Thirty-Second Task Leaders Meeting
International Energy Agency Implementing Agreement
on Energy Conservation and Emissions Reduction in Combustion
Nara Royal Hotel, Nara, Japan, July 25-29

1.6A.06: Okayama University, Japan
Prof. Eiji Tomita
Dual fuel: Premixed gaseous fuel and diesel direct injection

Effect of component of biomass-based gaseous fuels on combustion in a super-charged gas engine with micro-pilot injection

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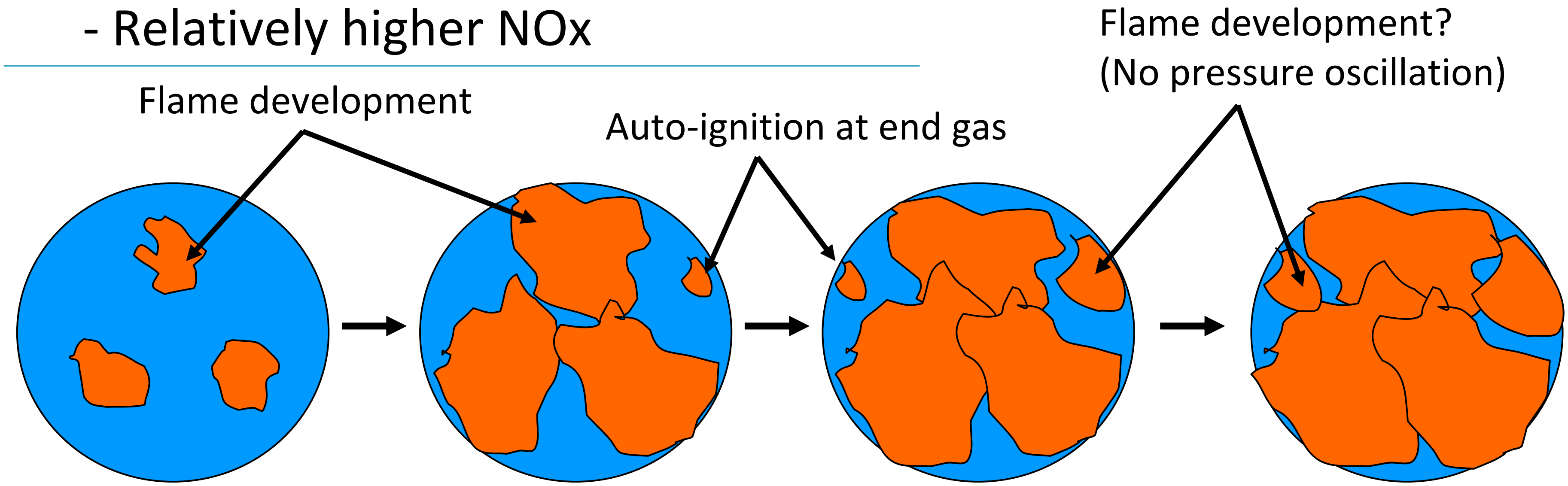
Flame development → auto-ignition without knock

→ other flame developments
or mild auto-ignition

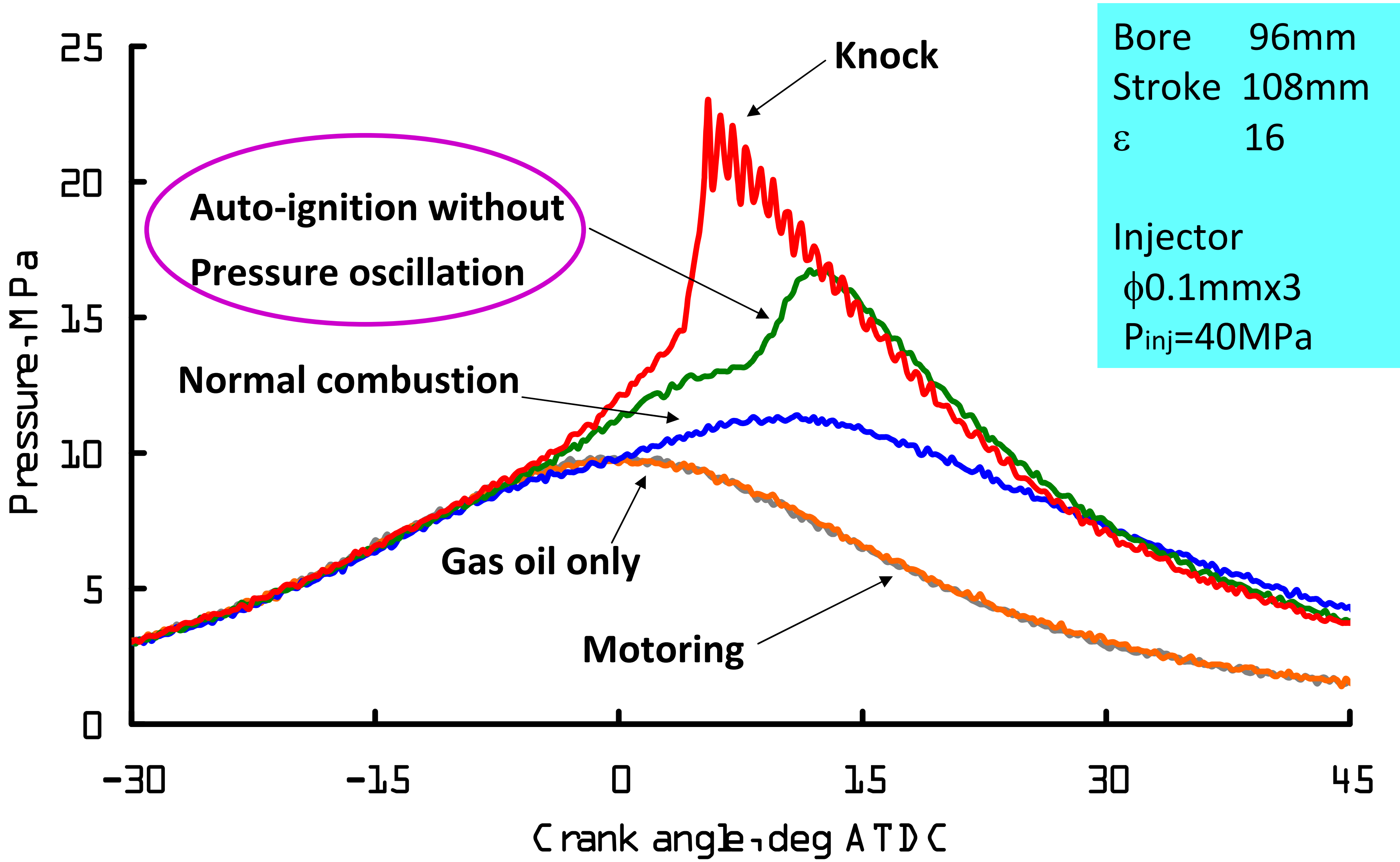
Engine: Lean burn gas engine ignited with diesel fuel (Gas oil)

Features

- Higher thermal efficiency
- Lower HC
- Relatively higher NOx

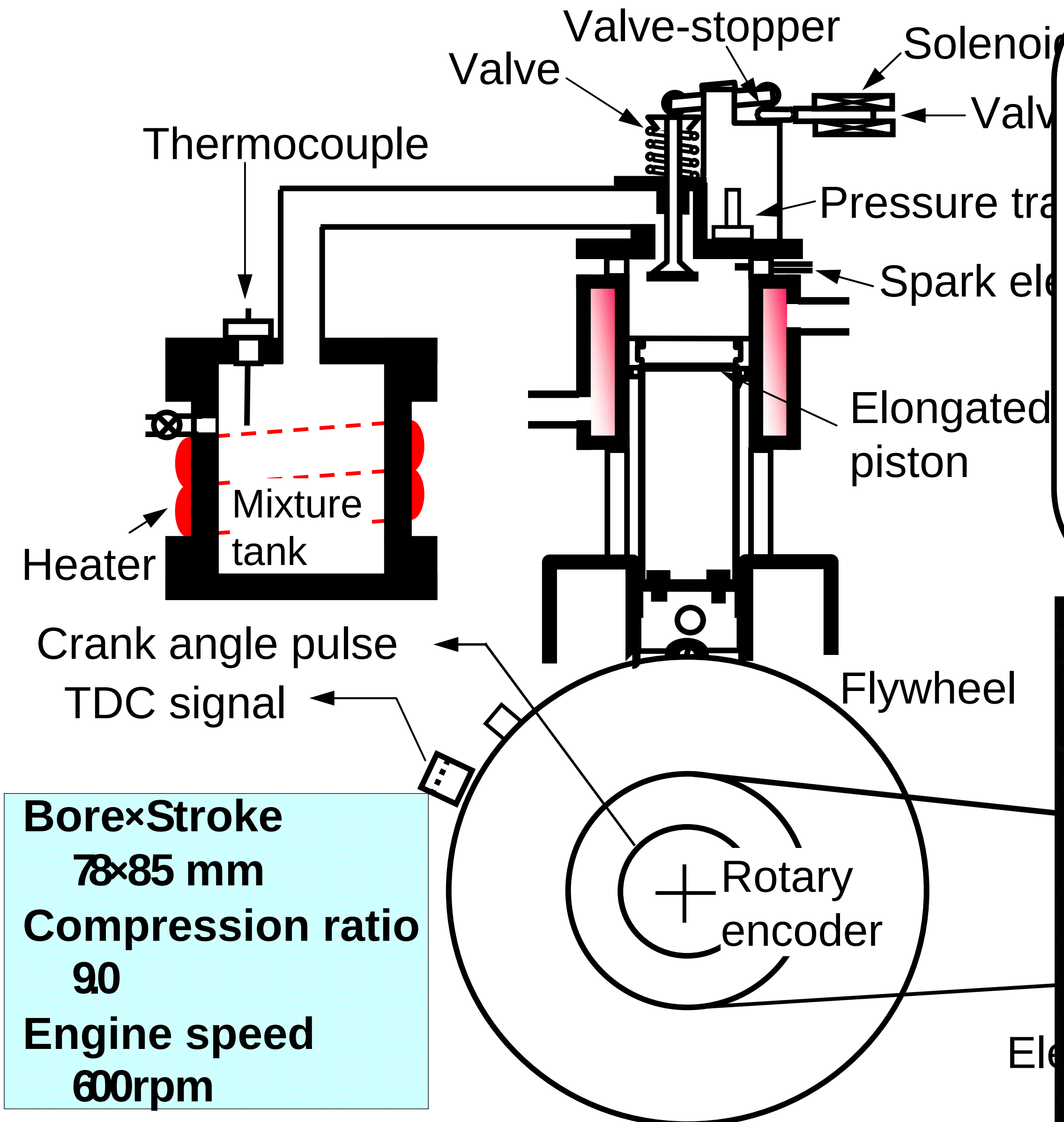


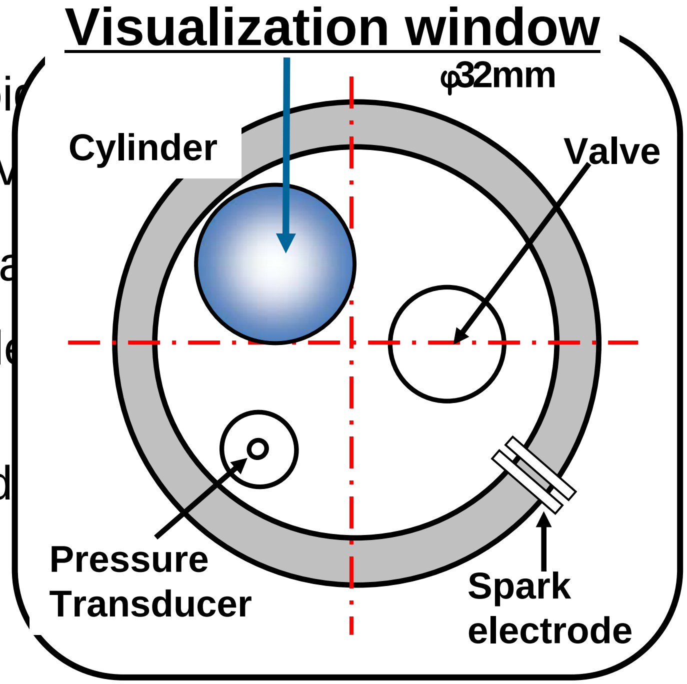
Motivation

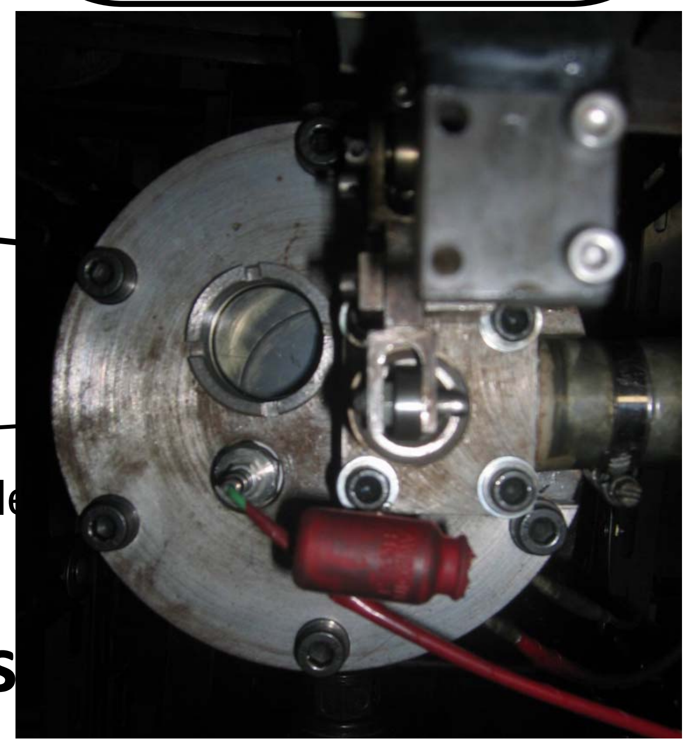


n=1000rpm, Natural gas + diesel fuel ϕ_t=0.6, m_{go}=2.0mg/cycle, P_{in}=200kPa

Natural gas engine ignited with pilot diesel fuel

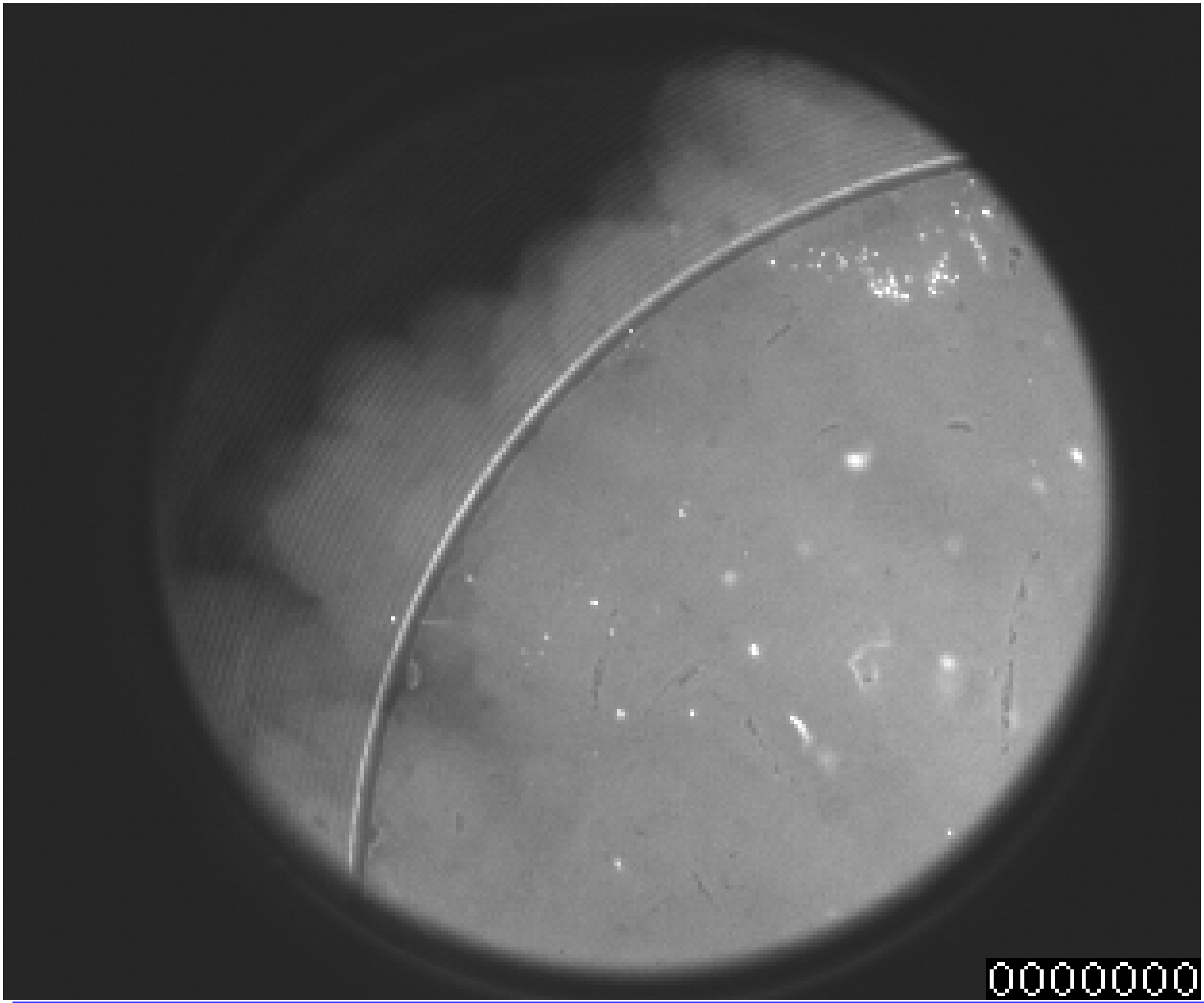






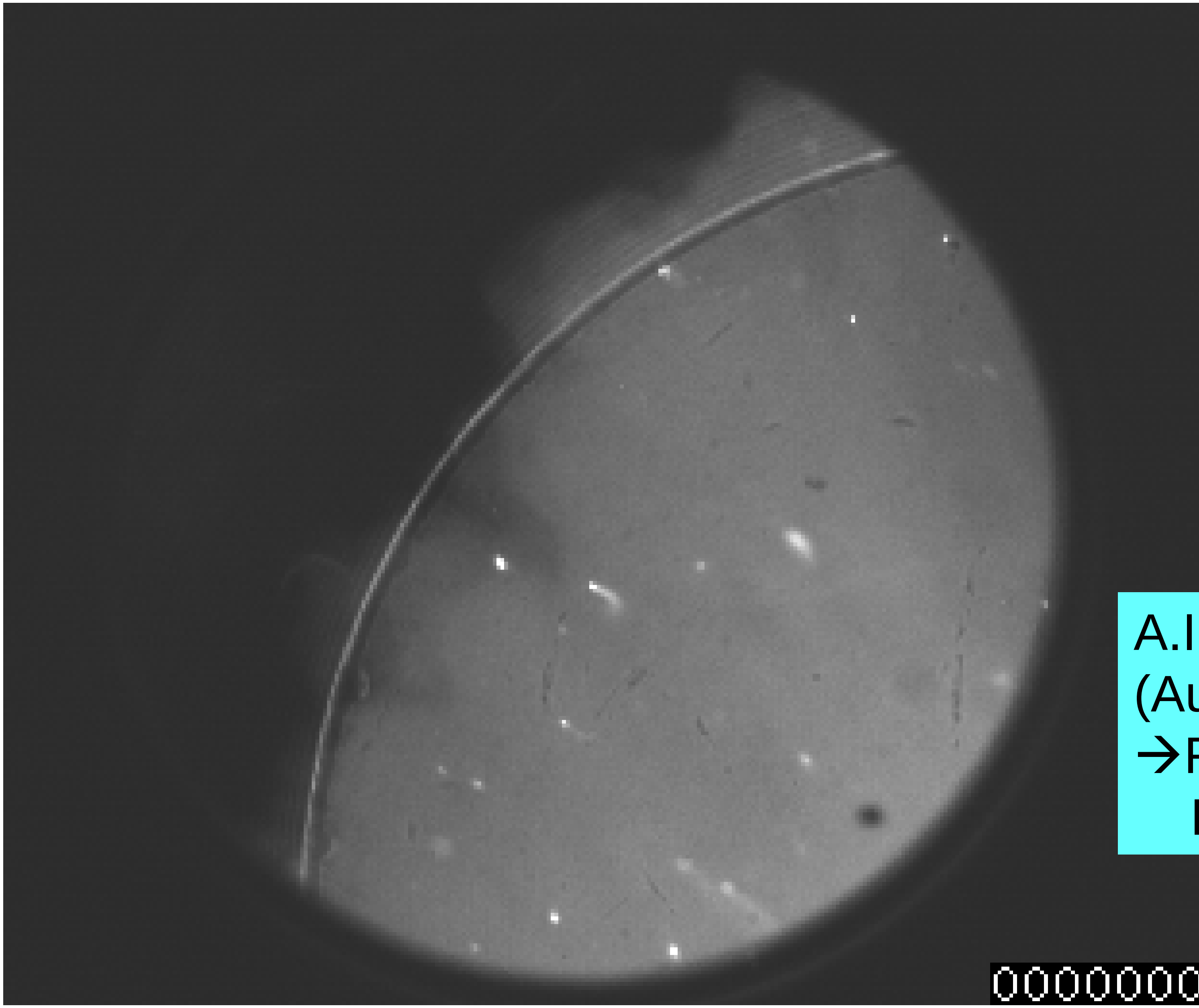
Bore×Stroke
78×85 mm
Compression ratio
9.0
Engine speed
600rpm

Experimental s



Knock

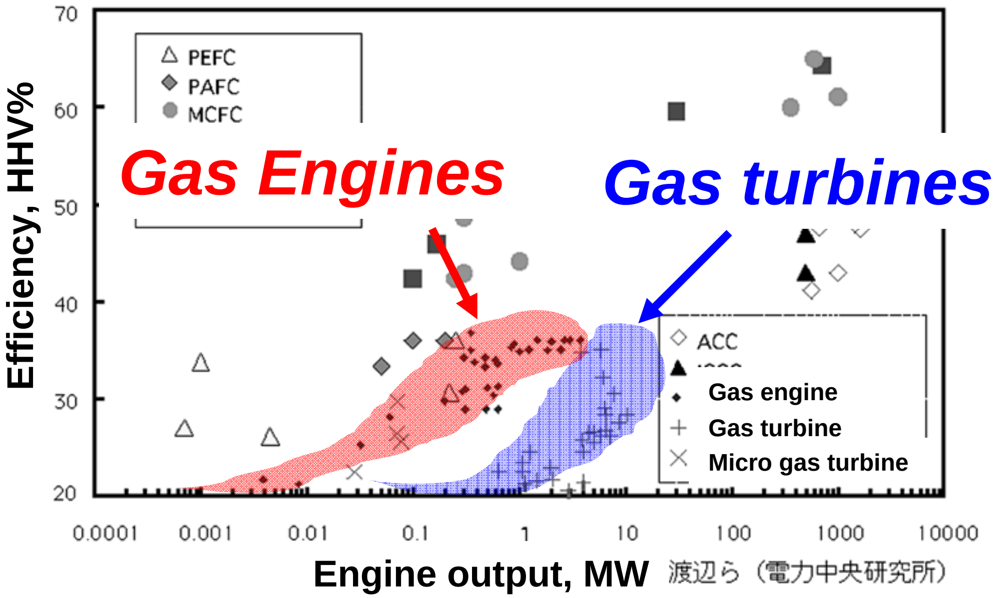
Combustion near end gas region with a high-speed video camera



A.I. →F.P.
(Auto-ignition
→Flame
Propagation)

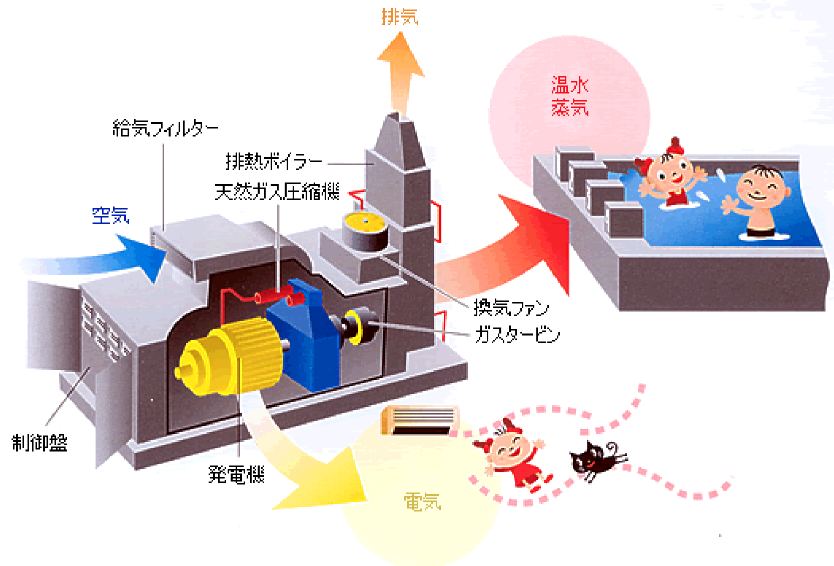
Combustion near end gas region with a high-speed video camera

Power generation



Reference

http://www.iae.or.jp/publish/kihou/29-1/03_7.html



Gas Engines

Gaseous fuel

High octane number

Ignition systems

Dual-fuel gas engine

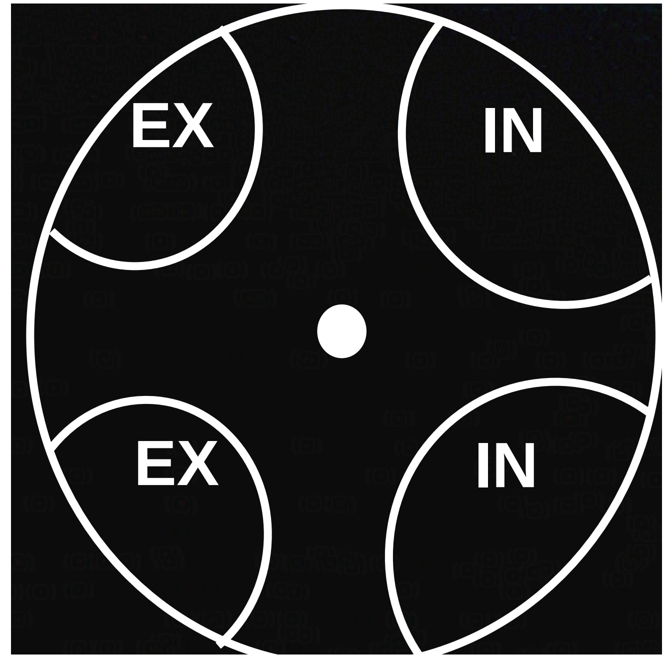
(6 cylinders, 1000kW)

Background

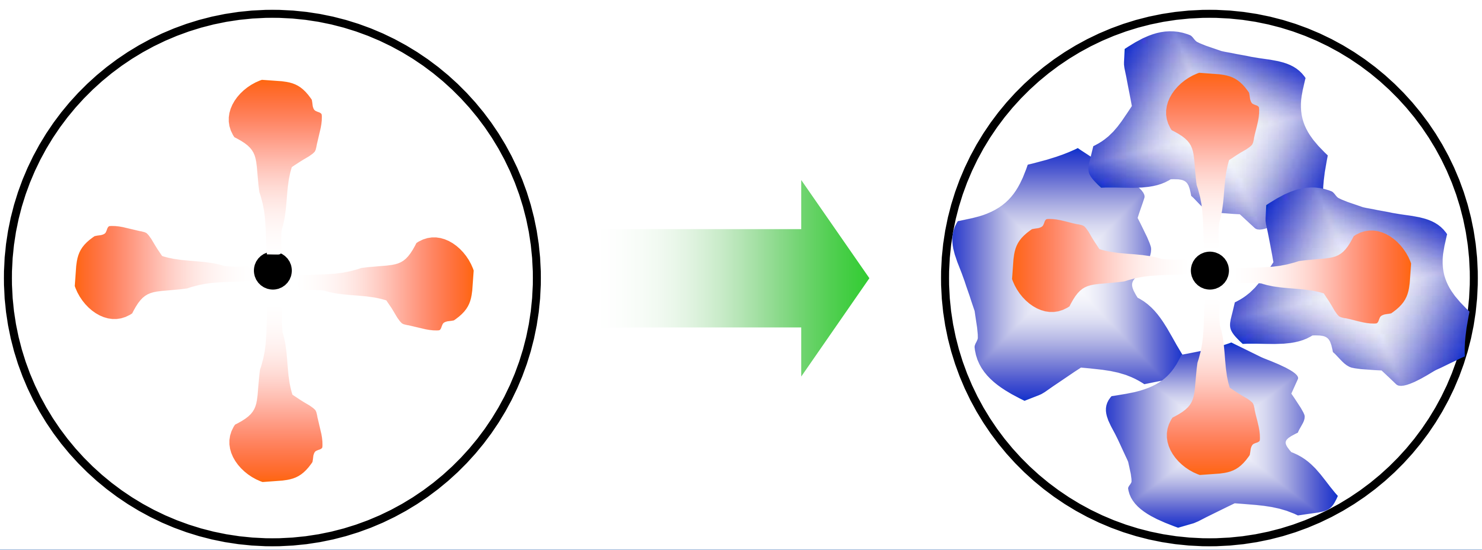
Dual-fuel system

Diesel fuel ; ignition sources

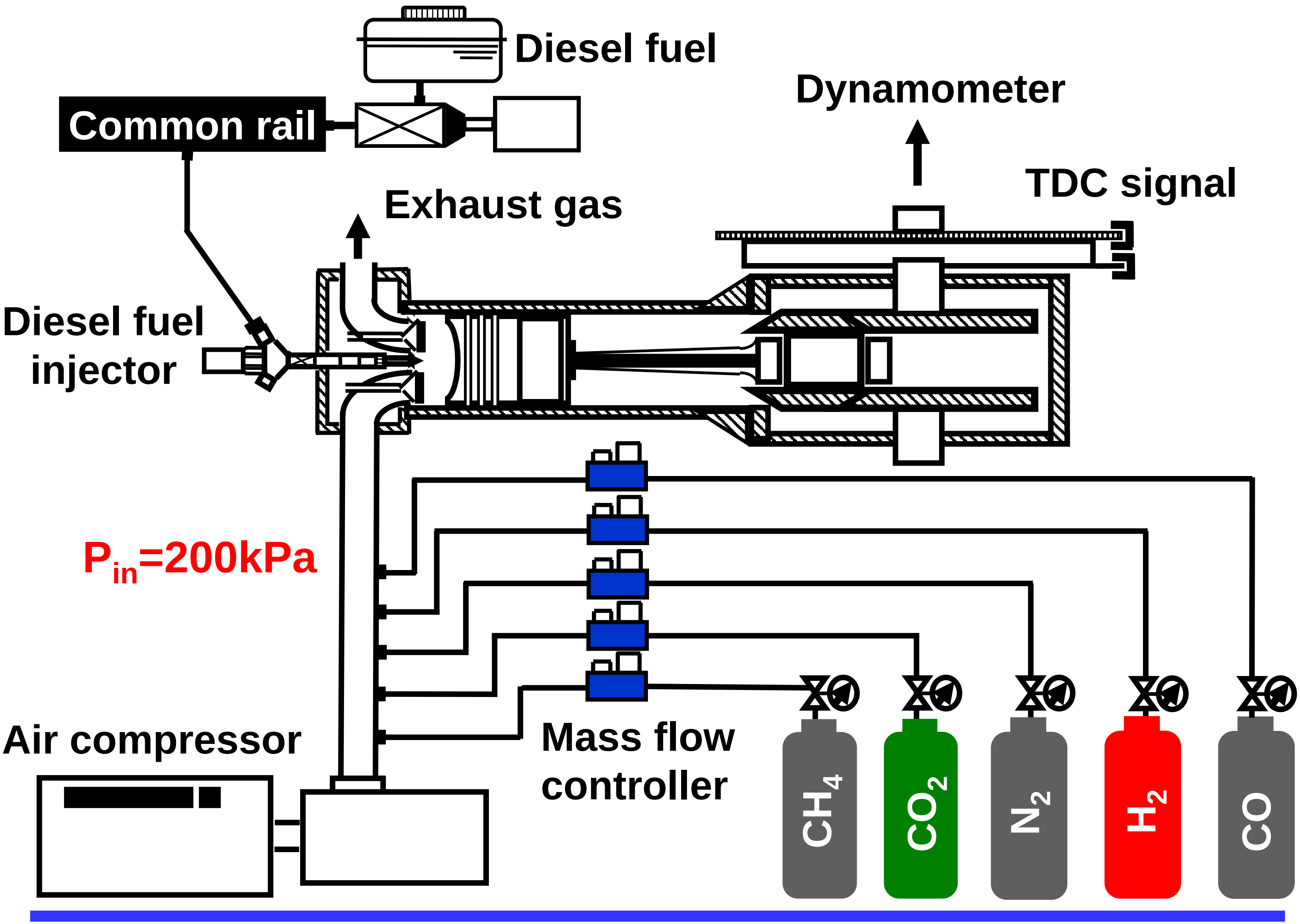
- ***Multi-point ignition***
- ***Easy control of ignition energy***
- ***High power and thermal efficiency***



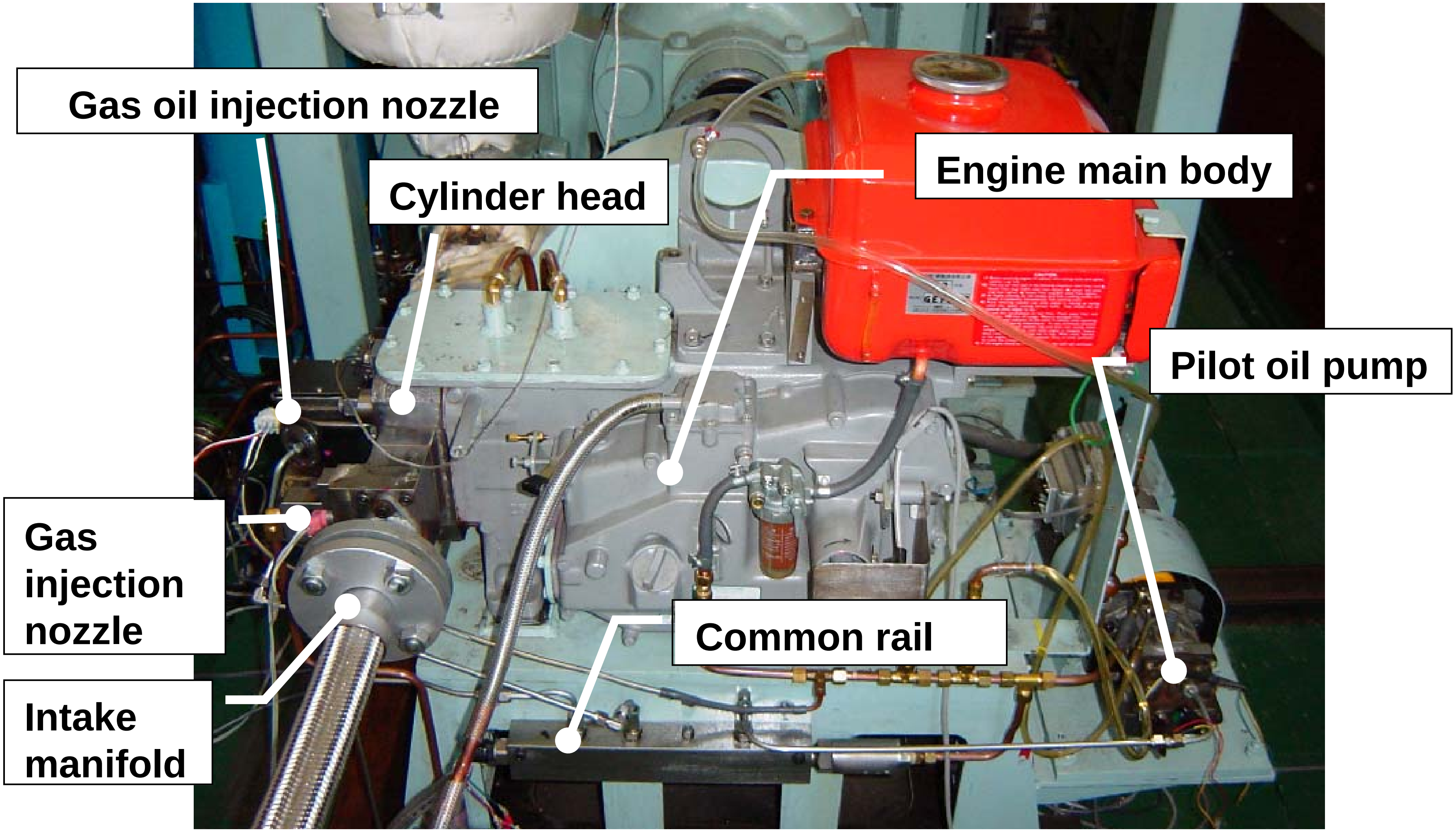
Auto-ignition of diesel fuel ***Flame development of gaseous fuel***



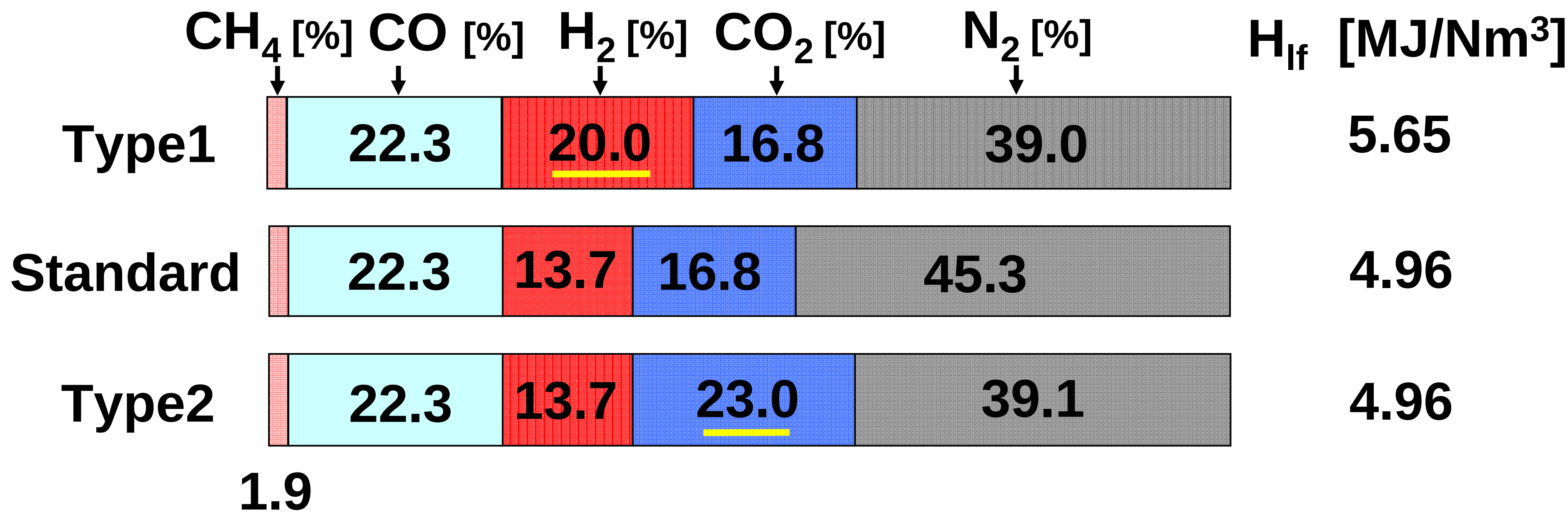
Dual - fuel system



Experimental apparatus



Bore×Stroke	96×108 mm (782 cc)
Compression ratio	16.0
Engine speed	1000 rpm
Intake pressure	200 kPa



Standard : Biomass gas made of wood tips

Type□ H2-enriched

Type2: CO2-enriched

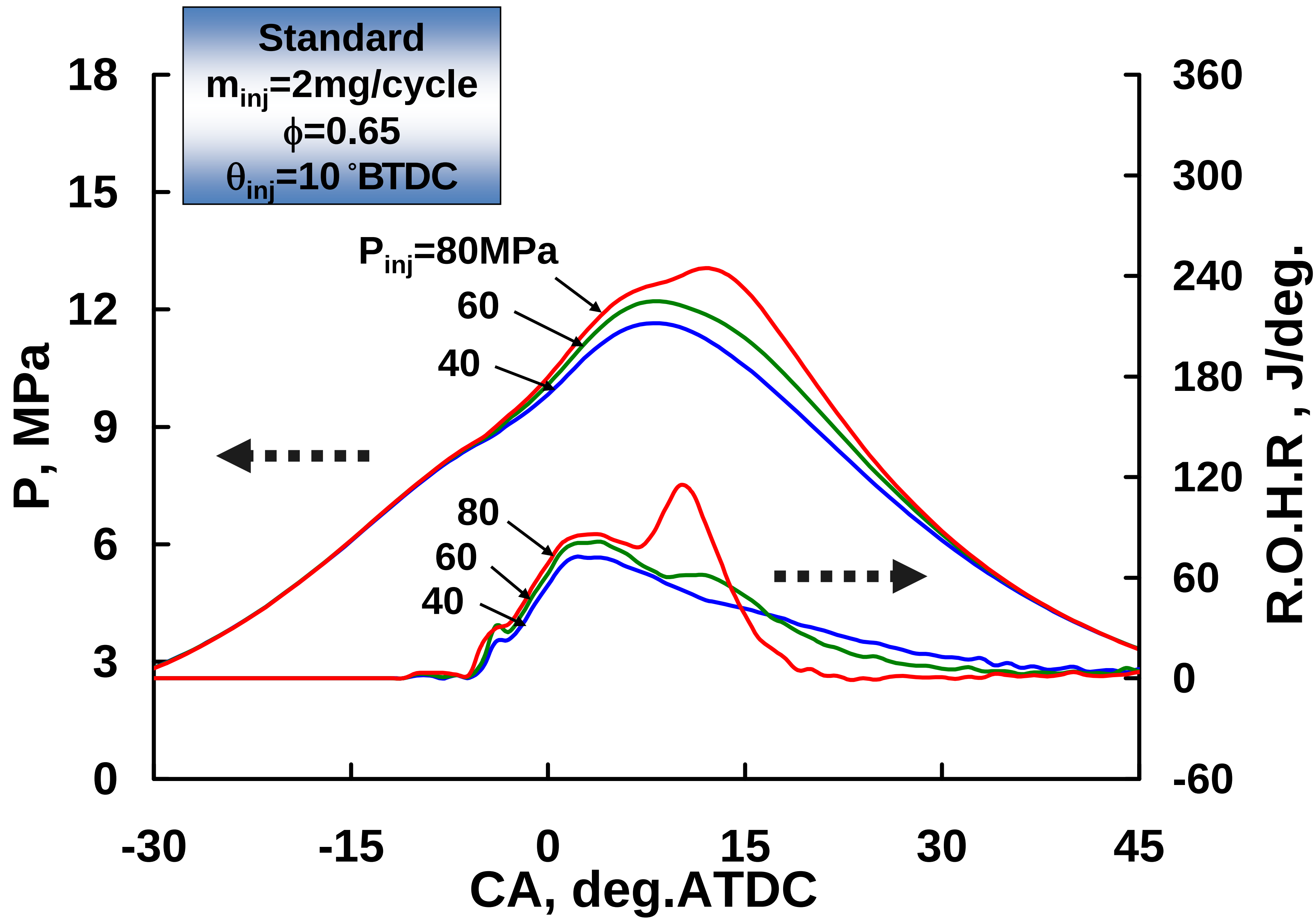
	CH_4 [%]	C_2H_6 [%]	C_3H_8 [%]	C_4H_{10} [%]	H_{lf} [MJ/Nm^3]
NG(13A)	88.9	6.8	3.1	1.2	39.2

Gas components

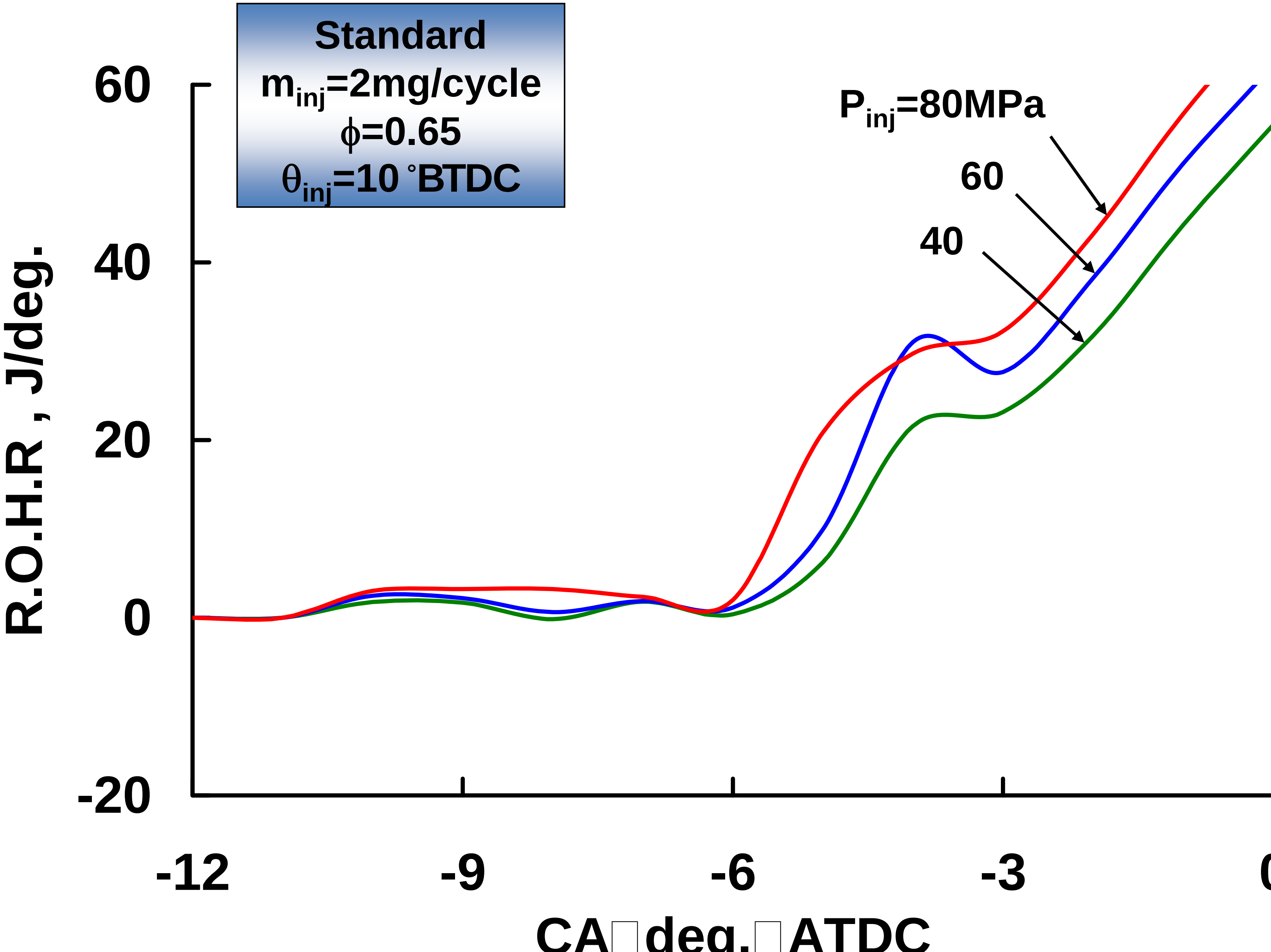
Effects of injection pressure and amount of diesel fuel on combustion and exhaust emissions

Standard

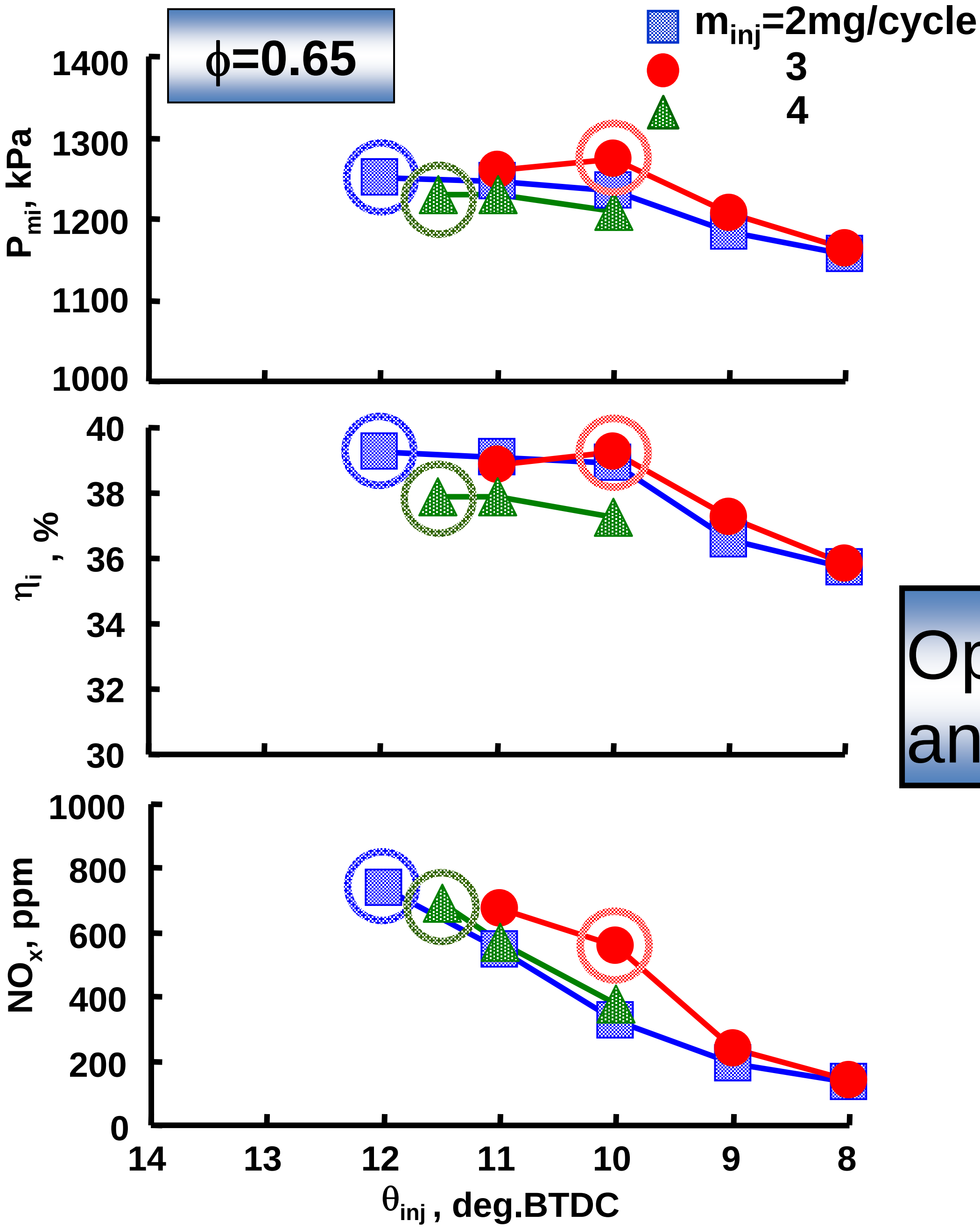
$\boldsymbol{\phi_{\square}=0.65}$



Effect of injection pressure of diesel fuel (m_{inj}=2mg/cycle)



Effect of injection pressure of diesel fuel on ROHR



IMEP

High load

Thermal efficiency

High efficiency

Optimum injection pressure and amount of diesel fuel

P_{inj}=80MPa□

m_{inj}=3mg/cycle

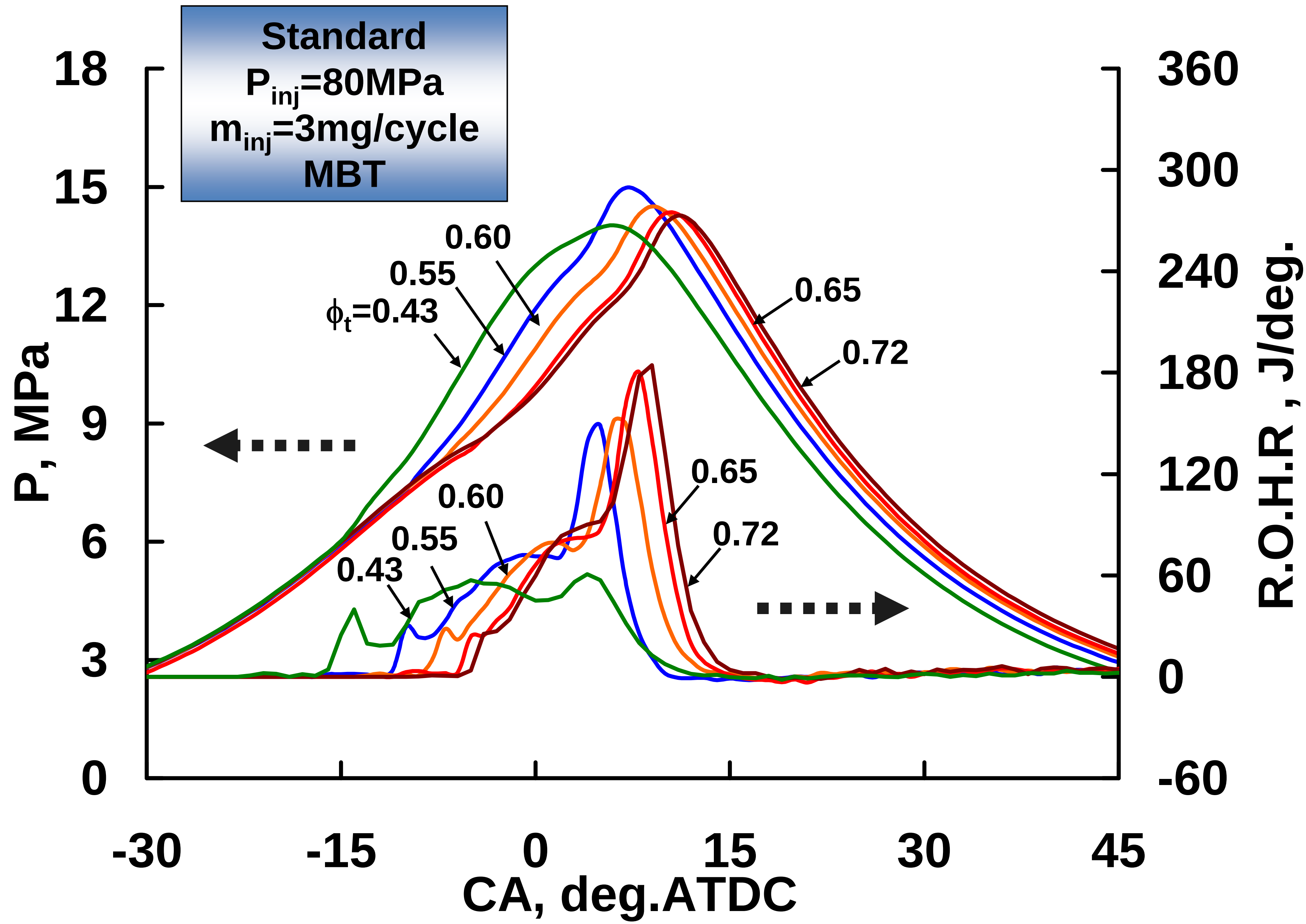
Effect of amount of diesel fuel on combustion (P_{inj}=80MPa)

Effect of equivalence ratio on combustion and exhaust emissions

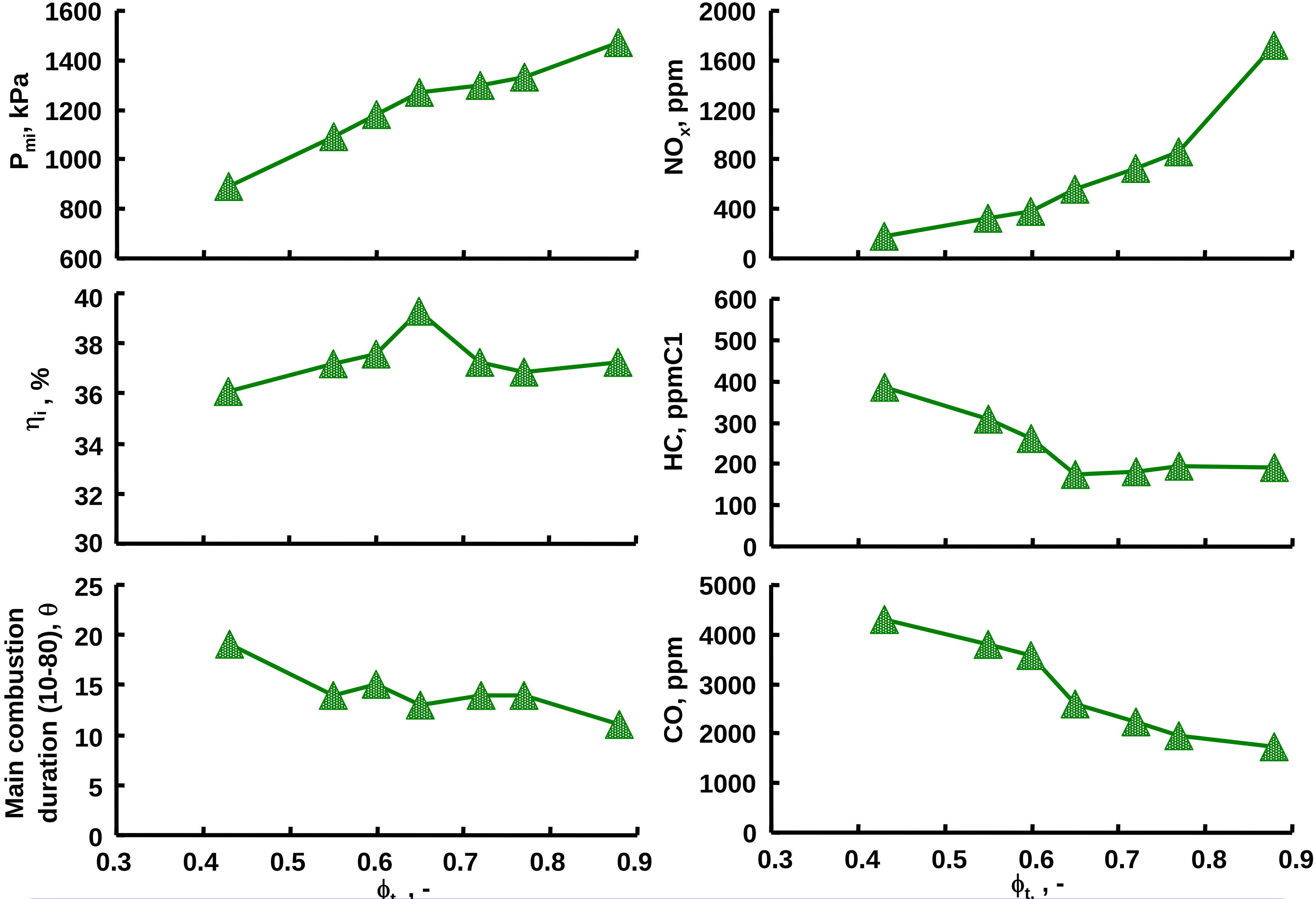
Standard

P_{inj} =80MPa

m_{inj} =3mg/cycle



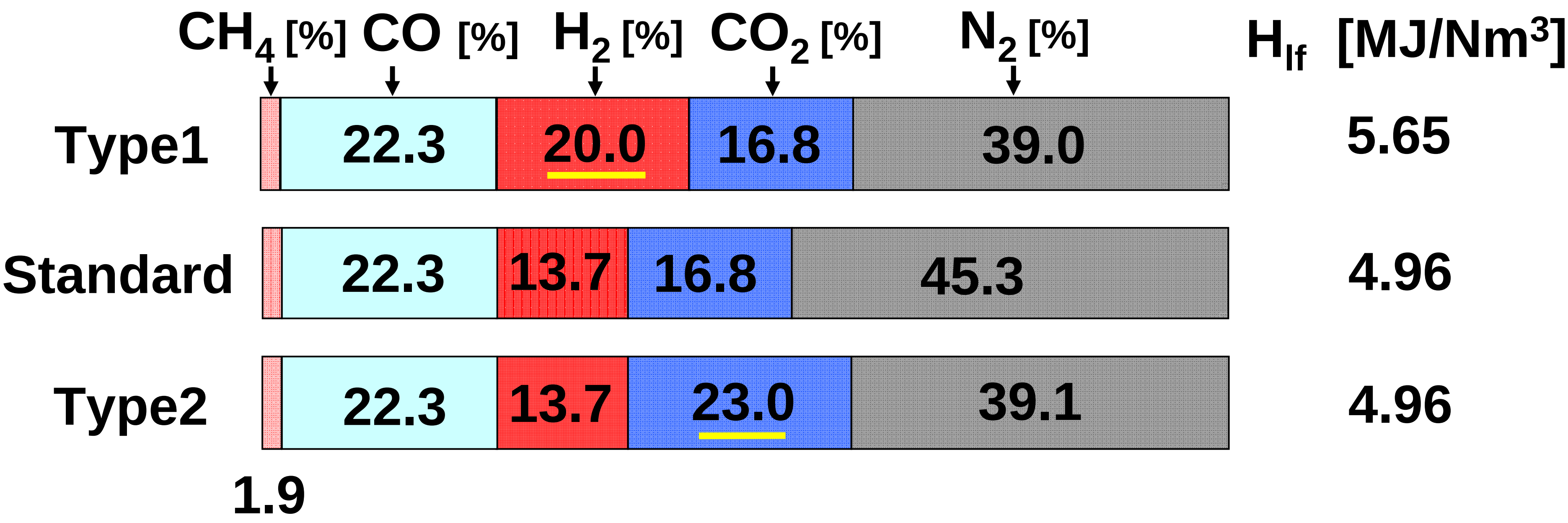
Effect of equivalence ratio on pressure history and ROHR



Effect of equivalence ratio on engine performance (Standard)

Effect of equivalence ratio on engine performance and exhaust emissions

P_{inj} =80MPa
m_{inj} =3mg/cycle
Standard, Type1, Type2



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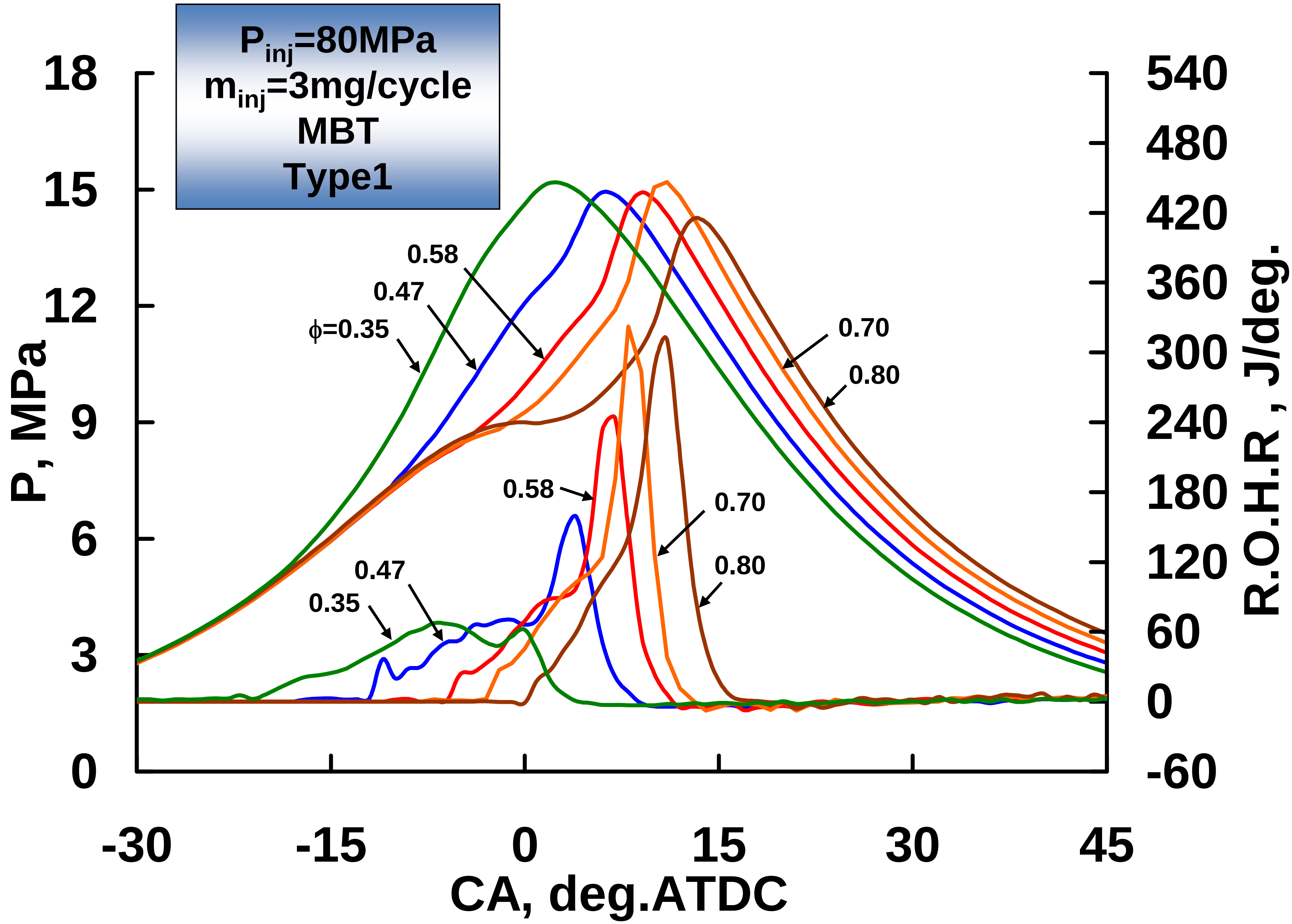
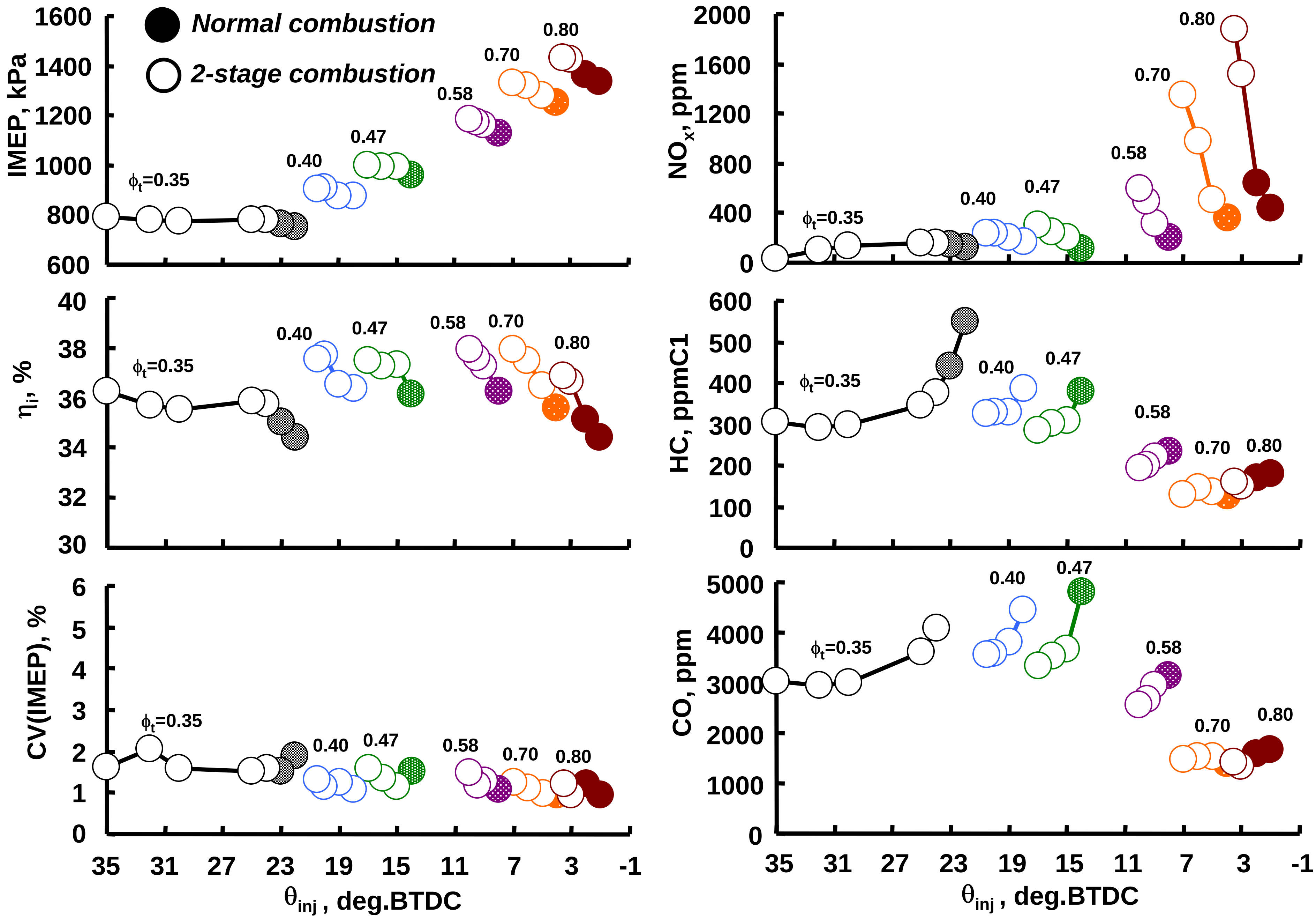
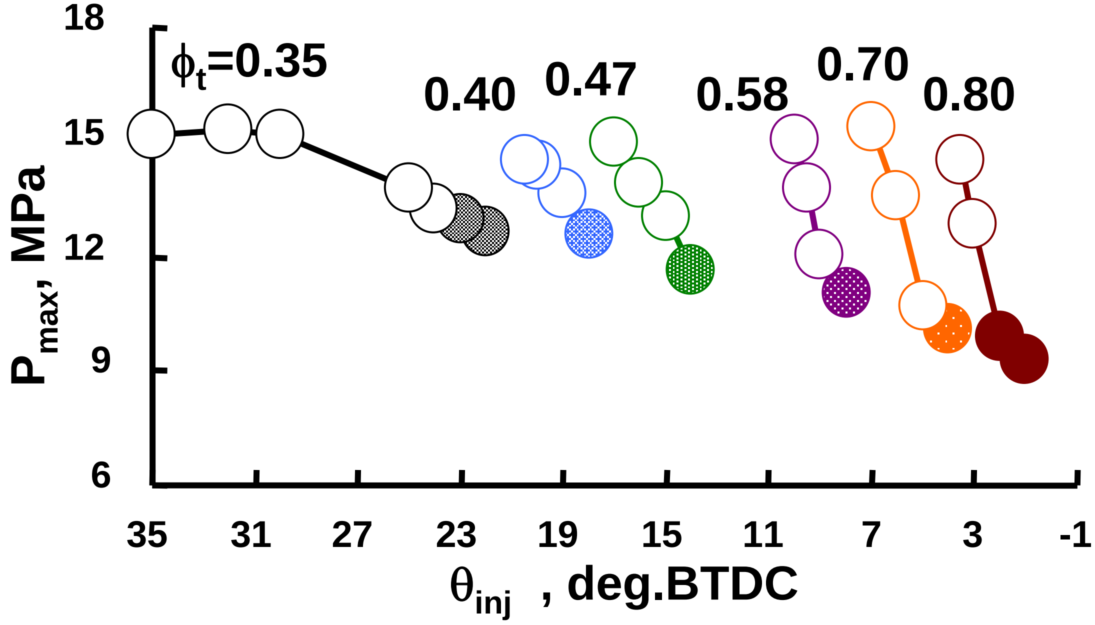
Gas components



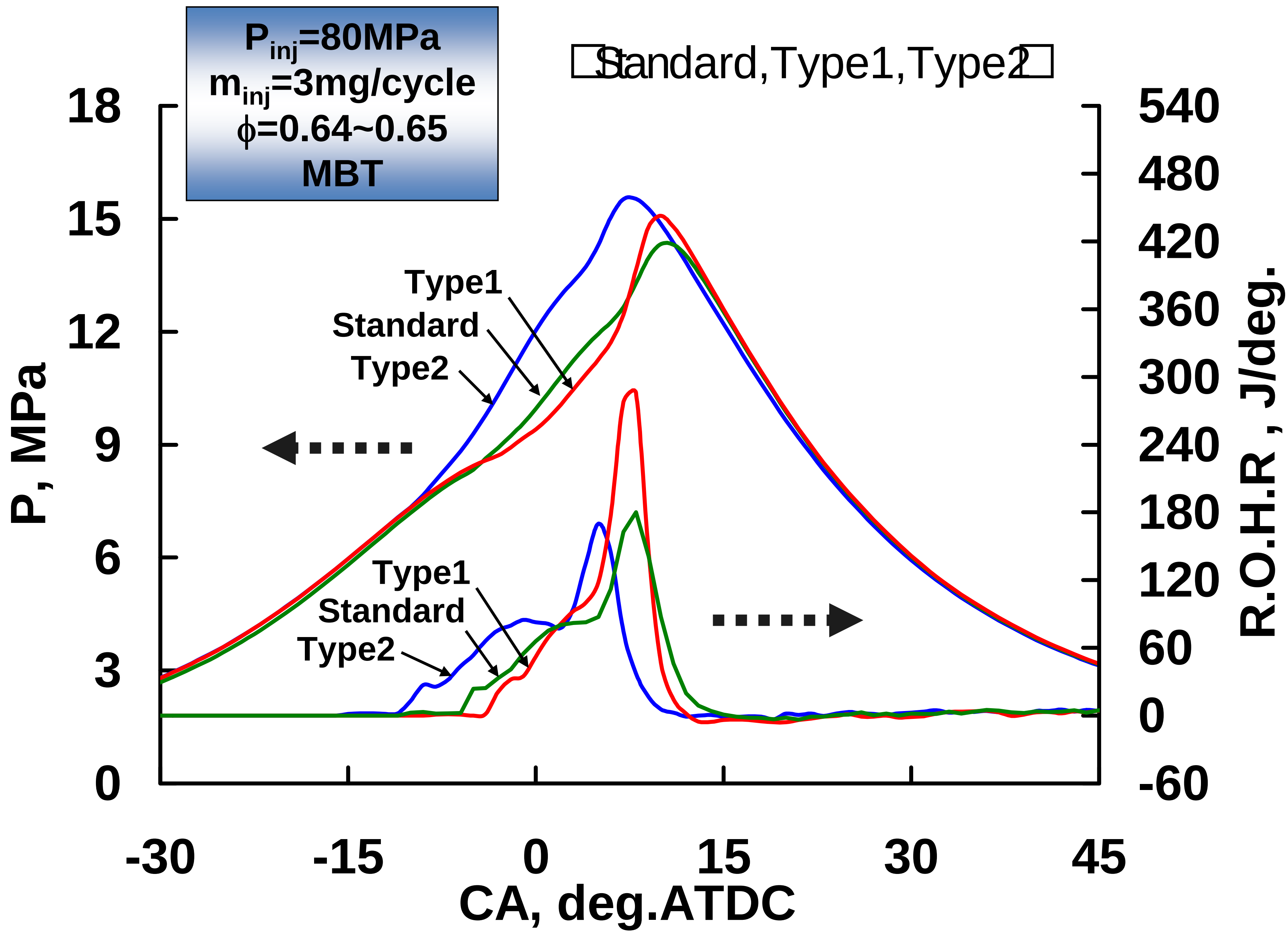
Pressure history and ROHR (Type 1; H2-enriched)



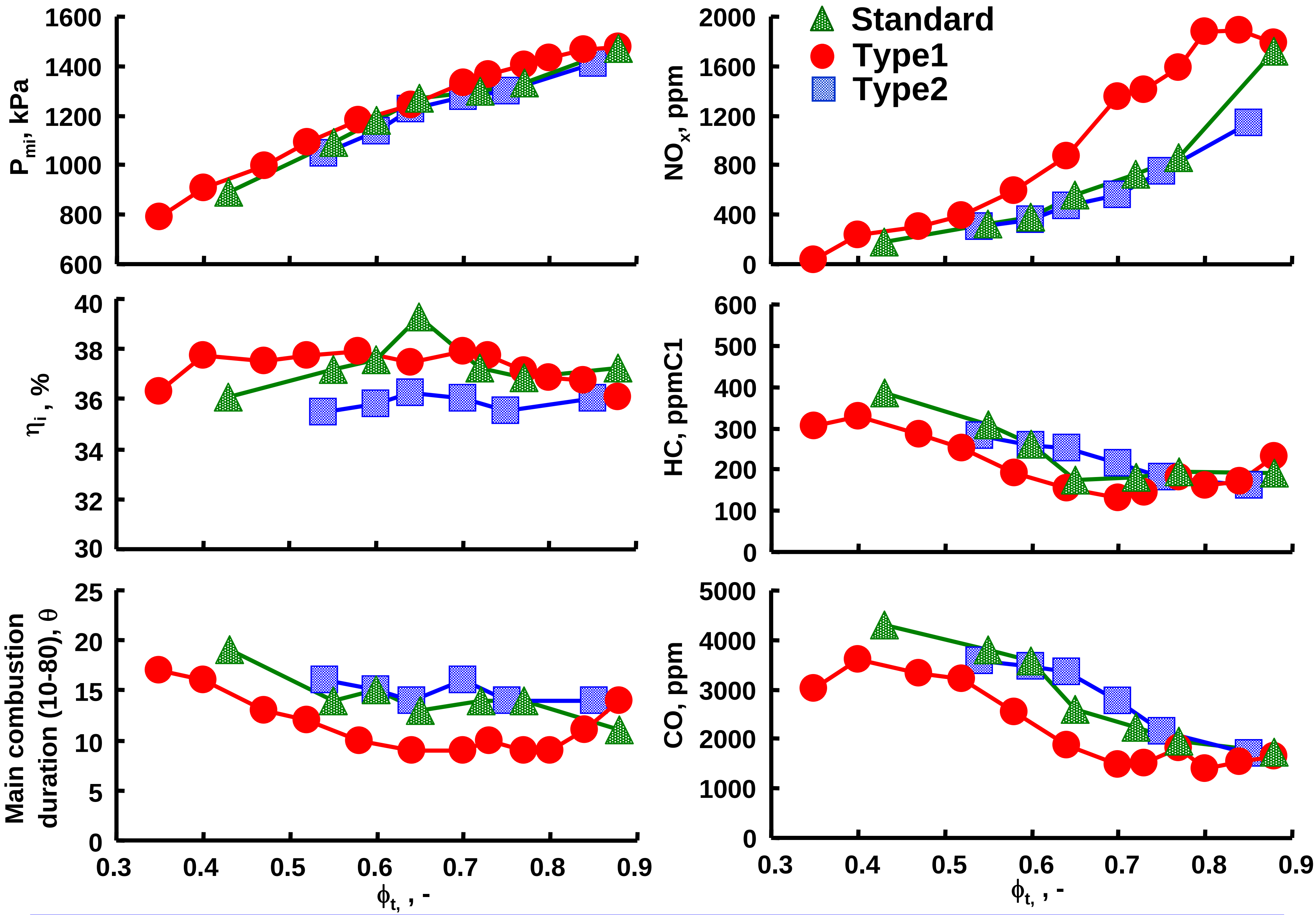
P_{inj}=80MPa, m_{inj}=3mg/cycle, Type1; H2-enriched



P_{inj}=80MPa, m_{inj}=3mg/cycle, Type1; H2-enriched



Effect of gas component on pressure history and ROHR



Effect of gas component on performance and exhaust emissions

(1) A broader window of fuel–air equivalence ratio (ϕ=0.42–0.79) was obtained using high H2-content producer gas. On the other hand, with low H2-content producer gas, the optimum window of fuel–air equivalence ratio was narrower (ϕ= 0.52–0.68).

(2) Two-stage combustion was an indicator of maximum power conditions as well as a precursor of knock for producer gases. The main combustion (10–80% MFB) with two-stage combustion cycles took less than half the time of normal combustion. In addition, high H2-content gas reduced the main combustion compared to the case with low H2-content gas in both normal and two-stage combustion.

Summary