An easy way for gas washing

F.Annunzi[1] ,F.Guastini[3] G.Nardini[1], A.Paglianti[2], L.Petarca[2]

[1]Consorzio Polo Tecnologico Magona,Via Magona 1 Cecina (LI), Italy
[2]Dipartimento di Ingegneria Chimica, Chimica Industriale e Scienza dei Materiali,
Università di Pisa, Via Diotisalvi 2, Pisa, Italy
[3]Termomeccanica Ecologia, Via del Molo 3, La Spezia, Italy

The idea, not so original, but in this research thoroughly investigated, is to try to abate pollutants such as SO_2, HCl, NH_3, NO_2 and others from waste gas, using a simple pipe, instead of the traditional absorption tower.

This research, financially and technically supported by TME, is a part of a more extensive project which tries to reach, respect to European legislation, lower limit for gaseous pollutant.

Influence of gas velocity (type of two phase flow obtained inside pipe) and liquid mass rate were also tested.

The possibility of recycling washing solution was also tested in order to minimize consumption of washing agent.

With this recycle possibility in mind, sodium bicarbonate solution has been used in order to avoid rust problem on liquid distribution nozzle, washing pipe and mainly, on impact type separator.

Introduction

The research of purification of gaseous flows with the aim of following the most stringent rules in a polluted atmosphere, is very frequent in an industrial environment. Such operations can be conducted through water solutions appropriate to the aim of enabling the chemical–physical absorption of the pollutant. Suitable methods to achieve such an operation are varied and differ due to the type of contact between the gaseous phase and the liquid in counter current, co-current and cross flow.

Washing in a packed tower, washing in a tray tower and washing in a spray tower are the most frequently used techniques for putting the two phases in contact.

This work will examine the use of an innovative purification technique that predicts the removal of the pollutants in the gaseous current. The process avoids the use of particularly complex and expensive equipment, by means of a cleaning process in a horizontal pipe.

The purification of the gaseous flow therefore, takes place in a rectilinear pipe placed horizontally. The emission of liquid occurs through a nozzle situated on the inside of the pipe. The gaseous phase circulates towards the liquid phase in order to achieve a configuration of co-current flow. At the end of the pipe, the two flows are separated through the use of a gas-liquid separator. Before re-joining the fan, the gas, which is flowing counter current, crosses the packed tower containing water. The fan, positioned immediately after the packed tower exit, keeps the whole plant in suction.

This work has attempted to identify the optimum operative conditions to abate pollutants.

Experimental apparatus and operative conditions

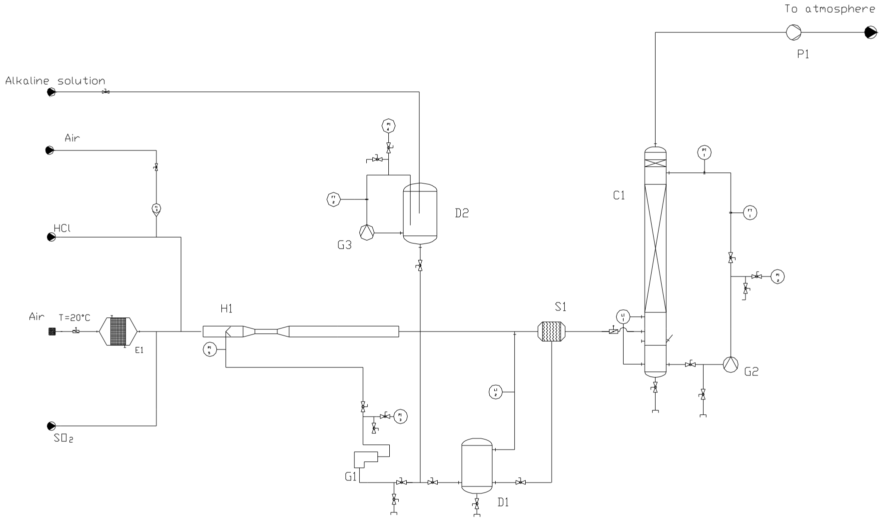

Figure 1. Simplified sketch

Figure 1 is a simplified diagram of experimental apparatus.

Finned pipe heat exchanger 65600 Kcal/h (E1)

Test pipe with liquid injection nozzle (H1), length pipe 20 m, diameter 0.100 m

Metering pump 0-80 l/h (G1)

Impact type entrainment separator Type Vico-Vane Costacurta (S1)

Final washing packed tower, packing height 4 m, diameter 0.700m (C1)

Fan, 1200 Nm^3/h, head 10 kPa (P1)

Air is sucked into the pipe, passing across heating system (E1) to investigate influence of temperature of pollutant abatement; flow rate is regulated by a manual butterfly valve.

At the inlet of pipe, immediately after heating exchanger, the desired amount of pollutant is added; SO_2 and HCl were used in this research.

Along the pipe (C2) are located sampling pipes, to test influence of length (residence time) on abatement of acid gases.

Influence of gas velocity (type of two phase flow obtained inside pipe) and liquid mass rate were also tested.

Recycling possibility of washing solution was also tested in order to minimize consumption of washing agent.

Taking into consideration recycle possibility, sodium bicarbonate solution has been used, rather caustic soda, in order to avoid rust problem on liquid distribution nozzle, washing pipe and, mainly, on impact type separator.

With regard to SO_2 runs have been used to gas velocities: 15, 20, 28 and 40 m/s; inlet SO_2 concentrations were 250 and 500 mg/Nm^3; liquid mass rate were 40, 60, 80 l/h.
Measurements were performed at 5,12,20 m from the liquid nozzle.
Initial concentration of SO_2 is important because for higher concentration length of pipe must be larger.
With regard to HCl runs have been used with the same operative conditions but inlet concentration was only 50 mg/Nm^3.
A sodium bicarbonate solution at 4 % was used for washing.
The abatement efficiency is evaluated as

$$\eta = \left(1 - \frac{C_{out}}{C_{in}} \right) \cdot 100 \qquad [1]$$

where :
C_{in} inlet concentration of pollutant
C_{out} outlet concentration of pollutant gas after washing

Results and discussion

Influence of recycled solution on abatement of SO_2

First runs were carried out to verify possibility of recycling washing solution separated by S1 to injection nozzle. Results are given in Fig.2 where efficiency is given versus distance from injection nozzle.

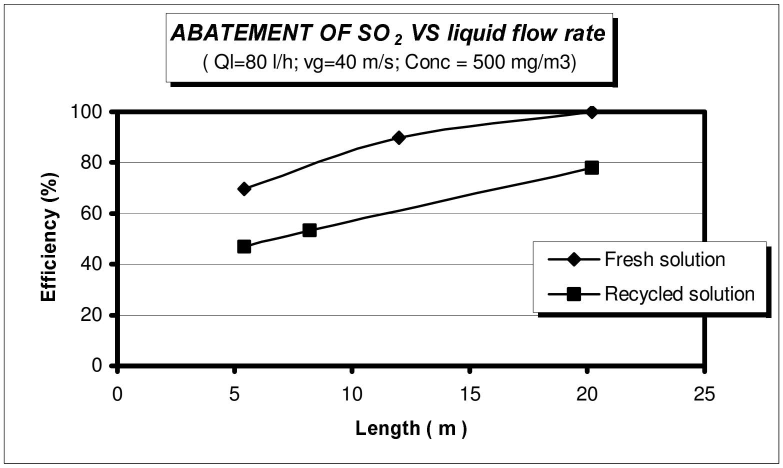

Figure 2. Efficiency of abatement with fresh and recycled washing solution

Recycle has a negative influence an abatement. All this is not due to exhaustion of solution because a sufficient amount of sodium bicarbonate solution was recovered by titration, but to increasing acidity, pH 5.73, probably caused by the presence of CO_2 in solution.

To prove this, the solution was heated up to 100°C. After cooling pH again reached approximately initial value, pH 7.91.

Influence of gas flow on abatement efficiency

Gas flow rate influences greatly mass transfer (Mandhane, Hewitt). When gas velocity is too low conditions of stratified flow are arising. High gas velocity generates a dispersed flow.

In fact under 20 m/s it has stratified flow and liquid droplets fall down below 20%. Up to 28 m/s efficiency reaches values about 100%; which means dispersed flow has been reached.

These results are shown in Fig.3

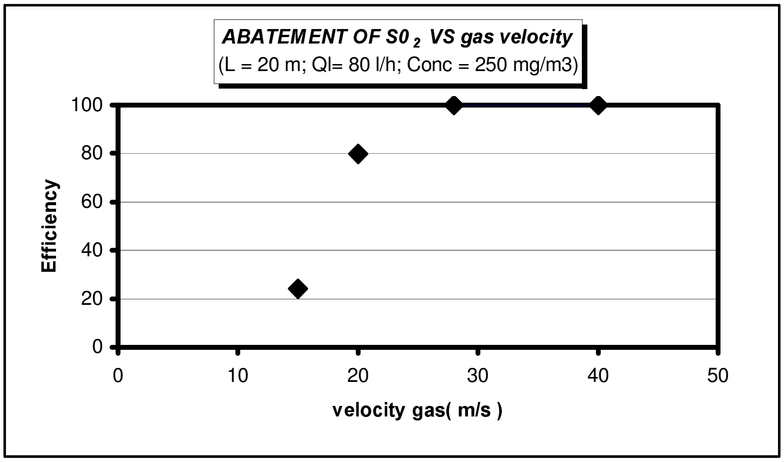

Figure 3. Efficiency vs. gas velocity

Influence of liquid flow on abatement efficiency

Gas liquid interfacial area is a function of number of droplets present into the stream (Ambrosiani, Dallman). If gas velocity is constant, number of drops depend on liquid flow rate:

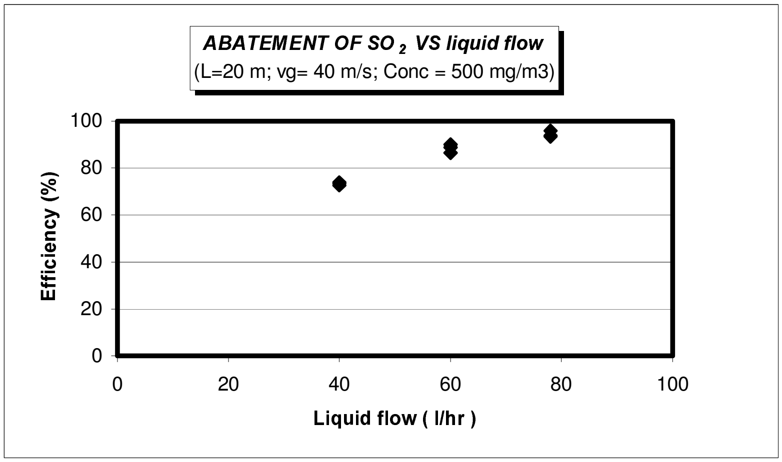

Figure 4. Efficiency versus liquid flow

When liquid flow rates decrease ,number of droplets decrease and consequently interfacial area. For this reason also abatement efficiency decreases. All this is shown in Fig.4 .

Abatement of HCl

Some runs have been carried out using HCl; concentration was very low, 50 mg/Nm^3 because when concentration decreases difficulty of abatement increases.

Gas velocity was 40 m/s and liquid flow rate 80 l/h. After 20 m efficiency was 100%.

Conclusion

Gas flow rate is fundamental for the flow conditions (Mandhane, Hewitt), if there isn't a dispersed flow, a sufficient mass transfer is not obtained to realize an efficient abatement of pollutant.

Liquid flow influences the process by varying mass transfer surfaces (Ambrosiani); the greater flow rate, the greater exchange area with a consequent higher efficiency.

As regards recycling of solution, this must be done with caution, and in such conditions to guarantee stripping of the CO_2, which is formed during reaction of abatement of pollutant. Therefore the washing solution must be heated and subsequently cooled before being recycled.

Length of washing pipes affects the process since the longer the pipe, the greater the time of residence. Results have highlighted that it is necessary to have a time of residence of about 0.5 second to have a pulling down efficiency superior to 99%.

It is possible to conclude that the benefits of this system of abatement of polluted currents over traditional methods is more than validated, both for the reached pulling down efficiency values and for the economic advantage of the plant.

Symbology

L	Length of washing pipes.
Vg	velocity gas
Ql	liquid flow
Conc	concentration of pollutant.

References

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