Evaluation of detached plume and total organic carbon in the main chimney of the Indocement Plant 9-10 Palimanan to optimize clinker production and its influence on SO_2 emissions

Muziibu Alfisyah [1*], *Osvaldo Zubeldia* Sitohang[1], and *Wisnu* Indriyanto[1]
[1]PT Indocement Tunggal Prakarsa, Tbk. Plant 9-10, Palimanan, Cirebon

Abstract. Detached Plume is the phenomenon of the formation of a cloud of gas/smoke that is interrupted in the main chimney of a cement Plant from the combustion of a kiln containing compounds consisting of Ammonia, Sulfur and Organic Carbon. The Detached Plume that occurred at Plant 9-10 of Indocement-Palimanan was analyzed and controlled so that the SO_2 emissions produced could be reduced. This research aims to analyze the effect of Total Organic Carbon (TOC) on clinker production at Plant 9-10, understand the control of Detached Plume and SO_2 emissions produced in the main chimney of Plant 9-10, and determine the optimization of the clinker production process at Plant 9-10 by Total Organic Carbon as a variable in Raw Meal. The analysis methods used include monitoring the Detached Plume phenomenon in the Main Chimney, its effect on SO_2 Emissions, observing the effect of TOC changes in Raw Material on Clinker production capacity at Plant 9-10. The research results show that the TOC value of Plant 9 is 1.22%, thereby reducing Clinker production capacity to 3466 tpd from the target of 3600 tpd. On the other hand, the TOC value for Plant 10 in the month was 1.00%, thereby reducing Clinker production capacity to 4070 tpd from the target of 4200 tpd. This shows that a significant increase in TOC value in Raw Meal reduces Clinker production capacity. The Detached Plume is also influenced by the ammonia gas content in the main chimney emissions, where the ammonia content > 2 mg/Nm^3 increases the visibility of the Detached Plume in the main chimney of Plant 9-10, and the SO_2 value

1 Introduction

The cement production process requires large amounts of thermal energy, about 40% of the overall operating costs in the cement industry are spent on energy procurement. Fossil fuels, such as coal, have generally been used as an energy source in the cement industry. The main environmental impact of the cement industry caused by high energy use is air emissions, especially CO_2 emissions, which affect climate change. *Global Warming* due to Greenhouse Gases (GHG) is one of the main environmental issues facing the world today. In addition,

* Corresponding author: muziibu.alfisyah@indocement.co.id

other emission gases such as SOx & NOx in the main chimney of cement plants are also a concern and must be monitored.

One of the problems that arise in the cement industry today is the *Detached Plume*, also known as the blue haze phenomenon. The *Detached Plume* phenomenon does not always produce a blue color in the output gas. There are three possible colors that can come out: white, grey and blue. The phenomenon that occurred at PT Indocement Tunggal Prakarsa Tbk. was the formation of gray and white gas which was indicated as *Detached Plume*.

There are two possibilities for the formation of *Detached Plume*, namely the condensation of organic components (Total Organic Carbon) in the output gas of the chimney and the *Detatched Plume* phenomenon is also formed due to the presence of ammonia gas which reacts with SO_2 to form ammonium sulfate compounds which are then condensed into submicron particles in the temperature range of 130°-200° C and form disconnected smoke in the chimney.

The impact of a *Detached Plume* on the environment is less harmful than other invisible gaseous emissions. This is because the amount of *Detached Plume* formed is not large enough. However, the center of attention on this issue is that the *Detached Plume* formed can be clearly seen, causing negative speculation for the surrounding community.

Detached Plume that occurs at PT Indocement Tunggal Prakarsa Tbk also affects the production of clinker so, PT Indocement Tunggal Prakarsa Tbk. conducts research aimed at minimizing the formation of *Detached Plume* from the results of the cement manufacturing process.

1.1. Problem formulation

Based on this background, the problem formulation in the preparation of this journal is as follows:

1. How does Total Organic Carbon (TOC) affect the production of Clinker Plant 9-10?
2. How to control the *Detached Plume* phenomenon that occurs in the main stack emissions of Plant 9-10?
3. How to optimize the production process of Clinker Plant 9-10 with TOC variables and *Detached Plume* phenomenon so that the Clinker capacity target is still achieved?

1.2 Problem limitation

The problem limitations that are the scope of the preparation of this journal are as follows:

1. The discussion in this journal covers the effect of Total Organic Carbon on the production capacity of Clinker Plant 9-10.
2. The object of research is Total Organic Carbon content in Kiln Feed and SO_2 gas emissions in the main chimney of Plant 9-10?
3. The data period used is from August 2017 to December 2018 and October 2020 to November 2020.

1.3 Research Objectives

The objectives of this journal are:

1. To determine the control of *Detached Plume* and SO_2 Emissions generated in the main stack of Plant 9-10.
2. Knowing the optimization of the Clinker Plant 9-10 production process with the Total *Organic Carbon variable in Raw Meal*.

2 Theoretical basis

2.1 *Detached* plume

Detached Plume is one of the phenomena of interrupted smoke formation in the main chimney that comes from the gas from kiln combustion. This disconnected smoke cannot be read as opacity in the CEMS of the main chimney.

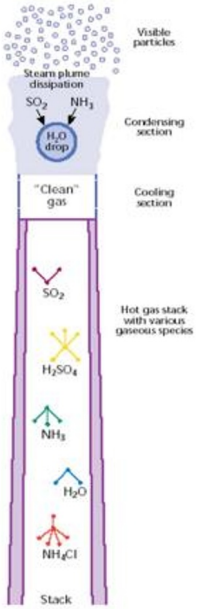

Fig. 1. Detached plume formation

Detached Plume will be visible at a distance of 4-5 meters from the upper lip of the main chimney (cut off), can be white or gray smoke. *Detached plume* can be caused by chemical compounds of combustion gas that react with the air around the chimney. This compound can be ammonium chloride or ammonium sulphate.
Ammonium Chloride

$$NH_3 + HCl \rightarrow NH_4Cl$$

Ammonium Sulfates

$$NH_3 + SO_3 + H_2O \rightarrow NH_4HSO_4$$

$$2NH_3 + SO_3 + H_2O \rightarrow (NH_4)_2HSO_4$$

$$NH_3 + SO_2 + H_2O \rightarrow NH_4HSO_3$$

The phenomenon of *Detached Plume* indicates that there is excess sulfur in the exhaust gas, so control needs to be done so as not to pollute the environment around the cement industry.

2.2 SO_2 emissions

Indocement as one of the cement manufacturing industries is an industry that will certainly contribute emissions to the surrounding environment. The area around the cement factory will certainly be exposed to air emissions produced by the factory. Emissions produced by cement plants consist of dust and gas, one of the gases produced is sulfur dioxide (SO_2). SO_2 is produced because in the process of making cement using rock raw materials containing sulfur where SO_2 is formed by the combustion process of fuel oil, gas and coal containing high sulfur.

Based on PermenLH Number 19 of 2017, it is stated that the SO_2 emission threshold value for the cement industry is a maximum of 650 mg / Nm^3. Indocement has a continuous emission monitoring system (CEMS), where SO_2, NO_2, CO, CO_2, and particulate matter emission factors are monitored online, so that the cement production process in Indocement can be controlled in accordance with environmental standards.

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TENTANG
BAKU MUTU EMISI BAGI USAHA DAN /ATAU KEGIATAN INDUSTRI SEMEN

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No	Sumber Kegiatan	Parameter	Satuan	Nilai Baku Mutu		
				A	B	C
1	Tanur/ tungku (*Kiln*)	Partikulat	mg/Nm³	75	70	60
		SO_2	mg/Nm³	650	650	650
		NO_x	mg/Nm³	800	800	800
		Hg	mg/Nm³	0,2	0,2	0,2
2	Pendingin Terak *(Clinkers Coolers)*	Partikulat	mg/Nm³	75	70	60
3	Unit pencampuran *(Milling)* dan/atau penggilingan (*grinding*)	Partikulat	mg/Nm³	75	70	60
4	*Unit pengumpul debu (Dust Collector)* pada Alat Transportasi unit-unit produksi*	Partikulat	mg/Nm³	60	60	60

Fig. 2. Cement plant emission threshold value

2.3 Thinking framework

The study of *Detached Plume* in the cement industry is to determine the effect on operations and the environment around the cement plant. *Detached Plume* is a phenomenon of the formation of a puff of gas / smoke cut off in the main chimney of a cement factory from the combustion of kilns. With the content of compounds consisting of Ammonia, Sulfur and Organic Carbon, so the factory requires control of this phenomenon.

Control of *Detached Plume* can be done by controlling the source of raw material to be fed to the Kiln. By sorting raw materials containing Sulfur lower than 0.6% and TOC content <1.0%. Quarry Management and Mapping of sulfur and TOC content in Cirebon Quarry is very helpful to anticipate early the material that will be fed as raw material Plant 9-10.

In addition, controlling the visibility of the *detached plume* can also be done by controlling the temperature of the exhaust gas in the main chimney, namely by controlling the temperature of 100-115°C. By lowering the temperature in the exhaust gas will reduce the volume of gas so that the appearance of detached plume can be reduced visibility. This control can be done using a gas conditioning tower, and Cyclone no.3 water spray.Studies on

the effects on operations, especially on clinker capacity produced with materials containing sulfur and high TOC are carried out so that the production process can find out the optimal value that can be used so that production capacity is still achieved but does not disturb the environment around the factory. TOC content> 1.0% has the potential to reduce clinker production capacity, therefore some modifications can be made to increase clinker production capacity when facing materials with certain TOC levels. Control upstream (Quary Management) and downstream (production process) needs to be carried out to obtain clinker production capacity targets and fulfill environmental aspects.

3 Discussion

3.1 Data presentation

3.1.1 TOC vs SO_2 vs RM SO_3 detached plume plant 9-10

Monitoring of the Detached Plume phenomenon was carried out in the period August 2017 to December 2018 for Plants 9-10. Where the following results are obtained:

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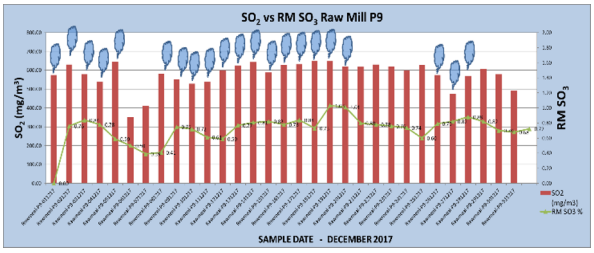
SampleName	Pyrite %	RM SO3 %	Temp. Inlet BF (degC)	SO2 (mg/m3)	Limestone Quarry % A	B	C	TOC Raw Meal	Kiln Feed tph	Clinker tpd	Plume
Rawmeal-P9-011217	0.48	0.76	121.92	574.86				1.35	235.87	3187.68	PLUME
Rawmeal-P9-021217	0.36	0.84	122.60	630.23	0.00	59.14	40.86	1.65	274.89	3399.95	PLUME
Rawmeal-P9-031217	0.26	0.78	122.40	579.21	0.00	40.75	59.25	1.17	270.61	3386.19	PLUME
Rawmeal-P9-041217	0.23	0.59	122.13	540.40	0.00	29.15	70.85	0.94	291.77	3657.87	PLUME
Rawmeal-P9-051217	0.22	0.50	122.34	645.41	15.57	45.23	39.20		288.51	3802.77	PLUME
Rawmeal-P9-061217	0.15	0.39	122.32	350.83	8.28	47.46	44.26	0.61	283.26	2057.75	Clear
Rawmeal-P9-071217	0.32	0.41	121.08	410.50	0.00	49.54	50.46		0.00		Clear
Rawmeal-P9-081217	0.37	0.75	123.90	582.45	0.00	53.14	46.86	1.04	243.41	2591.81	PLUME
Rawmeal-P9-091217	0.27	0.72		550.32	0.00	76.73	23.27	1.25	270.75	3488.34	PLUME
Rawmeal-P9-101217	0.16	0.61		528.78	0.00	66.96	33.04	1.92	260.10	3447.04	PLUME
Rawmeal-P9-111217	0.33	0.59	121.50	540.30	0.00	59.87	40.13	0.62	287.56	3692.64	PLUME
Rawmeal-P9-121217	0.32	0.77	121.70	600.21	0.00	53.78	46.22	0.87	297.98	3545.57	PLUME
Rawmeal-P9-131217	0.42	0.81	124.57	625.32	0.00	50.82	49.18	1.39	300.77	3460.81	PLUME
Rawmeal-P9-141217	0.38	0.82	121.86	643.62	0.00	48.62	51.38	0.96	293.68	3541.95	PLUME
Rawmeal-P9-151217	0.35	0.78	117.83	588.76	0.00	41.44	58.56	1.22	281.53	3571.65	PLUME
Rawmeal-P9-161217	0.39	0.84	120.45	626.72	0.00	36.45	63.55	1.63	285.86	3306.49	PLUME
Rawmeal-P9-171217	0.45	0.73	121.42	632.65	0.00	44.63	55.37	1.26	293.06	3422.41	PLUME
Rawmeal-P9-181217	0.36	1.03	121.66	649.32	0.00	54.38	45.62	1.45	289.46	3464.43	PLUME
Rawmeal-P9-191217	0.35	1.01	134.21	648.20	0.00	39.08	60.92	1.36	295.25	3372.42	PLUME
Rawmeal-P9-201217	0.33	0.80	124.57	620.34	0.00	59.68	40.32		290.11	3281.86	PLUME
Rawmeal-P9-211217	0.35	0.78	126.24	618.30	13.19	53.32	33.50	0.98	283.99	3685.40	Clear
Rawmeal-P9-221217	0.40	0.76	124.05	630.23	61.09	13.62	25.29	1.33	278.62	3603.53	Clear
Rawmeal-P9-231217	0.30	0.74	126.56	620.43					284.08	1878.22	Clear
Rawmeal-P9-241217	0.26	0.60	131.33	600.34	30.36	27.53	42.11		0.00	0.00	Clear
Rawmeal-P9-251217	0.25	0.79	129.60	626.74	24.11	33.35	42.53	1.00	271.34	2424.74	PLUME
Rawmeal-P9-261217	0.36	0.82	127.38	575.44	47.61	30.38	22.01	1.30	290.71	3367.35	PLUME
Rawmeal-P9-271217		0.88	127.56	475.23	42.78	57.22	0.00	1.46	262.84	3118.13	PLUME
Rawmeal-P9-281217		0.82	124.51	570.75	41.37	58.63	0.00		214.37	406.23	PLUME
Rawmeal-P9-291217		0.70	123.59	606.97	35.29	52.66	12.06		0.00	0.00	Clear
Rawmeal-P9-301217		0.68	124.71	579.01	33.77	38.75	27.48		0.00	0.00	Clear
Rawmeal-P9-311217		0.72	126.81	491.66	29.47	37.32	33.21		252.38	1535.52	Clear
Average	0.33	0.74	124.17	579.47	13.20	46.88	39.91	1.22	241.06	2789.96	
Min	0.15	0.39	117.83	350.83	0.00	13.62	0.00	0.61	0.00	0.00	71%
Max	0.48	1.03	134.21	649.32	61.09	76.73	70.85	1.92	300.77	3802.77	



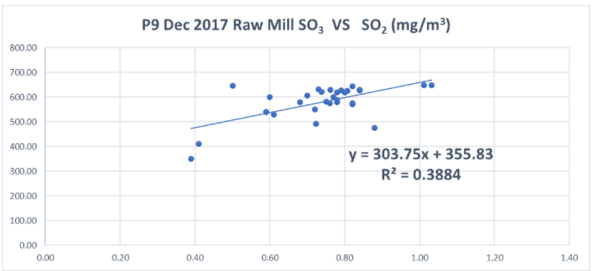


Fig. 3. Monitoring of the detached plume phenomenon

In December 2017 Plant 9 had 71% of the days with Detached Plume Data Presentation in the main chimney, and the average SO_2 CEMS observed was 579 mg / Nm^3 where this value was close to the threshold value set by the Ministry of Environment of 650 mg / Nm^3. with raw material analysis in the form of TOC, RM SO_3, and SO_2 Emissions. The average value of TOC : RM SO_3 at Plant 9 in December 2017 was 1.22 : 0.76. From the chart it can be seen that the tendency of *Detached Plume* to appear in the main chimney is when the TOC value > 1.0%, and RM SO_3 > 0.6%. Where the source of the raw material comes from the proportion of Quarry A : Quarry B : Quarry C = 13% : 47% : 40%. From the scatter chart, we get an R2 value of 0.3884 for RM SO_3 vs SO_2 Emissions at December 2017 Raw Mill Plant 9.

In December 2017 at Plant 10 there were 39% days with *Detached Plume* sightings in the main chimney of Plant 10, and the average SO_2 CEMS observed was 561 mg / Nm^3 where this value is close to the threshold value set by the Ministry of Environment of 650 mg / Nm^3. With Raw material analysis in the form of TOC, RM SO_3 and SO_2 Emissions. The average value of TOC : RM SO_3 at Plant 10 in December 2017 was 1.02 : 0.83. From the chart it can be seen that the tendency of Detached Plume to appear in the main chimney is when the TOC value > 1.0%, and RM SO_3 > 0.6%. And obtained the value of R2 SO_2 vs RM SO_3 Raw Mill Plant December 10, 2017 at 0.4995.

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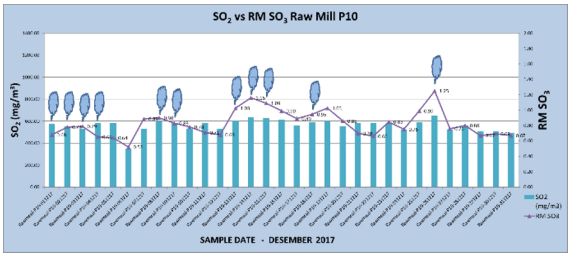
SampleName	Pyrite	RM SO3	Temp. Inlet	SO2	Limestone Quarry %			TOC	Kiln Feed	Clinker	Plume
----------	%	%	BF (degC)	(mg/m3)	A	B	C	Raw Meal	tph	tpd	
Rawmeal-P10-012217	0.31	0.68	121.92	574.86	0.00	39	61.17	0.98	291.26		PLUME
Rawmeal-P10-021217	0.31	0.78	122.60	552.11	0.00	39	60.58	0.99	301.47		PLUME
Rawmeal-P10-031217	0.31	0.79	122.40	533.52	0.00	58	42.45		306.35		PLUME
Rawmeal-P10-041217	0.30	0.65	122.13	582.78	0.00	51	49.11	1.15	307.85		PLUME
Rawmeal-P10-051217	0.24	0.64	122.34	582.46	0.00	59	40.64	0.98	305.44		Clear
Rawmeal-P10-061217	0.23	0.52	122.32	350.83	0.00	61	38.57	0.83	303.73		Clear
Rawmeal-P10-071217	0.26	0.89	121.08	533.04	0.00	48	51.52	1.10	301.22		Clear
Rawmeal-P10-081217	0.31	0.90	123.90	600.32	0.00	43	56.97	1.20	308.72		PLUME
Rawmeal-P10-091217	0.38	0.83		580.48	0.00	43	56.51	1.01	309.63		PLUME
Rawmeal-P10-101217	0.37	0.78		528.78	0.00	47	52.66	0.95	305.83		Clear
Rawmeal-P10-111217	0.27	0.71	121.50	583.45	0.00	55	45.47	0.87	307.88		Clear
Rawmeal-P10-121217	0.18	0.68	121.70	528.89	0.00	45	55.47	0.90	311.13		Clear
Rawmeal-P10-131217	0.25	1.03	124.57	602.99	0.00	45	54.55	1.13	308.42		PLUME
Rawmeal-P10-141217	0.30	1.16	121.86	633.77	0.00	41	58.59	1.29	304.77		PLUME
Rawmeal-P10-151217	0.36	1.09	117.83	627.98	0.00	47	53.19	1.15	309.35		PLUME
Rawmeal-P10-161217	0.37	0.99	120.45	612.86	0.00	74	26.47	0.98	302.72		PLUME
Rawmeal-P10-171217	0.36	0.89	121.42	557.37	0.00	52	47.78	0.71	309.31		Clear
Rawmeal-P10-181217	0.32	0.95	121.66	591.92	0.00	32	68.49	1.15	310.40		PLUME
Rawmeal-P10-191217	0.32	1.03	134.21	600.88	0.00	48	52.35	0.99	301.01		Clear
Rawmeal-P10-201217	0.37	0.86	124.57	555.78	30.56	43	26.08		303.96		Clear
Rawmeal-P10-211217	0.33	0.70	126.24	583.80	15.92	58	25.85	0.74	307.25		Clear
Rawmeal-P10-221217	0.29	0.66	124.05	581.10	48.10	26	25.58	0.72	298.74		Clear
Rawmeal-P10-231217	0.27	0.85	126.56	572.65	28.83	30	40.97		302.03		Clear
Rawmeal-P10-241217	0.27	0.75	131.33	524.85	0.00	86	14.20	0.94	297.02		Clear
Rawmeal-P10-251217	0.31	0.99	129.60	590.98	16.54	57	26.10	1.08	304.18		Clear
Rawmeal-P10-261217	0.32	1.25	127.38	648.43	64.95	35	0.00	1.25	295.99		PLUME
Rawmeal-P10-271217	0.28	0.76	127.56	525.43	34.37	31	34.50	1.09	301.49		Clear
Rawmeal-P10-281217	0.20	0.80	124.51	562.93	15.09	34	50.77	0.82	284.92		Clear
Rawmeal-P10-291217	0.26	0.67	123.59	507.87	27.99	48	24.00	1.03	299.96		Clear
Rawmeal-P10-301217	0.32	0.69	124.71	509.54	59.80	40	0.00		292.61		
Rawmeal-P10-311217		0.67	126.81	491.66	40.49	21	38.04		300.49		
Average	0.30	0.83	124.17	561.75	12.34	**46.51**	41.25	1.00	303.07	#DIV/0!	**39%**
Min	0.18	0.52	117.83	350.83	0.00	21.47	0.00	0.71	284.92	0.00	
Max	0.38	1.25	134.21	648.43	64.95	**85.80**	68.49	1.29	311.13	0.00	



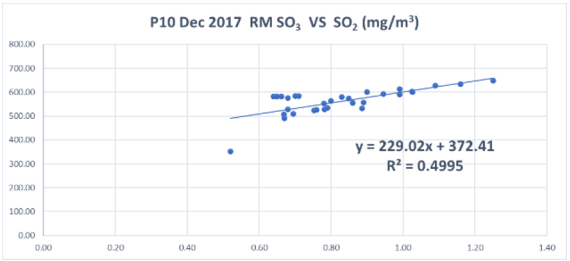


Fig. 4. Monitoring of the detached plume phenomenon

Where the source of the raw material comes from the proportion of Quarry A : Quarry B : Quarry C = 13% : 46% : 41%. Analysis of several Limestone samples from each Quarry is as follows:

TOC Content	Sample From Quarry A (%)	Sample From Quarry B (%)	Sample From Quarry C (%)	Average	Average w/o Quarry A
< 1.0	86	45	58	64	49
1.0 – 1.5	9	27	34	22	29
> 1.5	5	28	8	15	21

No	Sample Name	Sample Date	Moisture Content	XRF								Carbon			Clay Content	XRD
				SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	TC	TIC	TOC		FeS_2
1	TOC B.160-1 SLS	29-Jan-18	7.2	9.53	3.21	1.29	41.77	6.11	1.26	0.19	0.25	10.1051	9.3221	0.7830	2.60	1.09
2	TOC B.160-2 SLS	29-Jan-18	0.79	4.54	1.70	0.60	52.25	0.65	0.87	0.22	0.12	11.5288	10.5343	0.9945	0.80	0.23
3	TOC B.160-3 SLS	29-Jan-18	12.53	5.87	2.90	0.88	50.02	0.66	1.25	0.18	0.05	13.6283	8.9674	4.6609	1.60	0.83
4	TOC B.160-3A SLS	29-Jan-18	57.55	43.64	21.89	7.89	19.13	1.07	4.20	0.11	0.38	4.0418	0.5332	3.5086	9.60	5.10
5	TOC B.160-4 SLS	29-Jan-18	7.29	3.28	1.13	0.33	53.27	0.59	0.57	0.25	0.09	13.4191	10.3054	3.1137	0.40	0.11
6	TOC B.160-5 SLS	29-Jan-18	1.35	10.44	3.75	1.14	46.22	0.64	1.51	0.15	0.18	12.6309	9.2572	3.3737	1.80	0.70
7	TOC B.160-6 SLS	29-Jan-18	4.35	4.88	1.98	1.91	50.04	0.59	3.21	0.16	0.06	11.9000	10.3043	1.5957	1.00	0.49
8	Liparite	29-Jan-18	8.08	55.20	17.93	7.27	17.64	0.69	6.23	2.76	0.93	0.6175	0.1119	0.5056	2.80	1.63
9	SLS - 30 TOC	29-Jan-18	9.05	24.14	7.99	2.65	34.07	1.95	2.78	0.22	0.72	8.2096	7.4123	0.7973	3.80	1.80
10	SLS + 30 TOC	29-Jan-18	21.23	32.13	11.66	3.56	28.60	1.89	3.34	0.28	0.94	5.9999	5.0582	0.9417	4.80	2.71
11	SLS + 50 TOC	29-Jan-18	3.96	10.66	3.45	1.00	45.70	1.78	1.13	0.17	0.27	10.0993	9.6667	0.4326	1.60	0.55
12	SLS + 200 TOC	29-Jan-18	4.57	5.55	1.77	1.17	46.91	4.10	1.14	0.16	0.10	11.2594	10.7064	0.5530	1.60	0.65

Fig. 5. Limestone samples samples from each Quarry

Based on several QC Department laboratory analyses of Limestone samples in Quarry A-B-C, data was obtained that the TOC content in Quarry B contained TOC <1.0 % as big as 45% ; TOC 1.0 – 1.5% 27%, and TOC >1.5% as big as 28%.

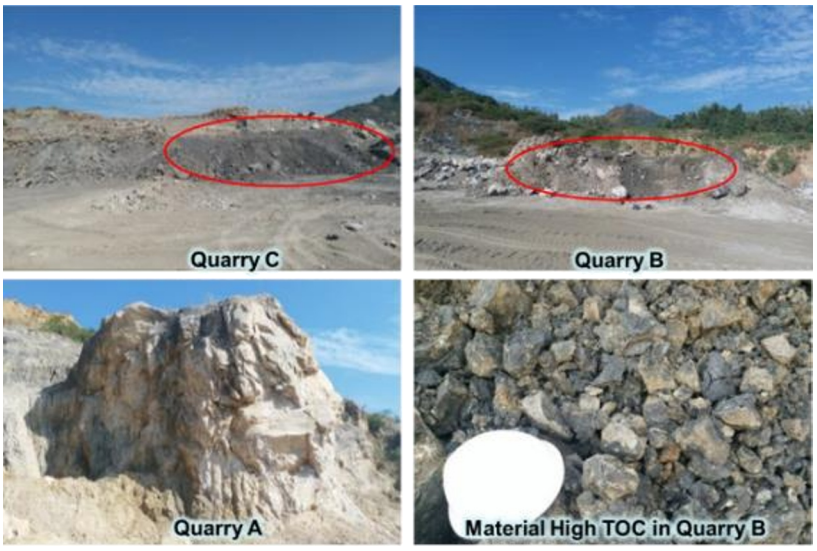
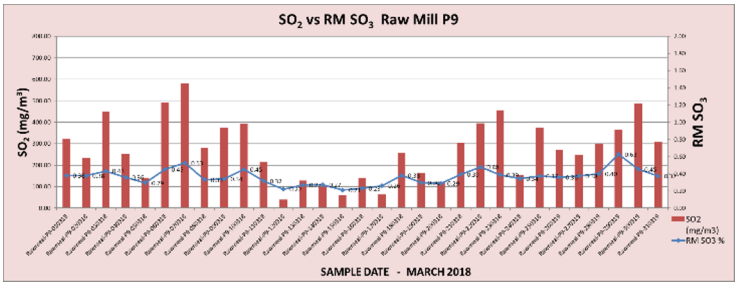


Fig. 6. Quarry A-B-C

From the results of the analysis of the Raw material content derived from each Quarry, management of the use of Raw material quarry (managed by the Mining Dept. and Quality Dept.) was carried out to determine the effect caused by the Detached Plume phenomenon and the increase in SO2 emissions in the main chimney CEMS. Significant results were obtained in March 2018, where at Plant 10 for 31 days there was 0% Detached Plume appearance in the main chimney, and monitoring of CEMS SO_2 emissions averaged 301.59 mg / Nm^3, with a proportion of Quarry A : B : C : D = 32% : 38% : 32% : 8%. The average value of TOC : RM SO_3 at Plant 9 in March 2018 was 0.57 : 0.36. Here are the results of such monitoring. For Plant 9 March 2018

Mar-18

SampleName	Pyrite %	RM SO3 %	Temp. Inlet BF (degC)	SO2 (mg/m3)	Limestone Quarry % A	B	C	D	TOC Kiln Feed	Kiln Feed tph	Clinker tpd	Plume
Rawmeal-P9-010318	0.16	0.38	117.35	321.50	5.03	54.04	36.60	4.34	0.33	258.51	3702.99	Clear
Rawmeal-P9-020318		0.38	122.65	233.19	9.40	38.13	32.02	20.45	0.31	259.85	2736.66	Clear
Rawmeal-P9-030318		0.43	122.64	450.62	13.01	36.64	37.06	13.29	0.36	263.27	3615.51	Clear
Rawmeal-P9-040318		0.36	116.49	250.76	49.64	34.88	15.48	0.00	0.51	261.07	2278.85	Clear
Rawmeal-P9-050318	0.21	0.29	111.05	139.56	28.26	53.33	18.41	0.00	0.43	269.03	3660.27	Clear
Rawmeal-P9-060318	0.34	0.45	116.40	493.97	39.23	26.13	31.67	2.97	0.24	273.32	3859.63	Clear
Rawmeal-P9-070318	0.30	0.53	119.53	582.45	43.17	22.33	29.41	5.09	0.55	282.59	4179.01	Clear
Rawmeal-P9-080318	0.24	0.33	119.72	281.82	0.00	0.00	0.00	0.00	0.40	282.96	4063.06	Clear
Rawmeal-P9-090318	0.25	0.34	122.16	376.43	38.38	33.33	28.28	0.00	0.45	268.99	3882.01	Clear
Rawmeal-P9-100318	0.27	0.45	114.54	393.95	20.86	20.68	28.14	30.32		270.88	3890.14	Clear
Rawmeal-P9-110318	0.24	0.32	115.85	216.15	9.69	17.01	39.89	33.41	0.39	229.25	2787.56	Clear
Rawmeal-P9-120318	0.16	0.22	123.08	39.24	0.00	0.00	93.60	6.40	0.25	248.71	3495.49	Clear
Rawmeal-P9-130318	0.13	0.27	122.45	128.77	0.00	19.06	46.52	34.43	0.37	265.92	3871.83	Clear
Rawmeal-P9-140318	0.18	0.27	122.45	100.23	33.33	33.33	33.33	0.00	0.32	270.19	3936.93	Clear
Rawmeal-P9-150318	0.11	0.21	117.77	59.76	0.00	0.00	100.00	0.00	0.69	264.25	3914.55	Clear
Rawmeal-P9-160318	0.06	0.23	113.16	140.30	12.85	16.81	66.15	4.18	0.61	260.35	2132.14	Clear
Rawmeal-P9-170318	0.09	0.26	122.63	62.90	0.00	50.44	49.56	0.00	0.25	244.15	2800.73	Clear
Rawmeal-P9-180318	0.19	0.38	119.87	255.55	43.56	12.80	33.93	9.71		267.37	3786.39	Clear
Rawmeal-P9-190318	0.14	0.30	118.98	162.99	20.41	9.14	70.45	0.00	0.47	268.62	4077.30	Clear
Rawmeal-P9-200318	0.30	0.29	124.00	119.25	44.07	31.02	24.91	0.00	0.40	265.06	3906.42	Clear
Rawmeal-P9-210318	0.26	0.39	120.04	305.48	59.41	0.00	40.59	0.00	0.54	270.43	3882.01	Clear
Rawmeal-P9-220318	0.21	0.48	122.96	395.31	30.47	35.95	33.58	0.00	0.60	266.38	3761.98	Clear
Rawmeal-P9-230318		0.39	121.40	455.71	33.04	21.78	45.18	0.00	0.50	269.73	3098.59	Clear
Rawmeal-P9-240318	0.17	0.34	115.84	155.30	40.23	0.00	57.56	0.00	0.49	225.83	2226.00	Clear
Rawmeal-P9-250318	0.23	0.37	122.90	372.80	53.08	0.00	46.92	0.00	0.84	258.74	3471.08	Clear
Rawmeal-P9-260319	0.16	0.36	119.11	271.46	50.00	1.65	48.35	0.00	0.76	266.80	3851.49	Clear
Rawmeal-P9-270319	0.25	0.38	117.19	247.38	38.51	24.87	36.62	0.00	0.55	276.09	3830.15	Clear
Rawmeal-P9-280319	0.17	0.40	122.12	298.32	37.74	30.82	31.45	0.00	0.59	279.01	3870.66	Clear
Rawmeal-P9-290319	0.45	0.63	119.88	364.94	15.97	15.97	68.05	0.00	0.92	276.37	3834.03	Clear
Rawmeal-P9-300319		0.45	120.95	485.75	45.19	0.00	54.81	0.00	0.57	277.49	3849.57	Clear
Rawmeal-P9-310319	0.16	0.37	121.98	308.81	23.74	34.92	41.34	0.00	0.69	278.61	3865.11	Clear
Average	**0.21**	0.36	119.59	**273.25**	27.04	21.78	42.58	5.31	0.50	265.16	3552.20	**0%**
Min	**0.06**	0.21	111.05	**39.24**	0.00	0.00	0.00	0.00	0.24	225.83	2132.14	
Max	**0.45**	0.63	124.00	**582.45**	59.41	54.04	100.00	34.43	0.92	282.96	4179.01	



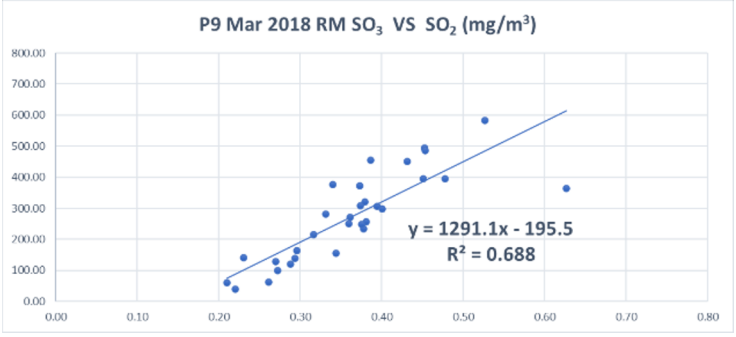


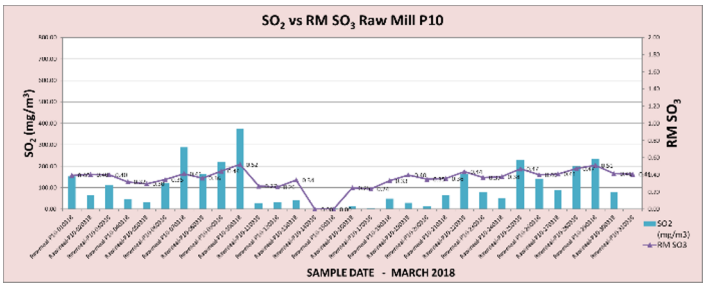
Fig. 7. Results of monitoring

As for Plant 10 in March 2018, significant results were obtained in March 2018, where in Plant 10 for 31 days there was 0% emergence of Detached Plume in the main chimney, and monitoring of average SO_2 CEMS emissions was 104.13 mg / Nm^3, with the proportion

of Quarry A : B : C : D = 26% : 24% : 43% : 7%. The average value of TOC : RM SO_3 : Fe_2S at Plant 10 in March 2018 was 0.45 : 0.38 : 0.20. Here are the results of the monitoring:

Mar-18

SampleName	Pyrite	RM SO3	Temp. Inlet	SO2	Limestone Quarry %				TOC	Kiln Feed	Clinker	Plume
----------	%	%	BF (degC)	(mg/m3)	A	B	C	D	Raw Meal	tph	tpd	
Rawmeal-P10-010318	0.20	0.40	116.69	151.88	19.74	31.47	48.79	0.00	0.22	297.01	4197.84	Clear
Rawmeal-P10-020318		0.40	110.76	65.26	0.00	31.50	39.93	28.57	0.22	197.47	3546.26	Clear
Rawmeal-P10-030318		0.40	112.77	112.85	29.80	28.55	29.63	12.02	0.40	289.26	4169.68	Clear
Rawmeal-P10-040318		0.32	112.21	45.77	42.53	31.43	26.04	0.00	0.52	297.72	4178.11	Clear
Rawmeal-P10-050318		0.30	112.27	32.58	51.66	30.06	18.28	0.00	0.44	299.38	4210.74	Clear
Rawmeal-P10-060318	0.22	0.35	117.55	123.48	35.34	20.80	30.18	13.68	0.35	295.65	4221.79	Clear
Rawmeal-P10-070318	0.24	0.41	120.13	288.92	12.86	15.94	41.46	29.74	0.25	296.24	4228.37	Clear
Rawmeal-P10-080318	0.23	0.36	114.84	163.83	4.76	26.45	43.13	25.66	0.35	297.03	4193.63	Clear
Rawmeal-P10-090318	0.26	0.44	115.97	219.70	13.58	36.04	23.66	26.72	0.60	297.07	4179.42	Clear
Rawmeal-P10-100318	0.32	0.52	116.18	373.56	39.07	0.00	44.47	16.47	0.60	296.12	4183.89	Clear
Rawmeal-P10-110318	0.18	0.27	117.57	26.54	0.00	0.00	43.42	56.58	0.23	294.09	4237.58	Clear
Rawmeal-P10-120318		0.26	113.08	31.90	0.00	0.00	66.41	33.59	0.38	292.68	4251.26	Clear
Rawmeal-P10-130318		0.34	114.39	41.21	0.00	26.10	55.71	18.18	0.34	289.38	4123.37	Clear
Rawmeal-P10-140318		0.00	69.39	0.03	2.96	18.45	49.01	29.58		0.00	1863.37	Clear
Rawmeal-P10-150318		0.00	65.99	3.23	14.35	14.13	42.93	28.59		0.00	1863.37	Clear
Rawmeal-P10-160318	0.14	0.25	110.48	15.28	0.00	0.00	57.79	42.21	0.47	248.02	3953.89	Clear
Rawmeal-P10-170318	0.13	0.24	118.39	4.29	0.00	43.56	30.31	26.12	0.26	283.16	4079.68	Clear
Rawmeal-P10-180318	0.12	0.33	117.23	49.00	58.15	12.30	19.19	10.36		294.73	4157.05	Clear
Rawmeal-P10-190318	0.19	0.40	105.58	30.20	44.16	18.78	24.64	12.42	0.28	279.26	2107.55	Clear
Rawmeal-P10-200318	0.13	0.35	106.50	12.33	3.38	25.24	56.61	14.77	0.53	219.50	1860.76	Clear
Rawmeal-P10-210318	0.17	0.36	121.42	64.99	0.00	0.00	0.00	0.00	0.46	282.00	4176.53	Clear
Rawmeal-P10-220318	0.21	0.44	120.08	162.50	28.60	0.00	40.36	31.04	0.63	288.47	4215.47	Clear
Rawmeal-P10-230318	0.26	0.37	116.22	80.50	18.03	10.09	42.56	7.10		281.83	3333.95	Clear
Rawmeal-P10-240318		0.38	110.48	51.59	22.28	5.89	49.43	4.14		239.43	2156.71	Clear
Rawmeal-P10-250318		0.47	119.70	229.35	28.39	0.00	54.00	17.62		288.66	4172.32	Clear
Rawmeal-P10-260318		0.40	119.36	141.66	22.97	29.03	48.00	0.00		286.26	4218.89	Clear
Rawmeal-P10-270318		0.41	122.15	87.65	39.08	0.00	60.92	0.00		288.70	4198.37	Clear
Rawmeal-P10-280318		0.47	120.62	199.29	21.69	26.34	51.98	0.00		293.05	4202.84	Clear
Rawmeal-P10-290318		0.51	119.22	235.39	26.02	28.17	45.81	0.00		292.96	4209.68	Clear
Rawmeal-P10-300318		0.41	119.17	79.16	8.82	20.64	70.53	0.00		293.85	4214.16	Clear
Rawmeal-P10-310318		0.41		0.00	39.15	20.38	40.47	0.00		296.85	3313.49	Clear
Average	0.20	0.35	112.55	100.77	20.24	17.79	41.79	14.65	0.40	264.38	3749.03	
Min	0.12	0.00	65.99	0.00	0.00	0.00	0.00	0.00	0.22	0.00	1860.76	0%
Max	0.32	0.52	122.15	373.56	58.15	43.56	70.53	56.58	0.63	299.38	4251.26	



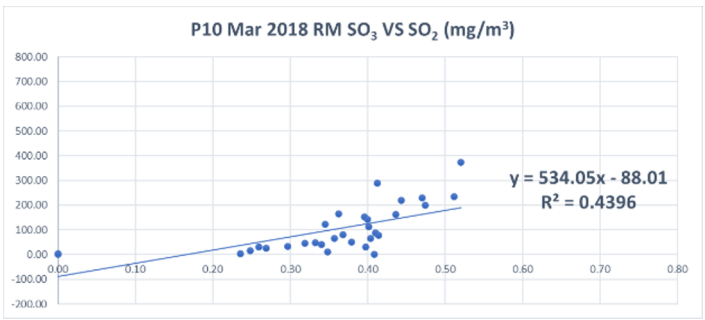


Fig.8. The results of the monitoring

Observations were made of the effect of changes in TOC Raw Material on the production capacity of Clinker Plant 9-10. By using a comparison of the same period, namely in December 2017 and March 2018, the following results were obtained:

Table 1. Results of periode December 2017 and March 2018 in Plant 9-10

Plant 9	**AVG TOC (%)**	**Avg clinker (tpd)**
December 2017	1,22	3466
March 2018	0,50	3835
Plant 10	**AVG TOC (%)**	**Avg clinker (tpd)**

December 2017	1,00	4070
March 2018	0,45	4181

With a Total Organic Carbon (TOC) value of >1.00%, there is a tendency to decrease Clinker capacity in Plant 9-10, where the Clinker capacity target for Plant 9 is 3650 tpd and Plant 10 is 4200 tpd.

3.1.2 Control of Detached Plume and SO_2 Gas Emissions

From significant lunar observations, the appearance of Detached Plume in the main chimney of Plant 9-10 was in December 2017 which was compared with March 2018 data where the phenomenon of Detached Plume and SO_2 CEMS emissions in the main chimney were not an issue. There are several factors that can be used as controls for control, namely:

A. RM SO_3 (Quarry Management)

The significant SO_3 *Raw Mill* found in Limestone needs to be controlled because it is the largest source of Sulphur which is a gas emission in the main chimney of Plant 9-10. Where the value based on data is a maximum of 0.6%. In addition, this high RM SO_3 value has a high potential for the formation of Detached Plume as well.

Table 2. Results of periode December 2017 and March 2018 in Plant 9-10

Plant 9	**AVG TOC (%)**	**Avg RM SO_3 (%)**	**SO_2 CEMS (mg/Nm^3)**	**PLUME**	**Source Quarry A:B:C:D**
December 2017	1,22	0,76	579,61	Yes	13 : 47 : 40 : 0
March 2018	0,57	0,36	301,53	No	32 : 38 : 32 : 8
Plant 10	**AVG TOC (%)**	**Avg RM SO_3 (%)**	**SO_2 CEMS (mg/Nm^3)**	**PLUME**	**Source Quarry A:B:C:D**
December 2017	1,02	0,83	561,75	Yes	13 : 46 : 41 : 0
March 2018	0,45	0,38	104,2	No	32 : 38 : 32 : 8

From the table above, SO_2 gas emissions in the main chimney in March 2018 after controlling RM SO_3 amounted to 301.5 mg / Nm^3 below the threshold value of the Ministry of Environment. The Mining Department and Quality Control Department conducted TOC and SO_3 mapping in Cirebon Quarry, so that Limestone material mixing was obtained withTOC < 1.0% and RM SO_3 <0.6%. Quarry B that has potential TOC 1.0-1.5% given proportions < 40% and the proportion of Quarry A plus up to 32%. However, this cannot be done continuously because Quarry A's reserves are very small, so comprehensive TOC and SO_3 mapping of B: C: D quarry is needed to obtain a mixing ratio of TOC and SO_3 materials. In addition, it is also necessary to control the clinker production process and engineering engineering at the Plantsite to deal with materials with TOC levels up to 1.5% and RM SO_3 to 0.6%.

B. Ammonia analysis of exhaust gas emissions

Detached Plume is a compound consisting of Ammonium and / or Sulfur-Chlor that reacts with water vapor formed above the main chimney of combustion gas. Detached Plume compounds can be ammonium bisulfite-ammonium bisulfate or ammonium chloride. As shown below:

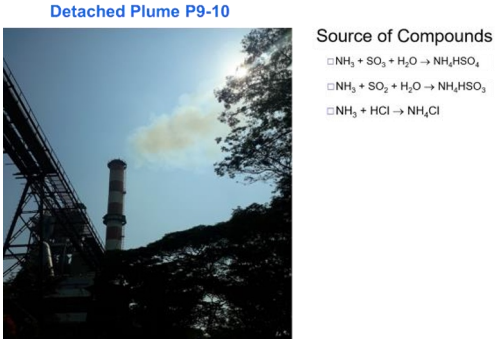


Fig. 9. main chimney of combustion gas

Based on external party measurement data for exhaust gas emissions in the main chimney of Plant 9-10 conducted by GEES ITB (quarterly), the following data were obtained:

Table 3. Plant 9 – CEMS & GEES ITB 2016-2017

2016	07-Mar				2016	18-Mei				2016	24-Agu				2016	18-Okt			
	ITB		CEMS			ITB		CEMS			ITB		CEMS			ITB		CEMS	
Dust	2,14	mg/m3	12	mg/m3	Dust	4,98	mg/m3	4,3	mg/m3	Dust	7,76	mg/m3	8,9	mg/m3	Dust	7,97	mg/m3	12,6	mg/m3
SO_2	**152,00**	**mg/m3**	**373,4**	**mg/m3**	SO_2	**91,8**	**mg/m3**	**406,5**	**mg/m3**	SO_2	**357,66**	**mg/m3**	**780**	**mg/m3**	SO_2	**247**	**mg/m3**	**325,4**	**mg/m3**
NO_2	562,57	mg/m3	266,7	mg/m3	NO_2	591,65	mg/m3	300	mg/m3	NO_2	354	mg/m3	326	mg/m3	NO_2	514,8	mg/m3	495,3	mg/m3
CO	736,05	mg/m3	812,5	mg/m3	CO	721	mg/m3	670,2	mg/m3	CO	741	mg/m3	720	mg/m3	CO	723	mg/m3	886,3	mg/m3
O_2	12,69	%	12,3	%	O_2	13,83	%	13,4	%	O_2	12,14	%	11,9	%	O_2	13,4	%	13,2	%
HCl	7,96	mg/m3			HCl	3,8	mg/m3			HCl	6,99	mg/m3			HCl	4,94	mg/m3		
HF	0,00	mg/m3			HF	0	mg/m3			HF	0	mg/m3			HF	0	mg/m3		
NH_4^+	3,52	mg/m3			NH_4^+	3,35	mg/m3			NH_4^+	1,91	mg/m3			NH_4^+	0,79	mg/m3		
TOC	23,86	mg/m3			TOC	0	mg/m3			TOC	7,25	mg/m3			TOC	9,29	mg/m3		

2017	09-Feb				2017	06-Apr				2017	12-Jul				2017	14-Nov			
	ITB		CEMS			ITB		CEMS			ITB		CEMS			ITB		CEMS	
Dust	25,54	mg/m3	17,41	mg/m3	Dust	20,63	mg/m3	14	mg/m3	Dust	32,15	mg/Nm3	8,2	mg/m3	Dust	62,86	mg/m3		mg/m3
SO_2	**13,11**	**mg/m3**	**382,4**	**mg/m3**	SO_2	**107,9**	**mg/m3**	**283,2**	**mg/m3**	SO_2	**382,1**	**mg/Nm3**	**509,6**	**mg/m3**	SO_2	**413,5**	**mg/m3**		**mg/m3**
NO_2	592,00	mg/m3	264	mg/m3	NO_2	567	mg/m3	232,8	mg/m3	NO_2	523,12	mg/Nm3	341,8	mg/m3	NO_2	718,99	mg/m3		mg/m3
CO	748,00	mg/m3	919	mg/m3	CO	694,88	mg/m3	625,21	mg/m3	CO	823,1	mg/Nm3	1225,5	mg/m3	CO	1447,8	mg/m3		mg/m3
O_2	12,12	%	12,37	%	O_2	12,59	%	12,96	%	O_2	11,83	%	11,25	%	O_2	15,07	%		%
HCl	3,93	mg/m3			HCl	2,29	mg/m3			HCl	8,42	mg/m3			HCl	3,45	mg/m3		
HF	0,74	mg/m3			HF	0,08	mg/m3			HF	0	mg/m3			HF	0	mg/m3		
NH_4^+	2,00	mg/m3			NH_4^+	0,55	mg/m3			NH_4^+	0	mg/m3			NH_4^+	1,04	mg/m3		
TOC	26,16	mg/m3			TOC	13,1	mg/m3			TOC	53,81	mg/m3			TOC	62,11	mg/m3		

Table 4. Plant 10 – CEMS & GEES ITB 2016-2017

2016	08-Mar				2016	17-Mei				2016	23-Agu				2016	20-Okt			
	ITB		CEMS			ITB		CEMS			ITB		CEMS			ITB		CEMS	
Dust	60	mg/m3	148,9	mg/m3	Dust	68,75	mg/m3	122,2	mg/m3	Dust	61,21	mg/m3	23,49	mg/m3	Dust	70,66	mg/m3	82,9	mg/m3
SO_2	**39,1**	**mg/m3**	**359,4**	**mg/m3**	SO_2	**191**	**mg/m3**	**125,3**	**mg/m3**	SO_2	**134**	**mg/m3**	**205,4**	**mg/m3**	SO_2	**45,4**	**mg/m3**	**541,6**	**mg/m3**
NO_2	187	mg/m3	183,1	mg/m3	NO_2	420	mg/m3	235,8	mg/m3	NO_2	273	mg/m3	167,9	mg/m3	NO_2	428	mg/m3	231,5	mg/m3
CO	738,69	mg/m3	144	mg/m3	CO	738,69	mg/m3	1393,4	mg/m3	CO	743,96	mg/m3	1077,2	mg/m3	CO	742	mg/m3	1223,9	mg/m3
O_2	11,15	%		%	O_2	10,82	%	11,4	%	O_2	11,42	%	11,01	%	O_2	13,52	%	10,27	%
HCl	3,69	mg/m3			HCl	1,77	mg/m3			HCl	1,51	mg/m3			HCl	0,86	mg/m3		
HF	0	mg/m3			HF	0	mg/m3			HF	0,34	mg/m3			HF	0	mg/m3		
NH_4^+	2,48	mg/m3			NH_4^+	2,82	mg/m3			NH_4^+	2,49	mg/m3			NH_4^+	0	mg/m3		
TOC	14,48	mg/m3			TOC	18,84	mg/m3			TOC	1,93	mg/m3			TOC	8,68	mg/m3		

2017	08-Feb				2017	05-Apr				2017	11-Jul				2017	15-Nov			
	ITB		CEMS			ITB		CEMS			ITB		CEMS			ITB		CEMS	
Dust	72,39	mg/m3	21,96	mg/m3	Dust	76	mg/m3	16,6	mg/m3	Dust	1,97	mg/Nm3	4	mg/m3	Dust	21,89	mg/m3		mg/m3
SO_2	**22,7**	**mg/m3**	**99,03**	**mg/m3**	SO_2	**36**	**mg/m3**	**19,84**	**mg/m3**	SO_2	**650,15**	**mg/Nm3**	**895,6**	**mg/m3**	SO_2	**511,5**	**mg/m3**		**mg/m3**
NO_2	314	mg/m3	209,9	mg/m3	NO_2	412,21	mg/m3	216	mg/m3	NO_2	433,2	mg/Nm3	160,1	mg/m3	NO_2	568,9	mg/m3		mg/m3
CO	736	mg/m3	2163	mg/m3	CO	716,87	mg/m3	1413,3	mg/m3	CO	794,9	mg/Nm3	1362,5	mg/m3	CO	824,61	mg/m3		mg/m3
O_2	10,72	%	10,3	%	O_2	11,38	%	10,38	%	O_2	10,37	%	10,05	%	O_2	12,43			
HCl	0	mg/m3			HCl	0,73	mg/m3			HCl	8,71	mg/m3			HCl	5,33	mg/m3		%
HF	0,8	mg/m3			HF	0,13	mg/m3			HF	0	mg/m3			HF	0	mg/m3		
NH_4^+	0,65	mg/m3			NH_4^+	0,47	mg/m3			NH_4^+	0	mg/m3			NH_4^+	15,56	mg/m3		
TOC	9,56	mg/m3			TOC	10,8	mg/m3			TOC	48,07	mg/m3			TOC	7,41	mg/m3		

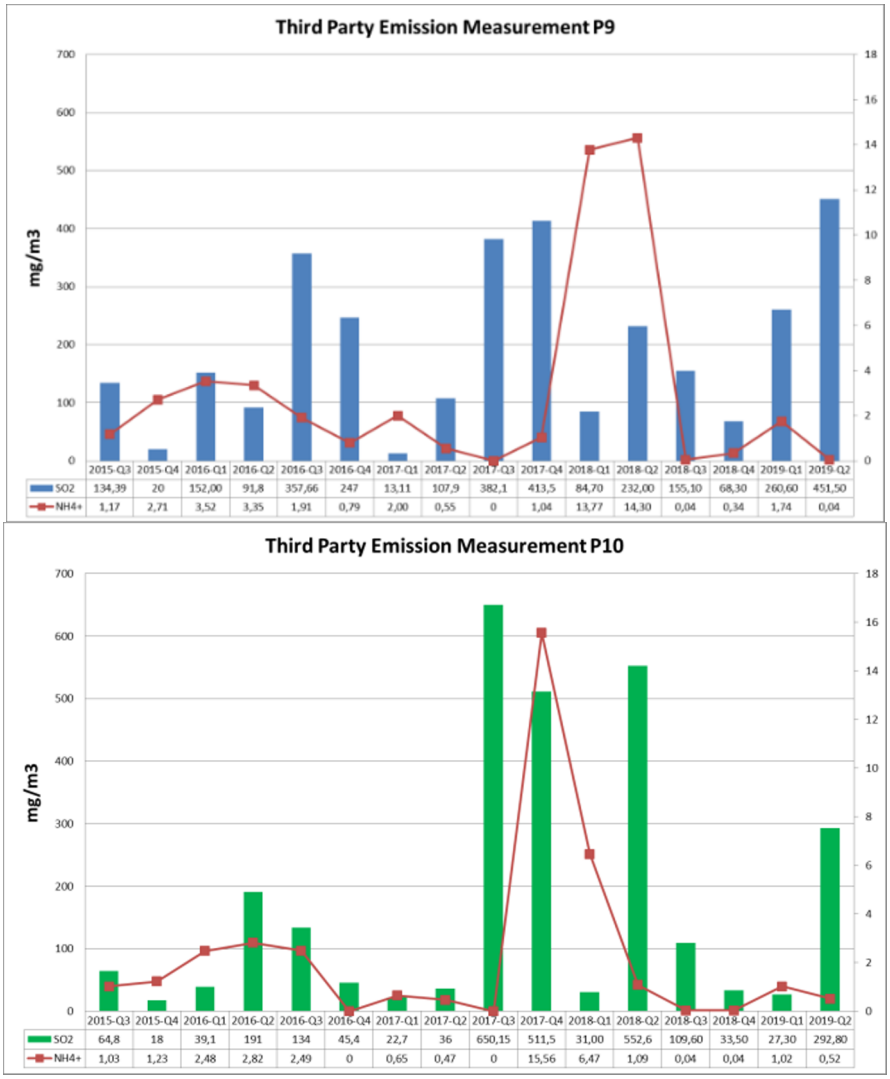


Fig. 10. The measurement data of main chimney of Plant 9-10

Gas emission measurements conducted by GEES ITB, there was an increase in ammonia compounds in Quarter 4 2017 for Plant 9 at 13.77 mg/m3 and Quarter 1 2018 for Plant 10 at 15.56 mg/m3, where the previous average value was < 2 mg/m3. Due to the increase in ammonia compounds measured in the Plant 9-10 stack flue gas, plus the high RM of SO_3, the Detached Plume phenomenon occurred in the main stack of Plant 9-10. So that for control, continuos monitoring of ammonia is needed at CEMS Plant 9-10 or re-mapping is carried out in the Quarry on ammonia variables.

C. Process Optimization of Plant 9-10 Main Chimney Flue Gas Temperature

Controlling SO_2 gas emissions and Detached Plume can also be done by engineering the temperature at the Bag Filter Outlet / Main Chimney Inlet. A decrease in the temperature of the main flue gas will be followed by a decrease in the concentration of SO_2 gas emissions and the visibility of Detached Plume. The following are the results of controlling the main flue temperature:

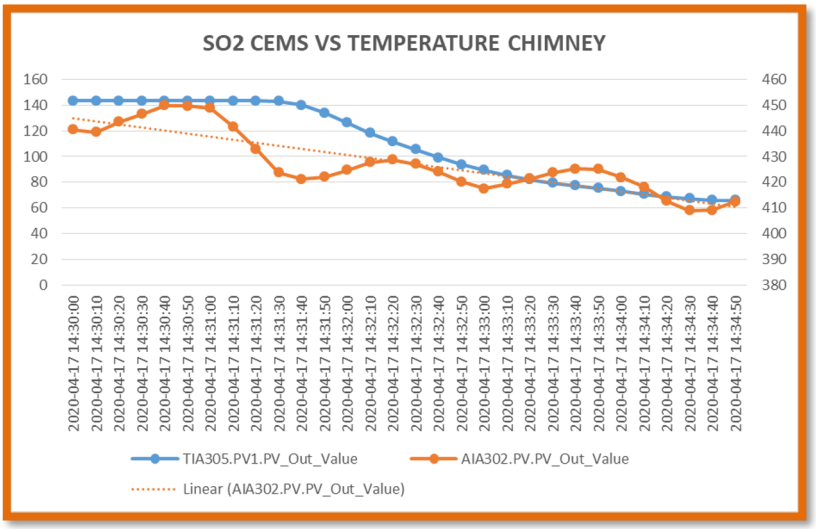


Fig. 11. The results of controlling the main flue temperature

From the results of the temperature control experiment at the inlet of the main chimney, a decrease in SO_2 emissions was obtained, so controlling the process temperature is necessary to keep SO_2 emissions below the threshold value set by the Ministry of Environment. Therefore, a Standard Operating Procedure is required for the SO_2 Emission parameter in the main chimney based on Bag Filter Temperature. The Standard Operating Procedure is schematized as follows:

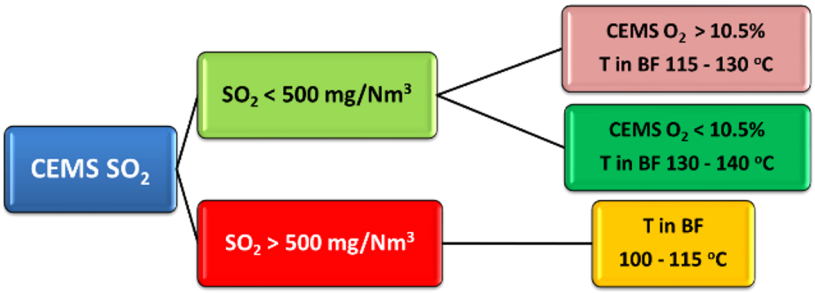


Fig. 12. Schematic of SO_2 emission control SOP vs bag filter temperature

3.2 Potential cost effiiciency of Plant 9-10 clinker production with TOC variation

With variations in Total Organic Carbon values found in Raw materials based on observations are seen to greatly affect the Clinker production capacity at Plant 9-10. The higher the TOC, the Clinker capacity will decrease as show n in the table below:

Des-17			
SampleName	TOC	Kiln Feed	Clinker
---	Raw Meal	tph	tpd
Rawmeal-P9-011217	**1,35**	235,87	3187,68
Rawmeal-P9-021217	**1,65**	274,89	3399,95
Rawmeal-P9-031217	**1,17**	270,61	3386,19
Rawmeal-P9-041217	**0,94**	291,77	3657,87
Rawmeal-P9-051217		288,51	3802,77
Rawmeal-P9-061217	**0,61**	283,26	
Rawmeal-P9-071217		0,00	
Rawmeal-P9-081217	**1,04**	243,41	
Rawmeal-P9-091217	**1,25**	270,75	3488,34
Rawmeal-P9-101217	**1,92**	260,10	3447,04
Rawmeal-P9-111217	**0,62**	287,56	3692,64
Rawmeal-P9-121217	**0,87**	297,98	3545,57
Rawmeal-P9-131217	**1,39**	300,77	3460,81
Rawmeal-P9-141217	**0,96**	293,68	3541,95
Rawmeal-P9-151217	**1,22**	281,53	3571,65
Rawmeal-P9-161217	**1,63**	285,86	3306,49
Rawmeal-P9-171217	**1,26**	293,06	3422,41
Rawmeal-P9-181217	**1,45**	289,46	3464,43
Rawmeal-P9-191217	**1,36**	295,25	3372,42
Rawmeal-P9-201217		290,11	3281,86
Rawmeal-P9-211217	**0,98**	283,99	3685,40
Rawmeal-P9-221217	**1,33**	278,62	3603,53
Rawmeal-P9-231217		284,08	
Rawmeal-P9-241217		0,00	
Rawmeal-P9-251217	**1,00**	271,34	
Rawmeal-P9-261217	**1,30**	290,71	3367,35
Rawmeal-P9-271217	**1,46**	262,84	3118,13
Rawmeal-P9-281217		214,37	
Rawmeal-P9-291217		0,00	
Rawmeal-P9-301217		0,00	
Rawmeal-P9-311217		252,38	
Average	**1,22**	241,06	3466,88

Fig. 13. Clinker capacity

Table 5. Clinker capacity

Plant 9	**AVG TOC (%)**	**Avg clinker (tpd)**
December 2017	1,22	3466
March 2018	0,50	3835
Plant 10	**AVG TOC (%)**	**Avg clinker (tpd)**
December 2017	1,00	4070
March 2018	0,45	4181

From the observation of the Total Organic Carbon value and Clinker production capacity of Plant 9 in December 2017, when the TOC value reaches 1.22%, the Clinker capacity will be corrected to 3466 tpd, which is 184 tons lower than the P9 target of 3650 tpd. Likewise, Plant 10 in December 2017 for an average TOC value of 1.0% obtained an average capacity of 4070 tpd where the Clinker production capacity is 30 tons lower than the target of 4100 tpd.

Des-17			
SampleName	TOC	Kiln Feed	Clinker
----------	Raw Meal	tph	tpd
Rawmeal-P10-011217	0,98	291,26	4121,53
Rawmeal-P10-021217	0,99	301,47	4133,37
Rawmeal-P10-031217		306,35	4152,05
Rawmeal-P10-041217	1,15	307,85	4124,68
Rawmeal-P10-051217	0,98	305,44	4087,58
Rawmeal-P10-061217	0,83	303,73	4167,05
Rawmeal-P10-071217	1,10	301,22	4094,95
Rawmeal-P10-081217	1,20	308,72	4043,37
Rawmeal-P10-091217	1,01	309,63	4045,47
Rawmeal-P10-101217	0,95	305,83	4036,79
Rawmeal-P10-111217	0,87	307,88	4070,74
Rawmeal-P10-121217	0,90	311,13	4057,58
Rawmeal-P10-131217	1,13	308,42	4062,84
Rawmeal-P10-141217	1,29	304,77	4027,32
Rawmeal-P10-151217	1,15	309,35	4058,11
Rawmeal-P10-161217	0,98	302,72	4058,11
Rawmeal-P10-171217	0,71	309,31	4111,00
Rawmeal-P10-181217	1,15	310,40	4100,47
Rawmeal-P10-191217	0,99	301,01	4043,37
Rawmeal-P10-201217		303,96	4122,32
Rawmeal-P10-211217	0,74	307,25	4109,68
Rawmeal-P10-221217	0,72	298,74	4119,42
Rawmeal-P10-231217		302,03	4126,79
Rawmeal-P10-241217	0,94	297,02	4043,89
Rawmeal-P10-251217	1,08	304,18	4015,47
Rawmeal-P10-261217	1,25	295,99	3943,63
Rawmeal-P10-271217	1,09	301,49	4092,05
Rawmeal-P10-281217	0,82	284,92	
Rawmeal-P10-291217	1,03	299,96	4055,21
Rawmeal-P10-301217		292,61	4059,68
Rawmeal-P10-311217		300,49	4069,95
Average	1,00	303,07	4078,48

Fig. 14. Clinker production capacity

Because the TOC factor of the Cirebon Quarry will range from 1.0 to 1.5% in the future, the Clinker production process optimization is carried out with a TOC value between 1.0 sd 1.5% to extend the life of the Cirebon Quary:

Table 6. Optimization Clinker production with TOC value between 1.0 sd 1.5%

Plant 9	**TOC %**	**Kiln Feed tph**	**Clinker product tpd**
01 Oct 2020	01.12	297	3510
02 Oct 2020	01.12	303	3519
03 Oct 2020	01.01	304	3508
04 Oct 2020	01.22	313	3549
05 Oct 2020	01.06	321	3650
06 Oct 2020	01.39	312	3655
07 Oct 2020	01.33	312	3661
08 Oct 2020	01.14	311	3664
09 Oct 2020	01.06	313	3661
10 Oct 2020	01.34	250	2775
Plant 10	**TOC %**	**Kiln Feed tph**	**Clinker product tpd**
16-Nov-20	01.00	293	4100,2

17-Nov-20	01.00	302,2	4100,2
18-Nov-20	01.20	304	4101,4
19-Nov-20	01.20	207,9	3189,5
20-Nov-20	01.15	376,3	4100,2
21-Nov-20	01.07	331,2	4100,2
22-Nov-20	01.17	334,3	4100,2

From the optimization of ClinkerPlant 9 production capacity, by increasing KilnFeed to >310 tph, a daily Clinker capacity of 3658 tpd is achieved (October 5-9, 2020) with an average TOC content of 1.19%. Meanwhile, optimizing the production capacity of Clinker P10 by increasing KilnFeed to >330 tph achieved a daily Clinker capacity of 4100 tpd (November 20-22, 2020) with TOC levels of 1.13%.

From the optimization of Clinker production using TOC 1.0 - 1.2%, it can be calculated the potential CostSaving incurred, which is based on the table above obtained a total of 222 tpd of additional Clinker with production using TOC 1.0 - 1.2% and KilnFeed optimization. The potential *CostSaving* incurred is equal to :

Table 7. Potential *CostSaving*

Plant 9	**TOC %**	**Clinker tpd**
October 2020	1,19	3658
December 2017	1,22	3466
	delta	**192**
Plant 10	**TOC %**	**Clinker tpd**
November 2020	1,13	4100
December 2017	1,01	4070
	delta	**30**

Based on the table above obtained a total of 222 tpd of additional Clinker with production using TOC 1.0 - 1.2% and Kiln Feed optimization. The potential cost savings incurred are as follows:

Cost Saving = 222 tpd x 400000 IDR/ton *Clinker* x 320 *running days*
Cost Saving = 28,416,000,000 IDR/tahun.

4 Conclusion and recommendations

Based on the results of the discussion, the following conclusions were obtained:

1. *Detached Plume* is influenced by the main flue gas ammonia content, where ammonia levels > 2 mg / Nm^3 increase the visibility of the Detached Plume in the main chimney of Plant 9-10. The potential for the *Detached Plume* $_{phenome2on}$ and the increase in SO_2

gas emissions in the main chimney occurs when the TOC value > 1.0%, RM SO_3 > 0.6%.

2. Optimization of the Clinker production process for TOC values of 1.0-1.5% by maximizing Kiln Feed P9 > 310 tph and Kiln Feed P10 >330 tph, Clinker P9-10 capacity can be achieved and the potential Cost Saving obtained from optimizing the Clinker production process using TOC 1.0 – 1.5% is Rp 28,416,000,000 per year.

References

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3. Cement *Plant* Operation Handbook, (2005).