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INVESTIGATION OF CLEANING EFFECTIVITY OF WASTE GASES FROM AN INCINERATOR

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Incineration of wastes is supposed to be an effective way of liquidation particularly of those hazardous ones from the medical centers. Most are, therefore, equipped with a modern incinerator. Moreover, flue gases must be effectively cleaned to meet hygienical standards.

This work is devoted to the investigation of some parameters characterizing the cleaning section of the Pardubice hospital incinerator. Because the measurement of concentration of some gaseous components in flue gases represents a legal duty of a company, optimization of the acid gases removal (HCl, Cl_2) and determination of composition of the dust particles was the aim of this first step of the work.

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Experimental

A pyrolytic incinerator type GG 14 produced by HOVAL (Hovalwerk AG, Vaduz) has been installed in the Pardubice hospital. The system is operated with less than stoichiometric quantity of oxygen in the pyrolytic chamber with subsequent combustion of energetically rich gases. Hot gases flow through the heat exchanger toward the cleaning part of the incinerator, formed by the Venturi and two alkaline packed absorbers. Hot gases are cooled from the temperature of about 250 °C in the Venturi by sprayed water, which forms here the large interfacial area. Due to this fact, absorption of some gases and removal of the dust particles occur here as well. Subsequently the gases flow through the scrubber I and scrubber II, while the scrubbing solution of NaOH is fed separately to scrubber II (pH = 7.5) and to scrubber I (pH = 7.0 – 7.5). The last parts of the acid gases and dust are removed here.

As it was mentioned before, the effectivity of HCl and Cl_2 absorption was investigated in this step simultaneously with the determination of the dust particles composition with regard to their contamination with heavy metals. The experiments were carried out during the current operation.

Gas samples were taken from the inlet pipeline of the Venturi by means of a metal sond, those after cleaning from the outlet pipe of the scrubber II. Chlorine concentration was determined after its absorption into the known amount of the solution of Na_3AsO_3 and iodometrical titration of its surplus; hydrochloric acid was determined by titration of chloride ions with $Hg(NO_3)_2$ after absorption into sodium hydroxide solution. The samples of the penetrated dust particles were trapped on paper filters mounted in the MSI 5000 analyser, which is a part of equipment for the incinerator. Elementary composition of the dust particles was evaluated by the X-ray energy-dispersion apparatus KEVEX DELTA V connected with the scanning electron microscope TESLA BS 340.

Results and Discussion

Chlorine Emission

The experiments did not prove the presence of free chlorine in the waste gases before their entering the cleaning part.

Efficiency of HCl Removal

The purpose of the study of HCl removal was to find the conditions for minimization of its emissions. It is obvious that the efficiency of HCl removal depends on many factors that, of course, cannot be changed arbitrarily. Some of them are fixed by the supplier as, for example, the type and the packing of the scrubbers, gas velocity in them and the amount of wetting solution. Temperature of the cleaning solution (in two ranges, 60 – 63 °C and 52 – 54.6 °C) and pH were chosen as the variables in this research.

The results calculated from experimental data are summarized in Table I. As can be seen from the table and from Fig. 1, the efficiency of absorption logically decreases in both temperature ranges with decreasing pH. It means, however, that it is more advantageous to operate at higher pH values, but it is necessary to optimize the NaOH consumption. According to the results, the absorption efficiency is higher at the higher temperature, which is probably caused by the fact that the scrubber process is rather complicated. Diffusion in liquid phase (higher at the higher temperatures), mixing of the liquid in the column and equilibrium relations are acting side by side.

Elementary Composition of the Dust Particles

This part of the study was aimed at assessing the harmfulness of penetrated particles with regard to the possibility of contamination with heavy metals.

It has been found that the mass amount of the penetrated particles is negligible, the changes in weight of the filters were under the detection limit of the analytical scales. For this reason, only the analysis of particles composition was carried out prior to the analysis of the particle size distribution. Eighty particles have been analysed. We suppose it was a representative choice because the particles were taken randomly from 10 filters, i.e. from 10 incinerating operations. The samples can be divided into 4 groups;

a) Nineteen samples (particles) contain Mg and Si as the dominating elements, usually with a small amount of Fe. The other samples contain besides Fe also Al (one sample), Ca (one), S (one), Ca + Cl (three), and/or more elements in trace amounts (two). It can be concluded, that these are mineral soil particles, probably oxides (oxygen is not recorded by the method used). Therefore, 27 particles are not toxically significant.
b) The particles in the second group contain dominating amounts of Al, Ca, Si or Fe in various combinations, again with trace admixtures of other elements (Na, Mg, S, Cl, K, Ti). As in the first group, we suppose that these particles are oxides. Some particles containing approximately equal abundances of Ca and S atoms are considered as calcium sulphate (usual in hospitals), particles containing K and S atoms at the ratio of 2 : 1 are considered as potassium sulphate. Therefore, these 26 particles are non-toxic.
c) Ba occurs in 7 samples, in many cases more than 10%. As there is also present

S, we consider them as barium sulphate.

d) In 7 samples we found Cu, in one of them also Hg, and next 12 samples contain various combinations of Zn, Pb and Cu, always with Cl. We conclude that these metals are not fixed, but they exist as chlorides. At the high temperatures in the incinerator they volatilize and after cooling they are sorbed on the surface of the particles. We regard this last group of dust emissions as hazardous.

Table I Efficiency of HCl removal

Sample No.	Cleaning solution		Conc. of HCl influent, mg m^{-3}	Efficiency, %	Sample No.	Cleaning solution		Conc. of HCl influent, mg m^{-3}	Efficiency, %
	pH	t, °C				pH	t, °C		
1	7.5	61	178.7	89.15	17	6.0	62	319.9	84.68
2	7.5	61	183.7	89.41	18	3.5	60	351.5	72.25
3	7.5	61	189.2	88.50	19	4.5	62	204.4	56.03
4	6.0	62	206.9	85.22	20	7.5	54.2	207.7	82.66
5	5.0	62	193.6	82.19	21	7.5	63	205.7	90.65
6	8.0	62	184.9	87.44	22	5.5	52.4	238.6	78.96
7	4.5	62	201.0	74.75	23	6.5	52.6	403.1	80.12
8	5.0	62	230.1	83.0	24	7.5	53.2	221.4	86.22
9	2.5	62	181.9	68.05	25	5.5	53.8	191.9	79.48
10	7.0	63	159.8	87.81	26	6.5	53.8	219.3	80.45
11	7.0	63	211.7	90.50	27	7.5	53	173.5	84.68
12	6.0	63	246.1	85.03	28	7.5	62	298.8	88.20
13	5.0	63	180.5	82.88	29	5.5	62	220.1	83.94
14	7.5	52.6	226.0	85.33	30	6.0	53	205.4	80.73
15	7.0	62	189.3	90.05	31	5.5	54.4	188.1	77.98
16	7.5	62	198.6	90.04	32	7.5	54.4	195.8	85.19

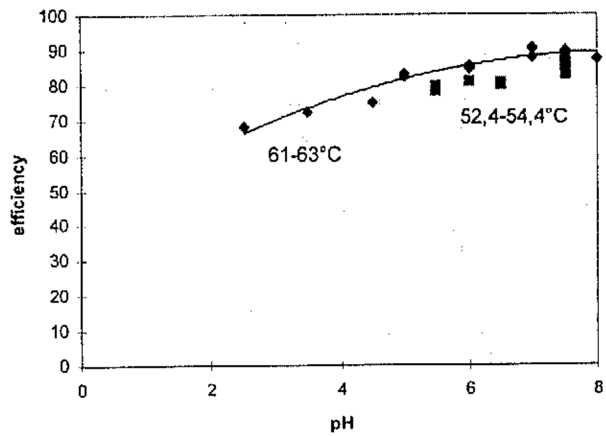

Fig. 1 Efficiency of HCl removal

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