The use of artificial wastewater for water feeding of scrubber for treating coal burning emission

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Abstract. The use of clean water for wet scrubbers needs to be reduced for water resource efficiency in the company. This research was conducted to examine the use of wastewater as wet scrubber feeding from boilers that use coal fuel. The scrubber type was spray tower using stainless steel material and packed bed with marbles. Artificial waste was made to imitate textile wastewater. Emission measurements at the outlet adopted SNI standard. Parameters observed in the flue gas were particulate (isokinetic), SO_2, and NO_2. We also observed the TSS and COD concentrations in the scrubbing liquid. The reduction pollutants concentration using artificial waste was 21 - 51% for particulate, about 45% for SO_2 concentration, and more than 90% for NO_2 concentration. The parameters of COD concentration in the outlet decreased by about 20% while the TSS concentrations increase almost two fold. This initial study shows that the use of wastewater for scrubbers is promising although it produced TSS pollutants in scrubbed wastewater.

1. Introduction

The use of water media for the treatment of air pollution in wet scrubbers will have two consequences: giving pressure to water supply and providing additional burden to the wastewater treatment unit because the outlet of the wet scrubber will usually be included in the WWTP. The average quantity of industrial WWTP varies greatly (depending on the industry scale), some are continuous, some are batch. As a result of industrial wastewater discharges, around 70% of Indonesia's rivers are classified as heavily polluted [1]. In Indonesia there were around 10,650 industries that produced liquid waste in 2002 [2].

Waste gas treatment with wet scrubbers is very common in the industrial world because of its high efficiency [3]. The consumption of water for wet scrubbers will increase more and more when the quantity of gas pollutants being processed is greater. The ratio of water demand for wet scrubber to the processed waste gas discharge is quite high, namely 0.5 to 3 L/m^3. With the depletion of water reserves in depressed soil aquifers as industrial raw water sources (both for processing production processes and for air pollution control installations), it is recommended to save water use. The savings

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in the use of water in the air pollution control unit can be initiated from the reuse of liquid waste (which is still relatively fresh) as a wet scrubber feed.

The potential use of saved water is quite large if the air pollution controller uses liquid waste. The challenge in utilizing industrial liquid waste as wet scrubber feed is a characteristic of liquid waste which is not necessarily meet with the characteristics of wet scrubber feed water. Industrial liquid waste usually has high BOD, COD, and turbidity characteristics as well [4]. In some cases industrial liquid waste has acidity or high alkalinity. Several heavy metals can also be dominant in industrial wastewater. For this reason, a priority selection of industrial wastewater is needed to know its ability to remove pollutants in the wet scrubber. Of course the performance considerations of wet scrubbers should not decrease significantly if industrial wastewater is used as scrubber media. Some industrial wastewater may have "good" characteristics to neutralize gas waste, for example alkaline liquid waste will be good for removing SO_2 gas pollutants so that the wet scrubber output will improve industrial wastewater quality. Industrial liquid waste must also be pre-treated to align with the minimum wet scrubber feed requirements. This research is aimed at analysing industrial liquid waste that is suitable for use as wet scrubber feed media for air pollution control and measuring the reduction potential of industrial air pollutants (SO_2, NO_2 and particulates) by using artificial industrial wastewater reuse.

2. Methodology

The scope of this research is the design and construction of packed wet scrubber combinations as air pollution control devices with the use of liquid waste. Process and analysis tests were carried out after the preliminary test was carried out on packed wet scrubbers to see the decrease in air pollution from the chimney combustion outlet with the main parameters were SO_2, NO_2 gas and total dust particles. The reactor scheme consisted of reactor scrubbers, water reservoirs for liquid scrubbing, combustion chamber with coal fuel, burners as depicted in Figure 1. Scrubber type is spray tower using media marbles as its packed bed. The source of artificial wastewater was liquid made of water with addition of glucose to imitate textile wastewater later. The L/G ratio used is in accordance with the ratio for the spray tower which is 5 gal/1,000 ft^3. The complete device used in the study can be seen in Figure 2. The variations used are the liquid variations, namely clean water and artificial wastewater reuse. We observe the variation of temperature during burning process in the top of burning coal as well as in the top of sampling point. In the inlet and outlet of scrubbed water, we measure the TSS concentration to know the effect of burned coal absorbed in the scrubbed water. We also measure the COD concentration of the liquid particularly before contacting with the gas stream and after contacting the gas stream.

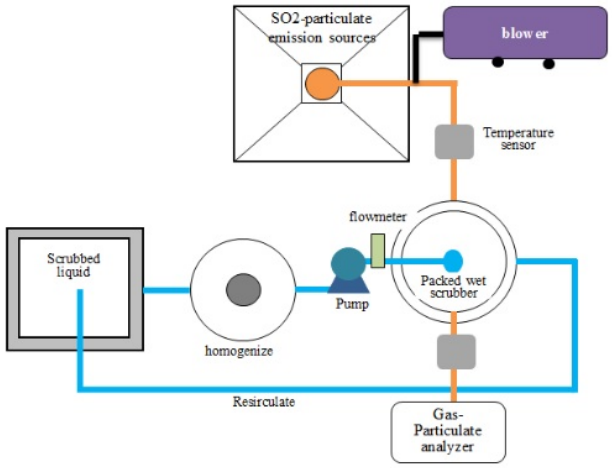

Figure 1. Reactor scheme

Figure 2. Reactor assembly

The coal used is typically sub bituminous coal having calorific value about 7000 cal/kg. The ultimate analysis of the coal revealed the composition of coal as follows: 58.36% C, 1.02% N, 6.59% H, 11.29% O, 0.56% S. We adopt national standard reference (SNI/Standar Nasional Indonesia) method for measuring the parameter of interest as summarized in Table.1

Table 1. List of method for measuring the parameter of interest

Parameter	Reference Number	Remarks
Gas Sampling point	SNI 19-7117.2-2005	Two sampling point (inlet-outlet)

Particulate sampling	SNI 7117.17:2009	Isokinetic sampling
Gas sampling	-	Using portable gas analyzer
COD test	SNI 6989.2-2009	Inlet – outlet of scrubbed water
TSS test	SNI 06-6989.3:2004	Inlet – outlet of scrubbed water

3. Research and Discussion

The experiment was carried out for 2 days which began with an experiment with clean water as a scrubber. The temperature observed when burning reaches 200 - 400°C (see Figure. 3) where initial burning for water feeding has higher maximum temperature. Generally the output temperatures were in the range of 35 – 40 °C. Higher observed temperature in the inlet position due to the temperature sensor is located near the coal combustion zone. There was relatively no difference of the temperature profile pattern between trial with scrubbed water and artificial wastewater. As depicted in Figure 5, the reduction pollutants concentration using artificial waste was 21 - 51% for particulate (Figure 5a), about 45% for SO_2 concentration (Figure 5b), and more than 90% for NO_2 concentration (Figure 5c).

The low efficiency of scrubbed pollutants (particulate and SO_2) might be caused by low intimate contact between gas stream and the liquid, even though it was counter current contact. We did not set the pressure of the scrubbed liquid then the sprayed liquid size may not as small as general spray tower has. The parameters of COD concentration in the outlet decreased by about 20% while the TSS concentrations increased almost double. It was not known why the COD of the scrubbed liquid also decreased. Presumably the use of marble as a bed for contacting liquid and gas played important role in adsorbing COD on the marble surface. Black layer on the surface of marbles (Figure 4) derived from coal fly ash may adsorb the COD component in the liquid. The TSS increased in the outlet of scrubbed water meaning that the dust of burning coal was partially absorbed in the liquid stream so as to add existing TSS in the liquid stream. The NO_2 concentration was not main focus of this research thus it was found to be minor pollutants generated by coal burning. Thus reduction emission by 90% might not the typical emission reduction since the NO_2 concentration was at low concentration. Moreover, the coal burning temperature i.e around 200 – 400 ºC was not ideal temperature for NO_2 gas generation. Based on this research, the use of wastewater for water scrubbing of gas, SO_2 in particular, as well as particulate might be a promising integrated treatment (water-air pollution treatment). We observed there were reduction of pH, though it was not significant, on the wastewater outlet indicating amount of SO_2 acid gas to be neutralized by wastewater (base solution). Further research is needed to design optimum sprayed liquid and to prolong detention time of wastewater in chamber to facilitate minimum TSS in scrubber device. This will, in turn, give effective contact between liquid and gas by spraying wastewater above barometric pressure.

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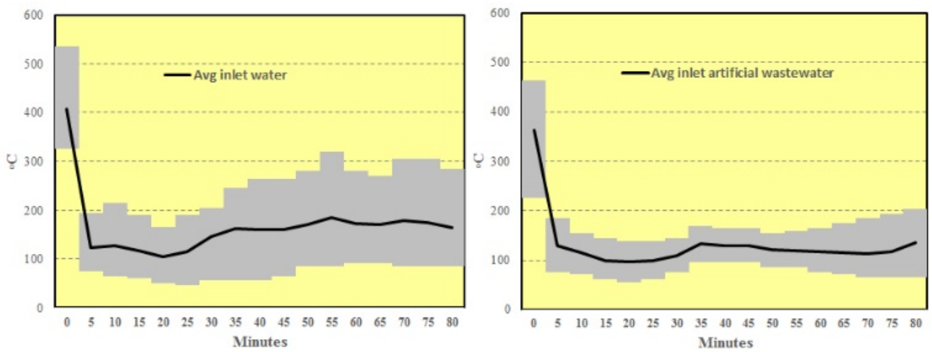
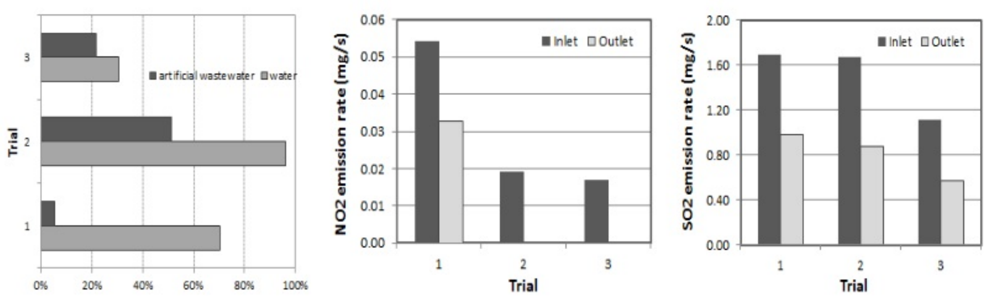


(a) (b)

Figure.3 Variation of temperature during experiment (a) water, and (b) artificial wastewater

Figure.4 Clean marbles before running (left) and black thickened marbles after running (right)



(a) (b) (c)

Figure.5 Emission reduction of (a) particulate, (b) SO_2, and (c) NO_2

4. Conclusion

Based on these experiments, the reduction pollutants concentration using artificial waste were 21 - 51% for particulate, about 45% for SO2 concentration, and more than 90% for NO_2 concentration. The parameters of COD concentration in the outlet decreased by about 20% while the TSS concentrations increase almost two fold. The use of wastewater for feeding the scrubber process is quite promising. However, it is necessary to optimize the process so that it can effectively reduce pollutant emissions. Increase of TSS pollutant concentrations at the outlet need to be anticipated in wastewater treatment

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