American Journal of Environmental Protection
2016; 5(4): 103-108
http://www.sciencepublishinggroup.com/j/ajep
doi: 10.11648/j.ajep.20160504.15
ISSN: 2328-5680 (Print); ISSN: 2328-5699 (Online)

Sulphur Dioxide Adsorption on Nickel Smelting Industry in East Luwu Using a Solution of Hydrogen Peroxide

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To cite this article:

Agus Dina, Muhammad Sjahrul, Muhammad Zakir, Dadang Ahmad Suriamihardja. Sulphur Dioxide Adsorption on Nickel Smelting Industry in East Luwu Using a Solution of Hydrogen Peroxide. *American Journal of Environmental Protection.* Vol. 5, No. 4, 2016, pp. 103-108.
doi: 10.11648/j.ajep.20160504.15

Received: June 22, 2016; **Accepted**: July 4, 2016; **Published**: July 16, 2016

Abstract: Research on SO_2 gas adsorption from emissions of nickel ore industries plant use coal in the smelting process and the production by using H_2O_2 as an adsorbent solution. The adsorbent used to reduce the level of SO_2 in the air pollution. This study includes the adsorption of SO_2 gas of 6 factory chimneys at the nickel ore industry (2 dryers, 2 kilns, and 2 furnaces). The results showed that the percentage ratio of the average absorbance between H_2O_2 and calcium carbonate in reducing greenhouse gas emissions of SO_2 into the air that is 95.00%: 93.34%. As for the rest of SO_2 gas unadsorbed fixed meet the quality standards specified (750 mg/m^3). Batch adsorption was conducted with respect to concentration of adsorbent, the adsorption temperature, and contact time. It was shown that the optimum concentration of adsorbent was 5%, the adsorption temperature was 20°C, and contact time was 1800 second.

Keywords: SO_2 Gas, Hydrogen Peroxide, Gas Emission

1. Introduction

Total human population that continues to increase accompanied by increased their requirement and their activities. Diverse human activities have negative and positive impact on the environment. One of its negative effects that currently very disturbing is air pollution. According [16], air pollution is the presence of one or more physical substance, chemical, or biological in the atmosphere in an amount which can endanger the health of humans, animals and plants.

One of the substances that can cause air pollution is sulfur. Sulfur compounds in different forms has been known as a major air pollutant industrial areas as a result of burning fossil fuels, and can be derived from volcanic eruptions. In the future, an estimated amount of sulfur discharged into the atmosphere would have increased 10-fold [41]. In the form of gas, SO_2 can cause irritation to the lungs that causing hard to breathing especially for people who has asthma, children and the elderly. SO_2 is also able to react with other chemical compounds formed sulfate particles that if inhaled can accumulate in the lungs and cause breathing problems, respiratory illnesses, and even death [9].

One of the industries that produce gas emission SO_2 is smelting industry Nickel located in Sorowako, East Luwu, South Sulawesi, where the production process is done by burning the raw material in the kiln-firing with coal and produce byproduct that is SO_2 [19]. The main problem that causing gas emissions SO_2 in the industry is coal as the main fuel, even if used is coal with the best quality (low sulfur content), sulfur dioxide will formed surely and estimated gas emissions SO_2 is wasted at least able to reach 13 tons/hour.

Reducing gas emissions SO_2 can be done with a wet scrubber systems, combustion flue gas is sprayed with slurry (lime slurry), $Ca(OH)_2$ were able to reduce SO_2 emissions of 88.5 thousand tons/year to 4.5 thousand tons/year or absorption SO_2 gas approximately 95% [24] but this process can produce CO_2 which is also one of the air pollutants. System wet scrubber also create problems with the chimney because there is spraying a slurry of lime on the chimney wall [43] and this system is costly because the industry had to prepare the land for mining and milling

limestone as well as land for waste disposal in a large capacity [48].

Based on the description above, it takes a process to reduce gas emissions SO_2 that are environmentally friendly and not damage the property industry. As it is known that the gas sulfur dioxide is a colorless, flammable and easily soluble in water, young oxidized, and can react with other compounds. Based on the chemical and physical properties, then the SO_2 can be removed by oxidation using oxidizing agent that is hydrogen peroxide and this reaction can produce sulfuric acid compound, so this research is carried out to reduce SO_2 gas emissions in the nickel industry located in the east Luwu using hydrogen peroxide.

2. Experimental

This research was carried out directly on the nickel smelting industry in East Luwu. This research is qualitative and quantitative research on the amount of SO_2 can react with the hydrogen peroxide. Samples emissions of SO_2 that get as laboratory scale using an instrument (Figure 1) and there are variation on concentrations, temperature and time of hydrogen peroxide to react with SO_2. This process is carried out at the time when the industry is operating in conditions of temperature, flow rate and pressure of maximum emissions. SO_2 concentration was measured using a UV - Vis spectrophotometer.

2.1. Instrument

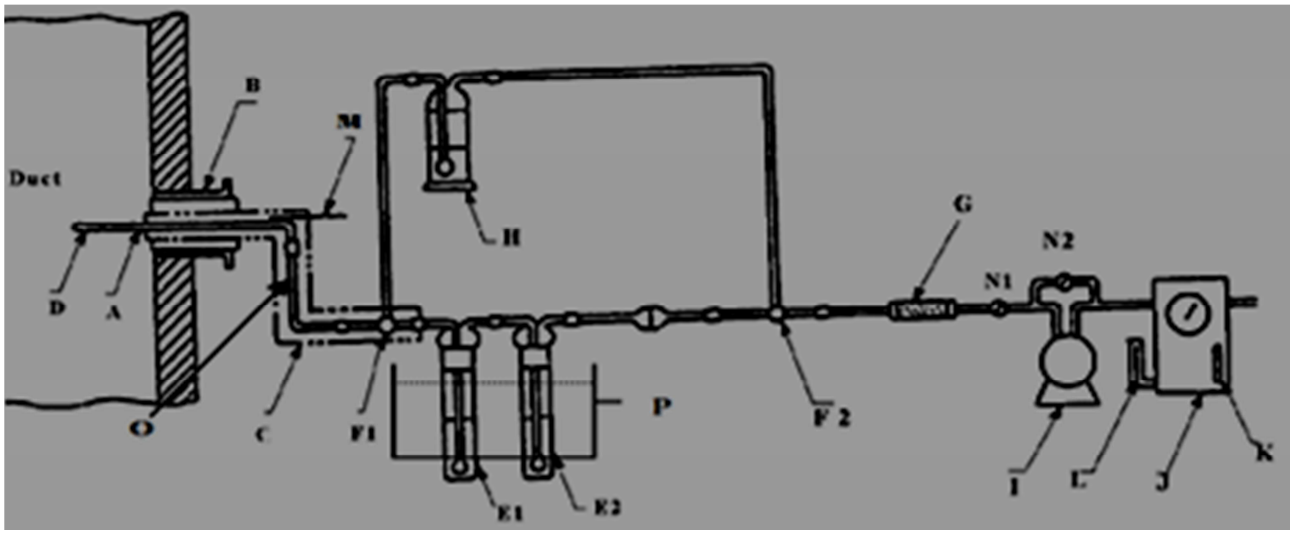

Figure 1. *The series of instrument of SO_2 sampling.*

Description of Instrument:
A: Pipe sampling test;
B: Flange;
C: heater element;
D: glass wool;
E1, E2: adsorption bottle of 250 mL;
F1,F2: junction three-cock;
G: drying tube;
H: wash bottle containing the adsorbent solution;
I: aspirator pump;
J: gas meter (capacity 1 L - 5 L per circle);
K: gas meter thermometer;
L: manometer;
M: thermometer;
N1: the cover faucet;
N2: faucet flow rate regulator:
O: rubber pipe *(flurorubber);*
P: cooling container.

2.2. Material

The materials used in this research are hydrogen peroxide 30%, NaCl, HCl (37% w/v), Glycerol, Barium chloride ($BaCl_2$), Sulfuric acid (H_2SO_4) 0,1 N; Sodium tetraborate (boraks, $Na_2B_4O_7.10H_2O$) 0,1 N; Indicator SM (sindur methyl) orMO (methyl orange) and Field blank solution.

3. Results and Discussion

Sampling and adsorption exhaust gas emissionsindustry conducted for twelve days in May 2015. The sampling is done where the condition of each chimney in a state of maximum 6 industrial chimney, each on 2 chimneydryer, 2 chimney Kiln, and 2chimney furnace. The sampling

technique uses a series of side tool probe, vacuum for sucking in air emissions and a series of impinger a place for adsorbent solution (hydrogen peroxide). To view the results adsorption of SO_2 gas, then conducted sample analysis in Laboratory Technical Implementation Unit of the Environment Agency of South Sulawesi province. Description of adsorption results concentration of SO_2 of each the chimney can be seen in the following chart.

Table 1. *Results of adsorption concentration of SO_2 gas in chimneys emissions based on variations concentration of adsorbent solution.*

No	Concentration (%)	Results (mg/M^3)					
		Hydrogen peroxide					
		Dryer 1	Dryer 2	Kiln 1	Kiln 2	Furnace 1	Furnace 2
1	1	2,585.25	3,185.07	4,093.89	3,031.75	6,345.13	6,495.09
2	2	4,558.59	4,383.21	4,717.91	3,432.83	6,462.34	6,290.94
3	3	5,545.59	4,390.07	4,949.44	3,790.89	8,414.79	8,052.81
4	4	4,824.26	5,468.10	6,067.79	4,548.50	8,570.97	8,406.47
5	5	5,562.36	5,610.57	7,805.51	6,099.64	10,501.50	10,590.40

Table 2. *Results of adsorption concentration of SO_2 gas in chimneys emissions by temperature variations of adsorbent solution.*

No	Temp. (°C)	Results (mg/M^3)					
		Hydrogen peroxide					
		Dryer 1	Dryer 2	Kiln 1	Kiln 2	Furnace 1	Furnace 2
1	20	5,328.14	5,377.72	6,674.04	5,316.34	9,613.78	10,015.3
2	25	4,526.98	4,988.47	6,466.24	4,381.93	9,603.76	8,610.69
3	30	4,083.60	4,918.19	6,006.50	3,854.37	8,433.09	8,563.33
4	35	3,437.75	4,765.20	4,018.89	3,694.13	7,257.47	6,373.46
5	40	2,780.29	3,333.34	3,573.66	2,852.99	6,229.25	6,236.93

Table 3. *Results of adsorption concentration of SO_2 gas in chimneys emissions based on time variation of adsorbent solution.*

No	Time (second)	Results (mg/M^3)					
		Hydrogen peroxide					
		Dryer 1	Dryer 2	Kiln 1	Kiln 2	Furnace 1	Furnace 2
1	600	2,880.02	2,650.28	3,698.88	2,796.12	5,789.36	4,584.16
2	900	3,389.42	3,665.24	4,864.09	3,222.10	6,741.13	5,528.04
3	1200	4,673.73	4,305.88	5,552.45	4,538.86	8,455.43	8,149.12
4	1500	4,937.86	5,097.07	6,559.05	5,267.34	9,685.90	8,101.28
5	1800	5,447.36	5,585.66	7,466.57	6,019.59	10,271.01	10,249.52

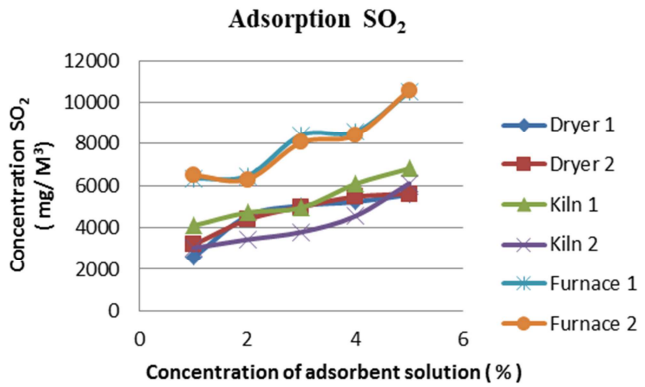

Figure 2. *Results of adsorption concentration of SO_2 gas in chimneys emissions based on variations concentration of adsorbent solution.*

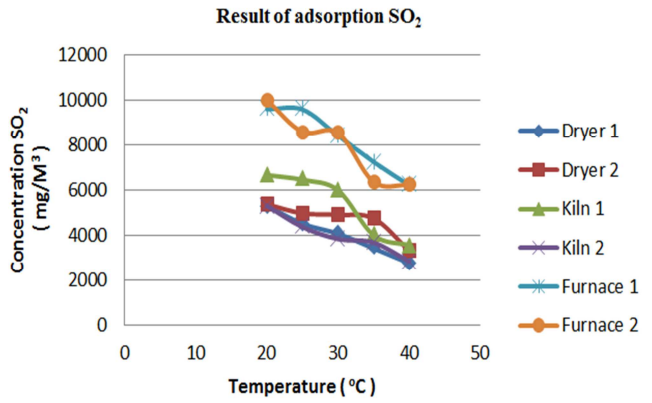

Figure 3. *Results of adsorption concentration of SO_2 gas in chimneys emissions by temperature variations of adsorbent solution.*

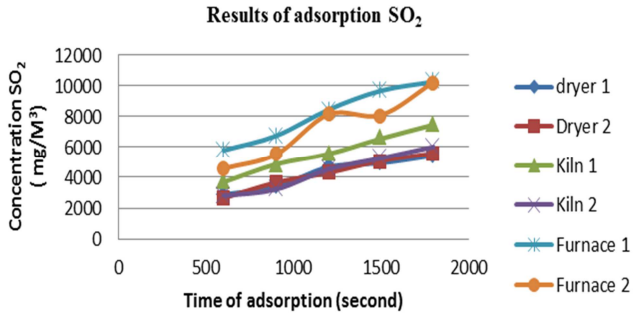

Figure 4. *Results of adsorption concentration of SO_2 gas in chimneys emissions based on time variation of adsorbent solution.*

Based on the test data exhaust gas of SO_2 is absorbed by the hydrogen peroxide from chimneys emissions at dryer 1 and 2; kiln 1 and 2; and furnace 1 and 2, increased concentration of maximum adsorption indicated in the treatment adsorbent solution on the condition of 20°C, with a concentration of 5% and length taking 1800 seconds. Results achieved in the adsorption capability of the accumulation of means as follows:

1. Dryer 1, cylindrical chimney with a height of 61.6 meters with a diameter of 4 meters at coordinates 02°34'8.3" LS and BT 121°22'38.9" with a gas flow rate 327.82 m^3/sec. Conditions of the emission gas temperature 140°C, resulting adsorption 5479.29mg/m^3, 4623.62 tons/month or 96.62%.
2. Dryer 2, cylindrical chimney with a height of 60.9 meters with 3.9 meter cross-sectional area at coordinates 02°34'8.4" LS and BT 121°22'39.5" with a gas flow rate 312.74 m^3/sec in the emissions gas temperature conditions ± 140°C produce adsorption 5361.79 mg/m^3 or 4348.41 tons/month or 90.87%.
3. Kiln 1 (Reduced 1) is a cylindrical chimney with a height of 61 meters with 2.9 meter cross-sectional area at coordinates 02°34'08.4 LS "and BT 121°22'38.8" gas flow rate 234.87 m^3/sec in the emission gas temperature conditions ± 168°C produces adsorption 4454.99 tons/month or 7315.25 mg/m^3 or 90.78%.
4. Kiln 2 (Reduction 2) is a cylindrical chimney with a height of 62 meters with 2.9 meter cross-sectional area at coordinates 02°34'09.1 LS "and BT 121°22'41.4" with a gas flow rate 291.39 m^3/sec in the emissions gas temperature conditions ±168°C resulted adsorption 4387.95 tons/month or 5811.85 mg/m^3 or 89.41%.
5. Furnace 1, cylindrical chimney with a height with a height of 61 meters with 4.1 meter cross-sectional area at coordinates 02°34'09.4 LS "and BT 121°22'42.9" with a gas flow rate 291.39 m^3/sec in the emissions gas temperature conditions ±200°C produce adsorption 4720.00 tons/month or 10128.76 mg/m^3 or 96.18%.
6. Furnace 2, cylindrical chimney with a height of 61 meters with 4.1 meter cross-sectional area at coordinates 02°40'15.1 LS "and BT 121°10'25.2". with a gas flow rate 291.39 m^3/sec in the emissions gas temperature conditions ±200°C produce adsorption 4720.84 tons/month or 10285.05 mg/m^3 or 96.19%.

Direct measurements of SO_2 gas emissions conducted in the same monthof the dryer 1 with a gas flow rate 239.39 m^3/sec, dryer 2 with a gas flow rate 212.39 m^3/sec produce an average of test results to produce ±4785.43 tons/month or equivalent to 8692.64 mg/m^3, while from kiln 1 with a flow rate 171.52 m^3/sec and kiln 2 with a flow rate 223.94 m^3/sec produce an average of ±4907.70 tons/month or equivalent to 9622.94 mg/m^3. Furnace 1 with a gas flow rate 236.63 m^3/sec and furnace 2 with a gas flow rate 170 m^3/sec also resulted in an average concentration ±4907.7 tons/month or equivalent to 9259.81 mg/m^3.

Gas emissionsthat are not adsorbed from flue dryer 1 is 161.81 tons/month or 190.59 mg/ m^3 or 3.38%, dryer 2 is 437.02 tons/month or 538.87 mg/m^3 or 9.13%, kiln 1 was 452.71 tons/month or 743.37 mg/m^3 or 9.22%, kiln 2 was 519.75 tons/month or 688.41 mg/m^3 or 10.59%, furnace 1 was 187.70 ton/month or 402.79 mg/m^3 or 3.82%, and furnace 2 was 186.86 tons/month or 407.10 mg/m^3 or 3.81%.

The results showed that the higher the temperature of the solution is getting lower to adsorb exhaust gas emissions, the lower the flow rate of the exhaust gas is getting greater the ability reaction of adsorbent and the nature of the gases emitted fluctuations in temperature, pressure and flow rate as well as the turbulence also affects the absorption of gas emissions factory chimneys.

Based on data from previous research using a slurry of lime (calcium hydroxide) which is able to adsorb sulfur dioxide by 95% equal to the adsorption ability of hydrogen peroxide that is 94.85% from industrial sources of nickel.

4. Conclusions

This result of this study that is comparison of percentage of the average adsorption accumulation between adsorbent solution using a solution of hydrogen peroxide and calcium carbonate slurry to reduce sulfur dioxide emissions into the ambient air show results approximately equal to the lime slurry that is 95.00%: 93.34%. The adsorption concentration of SO_2 greater if conditions adsorbent greater concentration, then the lower the temperature and the longer the adsorption time. Emissions of the six chimneys that are not adsorbed, they meet the standards set. under the rules of the Governor Number 69 Year 2010 on the quality standard emissions of SO_2 750 mg/m³, means that hydrogen peroxide as a adsorbent solution viable as an alternative instead of calcium carbonate.

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