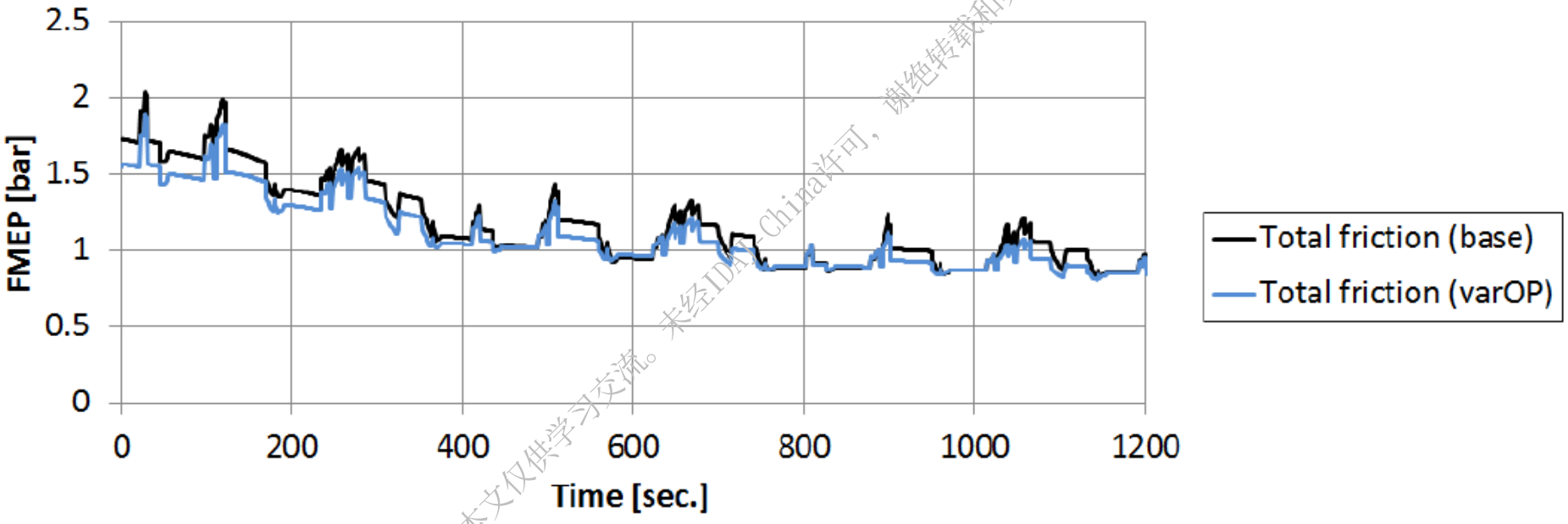
Results

Variable oil pump



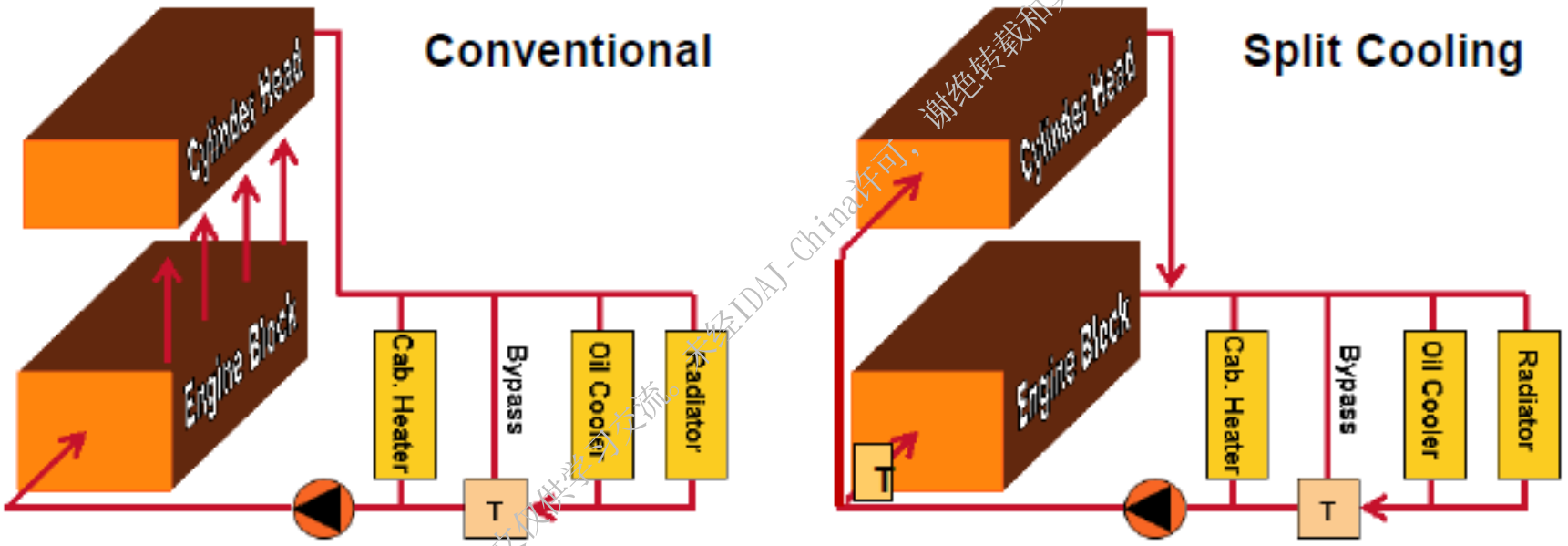
Results

Variable oil pump



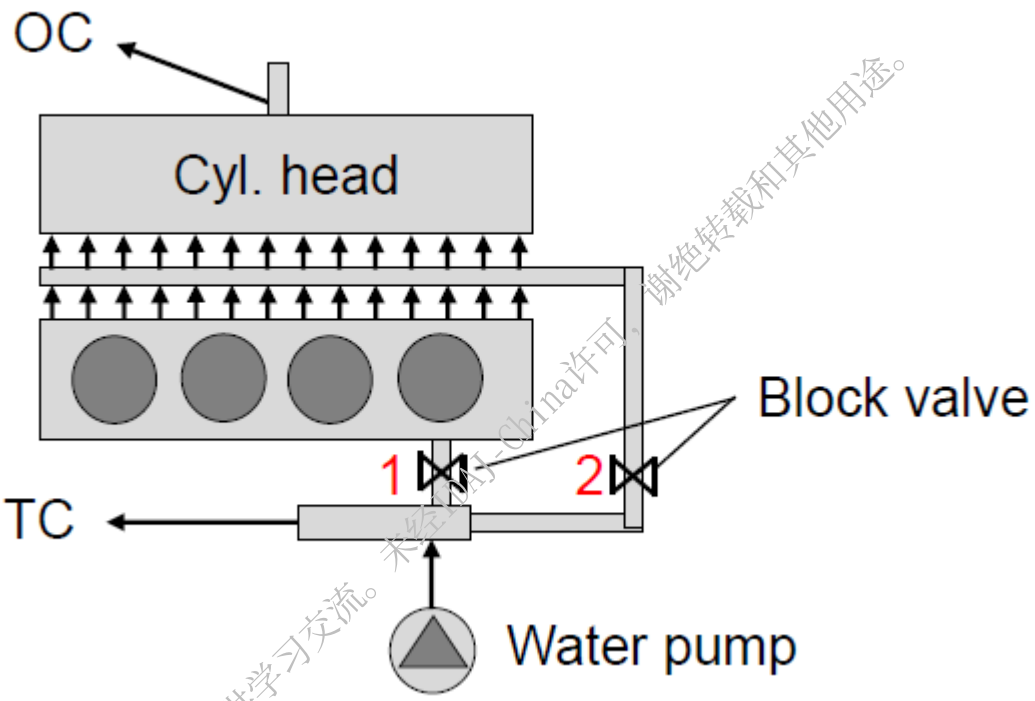
Results

Split cooling



Results

Split cooling

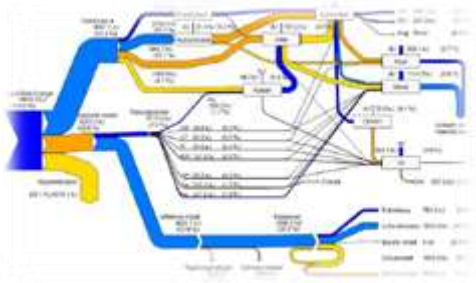


Cold engine: Valve 1 is closed, valve 2 is open
→ Split cooing without flow across the block

Warm engine: Valve 1 is closed, valve 2 is open
→ Original water jacket, but with different outlets to TC and OC

Results

	NEDC cold	NEDC standard
	Benefit(%)	Benefit(%)
Base	——	——
Electric water pump	0.942	0.443
Split cooling	0.979	0.451
Split cooling with Electric water pump	1.16	0.579
Map controlled thermostat	0.225	0.312
Variable oil pump	1.416	1.421



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Summary

- A accurate model was built, which includes cooling system, lubrication system, powertrain, vehicle, friction.
- The results showed the influence of existing technology for thermal management on SUV.
- Next, we will study the strategy with existing technology， furthermore，study new technology such as complex flow control valves、heat storage system using this model