THE EMISSIONS OF SELECTED AIR POLUTANTS FROM THE SINTERING PROCESS IN THAINGUYEN IRON AND STEEL JOINT STOCK COMPANY

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SUMMARY

The emissions of selected air pollutants being CO, CO_2, SO_2 and NO for the sintering process of the Pig Iron Factory of Thai Nguyen Iron and Steel Joint Stock Company were studied. The concentrations of these pollutants were measured five times by a combustion gas analyzer, Quintox KM – 9106 and following US.EPA Methods 1-3. Based on data monitored, total emissions and emission factors of these pollutants for the process were determined. The emission factors of CO, CO_2, SO_2 and NO on the basis of coal consumed are 142.9 g/kg; 1484.6 g/kg; 18.7 g/kg and 6.2 g/kg, respectively. In addition, based on the sintering product, the emission factors of CO, CO_2, SO_2 and NO are 19.6 kg/ton; 203.2 kg/ton; 2.6 kg/ton and 0.8 kg/ton, respectively. Emission factors obtained in this study are in the same range with those of other studies. These results of this study can be used for emissions inventory and air quality management.

Keywords: *Emission factor, sintering, iron and steel, flue gas, Thai Nguyen, Vietnam*

INTRODUCTION

The sintering process converts fine-sized raw materials, including iron ore, coke breeze, limestone, mill scale, and flue dust, into an agglomerated product, sinter, of suitable size for charging into the blast furnace [1]. Emissions from sinter plants are mainly particles, CO, CO_2, NO_x, VOCs, methane [2]. These air pollutants can cause health effects to the people. In order to assess the potential of health effects from the sintering process, the total emission of air pollutants need to be estimated. And one of effective tools for doing so in many countries is the application of emission factors. An emission factor is a tool that is used to estimate air pollutant emissions to the atmosphere. It relates the quantity of pollutants released from a source to some activity associated with those emissions. Emission factors have long been used as a cost-effective means to develop area-wide emission inventories [1]. Many databases of emission factors have been developed in developed countries and international organizations (such as AP-42 document of United State, the database of World Health Organization - WHO, the document of United Nations Environment Program – UNEP, the database of Intergovernmental Panel on Climate Change - IPCC) [1-4]. However, data on the emission factors for iron and steel industry are still scarce in many Asian developing countries, including Vietnam. This study is; therefore, aimed at the development the emission factors of selected air pollutants of iron and steel industry in Vietnamese conditions. This paper presents preliminary results on the emission factors of sintering process for Thai Nguyen Iron and Steel Joint Stock Company.

MATERIALS AND METHODS

Site description

The study was conducted at the Pig Iron Factory of Thai Nguyen Iron and Steel Joint Stock Company. The raw materials for sintering include iron ore, coke breeze or anthracite, limestone, mill scale, and flue dust that are pulverized and then mixed together to get suitable composition. The composition of the raw materials is presented in Table 1. These mixed materials are baked in sintering furnace. When temperature is reached to 1200°C, the particles are agglomerated to be

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suitable size for charging into the blast furnace. The flue gas of sintering process, after being treated by electrostatic precipitator (ESP), is emitted into the atmosphere via a stack. The stack is 25m high and 1.5m in inner diameter. There is a monitoring port located at 3m from the open end of this stack. This sampling port meets the requirement of 8D downstream and 2D upstream for the monitoring of pollutant emissions and/or total volumetric flow rate from a stationary source by US.EPA Method 1. Where, D is inner diameter. Three traverse points with the distances from the inside wall of the stack being 0.3, 0.4 and 0.5 m were used per sampling port (cross section). Monitoring sites in this study is shown in Figure 1.

Table 1: *The content of main parameters of the fuel and raw materials used in the plant*

	C	H	O	N	S
Iron ore	-	-	-	-	0.16
Mill scale	-	-	-	-	0.03
Anthracite	66.5	0.8	1.3	0.7	1.20
Lime stone	-	-	-	-	0.16

Monitoring

Monitoring time was selected based on the monthly coal consumption of the plants in 2-3 previous years as shown in Figure 2. From Figure 2, October is considered to be representative for the activities of the plant as their coal consumptions were in the average level. October, therefore, was selected for monitoring. Monitoring activities were conducted on 27th October, 2011.

Monitoring was conducted based on US. EPA Methods 1-3. Concentrations of selected air pollutants in the flue gas were directly measured by a combustion gas analyzer, Quintox KM - 9106 (Kane May, UK). Results were automatically converted and reported to the conditions of 1 atm and 25^{o}C by the analyzer. In order to obtain the net concentrations of these pollutants in the flue gas, their levels in the ambient air surrounding were also monitored. Detection limits of the equipment for the monitoring are CO - 0.01%, CO_2 – 0.01%, SO_2 – 1 ppm and NO – 1 ppm. Measurement was conducted five times, each time was separated by 20 minutes. Temperature and velocity of the flue gas were also measured.

RESULTS AND DISCUSSION

Concentrations of selected air pollutants

Average concentrations of the pollutants monitored in the flue gas of sintering are shown in Table 2.

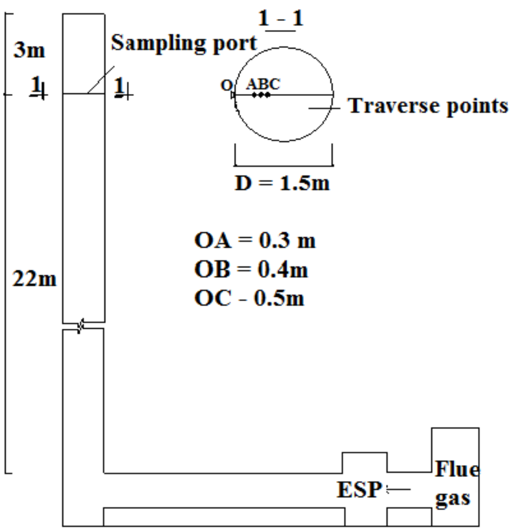

Figure 1. *Diagram of the flue gas treatment system and monitoring port of sintering*

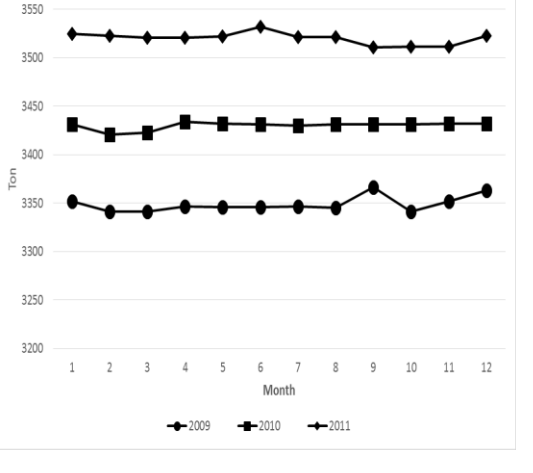

Figure 2: *Monthly coal consumption of the plants in 2009, 2010 and 2011*

Table 2: *Summary information of the flue gas of sintering process*

No	T (^oC)	Flow rate (Nm^3/s)	Concentration (25 ^oC and 1 atm)			
			CO ***(mg/Nm^3)***	***CO_2*** ***(g/Nm^3)***	***SO_2*** ***(mg/Nm^3)***	***NO*** ***(mg/Nm^3)***
TK1	53.9	243396.0	2990.0	30.5	394.0	135.0
TK2	53.4	243768.0	2995.0	28.7	396.0	123.0
TK3	52.6	244367.0	2890.0	32.3	395.0	134.0
TK4	55.1	242505.0	2999.0	30.5	387.0	136.0
TK5	54.3	243098.0	2996.0	32.3	378.0	118.0
Average	**53.9**	**243426.9**	**2974.0±47.1**	**30.9±1.5**	**390±7.6**	**129.2±8.2**

Table 3: *Emission factors of pollutants in sintering process*

No	Emission factors							
	CO		***CO_2***		***SO_2***		***NO***	
	(g/kg coal)	**(kg/ton sinter)**	**(kg/kg coal)**	**(kg/ton sinter)**	**(g/kg coal)**	**(kg/ton sinter)**	**(g/kg coal)**	**(kg/ton sinter)**
TK1	143.7	19.7	1467.1	200.8	18.9	2.6	6.5	0.9
TK2	144.1	19.7	1383.0	189.2	19.1	2.6	5.9	0.8
TK3	139.4	19.1	1559.7	213.4	19.1	2.6	6.5	0.9
TK4	143.6	19.6	1461.8	200.0	18.5	2.5	6.5	0.9
TK5	143.8	19.7	1551.6	212.3	18.1	2.5	5.7	0.8
Average	**142.9±2.0**	**19.6±0.3**	**1484.6±72.9**	**203.2±10.0**	**18.7±0.4**	**2.6±0.1**	**6.2±0.4**	**0.8±0.1**

As seen from Table 2, the concentration of CO, CO_2 were very high. Especially, the concentrations of CO exceeded the respective limit values of QCVN 19: 2009/BTNMT (column B) [5]. However, NO in the flue gas was not so high and did not exceed the respective standard of QCVN19:2009/BTNMT [5]. This can be understood. The concentrations of CO and NO is influenced by a number of factors including the excess air. The low excess air (3-5%) shows that the results of concentration of CO and NO is very logical. Of course the thermal NO can be formed at 1200^oC, however, the concentration of NO was still slow because excess air coefficient is very small [6].

Emission factor

Emission factors of each pollutant, coal-based and sinter-based, are obtained by dividing the total emission by the quantity of coal used/batch and quantity of coke produced/batch respectively. These results are shown in Table 3.

It is widely known that when the coal is burned, almost all of the sulfur in the fuel, whatever chemically bond or pyritic, is converted to SO_2 and carried along with stack gas [18]. The theoretical (calculated) emission factor of SO_2, which is based on the sulfur content of the coal, would be about 18 g/kg coal. This calculated value is slightly smaller than the results shown in Table 3. This can be understood because in fact, a small amount of SO_2 can be formed from iron ore (0.16%S), mill scale (0.03%S) and lime stone (0.16%S). Therefore, the actually measured emission of SO_2 is somewhat higher than theoretical results. The result of Carbon calculated from CO and CO_2 emission is only 70% of content of it in coal. It is very suitable with the report of combustion efficiency of the factory. According to Noel de Nevers [18], the NO emission much depends on the concentration of oxygen in the high–temperature part of the flame, meaning that, it can be minimized if excess air is minimized and vice versa. The excess air in this process is much low (3-5%) leads to a significant reduction of the emissions of all types of nitric oxides (thermal, prompt and fuel).

Data on the emission factors of gaseous pollutants in this study were compared with other documents as shown in Table 4 [2, 4]. Generally, the emission factors in this study can be considered to be in the same range with those of these studies. This may reflect the reliability of the emission factors obtained although it is understood that, the comparison, in many cases, is relative as emission factor is a function of several factors including fuel quality, conditions of combustion/process, air pollution control system.

Emission rate

Emission factor is a good basis to compare pollutant emission from combustion of different fuels. However, to assess the harmful effects of emission, the emission rate of pollutants in smoke should be of more interest since they are directly related to duration and levels of exposure. Emission rates are usually expressed as the weight of pollutant emitted divided by duration of the activity emitting the pollutant. The emission rates of CO, CO_2, NO and SO_2 in the flue gas were calculated and shown in Table 5.

CONCLUSIONS

Emission factors of selected air pollutants being CO, CO2, SO2 and NO of coal-based and sintering-based for sintering process of Thai Nguyen Iron and Steel Joint Stock Company were determined. This is a significant contribution to Vietnam database of emission factors for sintering process in particular and for iron and steel industry in general. These emission factors can be used for emissions inventory and air quality management at the company. Methodology used in this study can be applied to other iron and steel industrial enterprises in the country.

Table 4. *Comparison of emission factors in this study with others*

Pollutants	This study (kg/ton)	UNEP [2] (kg/ton)	IPCC [4] (kg/ton)
CO	19.6	20.0	-
CO_2	203.2	150.0	200.0
SO_2	2.5	1.5	-
NO	0.9	0.6	-

Table 5: *Emission rate of selected pollutants*

No	Hours (h)	Emission rate (g/s)			
		CO	*CO_2*	*SO_2*	*NO*
TK1	7.7	202.2	2064.2	26.6	9.1
TK2	7.7	202.8	1945.7	26.8	8.3
TK3	7.7	196.2	2194.3	26.8	9.1
TK4	7.7	202.0	2056.6	26.1	9.2
TK5	7.7	202.3	2182.9	25.5	8.0
Average		**201.1±2.8**	**2088.8±102.6**	**26.4±0.6**	**8.7±0.6**

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TÓM TẮT

MỨC ĐỘ PHÁT THẢI CỦA MỘT SỐ KHÍ Ô NHIỄM TRONG QUÁ TRÌNH THIÊU KẾT TẠI CÔNG TY CỔ PHẦN GANG THÉP THÁI NGUYÊN

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Nghiên cứu này được thực hiện để xác định mức độ phát thải của CO, CO_2, SO_2 và NO trong quá trình thiêu kết. Nồng độ các chất ô nhiễm được đo đạc bằng thiết bị đo nhanh - Quintox KM-9106 - tại Nhà máy Luyện gang, Công ty cổ phần Gang thép Thái Nguyên theo phương pháp US.EPA 1-3. Tổng lượng phát thải chất ô nhiễm và hệ số phát thải của từng chất đã được tính toán dựa trên kết quả quan trắc và thông tin về quá trình.Tính theo nhiên liệu, hệ số phát thải của CO, CO_2, SO_2 và NO tương ứng là 142.9 g/kg; 1484.6 g/kg; 18.7 g/kg và 6.2 g/kg. Dựa theo lượng sản phẩm thiêu kết, hệ số phát thải của CO, CO_2, SO_2 và NO tương ứng là 19.6 kg/ton; 203.2 kg/ton; 2.6 kg/ton và 0.8 kg/ton. Kết quả đạt được trong nghiên cứu này có thể được sử dụng trong kiểm kê phát thải công nghiệp và quản lý môi trường không khí tại Việt Nam.

Từ khóa: *Hệ số phát thải, thiêu kết, gang thép, khí thải, Thái Nguyên, Việt Nam*

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