ZEP: a new process for abatement acid pollutants from waste gases

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1 - Introduction

Because of pollutant limits lower and lower given by International Legislation, a new abatement process for HCl and SO_2 has been proposed for incinerator or chemical plant waste gases.
Such a process is a combination of dry process and wet process.
The first step is a conventional abatement of acid gas using $NaHCO_3$ technology which is now well known.
The second step consists of alkaline washing followed by water washing, both in packed towers.
The reason why water washing follows alkaline washing is due to the choice to remove from gaseous stream coming up from first tower, drops entrained and containing salts.
Problems arise during effluent analysis because of presence of salt, sodium chloride, which make possible to exceed law limits for Cl^-.
By proposed process content of Cl^- can be reduced below 5 mg/Nm^3.
Other particularity of the proposed process is the use of powder separated by a filter bag and containing an excess of sodium carbonate as an alkaline medium for obtaining a solution which can be used in the first washing tower.
In such a way consumption of $NaHCO_3$ is minimized because excess of this product used in dry abatement is re-utilized in wet process.
Alkaline solution is obtained in a mixed reactor where leaching of the alkaline product is performed by water.
Washing solution is obtained by the filtration of suspension coming from reactor.

2 - Pilot Plant And Process Description

Process is described in Figure 1
Fan P2,installed after final column C2, sucks air into the pilot plant. In order to simulate hot gas, air is heated in E1 up to 200°C; HCl or SO_2 are added to the gas stream to reach desired concentration and milled $NaHCO_3$ is fed to gas stream before decomposition reactor R1. Air goes through the decomposition reactor where sodium bicarbonate is decomposed to sodium carbonate and CO_2. In R1 the reaction between sodium carbonate and HCl or SO_2 starts. After that, the gas goes through the filter bag F1, where reactions are completed.

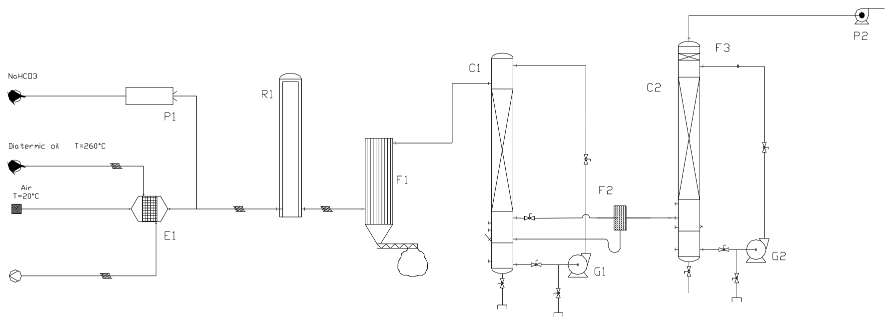


Figure1. Simplified sketch

In the case of dry abatement, gases after bag filter are discharged directly to atmosphere. In ZEP pilot plant, gases, after dry abatement, are fed to co-current washing column.
To verify possibility to use powder separated from bag filter as alkaline medium, powder coming from Municipal Waste (MW) incinerator has been leached, insoluble solid has been separated and obtained solution has been used as washing liquid in co-current column C1. Comparisons with sodium bicarbonate solution as washing medium were made.
After column C1 an impact entrainment separator is assembled in order to minimize entrainment between column C1 and C2.
After separator F2, gas flows into counter-current column C2, where water washes residual drops of solution still present. Column C2 is equipped on the top with a wire mesh demister.
This plant allows to reach values of emission limit of Cl^- and SO_2 lower than law limits.
Characteristics of apparatus are given below
E1 Heat exchanger 65600 kcal/h;
R1 Reactor, diameter 0.700 m, height 4.5 m;
F1 Bag filter;
P1 Mill, 50 kg/h, 8600 r/min;
C1 Alkaline packed tower, packing height 4 m, diameter 0.700 m;
F2 Impact type entrainment separator, Type Vico-Vane Costacurta;
C2 Washing packed tower, packing height 4 m, diameter 0.700 m,
F3 Wire mesh demister, Type Vico-Chevron Costacurta;
P2 Fan 1200 Nm^3/h, head 10 kPa;

3 - Experimental Results

Two series of experimental runs were performed: the first one using dry abatement process for investigating influence of hot gas temperature and size reduction of SO_2 abatement using sodium bicarbonate and second one to test possibility of using solution obtained from alkaline powder coming out from a bag filter of a Municipal Waste incinerator and to study performance of an impact type separator put on the bottom of a co-current washing column.

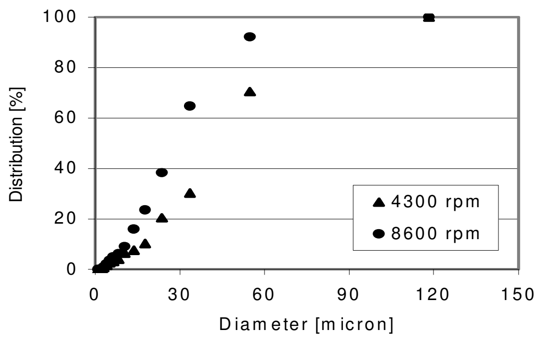
3.1 - Dry process

3.1.1Milling

Commercial sodium bicarbonate was milled in order to reduce the particle size of commercial sodium bicarbonate.

In Fig.2 size distribution is given for two different mill speed.

Speed of mill was changed by using frequency converter. The rpm of mill was 8600 rpm at 50Hz and 4300 for 25 Hz.



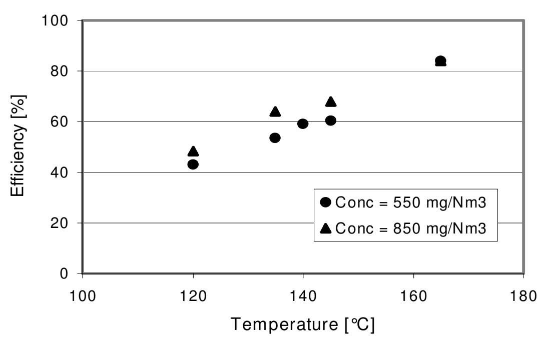
The per cent weight between 85% and 95 %, depending on mill speed has particles below 80 µ in diameter.

Such milled powder is fed into hot gas stream, before reactor R1, for dry abatement of pollutants.

Fig.2 –Size distribution of milled powder

3.1.2 - Abatement of SO_2 with sodium bicarbonate

Abatement tests have been carried out using SO_2 as pollutant and analysis of abatement efficiency were made immediately after rector R1 using an electrochemical analyser mod. Land Lancom III



SO_2 concentration was changed between 550 mg/Nm^3 and 850 mg/Nm^3. Because of importance of decomposition of sodium bicarbonate to sodium carbonate with formation of particles with an high porosity structure, influence of the temperature was investigated between 120°C and 165°C. Data are given in Fig.3.

Fig.3 –Efficiency of abatement vs temperature and concentration

Abatement efficiency is strongly dependent on temperature of hot gas. This is an important conclusion about limitation of heat recovery from incinerator fumes.

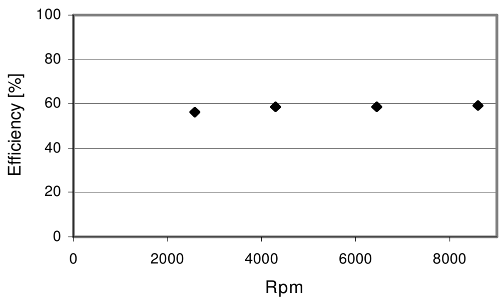


Figure 4 Efficiency of abatement vs mill speed

In Fig.4 influence mill speed and consequently size distribution of particles on abatement efficiency at temperature of 140°C is given; excess of 100% of bicarbonate was used.
Concentration of SO_2 after filter bag was always undetectable by analyser.

3.2 - Wet Process

3.2.1 - Abatement of SO_2 by solution of Municipal Waste bag filter powder

The same tests have been led using as washing solution, on packed tower C1 , a solution obtained by dissolution of powder separated by filter bag and a solution of sodium bicarbonate 4%.
In both cases after C1 and C2, SO_2 was undetectable, starting from a 850 mg/Nm^3 concentration of SO_2 at inlet of C1.

3.2.2 - Powder characterisation

Powders are characterized by

- TG analysis
- Chemical analysis
- Solution titration

Figure 5 shows results of TG analysis.

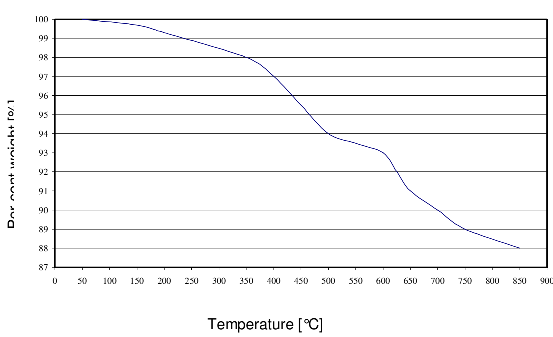


Figure5. Per cent trend of weight of powders

The residual is completely vitrified and its colour is darker than the initial powders.
Moreover, it has to be pointed out that between 0° and 100°C the powders lose humidity and consequently lose weight.

Comparing a TG of sodium bicarbonate (where a considerable loss of weight takes place at about 200° C) there isn't any correlation, so sodium bicarbonate presence can be excluded.
Table 1 shows results of chemical analysis

$SO_4^{=}$	2799.8 mg/l
Cl^-	5637.6 mg/l
Bicarbonate	absent
Carbonate	7.2 meq/l
Hydroxide	2.4 meq/l

Table 1. Chemical analysis of powders

To calculate CO_3^{2-} ion percentage, the solution obtained from the dissolution of a known quantity of powders in water was titrated with HCl 0.1 N. The result was a deep-yellow solution ,probably due to iron presence.. The presence of white flakes during the titration makes titration difficult. At the beginning, at a pH value of 10, there is a slight flex due to the presence of hydroxides, and the second flex corresponds to the equivalent point where the passage from carbonates to bicarbonates takes place. Just at this second point it can noticed gas formation in the solution. By calculating the volume of HCl between the two equivalent points, it results that there is a percentage 6.5 % of carbonates in the powders. This means that to obtaine 1liter of solution 4% in sodium carbonate, 615 g of bag filter powders must be used.

3.2.3 - Entrained liquid evaluation
NaCl as a tracer was used to detect amount of entrained liquid from C1 to C2. Entrainment was measured by variation of conductivity of liquid present in C2.
Separator between C1 and C2 was an impact type separator .

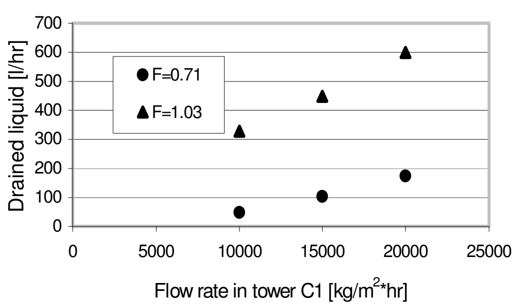


Figure 6 shows liquid flow at the outlet of separator versus recycled liquid flow in the tower for two different F factor ($F=u*\rho_{gas}^{1/2}$).

Figure 6. Drained liquid from impact type entrainment separator

Figure 7 shows liquid entrained by gas stream after separator F2. Entrainment seems to be independent on the flow of liquid circulating into the tower C1 (L= Flow rate/Area $_{tower}$ [kg/m^2h]).

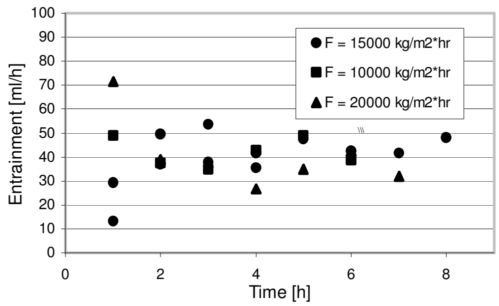


Figure7. Liquid entrained by gas after separator F2

4 - Conclusion

Incinerator fumes, after recovery heat boiler, must be to a temperature not lower than 150-160°C, so that the reaction of decomposition of sodium bicarbonate completely takes place.

Powders of bag filter can be used to obtain an alkaline solution to be used in washing tower, so to decrease the production of solid waste materials.

The solution to realize the alkaline washing tower in co-current followed by water washing in count-current, it can be applied since separator accommodated between two towers, minimizes liquid entrained.

The realized pilot plant further on allows the possibility to test processes of abatement, also a flexibility of employment.