The Effect of Result Flue Gas Emission With or Without

by Dewi Puspitasari

The Effect Of Measurement Results Flue Gas Emission With And Without Using Flow Straightener on Stack

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Abstract. The industry's dependency on fossil fuel in Indonesia is still very high and may cause air pollution that is harmful to environment. The government's regulation to prevent air pollution problem through KEPMENLH number 13 of 1995 on dealing with gas emission from stationary source must be monitoring the flue gas emission measurement on the stack. But the main problem during measurement is fluctuated measurement result because of cyclonic and less uniform flue gas flow. In case of reducing the Relative Standard Deviation is by installing a flow straightener inside the stack. This research has four measurement conditions such as stack without flow straightener, stack with flow straightener level 0.75D, 1D and 1.25D from the bottom interference of the stack. From this work results that the use of flow straightener can reduce the Relative Standard Deviation (RSD) as in NO_2 which tend to decrease, in condition of stack without flow straightener has 8.63265 % of RSD, stack with flow straightener respectively are 0.75D has 8.39012 % of RSD, 1D has 3.746% of RSD and 1.25D has 0% of RSD. However, the installation of flow straightener could increase the isokinetics percent in particulate sampling. The isokinetics percent of the stack without flow straightener, with flow straightener 0.75D, 1D and 1.25D respectively are 94.88 %, 114.83 %, 134.48 % and 148.66 %.

Keywords : Flow straightener, Flue gas concentration, Particulate content, Relative Standard Deviation

INTRODUCTION

Indonesia is a country with one Trillion Dollars of Gross Domestic Product (GDP). With the increase in economic growth, the need of energy demand will also increase [1]. Industry has significant role to fulfill the society's welfare. Actually the use of fossil fuel in industry is still very high and may cause harmful air pollution.

Responding to the air pollution problem, the Indonesian government established the quality standard regulation of gas emission from stationary source through KEPMENLH number 13 of 1995 [2]. The flue gas concentration and particulate content are measured isokinetically based on standardization of US-EPA method 1-5 or SNI 7117.13-2009 – 7117.17-2009. The measurement result on gas analyzer is frequently fluctuate, so it makes the measurement result less precise. This problem occurs because of cyclonic and less uniform flue gas flow. To overcome this problem is by installing a flow straightener inside the stack [3]. This experiment is using a 45° degree conical flow straightener (upward) and installed at various distances such as 0.75D, 1D and 1.25D from the bottom interference of the stack based on previous research [4].

By using bituminous coal as fuel, this experiment is expected to be able to analyze the difference of the flue gas emission measurement result between stack without flow straightener and stack with flow straightener.

RESEARCH METHOD

Stack And Flow Straightener

The stack has 6 inch of diameter and 36 inch (6D) of height. The stack also has two sampling points which are located at 4D from the bottom interference or 2D from the top interference of the stack. Bituminous coal is burned inside the furnace as in figure 1 a. Flow straightener has 6 inch of diameter and located at 0.75D, 1D and 1.25D from the bottom interference of the stack.

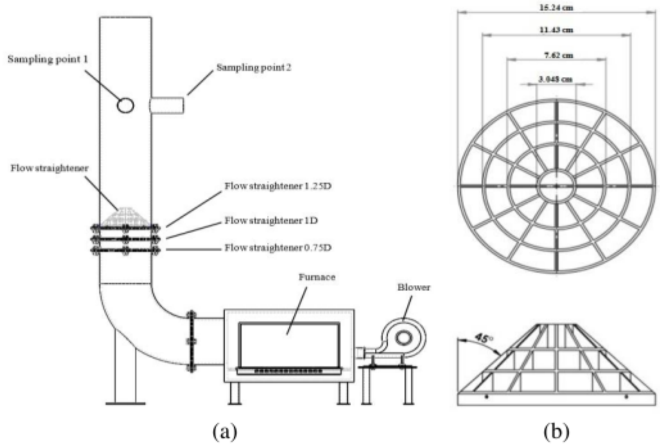


FIGURE 1. (a) The schematic of experiment stack, (b) The 45° conical flow straightener

Sampling And Traverse Point

Sampling point is a location for sampling or measuring the flue gas emission, while the traverse point is the minimum number of cross point sampling. To determine the location of sampling and traverse points is based on US-EPA method 1 or SNI 7117.13-2009. The stack has 4 inch of sampling point diameter. Sampling point located at 4D from the bottom and 2D from the top interference of the stack and the probe entered in the straight direction according to the distance of traverse point as in Figure 2. For stack with alternative sampling location less than 8D and 2D criteria, the required numbers of traverse points are 2 to 4 on stack with less than 0.3 m of diameter.

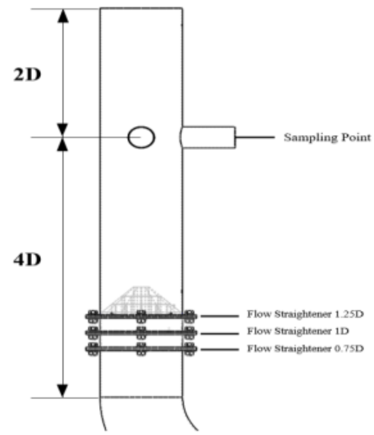


FIGURE 2. Sampling point location

Flue Gas Analyzer and Method 5 Sampling Train

Flue gas concentration is measured by using flue gas analyzer. The gases measured in this experiment such as SO_2, NO_2, CO, CO_2 and O_2. Each gas is measured ten times in ten minutes in every sampling point. For SO_2, NO_2, CO are expressed in mg/m^3 unit whereas CO_2 and O_2 are expressed in percent.

FIGURE 3. Flue gas analyzer

Method 5 sampling train is used to determine the particulate content. This instrument has probe and filter to collect particulates and then the particulate content is determined gravimetrically.

FIGURE 4. Method 5 sampling train

Relative Standard Deviation And Isokinetic Percent

Relative Standard Equation (RSD) is a parameter used to express the accuracy and precision in measurement. It is also defined as the ratio of standard deviation to the mean. The lower the RSD, the more precise the measurement result and vice versa. RSD is used in flue gas concentration measurement. The relative standard deviation can be defined as :

$$RSD = \frac{SD}{\bar{X}} \times 100\ \% \qquad (1)$$

When measuring the particulate content, the initial variables that must be determined are the location of sampling and traverse point, the linear velocity, molecular weight and moisture content of flue gas. When all particulate content calculation is completely done, the next step is to determine the percentage of isokinetic. The acceptable isokinetic percentage is 100 % ± 10 % based on SNI 7117.17-2009 [5]. The isokinetic percentage can be written as:

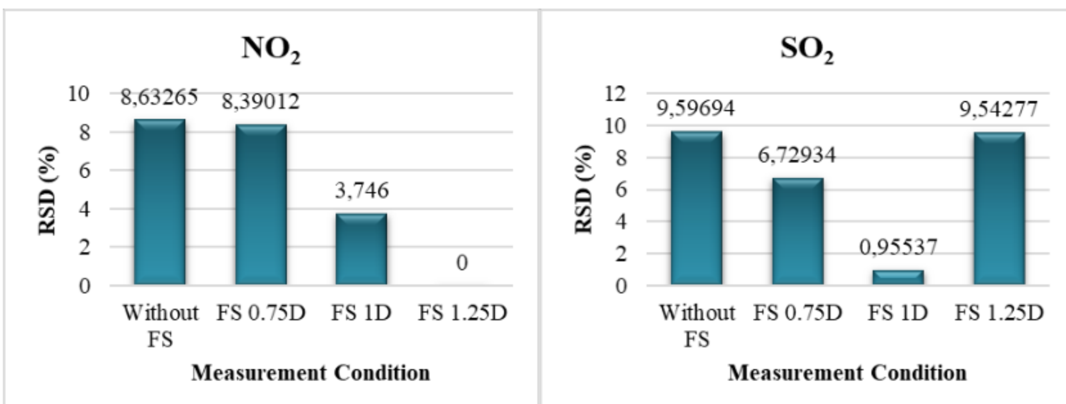
$$I = \frac{100 \times T_s \times V_{m(std)} \times P_{std}}{60 \times T_{std} \times v_s \times \theta \times A_n \times P_s \times (1 - B_{ws})} \qquad (2)$$

This experiment has four measurement conditions such as stack without flow straightener, stack with flow straightener 0.75D, stack with flow straightener 1D and stack with flow straightener 1.25D.

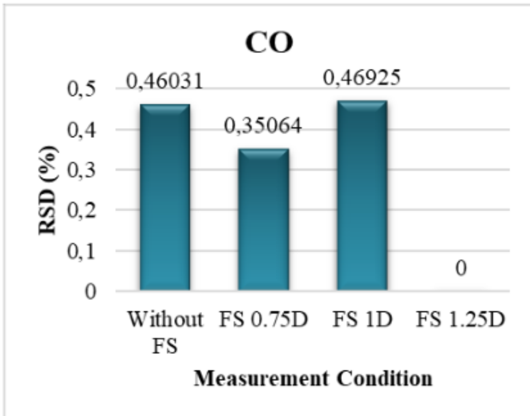
RESULTS AND DISCUSSION

Relative Standard Deviation

After measuring the flue gas concentration, then calculate the average of the gas concentration and also calculate the standard deviation. By using equation (1), the relative standard deviation on each measurement conditions for SO_2, NO_2, CO, CO_2 and O_2 are expressed in charts below



(a) (b)



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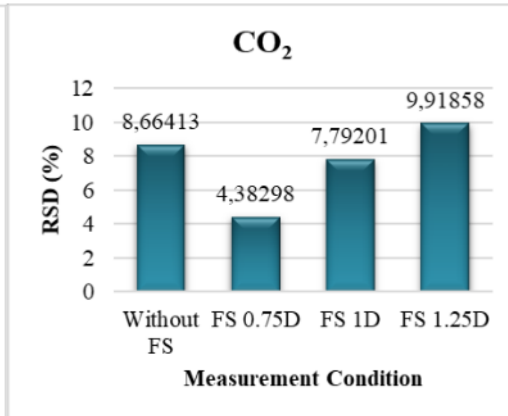

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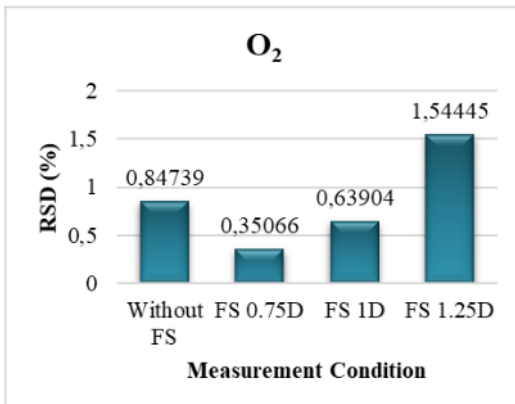

(e)

FIGURE 5. Relative standard deviation chart (a) SO_2, (b) NO_2, (c) CO, (d) CO_2, (e) O_2

TABLE 1. The average of Relative Standard Deviation on each measurement condition

RSD	**Measurement conditions**			
	Without FS	**FS 0.75D**	**FS 1D**	**FS 1.25D**
SO_2 (%)	9.59694	6.72934	0.95537	9.54277
NO_2 (%)	8.63265	8.39012	3.746	0
CO (%)	0.46031	0.35064	0.46925	0
CO_2 (%)	8.66413	4.38298	7.79201	9.91858
O_2 (%)	0.84739	0.35066	0.63904	1.54445
Average (%)	5.640284	4.040748	2.720334	4.20116

From fig. 5, it can be observed that the use of flow straightener inside the stack produce lower RSD rather than the stack without using flow straightener. The lowest RSD is produced by flow straightener 1.25D whereas the effective position of flow straightener is at 1D from the bottom interference of the stack based on the average from Table 1.

Particulate Content And Isokinetic Percent

The particulate content of all measurement conditions are expressed in the following chart below

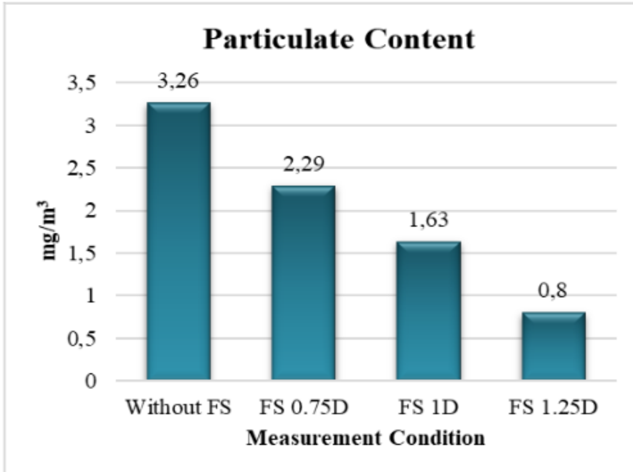

FIGURE 6. Particulate content of all measurement conditions

It can be observed that the stack without flow straightener produce the highest particulate content. The use of flow straightener makes the particulate content decrease. The farther the flow straightener installation from the bottom interference of the stack, the lower the particulate content result. The next parameter to be calculated is isokinetic percentage by using equation (2). The isokinetic percentage of all measurement conditions are expressed in the chart below

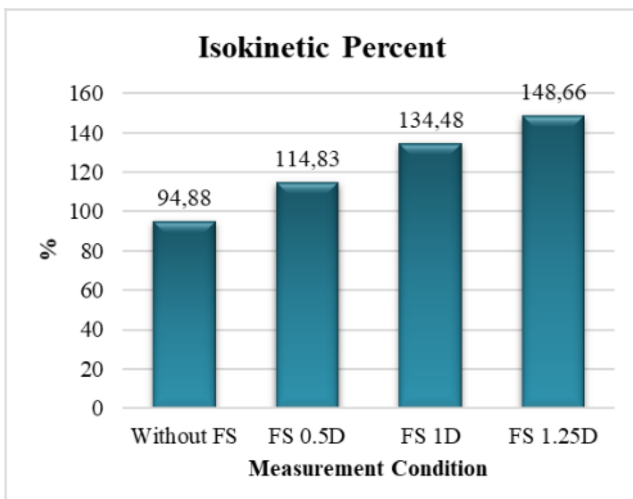

FIGURE 7. Isokinetic percent of all measurement conditions

From Figure 7, the isokinetic percent of stack without flow straightener is the lowest and within acceptable range. On the other side, the stack using flow straightener has higher isokinetic percent and out of acceptable range. The farther the flow straightener installation from the bottom interference of the stack, the higher isokinetic percent.

It happened because of the decrease in linear velocity. The linear velocity chart is expressed in the following chart below

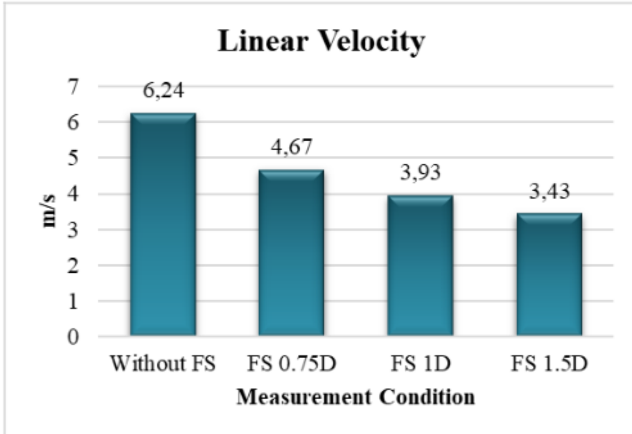

FIGURE 8. Linear velocity

CONCLUSIONS

Based on the experiment, it can be concluded that the use of flow straightener inside the stack can reduce the relative standard deviation rather than the stack without using flow straightener. From table 1, we could find out the effective of flow straightener installation position is at the distance of 1D from the bottom interference of the stack. Then, the use of flow straightener inside the stack produce higher isokinetic percent, the farther the flow straightener installation from the bottom interference of the stack, the higher isokinetic percent.

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