Numerical Investigation of SNCR DeNOx Technology in a Full-Scale Stoker Incinerator and Industrial Boiler

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Extended Abstract

Recently increasing attention has been paid to the study of efficient combustion of fossil fuel with the particular emphasis on the reduction of pollutant emission such as NOx. The popular and conventional techniques of NOx reduction employ the combustion modification techniques to limit the formation of nitrogen oxides such as low NOx burner and staged combustion, etc. Currently, however, the effective alternative method to reduce NOx emission by noncatalytic means is to use fuel reburning and selective noncatalytic reduction(SNCR). In SNCR systems, a reagent is injected into the flue gas within the appropriate temperature window and reduces NOx emissions up to 50%. The NOx and reagent(ammonia or urea) react to form nitrogen and water. The main reactions are

$$NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O \qquad \text{(using ammonia)}$$

$$NO + 2CO(NH_2)_2 + O_2 \rightarrow 4N_2 + 2CO_2 + 4H_2O \qquad \text{(using urea)}$$

The purpose of this study is to investigate the enhancement of the NOx removal efficiency in the application SNCR system to a full-scale stoker incinerator and a furnace like an industrial boiler. Numerical calculations have been performed for the after-burner region of a stoker incinerator with a capacity of 200ton/day located at Daejon 4th industrial area together with an industrial boiler using heavy oil. The stoker incinerator is modeled by 3-D axi-symmetric coordinate and the industrial boiler by 3-D rectangular frame, respectively.

For the development of computer program, a control-volume based finite-difference method is used with the Patankar's SIMPLE algorithm. A two-equation k-ε and RNG k-ε turbulence models are incorporated for Reynolds stresses and the eddy breakup turbulent reaction model is employed with proper combustion chemistry for waste-off fuel burning together with the NO reduction process with NH_3. Further, droplet trajectories are traced in a Lagrangian frame by the incorporation of drag force.

For the full – scale stoker incinerator, the calculation results are compared successfully against experimental data such as velocity and oxygen concentration at the exit of the incinerator. Systematic investigation has been made in order to figure out the characteristics of waste incineration and NO reduction in terms of important parameter such as waste heating value, loading amount of domestic

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waste, and the location of reduction reagent injection point as well as castable height for wall insulation. Generally the calculated results are consistent and physically acceptable.

A similar numerical investigation has been also made for the case of a rather small industrial boiler in terms of operating and dimensional parameters of combustor such as combustor size and condition of NO reduction material injection. However, the reduction material was not penetrated well into a main flow stream and thereby not properly mixed with the NO species due to the rather small residence time and relatively high flow of gaseous velocity of this afterburning region. This kind of inherent difficulty is considered as one of the well-known phenomena for the application of SNCR technique to a rather small-scale industrial boiler. Therefore in this study a number of remedies have been investigated and reported to overcome this difficulty such as combustor size , the effective initial mixing of reduction material by tertiary air and variation of droplet diameter, etc.

In general the computational method shows the potential ability as a promising research tool to investigate the NO control methods in various NO generating systems.

Key words : NO reduction, SNCR, stoker incinerator, industrial boiler, SIMPLE