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NO_X REDUCTION BY USING EB IRRADIATION UNDER INFLUENCE OF ALCOHOL

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A b s t r a c t. NO_x reduction by using eb irradiation under influence of alcohol was investigated in pilot plant – EPS Kawęczyn. Flue gas flow rate was 5000 NM3/hr, humidity was 4.5%, inlet concentrations of SO_2 and NO_X were 192ppm and 106ppm, and ammonia addition was 2.745M3/hr. It was found that NOx removal efficiency in the presence of alcohol was increased by 10% than without alcohol's addition when the absorbed dose was below 6 kGy, but NO_x removal efficiency was decreased when the absorbed dose was higher than 10 kGy.

K e y w o r d s: NO_x reduction, electron beam, flue gas.

INTRODUCTION

Industrial off-gas(mainly SO_2, NO_x) treatment by using eb irradiation in the presence of ammonia has been studied for many years[1-4]. From laboratory result to pilot plant result, it is known that SO_2 removal efficiency is enhanced by increasing flue gas humidity and NH3 addition(Ammonia stoichiometry:0.90),SO_2 removal efficiency reached to 90% at the absorbed dose below 6 kGy; while NO_x removal efficiency mainly depends on the absorbed dose, less than 70% NO_x is removed at the 6 kGy dose. High removal efficiency of NO_x could be reached by increasing an applied dose.

There is an energy consumption problem concerning NO_x removal. Scientists are looking for effective methods to increase NO_x removal efficiency, eg.: by injection organic compounds method [5], by using catalysis method [6] or combination both of them. This paper studied possibility of applying injection selected organic compound (alcohol) method into flue gas , it is the first time to apply this method in industrial pilot plant.

EXPERIMENTAL

Pilot plant installation

Pilot plant installation was described by Chmielewski *et al.*[7]. In brief, the pilot plant was installed on a bypass stream (5000 NM^3/hr) of the main flue gas , which was emitted from a coal –fired boiler WP-120 at EPS Kawęczyn. Alcohol vapor (95% purity) and ammonia from a gas cylinder were added to the flue gas. Flue gas was passing a reaction vessel and was irradiated by a 50kW/700keV electron accelerator.

Laboratory installation

Laboratory installation has been described by A.G.Chmielewski *et al.*[8]. In brief, simulated flue gas was prepared by adding SO_2, NO_x from gas cylinders into flue gas which was emitted from natural - gas burner. Water vapor, alcohol vapor (95% purity) and ammonia from a gas cylinder were added to the simulated flue gas, respectively, as scavengers. Simulated flue gas was passing reaction vessel at a flow rate 20m^3/hr and was irradiated up to 11kGy.

Analysis

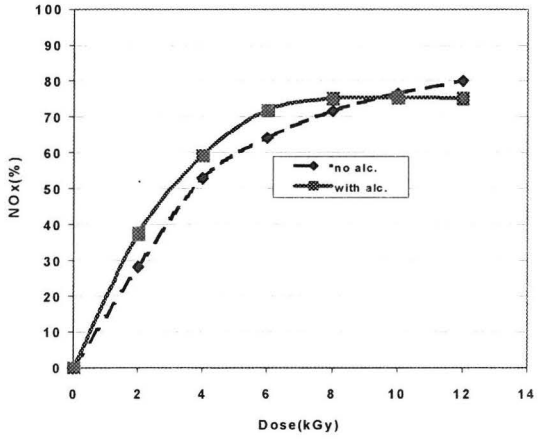
SO_2, NO_x concentration were analyzed by SO_2, NO_x gas analyzers (SO_2 model 40, NO_x /NO model 10AR, Thermo Environmental Instruments, USA), respectively. Analytical method was the same as our previous work [9].

RESULTS AND DISCUSSION

Alcohol influences on the NO_x removal and mechanism

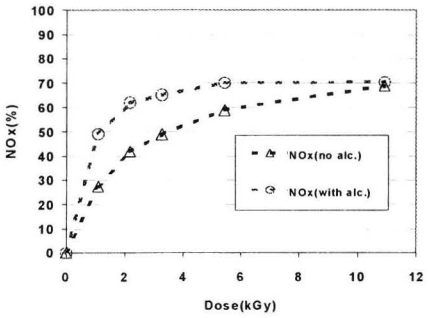
Alcohol addition into the flue gas increased NO_x removal efficiency at the dose below 6kGy. Figures 1 and 2 proved it. With the absorbed dose increasing (>10kGy), NO_x removal efficiency is decreased in the presence of alcohol. The mechanism of alcohols influences on the NO_x removal were shown in Fig.3.

Fig.1 NOx removal efficiency vs. dose under the influence of alcohol in the pilot plant EPS Kaweczyn



SO2(inl.)=192ppm; NOx(inl.)=120ppm; NH3=2.72M3/hr; Flue gas=5000M3/hr; Alc.=600 l/hr(when alc. was added).s(Alc:NOx)=1; sNH3=0.88; 60% SO2 was removed;Humidity:4.5%

Fig.2. Laborotary results of NOx removal efficiency vs. dose in the presence of alcohol



(no alc): Flue gas:20M3/hr, [SO2]ini. = 953.6ppm, [NOx]ini.=428.6ppm, s[NH3]=0.71, H2O=10.76%;

(with alc.): Flue gas=20M3/hr, [SO2]ini. = 991ppm, [NOx]ini.=495.5ppm, s[NH3]=0.59, H2O=10.63%, alc.=30l/hr, s[alc.:NOx]=3

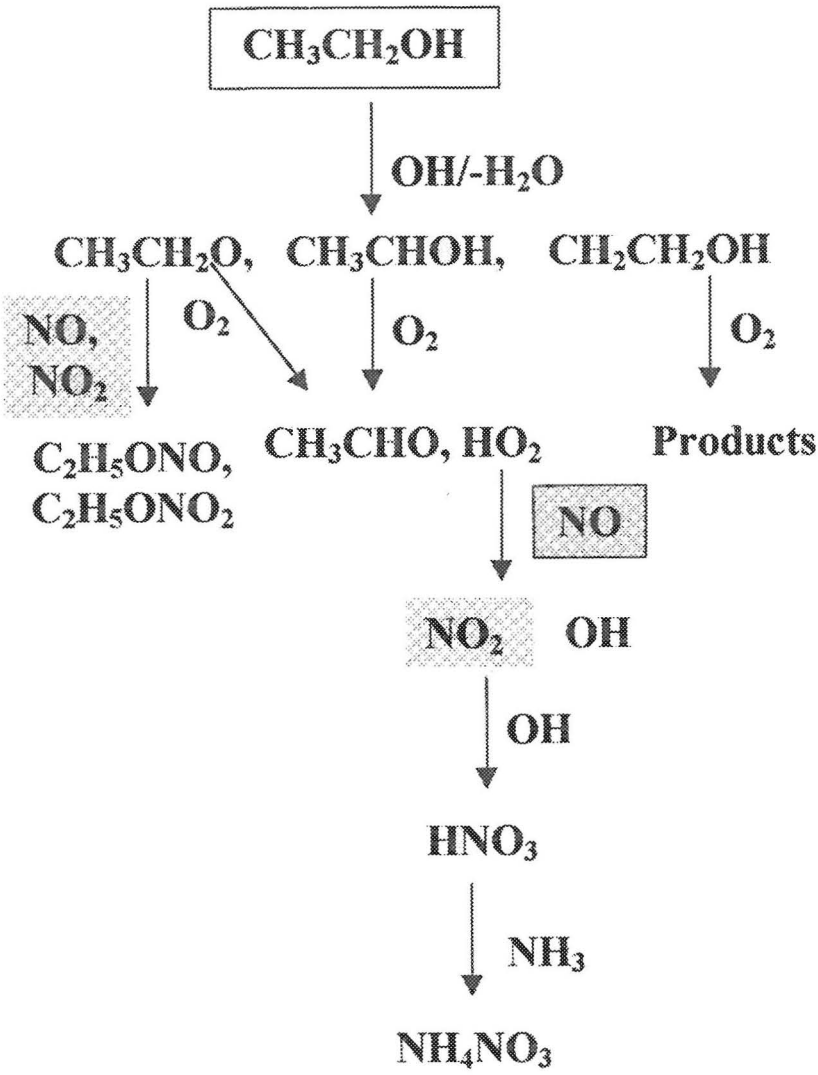


Fig.3. Mechanism of alcohol addition influence on the NO_x removal.

Economical comparison

Table 1. contents list dose vs. power for one accelerator(50 kW/ 700 keV) of EPS Kawęczyn in an experimental condition.

Table 1. Dose vs. power of accelerator in EPS Kawęczyn

Dose(kGy)	0	2	4	6	8	10	12
Power(kW)	7.4	21.9	25.1	31	34.6	38	42.5

From Fig.1, it is shown that alcohol injection can reduce 1-2 kGy absorbed dose at the same NO_x removal efficiency without alcohol injection when dose ≤8 kGy. For example, when NO_x removal efficiency was 70%, 8kGy and 6 kGy absorbed dose were needed at without alcohol injection and with alcohol injection conditions, respectively. Table 2 list cost of removal 70% NO_x in the EPS Kawęczyn by eb irradiation. Here should be mentioned that this calculation does not include NH_3, water etc. expenditure.

Table 2. Cost of removal 70% NO_x in the EPS Kawęczyn by eb irradiation(one hour process).

No alcohol	20.9 PLN
With alcohol	30.6 PLN

This calculation was based on an assumption that:
Electricity: 0.60 PLN /(kW.hr); Line-Clean ethanol :12 PLN/liter
Experimental condition:
NO_x (inlet):120 ppm; flue gas : 5000M^3/hr

Alcohol's fate in the flue gas

In the Fig.1 experimental condition, alcohol addition increased NO_x removal efficiency by 10%, in other words, 10% alcohol involved in the NO_x reaction. For initial concentration 120 ppm NO_x, 12 ppm alcohol reacted with NO_x, about 100 ppm alcohol involved in other reactions, e.g.: to form acetaldehyde , H_2, etc. or emit into atmosphere. Whether byproducts of alcohol will be beneficial to the environment or not is under a question.

CONCLUSIONS

Alcohol injection into flue gas increases NO_x removal efficiency by 10% when dose ≤ 6 kGy. However, from economical point of view, it is not a promising method to apply alcohol injection into flue gas combining with present eb technology to remove NO_x in the industrial plant .

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REDUKCJA NO_X PRZY UŻYCIU WIĄZKI ELEKTRONÓW I DODATKU ALKOHOLU

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S t r e s z c z e n i e. Badano efektywność procesu redukcji NO_x przy użyciu napromieniowania wiązką elektronów i dodatku alkoholu w pilotowej Stacji Odsiarczania Spalin przy Elektrociepłowni Kawęczyn (gaz spalinowy 5000 Nm^3/hr, wilgoć 4.5%, stężenia SO_2 192ppm i NO_X 106ppm, a dodatek amoniaku 2.75m^3/h). W obecności alkoholu efektywność redukcji NO_x wzrosła o 10% przy dawce promieniowania poniżej 6 kGy i spada dla dawki powyżej 10 kGy.

S ł o w a k l u c z o w e : redukcja NO_x wiązka elektronów, gazy spalinowe.