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Original Research Paper

Removal of Sulphur Dioxide from Exhaust Sulphurous Flue Gases at Shree Cement Ltd., Beawar for Environment Cleaning

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ABSTRACT

Laboratory studies were conducted to know about the effect of pH of sodium hydroxide solution and its temperature for absorption of SO_2 contained in flue gases. it was found that the pH of the solution should be alkaline for good absorption of SO_2. Because of the acidic nature of SO_2, the reaction is restricted in acidic solution and maximum absorption of SO_2 was found in temperature range between 20-25°C. At higher temperature reversible reaction may take place and partially formed product may be changed back into initial reactants.

INTRODUCTION

Shree Cement Ltd., having a coal based power plant, is one of the top ten cement producers in India and as a leading player in north Asia. The main pollutants from thermal power plants are dust and objectible gases like CO, CO_2, SO_2, NO_2, etc. Sulphur dioxide is a major constituent in air pollution (Arthur et al. 1975). Coal is re-emerging as a dominant fuel for power generation in various power plants. Various coals such as petcock, lignite, bituminous, etc. are used in power plants in which sulphur is 6.0 %, 4.0 % and 3.8 % respectively. The common element in fuels is carbon, which is principle combustible constitute of all fossils. Oxygen, nitrogen, hydrogen and sulphur are not combustible elements (Ram 2005). Sulphur in coal reacts with oxygen and forms SO_2 and SO_3. Sulphur dioxide is a major constituent in air pollution, which affect the environment in number of ways like acid rain, corrosion and severe damage to health (Maohong 2002). A 22.5 MW power generation unit emits 1690 tons of SO_2 per year (Sheth et al. 2006, Shih-Wu Sung et al. 2002).

Flue gas desulphurization (FGD) is the technique used for removal of sulphur dioxide from the exhaust flue gases in power plants. The aim of this study is to reduce the SO_2 in environment and to produce a byproduct with SO_2 to control pollution.

In accordance with the invention, flue gases containing sulphur dioxide are passed through a solution rich in sodium ions. SO_2 reacts with these ions to produce sodium sulphate. Most complete removal of SO_2 in flue gases has been observed using this process in the power plant of Shree Cement Ltd, Beawar, Rajasthan.

MATERIALS AND METHODS

Experimental A: Effect of pH of solution for SO_2 absorption: All experiments were conducted on stack monitoring kit (Model No. and Make VSS1, 141 DTH 2005, Vayubodhan). First of all, SO_2 monitoring kit for SO_2 measurement was set up at chimney inlet of Boiler No. 4 of the industry. Ten

percent sodium hydroxide solution was taken in first impinger and flue gases containing SO_2 were passed through it using a flexible pipe connected to the SO_2 monitoring kit. The SO_2 flow was controlled using an inlet line rotameter and was maintained at 3 L/min.

One end of flexible pipe was connected to chimney inlet for suction of SO_2 and other end was connected to SO_2 monitoring kit which has impingers of 10 cm diameter and 100 cm length. The impinger was filled with 100 mL of scrubbing media i.e., NaOH solution. Samples of 10 mL were collected from the bottom at intervals of every 15 minutes and each sample was analyzed for pH and also titrated with 1 M oxalic acid to determine fall in concentration of NaOH. Three parameters, % SO_3 (gravimetric), % SO_2 (volumetric) and % alkalinity were analyzed by the methods of BIS ~~(8-13)~~.

Table 1: Operating conditions for SO_2 absorption in Sodium hydroxide solution.

S. No.	Operating Condition	Value
1	Initial Concentration of Sodium hydroxide solution	10 %
2	pH of solution	12.57
3	Total liquid hold up	100 mL
4	Temperature of solution	varying
5	Time period for reaction	0.5 hr
6	Flow of flue gas in impinger	3 LPM
7	SO_2 load in flue gas	3000-3200 ppm
8	Flue gas Temperature	135°C
9	Flue gas flow in duct of ESP O/L	150522 m^3/hr
10	Pet Coke Feeding Rate	13 ton/ hr
11	Lime Stone Feeding Rate	1.0 ton/hr

Table 2: Effect of pH of NaOH solution for absorption of SO_2.

S. No.	Time(Min.)	pH of solution	Volume of 1 M Oxalic acid consumed in titration using phenolphthalein indicator (mL)	Conc. of NaOH (%)
1	0	12.57	20.05	80.06
2	15	10.62	15.56	62.2
3	30	8.82	3.5	14.2
4	45	7.95	1.23	4.8
5	60	5.62	0.56	2.2
6	**75**	**4.75**	**0.32**	**1.2**

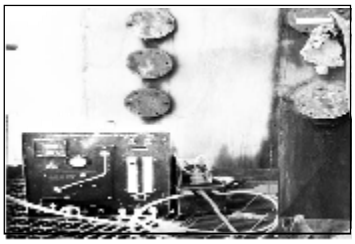

Fig. 1: Experimental setup by using SO_2 monitoring kit for absorption of SO_2.

Experimental B: Effect of temperature of NaOH solution for maximum recovery of SO_2: Experiment was conducted by passing flue gases directly at different temperatures of 10 % NaOH at the rate of 3 L/min. The pH of the solution was around 12.57 and time for every experiment was 30 min. Experimental set up is shown in Fig. 1 and operating conditions for SO_2 absorption are given in Table 1.

RESULTS AND DISCUSSION

Fig. 2 and Table 2 report the effect of pH of NaOH solution and absorption of SO_2 and it is confirmed that when there is an increase in the time period for absorption of SO_2 in NaOH solution, then there is a significant decrease in pH. Fig. 3 reports that with the increase of time period for absorption of SO_2 in NaOH solution there is a significant decrease in concentration of NaOH solution.

Fig. 4 and Table 3 show that by increasing temperature of NaOH solution, there is significant decrease in recovery of SO_2. It can be confirmed from Figs. 5 and 6 and Table 4 that precipitate,

Table 3: Effect of temperature of sodium hydroxide solution for maximum recovery of SO_2.

S. No.	Temperature of solution	Initial Conc. of SO_2 (ppm)	Conc. of SO_2 after formation of Sulphate (ppm)	Recovery (%)
1	20-25°C	3080	302	90.18
2	25-30 °C	3080	566	81.62
3	30-35 °C	3080	675	78.08

Table 4: Analysis results of precipitate which was prepared by varying the temperature of NaOH solution.

S.No	Temperature of NaOH solution	Yield(g)	$\%SO_3$	$\%SO_2$	$\%Na_2SO_4$	% Alkalinity
1	20-25°C	9.77	0.62	38.72	1.100	1.68
2	25-30°C	9.25	0.42	31.92	0.745	1.80
3	30-35°C	9.06	0.22	17.87	0.390	1.95

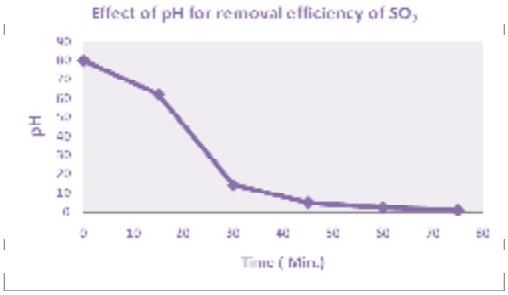

Fig. 2: Figure depicting relation between pH of NaOH solution and absorption of SO_2.

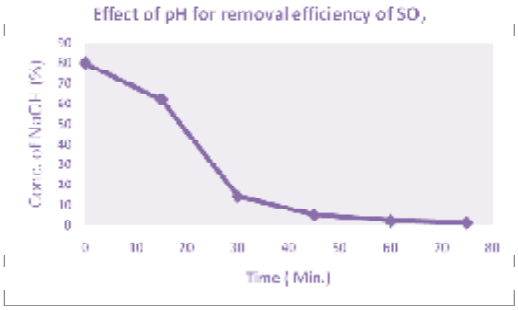

Fig. 3: Figure depicting relation between time period and falls in concentration of NaOH.

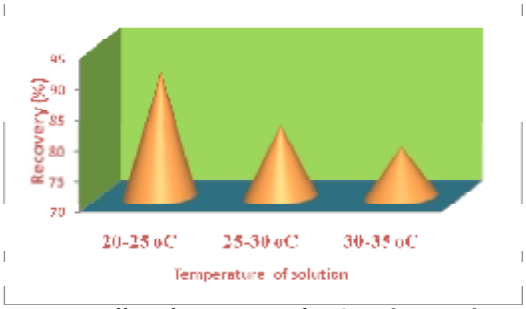

Fig. 4: Effect of temperature of NaOH solution and recovery of SO_2.

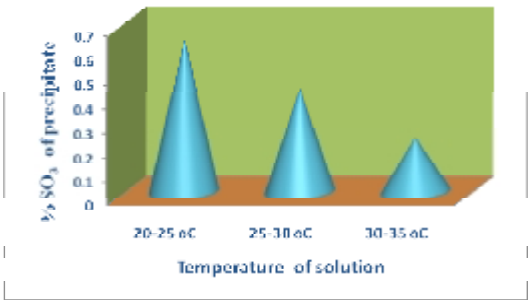

Fig. 5: Effect of temperature of NaOH solution and % SO_3 (gravimetric) of ppt.

which is formed by lower temperature of solution has maximum % SO_3 (gravimetric) and % SO_2 (volumetric). Fig. 7 reports that when % SO_3 decreases then % alkalinity increases in precipitate.

CONCLUSION

1. The change in colour of the solution can be seen easily, i.e., initial colour is white, and after passing SO_2 colour is yellow.

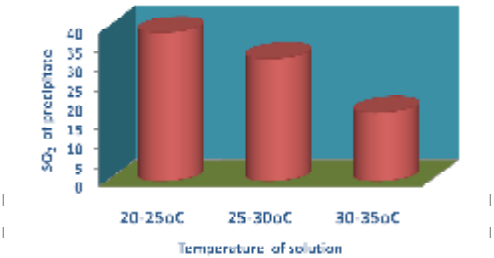

Fig. 6: Effect of temperature of NaOH solution and % SO_2 (Volumetric) of ppt.

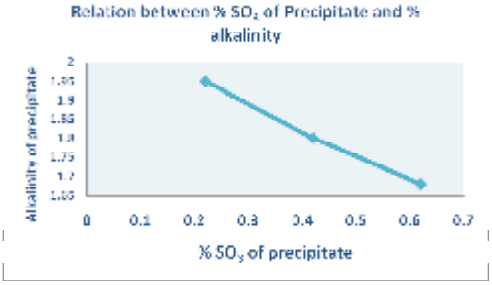

Fig. 7: Relation between % SO_3 and % alkalinity of precipitate.

2. The pH should be more alkaline for good absorption of SO_2.
3. Absorption and precipitisation of sulphate is a temperature sensitive reaction. At higher temperature the sodium sulphate is formed but remains soluble as solubility increases with the increasing temperature. The maximum recovery of SO_2 was found at the temperature in the range of 20-25°C and this seems to be optimum temperature.
4. At higher temperature, the reversible reaction may take place, and partially formed sodium sulphate may be changed back into NaOH.
5. Prepared Na_2SO_4 can be used as a home laundry detergent, and also used in paper production. In the laboratory Na_2SO_4 is used as an inert drying agent for removing traces of water from organic solutions.

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