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A study on combustion and emission characteristics in NH3-Diesel dual fuel engine under high load condition

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NH_3 is a promising substitute for fossil fuels, but its low ignitability and low burning speed are major challenges, hence mixing with diesel oil is effective for applying internal combustion engines. In this study, effects of NH_3 mixing ratio and air fuel ratio on combustion and emission characteristics have been investigated by chemical reaction calculation and experimental research on NH_3-diesel dual fuel engine under high load condition.

Table1 shows the numerical setup for chemical reaction calculation. Calculation was conducted under constant temperature and pressure conditions without considering changes due to the chemical reaction. Calculated φ-T map and adiabatic flame temperature of NH_3-Air mixture (pressure and temperature equals to 6.0 MPa and 1000 K) at each equivalence ratio are shown in Figure1. Since the combustion temperature decreases under lean conditions, unburned NH_3 and N_2O increased. NO+NO_2 is generated from fuel NO_x in lower temperature and thermal NO in higher temperature condition. Hence it's difficult to suppress NO+NO_2 by operating under lean condition. Therefore, in NH_3 combustion, high temperature combustion at a high equivalence ratio will be effective from point view of emissions.

Experimental research was conducted in 0.8L single cylinder CI engine under IMEP and engine speed equal to 1.0 MPa and 1200 min^{-1}. Figure2 shows experimental results of varied NH_3 mixing ratio and air fuel ratio. In this study, NH_3 mixing ratio is defined as energy ratio of diesel and NH_3. Also NH_3 combustion efficiency is defined as energy ratio of supplied and exhausted NH_3. NO+NO_2 and GHG emission are relative value based on diesel condition at the lowest air fuel ratio. In Figure3 NO+NO_2 was decreased due to the reduction of thermal NO from diesel diffusion combustion. At higher NH_3 mixing ratio, NO+NO_2 was increased due to fuel NO_x from lower temperature region and thermal NO generated by higher combustion temperature. Further detail research will be needed to reveal the producing mechanism of NO+NO_2. NH_3 combustion efficiency and N_2O emission were improved by decreasing air fuel ratio. GHG emission was strongly affected by N_2O and higher than diesel condition under low NH_3 mixing ratio and high air fuel ratio .

From these results, those emissions can be improved by air fuel ratio but it will be difficult to prevent completely by only improvement of combustion. Therefore, aftertreatment system will be mandatory for NH_3 internal combustion engine.

Table.1 Numerical setup

Solver	Cantera
Mechanism	Nakamura model (NH_3) SIP-Gd201-s2 (n-heptane)
Pressure [MPa]	6.0
Operation time [ms]	1.0
Temperature [K]	1000 ~ 3000
Equivalence ratio [-]	0.0 ~ 3.0

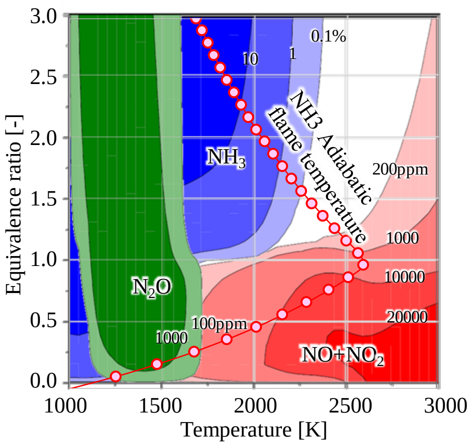

Figure.1 φ-T map of NH_3 - Air mixture

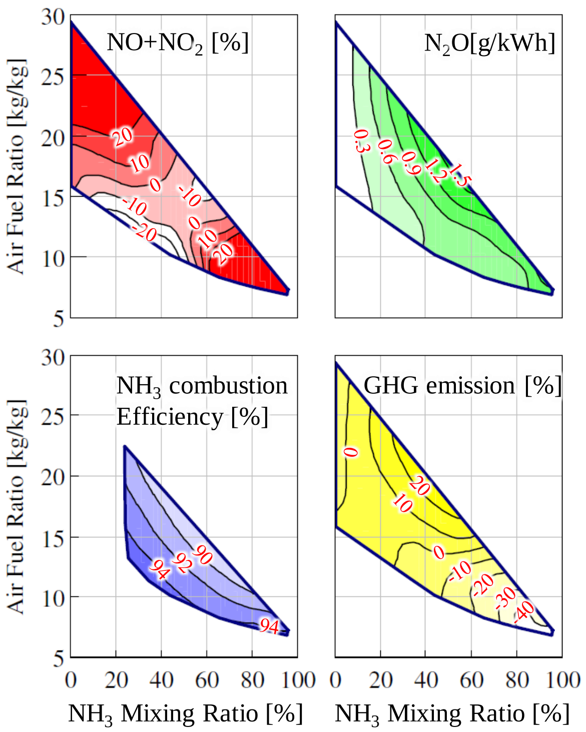

Figure.2 Contour map of NH_3 Mixing Ratio and Air Fuel Ratio