KTH ROYAL INSTITUTE
OF TECHNOLOGY

Heavy Duty DISI Gas Exchange Processes with Renewable Fuels

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08 September 2017, CCGEx – Research Day

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SCANIA
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Content

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- Objective
- Base Engine and Test data
- Theory and Method – Three pressure analysis
- Results
- Future work

Motivation

HD SI engines with renewable fuels

Diesel Power Density?

- **Markets**
  Renewable source of fuel and reduced imports
- **Direct Injection Spark Ignition**
  Improved Efficiency and lower knock tendency

Near *Zero* Emissions

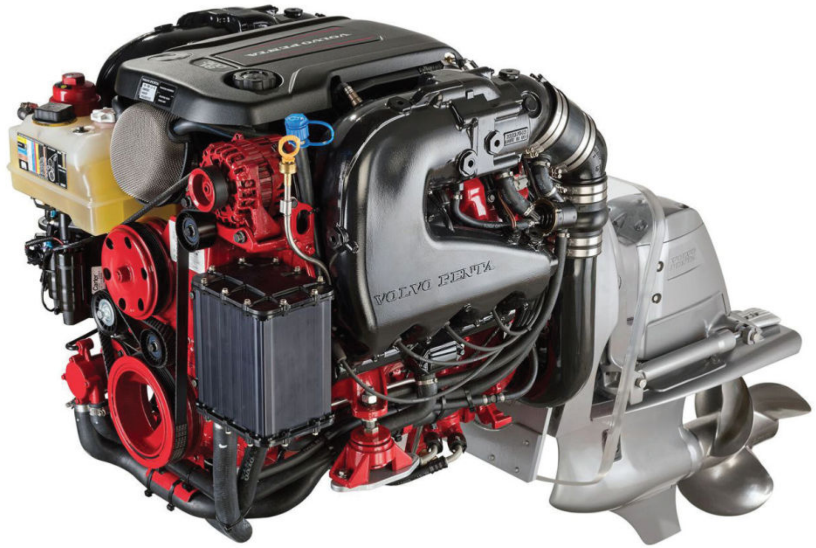
- **λ = 1 operation**
  Simple after-treatment
  Reduced capital costs for fleet owners
- **Oxygenated Fuels**
  Lower Particulate Emissions

Objective

1. Accuracy of 1d combustion / knock models
2. Experiments: derive the effect of fuel and EGR
3. Model validation for HD engine
4. Gas exchange system architecture – advantages and limitations

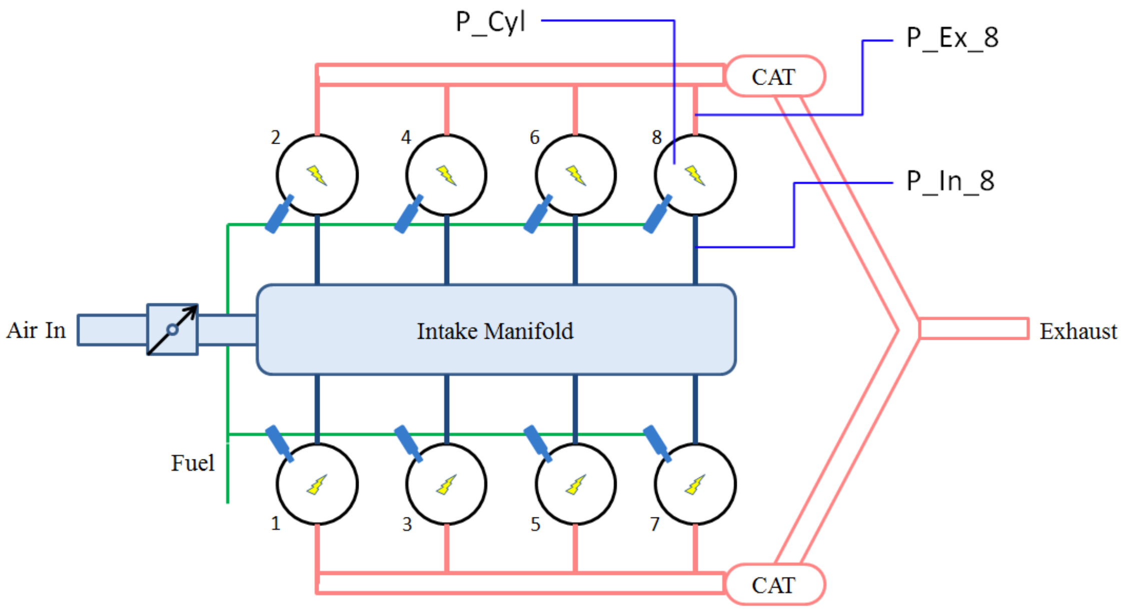
Base Engine

Engine Designation	V8 300 CE
Displacement	5.3L in V8 config
Bore	96 mm
Stroke	92 mm
Compression ratio	11
Fuel Injection	Direct injection
Valvetrain	Single Camshaft with phasing 2 valves per cylinder
Firing interval	90 deg 1-8-7-2-6-5-4-3



Volvo Penta SI Engine

Test Data



CA data Indicom (avg of 50 cycles)

- Intake and exhaust pressure
- Cylinder pressure

Time avg data

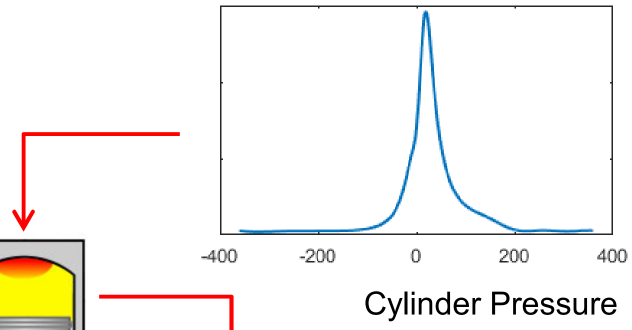
- Critical pressures and temperatures
- Emissions post catalytic converter
- Lambda
- Fuel flow
- Air flow calculated

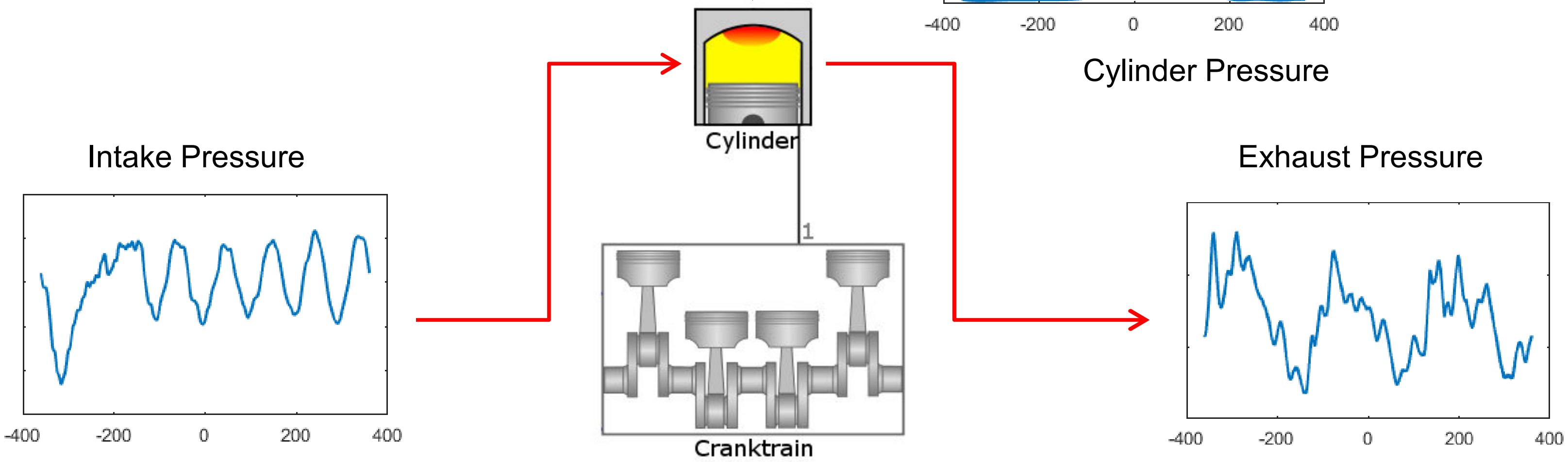
Predictive Combustion Model

Variable	Dependents	Calibration constants
Mass of entrained unburned mixture	• Flame area • Laminar flame speed • Turbulent flame speed	
Laminar flame speed	• Equivalence ratio • Temperature • Pressure • Dilution	1. Dilution exponent multiplier
Turbulent flame speed	• Turbulence intensity • Flame radius	2. Flame speed multiplier 3. Kernel growth multiplier
Taylor microscale	• Integral length scale • Turbulent Reynolds number	4. Length scale multiplier

Method – Three pressure analysis

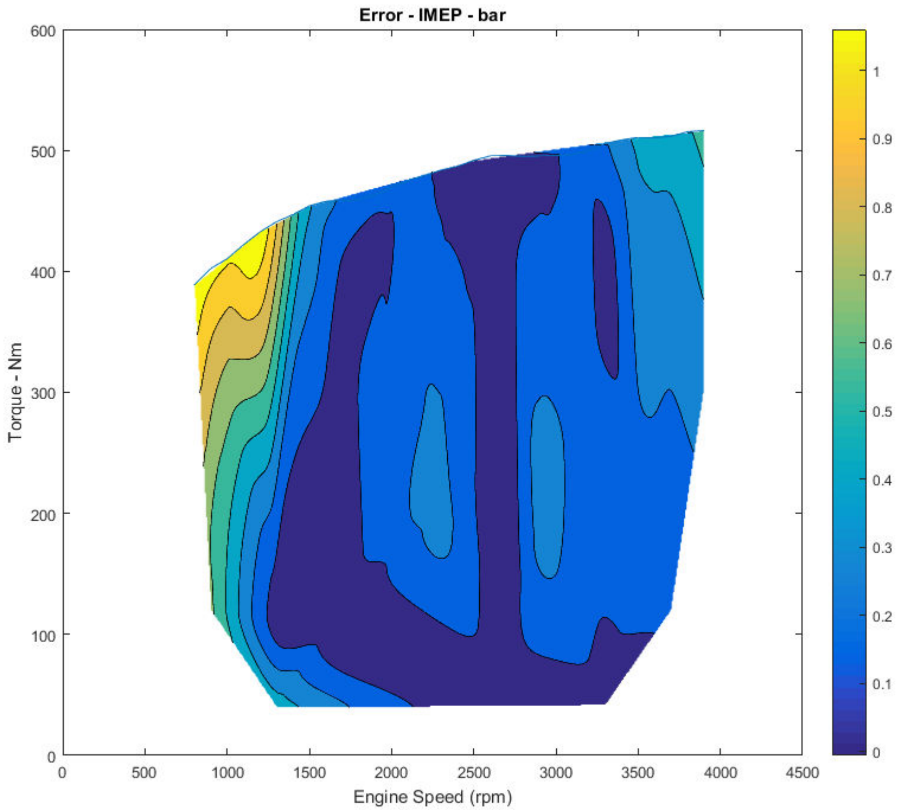
- Imposed pressure curves
- 22 operating points across the map
- Fixed combustion efficiency (95%)
- Target function to minimize burn rate error

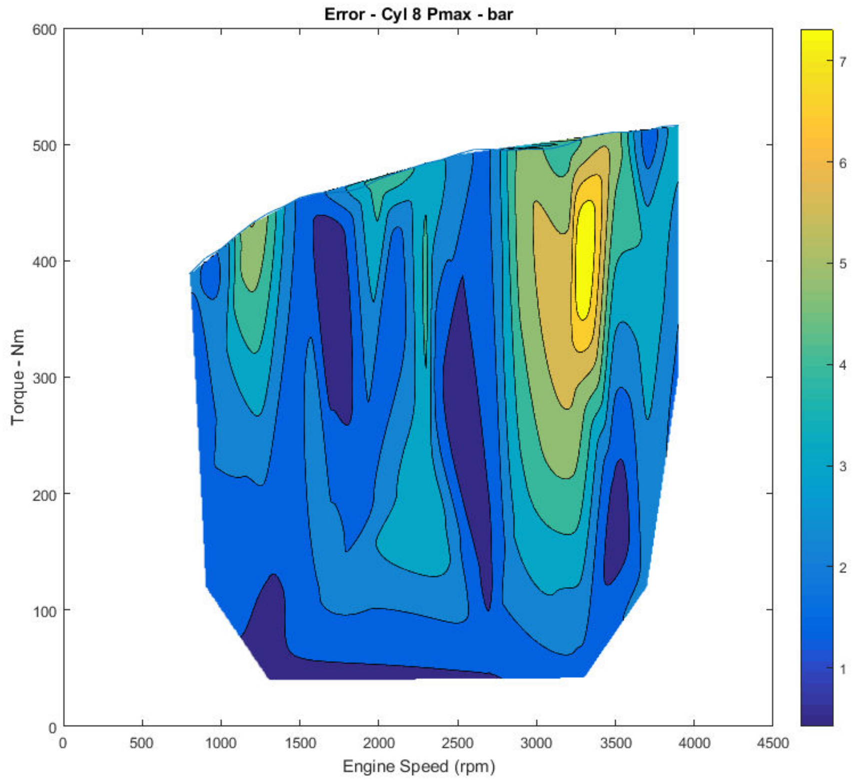




Single cylinder
GT Power Model

Results





Based on 22 calibration points and 12 verification points

Summary

- Model fit has improved in the last iteration
- Model fit is good at both calibration and test points
- Peak pressure error – cause unknown at this moment

Next Step:

- Fit a knock model for KLSA prediction at current spark advance levels (Tuning point will be selected based on low speed and high residual level)
- CCV model to be tuned to fit COV-IMEP data (Cyl 8) based on 50 cycles

Future Work

Volvo T6	Volvo Penta	1 cyl
2L I4	5.3L V8	2L
Bore Diameter: 82 mm	Bore Dia: 96 mm	Bore Dia: 127 mm
CR: 10.3	CR: 11	CR: 10

- Knock limited BMEP decreases with increase in bore diameter

  Residence time for end gas increases

- Important to model the effect of EGR and fuel on knock behavior

- How much change in the calibration constants would be needed to fit engines with larger bore diameters? Is the turbulence model the most critical difference?

Competence Center for Gas Exchange

”Charging for the future”