Subtask 3.1D

Numerical Analysis for Controlling Mixture Heterogeneity to Reduce Abrupt Combustion in Diesel PCCI Combustion

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Motivation and Purpose of the Study

- Switching the combustion mode between Diesel and PCCI has a potential to improve the emissions performance.

  - Diesel combustion mode at high load / the exhaust gas temperature is high enough to keep a catalytic converter active.
  - PCCI combustion mode at low load / the exhaust gas temperature is too low for a catalytic converter to be active. Low emissions and high efficiency of the PCCI has an advantage in such a condition.

- The purpose of the study is to develop an efficient LES computer model for a systematic analysis of the mixture formation in the PCCI combustion mode by comparing the computational results with experiments.

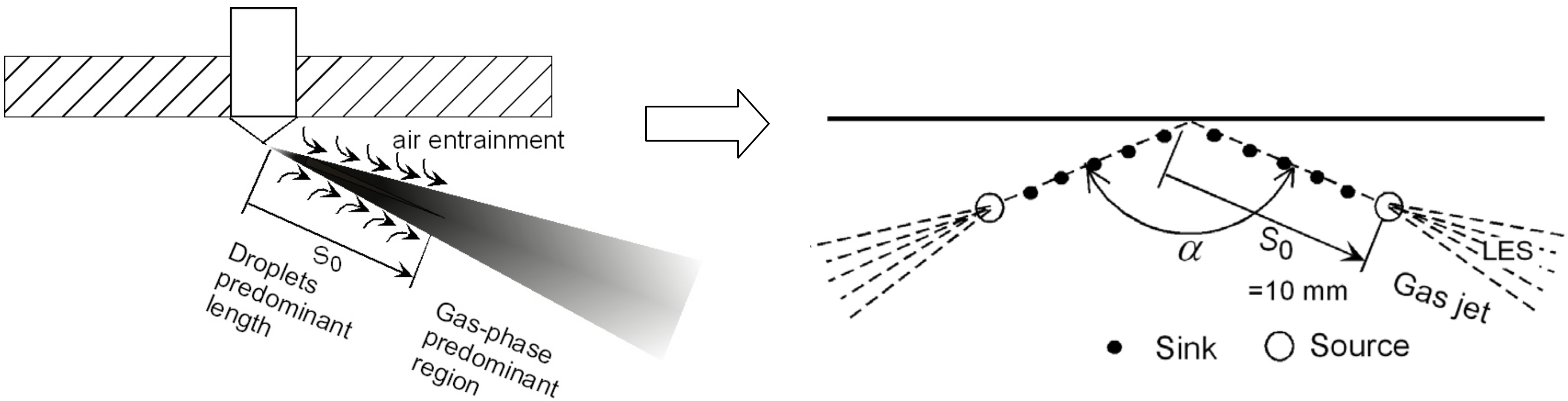
Outline of the Model

- CFD model: LES
  - Transport equations for mass, momentum, enthalpy and species mass fractions in spatially filtered forms
  - Sub-grid kinematic viscosity: Smagorinsky model
  - Initial instantaneous velocity field: Correlation Generating method

- Spray model to reduce computer load
  - Gas-jet model (Ikegami's model)

- Reaction kinetics to reduce computer load
  - Schreiber model – five step global reactions
  - Extended Zel'dovich model for thermal NO reaction

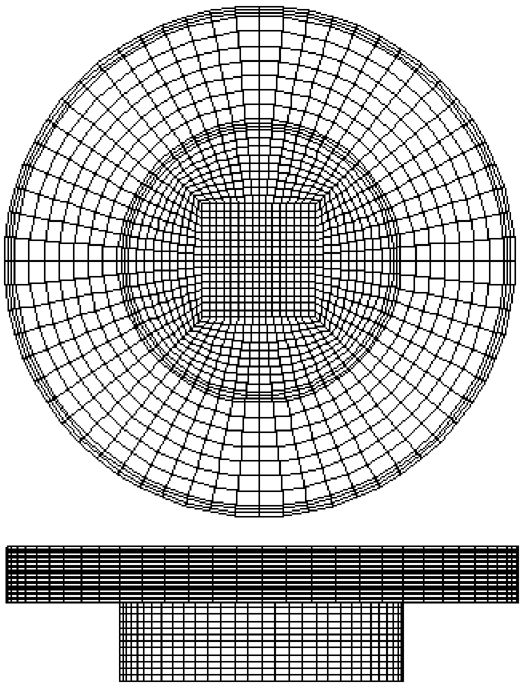
Gas Jet Model



- The gas jet model
  - The sinks are models for air entrainment. The mass of air entrained is estimated by Wakuri's model
  - The source ejects the mixture of gasified fuel and air with the sum of momentum of the fuel injected and the air entrained through the sinks

Computational Conditions

Computational Cells



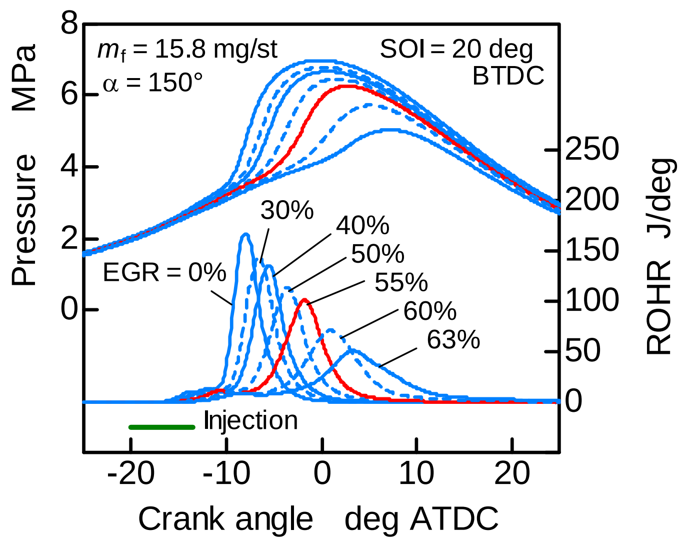
Total number of cells : 52224
(Cell volume)1/3☐2.6 - 1.0 mm
(bdc) (tdc)

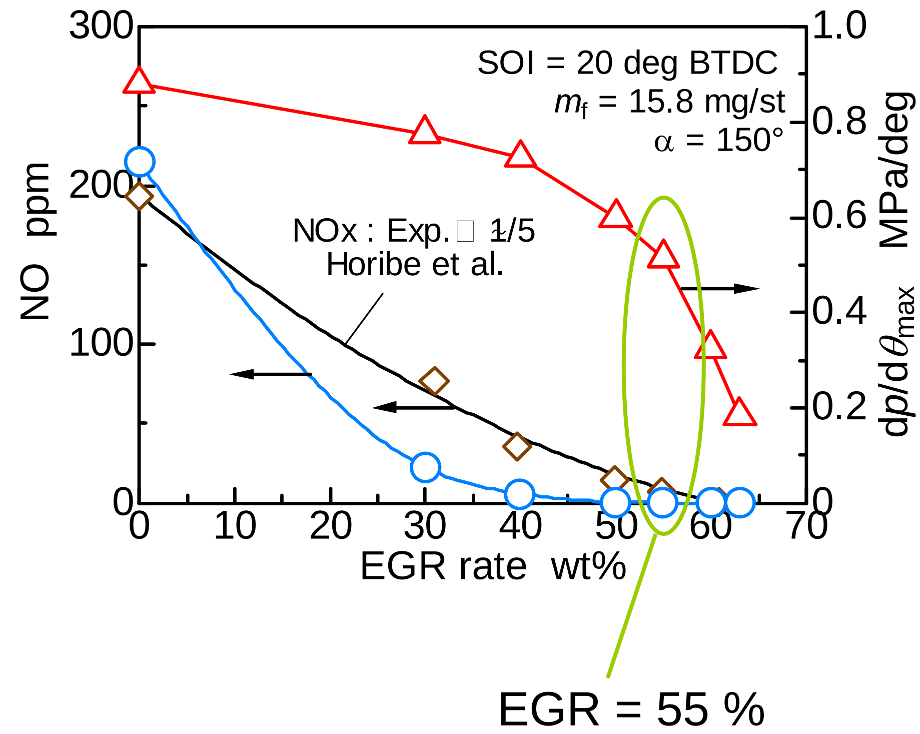
Measured integral length scale in literature: 4-5mm - 2.5mm
(bdc) (tdc)

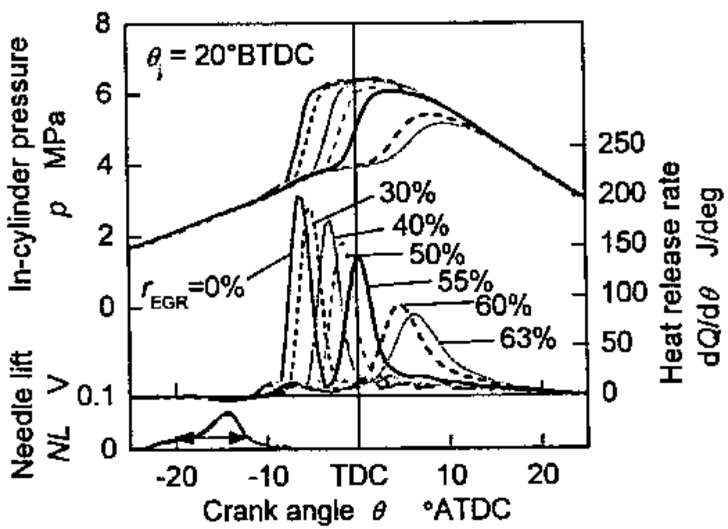
Engine Conditions

Bore×Stroke	102×105 mm
Stroke volume	857 cc
Compression ratio	15.5
Combustion chamber	Bowl-in-piston φ56.7 ×16 mm
Engine speed	1800 rpm
Fuel	n-Heptane
Injected fuel mass	15.8 mg/st
EGR rate	0 to 63 wt%
Intake O_2	22.6 to 8.0 wt%
Residual gas	7 wt%
Swirl ratio	Standard: 2.6
Wall temperature	523 K, uniform
Initial temperature	343 K, uniform

Comparison with Experiment







Experiment: Horibe et al., Trans. JSME, Vol.74, No.739, B, 2008

Effects of EGR on Pressure and ROHR

Comparison with Experiment