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REMOVAL OF SULPHUR DIOXIDE FROM FLUE GASES IN THERMAL PLANTS

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ABSTRACT

The demand of electricity is continuous increasing and it is expected to double in 7 -10 years and the pollution in the environment likely to increase in the coming years. The main pollutants from the thermal power plants are dust and objectible gases like CO, CO_2, SO_2, NO_2 etc. SO_2 is a major constituent in air pollution. Sulphur dioxide (SO_2) which produces during combustion of Coal in power plants and reacts with atmospheric water and oxygen to produce sulphuric acid (H_2SO_4). This sulphuric acid is a component of acid rain, which lowers the pH of soil and freshwater bodies, resulting in substantial damage to the natural environment and chemical weathering of statues and structures. Hence our aim of the project is removal of SO_2 in flue gases and production of commercial applicable product with these gases. Laboratory studies were conducted to compare the efficiency of different concentration of NaOH, pH of solution, and temperature of NaOH solution for absorption of SO_2 contained in flue gases. Thus it is concluded that the 5 % Conc. of the NaOH is found to be optimum as compared to higher concentrations. pH of the solution should be alkaline for good absorption of SO_2. Maximum absorption of SO_2 found in temperature range between 20- 25 ^oC.

Keywords: Flue gas desulphurization, flue gases, pH, concentration, Sodium Hydroxide, temperature, Sulphur di oxide.

INTRODUCTION

Thermal power plants are major sources of air pollutants. Three major air pollutants emitted from thermal power plant are SPM, SO_x, and NO_x. Sulphur in coal cannot be destroyed it can only be converted to one form to another. During the combustion process, sulphur reacts with oxygen and formed SO_2 and SO_3[1-2] Sulphur Di oxide affects the environment in number of ways like acid rain, corrosion and severe damages to the health. These emissions causes health problems reduce visibility and contribute to the acid rain problems significantly. The three constituents of flue gases which mainly affect acidity of the rains are CO_2, SO_2 and NO_x. The SO_2 emitted to the environment combines with water forms sulphuric acid and similarly NOx formed nitric acid. During the rainy season the acid formed in the atmosphere falls in to ground. The further detrimental effect of acid rain is the reduction of ground fertility and crop yield. There will be many bed effects on the overall biological life[3-5] as-

1. This rain is to increase the acidity of the lake, well water and rivers. When the acidity increased above a particular level (pH< 5) than fishes population dies totally. The most distinct effect of this is the death of fishes in large Numbers. Its number reduces gradually and becomes zero; such lakes are called as dead lakes.
2. Due to acid rains, the metals like Hg, Pb, in earth crust are gradually dissolved and are found in the body of the fishes and enter into body of human beings and cause many disease.
3. The concentration of acid rain completely destroyed the agricultural potential of the land.
4. The acid rain also damages national monuments and building such effects is already identified in Taj Mahal.[6-8]

Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defenses, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. Flue gas desulphurization (FGD) is the technique used for removal of sulphur dioxide from the exhaust flue gases in Power plants. Therefore our aim of the project is to reduce the percent SO_2 in environment. Therefore our environment becomes eco friendly [9-10]

$$2NaOH\ (liq) + SO_2\ (gas) \longrightarrow Na_2SO_3\ (solid) + H_2O\ (liq.)$$

$$Na_2SO_3\ (liq) + \tfrac{1}{2}\ O_2\ (gas) \longrightarrow Na_2SO_4\ (solid)$$

In accordance with the invention, flue gases containing sulphur dioxide are passed through a solution which was rich with Sodium ions using SO_2 monitoring kit of SO_2 measurement, then SO_2 reacts with these ions to produce Sodium sulphate. Prepared Na_2SO_4 can be used as a home laundry detergent, used in paper production. and in the laboratory Na_2SO_4 is used as an inert drying agent, for removing traces of water from organic solutions.

All most complete removal of SO_2 in flue gases has been observed using this Process in the Shree Power, Beawar Rajasthan.

EXPERIMENTAL

All experiments were conducted on Stack monitoring Kit (Model No. and Make -VSS1, 141 DTH -2005, Vayubodhan). First of all SO_2 monitoring kit of SO_2 measurement was set up at chimney inlet of Boiler of Shree power. Flue gas containing SO_2 was supplied from chimney via probe connected with flexible pipe of stack monitoring kit. The flow of flue gas was controlled using an inlet line rota meter and was maintained at a value of 2-3 liter per minute. The other end of flexible pipe carrying air and SO_2 respectively was connected to a impinger of 10 cm diameter and 100 cm length. The impinger was filled with 100 ml of scrubbing media in this experiment. i.e. sodium hydroxide. Then five sets of reading were taken by varied different concentration of NaOH. 100 ml of solution was taken in to first two different impinger for better absorption of SO_2 and 30 ml H_2O_2 was taken in third impinger for determination of remaining SO_2.

The concentration of SO_2 in flue gases was first measured by Stack monitoring Kit.

$$C_{SO2} = K_2 (V_t - V_{tb}) N (V_{soln.}) / V_{m(std)} * V_a$$

C_{SO2} = Concentration of sulphur dioxide, dry basis converted to standard conditions, mg/NM^3.
N = Normality of barium per chlorate titrant milliequivalent/ml.
K_2 = 32.03 mg/meq.
V_t = Volume of barium per chlorate titrant used for the sample, ml.
V_{tb} = Volume of barium per chlorate titrant used for the blank, ml
$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, NM^3.
V_a = Volume of sample aliquot-titrated, ml.

For determination of effect of pH of solution , 50 ml of 10 percent sodium hydroxide solution was taken in first two impinger and flowed SO_2 gas and pipette out 10 ml of this solution in every 15 min. and pH was analyzed, and also titrate with 1M oxalic acid for determination of fall in conc. of NaOH. Similar experiments were conducted at different temperatures of NaOH solution. Dissolved sulphate can be extracted from solution by heating till dryness. Three parameters regards to % SO_3 (gravimetric), % SO_2 (Volumetric) and % alkalinity have been analyzed in precipitate. The methods used as Indian standard method from bureau of Indian standard. [11-16] Operating condition of SO_2 absorption is given in Table-1. Experimental set up shown in Fig. 5.

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

S. No.	Operating Condition	Value
1	Initial Concentration of Sodium hydroxide solution	Varying
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	Direct
7	SO_2 load in flue gas	3000 – 3200 ppm
8	Flue gas Temperature	135 ^oC
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 Conc. of NaOH with recovery of SO_2 absorption.

S. No.	Concentration of reagent (%)	Initial Concentration of SO_2 at Chimney I/L(ppm)	Concentration of SO_2 at Chimney I/L after formation of Sulphates (ppm)	Percent recovery
1	5	3067	75	97.96
2	10	3067	158	95.08
3	15	3067	306	90.18
4	20	3067	324	88.02
5	25	3067	455	85.19

Table -3: Analysis results of ppt which was prepared by different concentration of NaOH and SO_2

S. No.	Conc. of reagent (%)	Percent SO_3 (By gravimetric method)	Percent Na_2SO_4	Percent SO_2 (By volumetric)	Percent Alkalinity
1	5	20.76	35.49	39.21	0.62
2	10	5.67	17.00	25.61	1.17
3	15	1.49	9.81	20.54	1.64
4	20	0.52	5.77	19.47	1.68
5	25	0.24	3.99	17.62	1.75

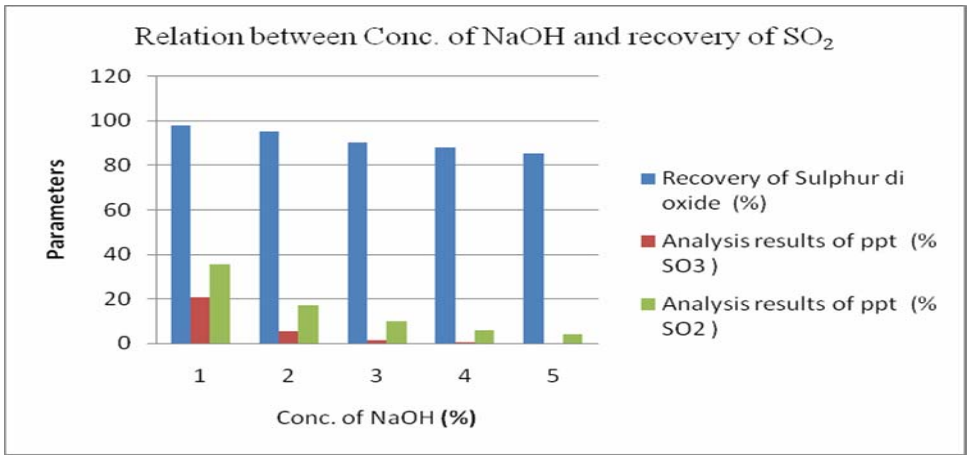

Fig.-1: Figure depicting relation between Conc. of NaOH solution and recovery of SO_2

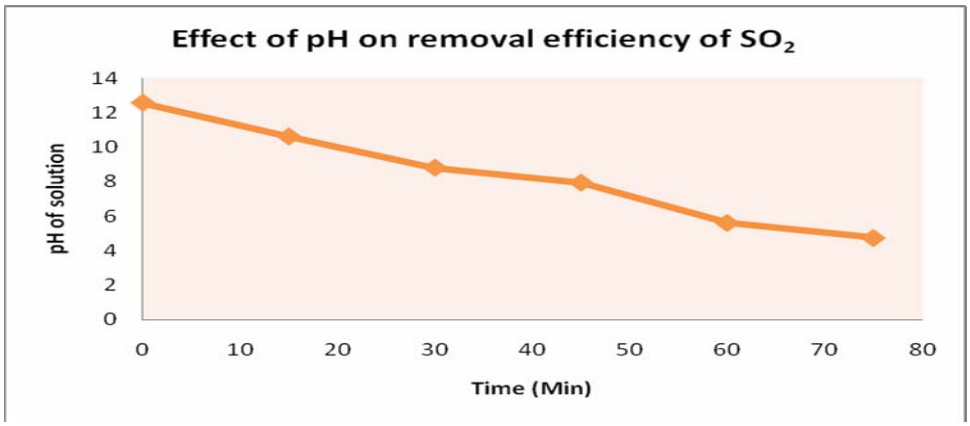

Fig.-2: Figure *depicting* relation between pH of NaOH solution and absorption of SO_2

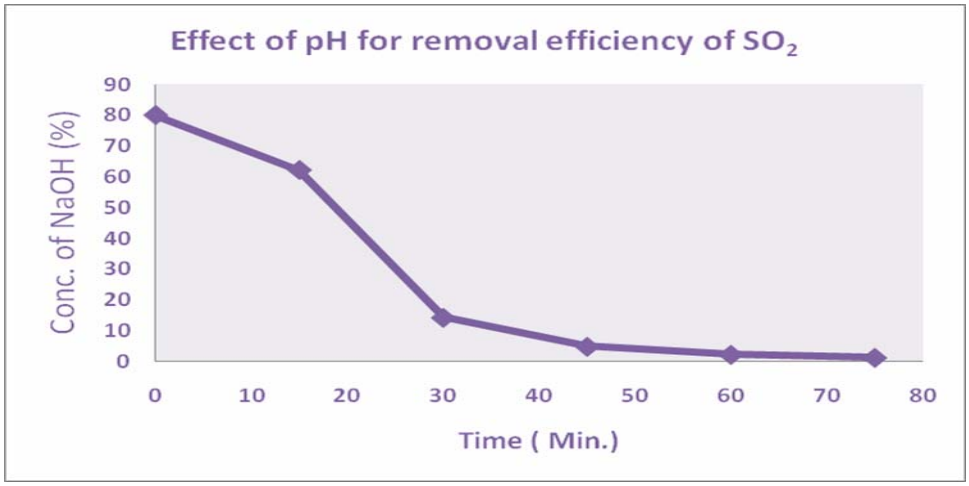

Fig.-3: Figure depicting relation between time period and falls in conc. of NaOH.

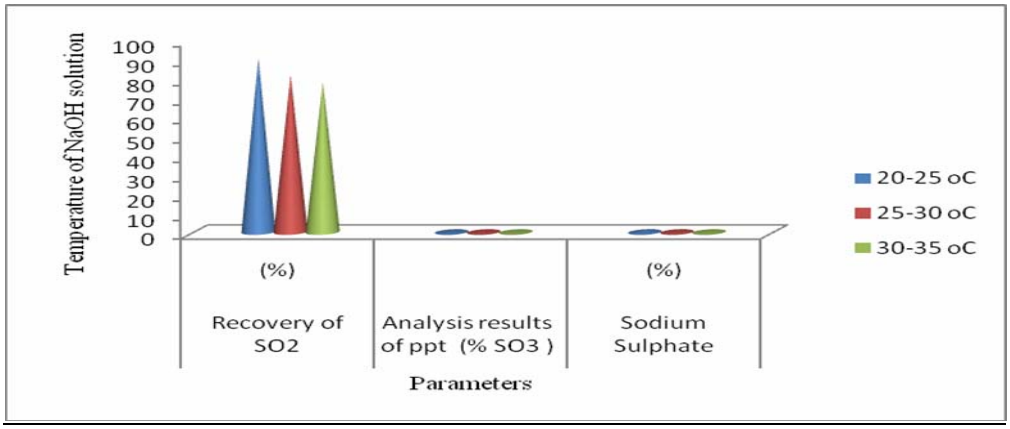

Fig.-4: Effect of temperature of NaOH solution and recovery of SO_2

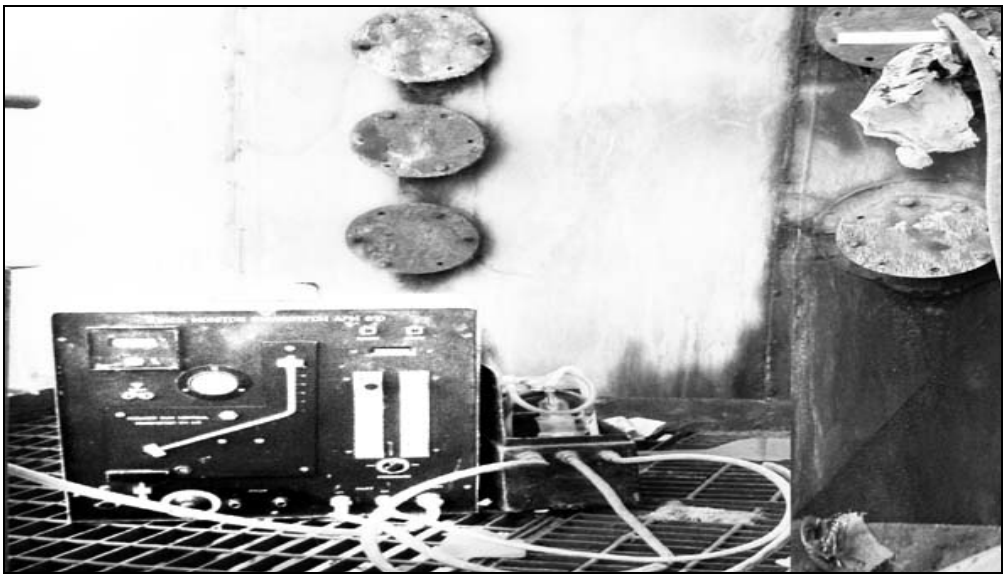

Fig.-5 : Experimental Set Up by using SO_2 monitoring kit for absorption of SO

RESULTS AND DISCUSSION

Figure 1 and Table-2 reports that effect of Conc. of NaOH solution with absorption of SO_2 and recovery of SO_2 and Table-3 shows analysis results of ppt. which is prepared by different conc. of NaOH and it is confirmed that when increase in the Concentration of NaOH there is a significant decrease in recovery of SO_2. The ppt which was prepared by lower conc. of NaOH having maximum % SO_3 and maximum % SO_2. Fig. 2 and Table-4 reports that when time period for absorption of SO_2 in NaOH solution increases, then there is a significant decrease in pH. Figure -3 reports that with the increase of time period for absorption of SO_2 in NaOH solution there is a significant decrease in conc. of NaOH Solution.

Table-5 and Fig. 4 reports that by increasing temperature of NaOH solution there is decrease in significant value of recovery of SO_2 which is also confirmed by analysis results of ppt. Table - 6 reports the ppt which was prepared by lower temperature of NaOH having maximum % SO_3 and maximum % SO_2.

Table-4: 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

Table -5: Effect of temperature of NaOH solution and removal efficiency 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 ^oC	3080	302	90.18
2	25-30 ^oC	3080	566	81.62
3	30-35 ^oC	3080	675	78.08

Table-6: Analysis results of ppt which was prepared by different temperature of NaOH and SO_2

S. No	Temperature of NaOH Solution	Percent SO_3(By gravimetric method)	Percent Na_2SO_4	Percent SO_2 (By volumetric)	Percent Alkalinity
1	20-25^{o}C	0.62	38.72	1.100	1.68
2	25-30^{o}C	0.42	31.92	0.745	1.80
3	30-35^{o}C	0.22	17.87	0.390	1.95

CONCLUSIONS

Maximum absorption of SO_2 was obtained in 5 % Sodium hydroxide solution while less in higher concentrations. Therefore 5 % conc. of Sodium hydroxide is the optimal concentration to be used.

1. The recovery of SO_2 in higher conc. of sodium hydroxide was found to be low due to the nature of SO_2 is acidic, so it reduces the pH of solution in half an hour. So SO_2 absorption is not possible.
2. Now we conclude that addition of more NaOH in solution results into less absorption and therefore it is not fruitful. This is because of load of SO_2 in flue gases is very low (at ppm level), Hence reagent remains as it is in solution after completely absorption of SO_2.
3. If 5 % NaOH solution is sprayed in the path of flue gases then we can recover maximum SO_2 and protect the environment from pathogenic effect of SO_2 and yield sulphate also.
4. SO_2 absorption has been taken place in the solution.
5. The change in colour of the solution can be seen easily during the experiment i.e. initial colour was transparent, and after passing SO_2 colour was yellow.

6. The pH should be more alkaline for good absorption of SO_2
7. 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.
8. The maximum recovery of SO_2 found at the temperature in the range of 20-25^oC. and this seems to be optimum temperature. At higher temperature the reversible reaction may be take place and partially formed sodium sulphate, may change in to NaOH.

9. If we can establish FGD system before Chimney than we can recover 90 % SO_2 in Waste stream of flue gases.
10. Sodium Sulphate can be used as a home laundry reagent, for paper production, and as a inert drying agent for removing of traces of water from organic solutions.
11. By this method we can conserve lakes, well water, rivers and lakes from acid rain effect of SO_2.
12. We can also procure fishes of water bodies, agricultural potential of land, national monuments and buildings.

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REFERENCES

1. Sheth K.N. Patel and Neha J. Patel, *Env. Poll. Cont. J*., **9,** 14(2006)
2. B. Buecker, *Power Engineering*, **110,** 32(2006)
3. Ram S. Gosavi, *Env. Poll. Cont. J.*, **8** , 5(2005)
4. Maohong Fan, C. brown, *Int. J. Env. Poll*., **17** ,102(2002)
5. Shih-Wu Sung, Robert C. Brown,*Int. J. Env. Poll*.**, 128,** 483(2002)
6. Aron D. Butler, Maohong Fan , Robert C. Brown, *J. Env. Engg.*, **74**, 308(2002)
7. C. Dene, P*ower Engineering*, **2**, 48(2002)
8. B. Buecker, *Power Engineering*, **110**, 10(1986)
9. Arthur kohl , Richard B. Nielsen, Gas Purification , V Edn., Gulf Publishing Company, **10**, 42, (1975)
10. A. V. Slack, G.A Hollindon, Sulphur di oxide removal from stake gases, II Edn. Noyes Data Corporation, **11**, 45(1971)
11. Indian standard method for Measurement of emission from stationary sources.IS 11255 (Part 2) 1985IS 5182 (Part 2) (2001)
12. Indian standard methods of sampling and test for quicklime and hydrated lime (1 st revision) IS No. 1514.
13. Indian standard methods of chemical analysis of limestone , dolomite and allied materials ,determination of iron oxide , calcium oxide and magnesia (1 st revision)IS No 1760 Part 3 (1992).
14. Indian standard methods of Sodium bi Sulphite technical (fourth revision). IS 248 (1987)
15. Indian standard methods of Caustic soda, pure and technical (third revision).IS 252 (1991)
16. Indian standard methods of sampling and test (physical and chemical) for water used in industries: IS 3025(1964)

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