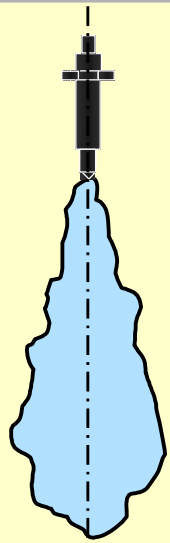
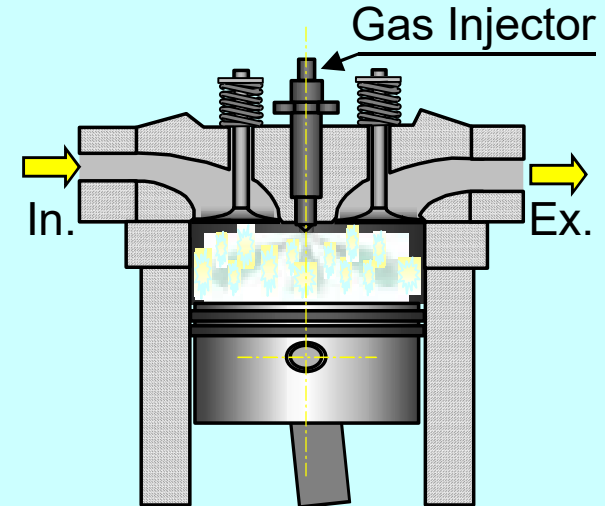


Applying Gaseous Fuels to IC Engines with Direct-Injection System

Potential & Technical Challenges of Direct Injection Compression Ignition

- Wide operation range
- Application to large-sized engine
- Prevention of abnormal combustion
- High combustion efficiency
- **Proper auto-ignition timing**
- **Control of combustion process**
- **Reduction of heat loss**



Fuel Injection

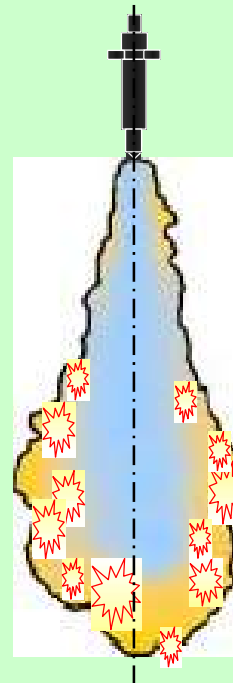
- Injection pressure
- Mass flow rate
- Nozzle configuration

Mixture Formation

- Underexpanded jet flow
- Local equivalence ratio
- Fuel distribution

Jet Development

- Entrainment
- Jet penetration
- Jet dispersion angle



Auto-Ignition Process

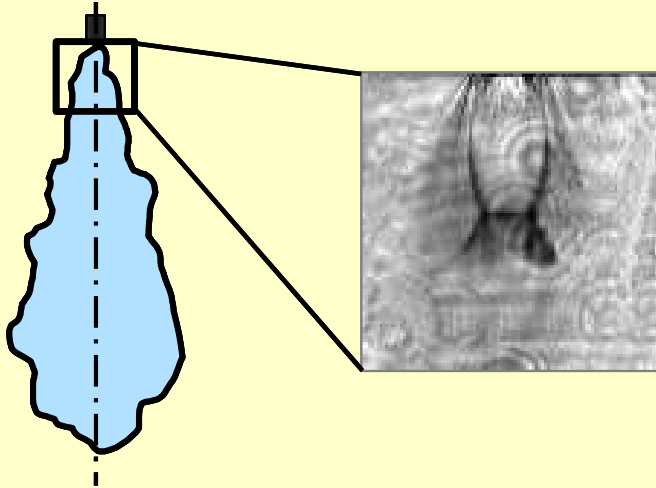
- Auto-ignition delay
- State of mixture
- Chemical kinetic modeling

Combustion Process

- Heat release rate
- Combustion regimes
- Combustion durations
- Heat losses
- Chemiluminescence

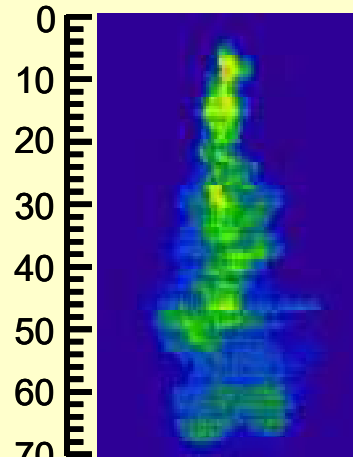
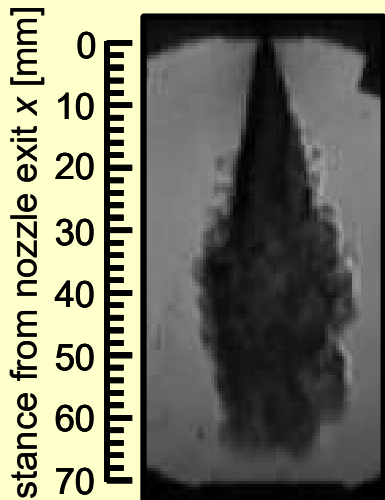
Mixing and Combustion Mechanisms Analyzed by Various Experimental Techniques

Underexpanded Jet Flow



Shadowgraphy

Rayleigh scattering

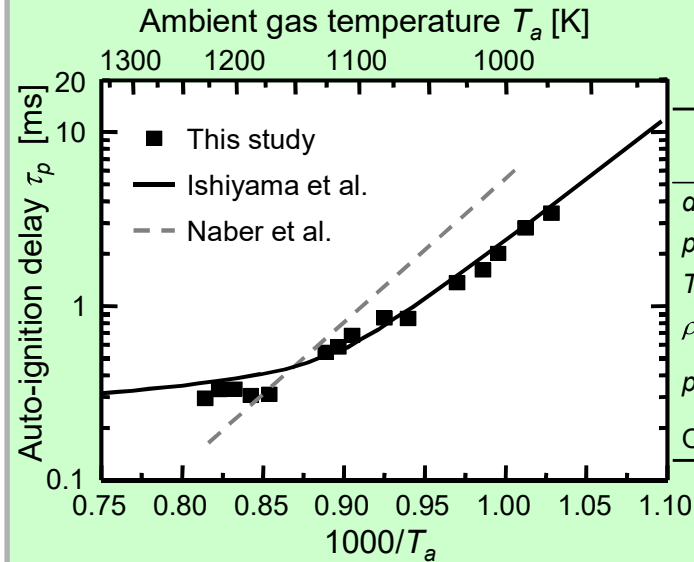


TASI* 1.0 ms

TASI* 1.0 ms

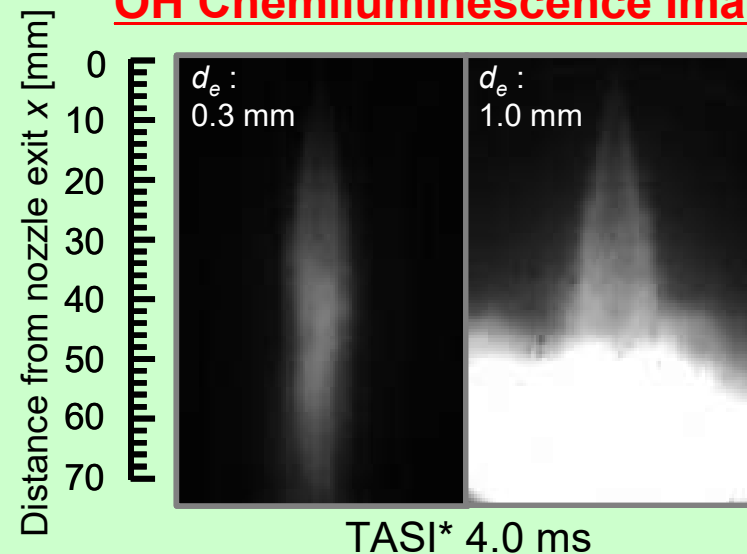
* TASI: Time After Start of Injection

Ignition Delay



	This study	Ishiyama et al.	Naber et al.
d_e [mm]	0.7	1.2	0.24
p_0 [MPa]	12	8	20.7
T_0 [K]	373	-	450
ρ_a [kg/m ³]	11.3	-	20.5
p_a [MPa]	2.9 - 3.63	4	5.78 (T_a : 1050 K)
O ₂ [%]	21	21	21

OH Chemiluminescence Image



p_0 [MPa]	12
ρ_a [kg/m ³]	11.3
T_a [K]	1080