Dimethyl-ether (DME) injection strategy for compression-ignition engine

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Dimethyl-ether (DME) is one of the most promising alternative fuels for compression-ignition engines. The reduction in NOx and particulate emissions can be achieved with DME at equal power and torque and equal fuel economy compared to diesel. Pilot injection is an effective way to reduce combustion noise and emissions. Pilot combustion increases in-cylinder pressure and temperature, which hastens the auto-ignition of the injected fuel. The shortened ignition delay and increased in-cylinder pressure and temperature change the configuration of heat release, influencing engine performance and exhaust emission. The effects of pilot injection on DME combustion were investigated in a single cylinder direct injection compression ignition engine with a common-rail injection system. The effects were studied with a fixed amount of total injected fuel mass at a fixed main injection timing. The combustion and exhaust emissions of diesel and DME were investigated and compared. The schematic diagram of the experimental setup for DME is shown in Fig. 1. The engine operating conditions are given in Table 1.

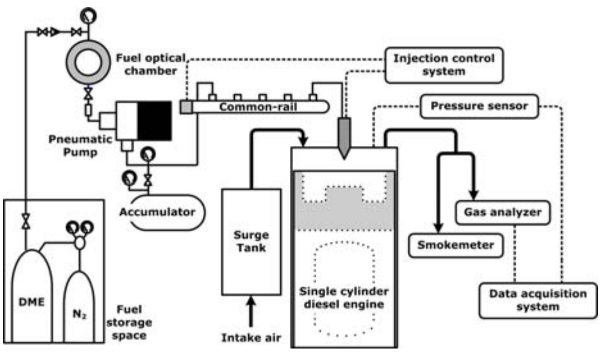

Fig. 1 Schematic diagram of the experimental setup

Table 1. Engine operating conditions

Engine speed	800 rpm		
Injection pressure	650 MPa		
Injection timing	DME	Main injection	TDC
		Pilot injection	50 CAD BTDC ~ 10 CAD BTDC
	Diesel	Main injection	10 CAD BTDC
		Pilot injection	60 CAD BTDC ~ 20 CAD BTDC
Total injected fuel quantity	DME	$22mm^3$	Corresponding to LHV of 405 J/cycle
	Diesel	$11.5mm^3$	

The following are the findings of combustion characteristics and engine-out emission of DME affected by pilot injection, compared with diesel combustion.

1. The pilot combustion increased the in-cylinder pressure and temperature under main injection timing; as a result, the start of main combustion was advanced with pilot injection.

2. The peak HRR of main combustion decreased with the pilot injection. As the pilot injection timing was advanced, the peak HRR of main combustion was increased; the peak HRR of pilot combustion was decreased. The variation in diesel combustion was more significant than that of DME due to diesel's inferior evaporation rate compared with DME.

3. The emissions of HC, CO and PM decreased with retarded pilot injection. However, these increased with advanced pilot injection timing due to the low temperature combustion of the premixed pilot fuel.

4. The NOx emission in diesel combustion was increased because of the activation of main combustion by pilot injection. On the contrary, in DME combustion, the NOx emission was decreased below that of single injection when the pilot ratio was more that 12 %.

5. PM was not emitted in DME combustion without a tradeoff with NOx since DME has good evaporation performance and good auto-ignition characteristics. Consequently, DME combustion could achieve reduction in HC and CO without an increase in NOx emissions.

The effects of pilot injection were less significant in DME combustion than in diesel. The pilot injection with diesel combustion helped evaporate the main injected fuel which made the main combustion more intense. Therefore, the pilot injection resulted in decreased emissions of HC, CO and PM; but doubled NOx emissions in diesel combustion. In DME combustion, the pilot injected fuel had its combustion phase independently, and the fuel injected during the main injection timing had sufficient evaporation performance even without the help of pilot combustion. Although pilot combustion activated the main combustion with increased in-cylinder pressure and temperature during main injection timing, the decreased main HRR with the decreased main fuel quantity caused NOx emissions to decrease.