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EXPERIMENTAL STUDY ON THE CHARACTERISTICS OF NANO-PARTICLE EMISSIONS FROM A HEAVY-DUTY DIESEL ENGINE USING A UREA-SCR SYSTEM

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ABSTRACT–Particulate matter in diesel engine exhaust, particularly nano-particles, can cause serious human health problems including diseases such as lung cancer. Because diesel nano-particle issues are of global concern, regulations on particulate matter emissions specify that not only the weight of particulate matter emitted but also the concentration of nano-particles must be controlled. This study aimed to determine the effects on nano-particle and PM emissions from a diesel engine when applying a urea-SCR system for NO_x reduction. We found that PM weight increases by approximately 90% when urea is injected in ND-13 mode over the emission without urea injection. Additionally, PM weight increases as the NH_3/NO_x mole ratio is increased at 250 ℃. In SEM scans of the collected PM, spherical particles were observed during urea injection, with sizes of approximately 200 nm to 1 μm. This study was designed to determine the conditions under which nano-particles and PM are formed in a urea-SCR system and to relate these conditions to particle size and shape via a quantitative analysis in ND-13 mode.

KEY WORDS : PM (Particulate Matter), NH_3 slip, SCR (Selective Catalytic Reduction), SV (Space Velocity), AOC (Ammonia Oxidation Catalyst), CPC (Condensation Particle Counter), SEM (Scanning Electron Microscopy)

1. INTRODUCTION

The harmful materials discharged from diesel engines primarily consist of carbon monoxide (CO), total hydrocarbon (THC), nitrogen oxide (NO_x), gaseous materials and particulate matter (PM). With the recent application of EURO-5/6 specifications, the exhaust emission regulations for diesel engines have become more stringent, making it more difficult to satisfy emission regulations for automobiles with the application of current engine combustion technology. Accordingly, studies on aftertreatment technology for automobile exhaust are being actively conducted worldwide. The PM in the exhaust gases from a diesel engine can be reduced by approximately 90% with a diesel particulate filter (DPF), and a number of studies have been conducted for the reduction of nitrogen oxide (NO_x) emissions (Helden and Gendereren, 2002; Hirata *et al*., 2005; Schmieg and Lee, 2002; Fischer and Hofmann, 2004; Khair and Mckinnon, 1999) using technologies such as lean NO_x traps (LNT), lean NO_x catalysts (LNC), and selective catalytic reduction with urea (urea-SCR). Urea-SCR technology has been applied in Japan and Europe for mid-to-large-sized commercial vehicles since 2005 and for heavy-duty diesel engines in Korea since 2008.

As for the other harmful substances produced by diesel engines, nano-particles in the PM are known to be harmful to human health. In general, diesel engines without after-treatment systems produce high concentrations of nano-particles with a size of 10 nm. Due to the decreased weight of particulate matter of such small size, these emissions can satisfy the PM weight standards but cause more harm to the human body. Europe PMP plans to regulate PM based on nano-particle density rather than weight, with enforcement starting in 2011. In 2011, particle emissions will be restricted to 6×10^{11} #/ km for diesel passenger vehicles, and domestic automobile makers must meet this regulation to export automobiles (Anderson and Clarke, 2006; Bernemyr and Angstrom, 2007).

Measurement technologies have been developed for nano-particle emissions. (Yun *et al*., 2009; Giechaskel and Carrier, 2009; Liu and Osmondson, 2005; Sakurai and Saito, 2007) studied measuring technologies for constraining particles formed by the condensation of volatile components using both a CPC and a rotary-type dilution apparatus. Particle loss

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