OXIDATION OF SULPHUR AND NITROGEN OXIDES BY PULSE CORONA DISCHARGE

R.H.Amirov, J.O.Chae*, Yu.N.Desiaterik, E.A.Filimonova, M.B.Zhelezniak

Russian Academy of Sciences, Institute for High Temperatures,
Izhorskaya 13/19 127412 Moscow, Russia

*Combustion Laboratory, Mechanical Department, INHA university
#235, Yong hyun-Dong Nam-Gu, Inchon, Korea

Among other researcher activities a new technology for the combined abatement of NO_x and SO_2 based on streamer corona in flue gas is being experimented [1,2]. With such a technique, oxidising radicals are produced and the reaction of NO_x and SO_2 with radicals yields several acids that can be neutralised by injecting ammonia into the gas. The final products, being solid particles, can be removed from the flue gas in an electrical precipitator.

The NO_x and SO_2 removal efficiency of the corona reactor has been measured both with and without ammonia addition to the gas stream. The gas conditions were: gas flow rate 10-55 Nl/min, gas temperature of 25 °C, pollutant gases initial concentration up to 800 ppm. Voltage pulses with amplitude up to 15 kV had rise time 20 ns and repetition frequency 500 Hz. The corona wire had length 70 cm. A high voltage divider (Tektronix P6015A) and self-made current shunt (0.9 Ω) were used. The waveforms were measured using digital oscilloscope Tektronix TDS 544A. Inputted into gas energy from one pulse was calculated by integration of voltage and current waveform multiplication for 250 ns. SO_2 concentration was measured by Pulsed Fluorescent SO_2 analyser 40 Thermoelectron, and NO_x concentration was measured by analyser NA 510-2.

The dependence of NO and SO_2 removal efficiency from gas flow rate and initial pollutant concentrations were measured. One test with fixed amount of the inputted energy per the unit of SO_2 but with different initial concentration have been made. It is found that increasing of the initial concentration from 200 ppm to 700 ppm can enlarge the removal efficiency by factor 2.5. Some tests were carried out with both pollutant gases SO_2 and NO simultaneously. An efficiency on the SO_2 removal of 96% and on the NO removal 70% in pulse corona have been achieved with ammonia addition when the SO_2 initial concentration was 480 ppm and the NO initial concentration was 230 ppm.

A numerical model for NO and SO_2 oxidation in homogeneous gas flow has been developed. The flow contains cold (T = 300-400 K) background components N_2, CO_2, H_2O, O_2 and impurities SO_2, NO_x , CO. A source of chemically active species is an electrical streamer discharge of corona type

An applications software RADICAL Ver. 4.3, calculating oxides removal, consists of a chemical database (93 reagents and 643 reactions from [3] and other papers), a program of kinetic calculation and auxiliary units. The model uses the following main parameters: pulse frequency *f*, an average specific energy input in

a streamer channels W_{st} and in a discharge chamber W_{dc}, a fraction of energy that consumes for production of active components q. The spatial nonuniformity of gas parameters, associated with existence of many streamer channels in discharge chamber, is taken into account. Concentrations of active components in streamers are calculated in the frame of G-factors approach utilising W_{st} and q values. These concentrations are used as initial conditions for a set of differential equations which describes chemical transformations in the flue gas and in the diffusion expanding channels. The calculations have been carried out for pulse series (about 1000 pulses in a series) considering change of the gas composition after each pulse.

An example of experimental and calculated results on NO and NO_x removal from air-water vapour mixture is shown in fig.1. The main processes of NO removal are $NO+O_3=NO_2+O_2$ and $NO+N=N_2+O$. Produced in the first reaction NO_2 forms then HNO_3 and HO_2NO_2 in radicals with OH and HO_2. The variation of some component concentrations in streamer channel after an electrical pulse is presented on the fig. 2. The curves have two shapes. The species, that are produced in streamer channel after discharge, as O_3, and HO_2, on the first stage increase due to reaction with active components. Then these concentrations decrease in consequence of diffusion expansion of the channel. The same processes form the NO concentration. On the first stage active radicals delete NO from channel and NO concentration has a minimum. This minimum is filled then by the NO molecules coming from the gas outside the channel. The total production of O_3 is positive and NO is negative per a pulse. The similar results were obtained for SO_2 removal.

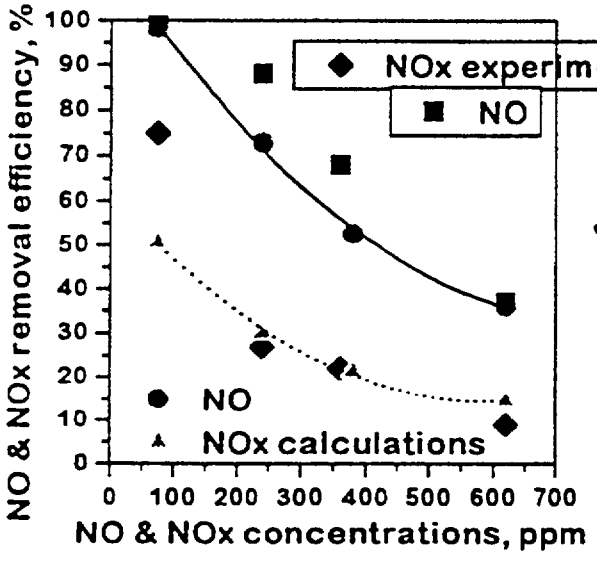

Fig.1

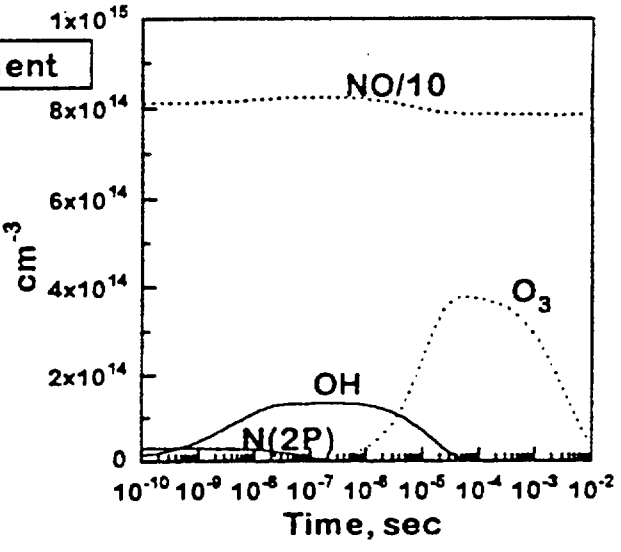

Fig.2

References

[1] S.Masuda, Pure & Appl. Chem. 60 (1988) 727
[2] G.Dinelli, L.Civitano and M.Rea, IEEE Trans. Ind. Appl. 26 (1990) 535
[3] H.Matzing, Tech. Report KfK 4494, Kerfirschungzentrum, Karlsruhe, 1989