Experimental Analysis of Ammonia Generation Characteristics by Heated wall under low temperature exhaust gas conditions

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In compression ignition engines, a urea SCR system is used to reduce NOx in exhaust gases. However, under low exhaust gas temperatures (below 200 °C), urea does not completely decompose, leading to the formation of solid deposits that can cause system failure and a decrease in NH_3 conversion rate. Additionally, the SCR catalyst does not reach activation temperature, reduced NOx purification rate. This study aims to declease solid deposit and stabilize NH_3 supply from UWS spray under low exhaust gas temperature conditions at the pre-stage of the SCR catalyst. To achieve this, this study focuses on promoting the uniform distribution of UWS spray droplets and promoting the thermal decomposition reaction, and investigated the use of Superheated wall for UWS impingement. The boiling region of UWS droplets changes on a high-temperature wall. As a result, the amount of heat transferred to the droplets varies, leading to changes in droplet lifetime. However, little research has been conducted on promoting the evaporation and thermal decomposition of UWS through droplet impingement on a high-temperature wall. Moreover, there is limited knowledge on wall heating and the acceleration of thermal decomposition reactions in SCR systems to declease solid deposit and quantify NH_3 generation. In this report, the effect of wall heating on solid deposit formation and NH_3 generation is experimentally analyzed in low exhaust gas temperature conditions using UWS injection system that simulates actual devices. In this experiment, a sampling probe is inserted into the exhaust pipe 500 mm downstream from the UWS injection point, corresponding to the SCR catalyst inlet in the actual system. The gas flow through the exhaust pipe is sampled, and gas components are measured by using FTIR (BEX-2000FT). The NH_3 concentration is measured at 13 points on the exhaust pipe cross-section, and the NH_3 concentration distribution is calculated using the curvature minimization method. The UWS temperature conditions are set to 20 °C .The wall tempertature conditions are set to 100 ℃ as the non heating temperature and 200 °C, 250 ℃, 300 ℃ as the superheated condition. The exhaust gas temperature is set to 100 °C to simulate low exhaust gas temperature conditions.

Figure 1 shows the solid deposits on the non-heated and superheated wall. From Figure 1, the solid deposit formation was significantly reduced under the superheated condition compared with the non-heated condition because the superheated wall promoted the evaporation and thermal decomposition of the UWS solution.

Figure 2 shows the measured NH_3 concentration distribution as a contour map. The NH_3 concentration is the integrated concentration over the measurement period (45 seconds) divided by the number of injections (30 injections), representing the integrated concentration for one injection. From Figure 2, the NH_3 concentration under the superheating condition (T_{wall}=250°C) is 4.5 ppm, while under the non heating condition (T_{wall}=100 °C), it is 0.3 ppm, indicating that NH_3 concentration increases by 15 times due to wall heating. Additionally, the NH_3 concentration at a T_{wall}=300 °C was lower than that at T_{wall}=250 °C. This is because film boiling reduced the amount of heat transferred from the wall to the UWS.

In conclusion, superheated wall reduces the solid deposit formation on the wall and increases the NH_3 concentration .

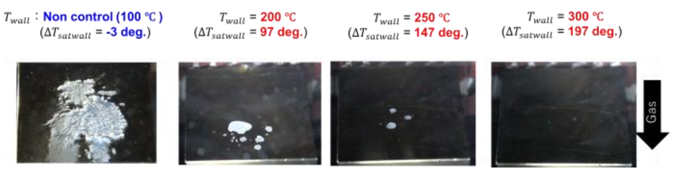

Fig.1 Solid deposits on the non-heated and superheated wall
(Q_{inj} : 35 mg, P_{inj} : 0.8 MPa, T_{gas} : 100 ℃, f : 1 Hz, n_{inj} : 30 injections, Q_{gas} : 65.6 g/s, T_{UWS} : 20 ℃, ΔT_{satUWS} : -83 deg.)

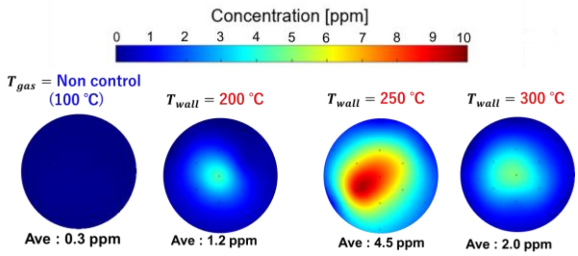

Fig.2 NH_3 concentration distribution
(Q_{inj} : 35 mg, P_{inj} : 0.8 MPa, T_{gas} : 100 ℃, f : 1 Hz, n_{inj} : 30 injections, Q_{gas} : 65.6 g/s, T_{UWS} : 20 ℃, ΔT_{satUWS} : -83 deg.)