

# Fogging and water spray velocity to reduce dust cement widespread

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**Abstract.** Climate change as the global issue should be analysed from mitigating especially in the cement industrial. This industry contributes up to 6% to the global warming. Cement plants must already take over management of the cement dust arising mainly on the production. However, there are still many who are exposed to cement dust into the surrounding environment, due to the dust cement contributes to air pollutant and give impact to climate change. This research aims to study the various strategies to catch a smooth dust using fogging methods with variable water speed. In such a device, as media dust catcher is mist generated from water which is converted into mist by sprayer. The dust catcher instrument installed at the location after the end of the cement factory chimneys. Of course, in order not to complicate the technical implementation in the chimney is curved downward so it is easier to install dust extraction tool such fogging method. The tool optimal conditions occur in the water velocity 110 ml per min with an efficiency of 63.60%. In the water velocity 110 ml per min it will form a mist with the optimal amount, if the water velocity is greater than 110 ml per min will tend to form droplets, on the contrary if the water velocity is less than 110 ml per min of the amount of haze formed is not maximized.

## 1. Introduction

Climate change is one of the major challenges of our time and adds considerable stress to our societies and to the environment [1]. According to IPCC [2], the current rate of emissions is likely to cause average temperatures to rise by 0.2°C per decade, reaching by 2050 the threshold of 2°C above pre-industrial levels. The major of emissions are nitrogen oxides (NOX), sulphur oxides (SOX), carbon dioxide (CO<sub>2</sub>), and dust emissions. One of industrial sector in the world should be responsible on that emission is cement industry. Emissions from cement manufacturing are one of the major contributors in climate change and global warming up to 6% in the world [3]. The cement production process such as excavation, demolition, storage of raw materials, grinding and mixing (only on dry process), clinker production and cooling, the final milling, and also packaging can increase the number of dust emission [4].

Dust emissions are a function of air movement and the dustiness of the grain. Grain dust particles commonly range in size from less than 5 to over 100 µm [5]. These particles have relatively low



settling velocities in air, ranging from 0.001 to 0.25 m per s [6], and are carried downstream by airflow. In a grain-receiving area, some airflow movement is generated as grain fills the hopper and displaces air from the hopper. Additional airflow is entrained with the grain stream while it falls into the receiving hopper; the amount of entrained air depends on grain drop height and flow rate [7].

In the current, with the various strategy, technology, and resources causing the issues of environment and the emissions (gas and dust) from cement industry has been reduced and controlled during the last decades [8]. The various strategy includes are wet scrubbers, electrostatic precipitators, and flexible pulse jet filters [9], but that strategy still not enough to pass from standardization of cement manufacturing process, for the example the wet scrubbers strategy which water is sprayed into the gas that has a dust so that the dust in the gas to be caught by the water, but this strategy not enough effort to catch a smooth dust particles. Therefore, this research aims to study the various strategies to catch a smooth dust using fogging methods with variable water speed.

## 2. Methods

### 2.1. Experimental sites

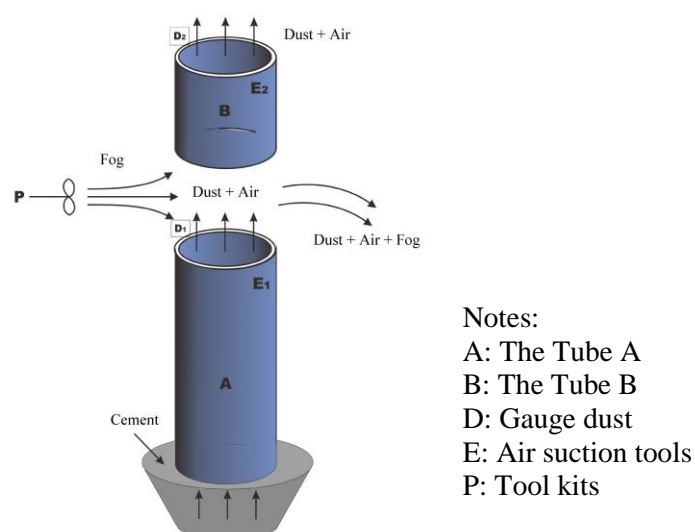
This research was conducted on (please input day per month per year of this research) in Tuban, East Java, which has one of big production cement in Indonesia with the production up to 14 million ton per year [10].

### 2.2. Tools and materials

Tools and materials of this research are tube, nozzles, dust gauges, fogging tools, water, and cement. Cement is produced from raw materials such as limestone, chalk, shale, clay, and sand. These raw materials are quarried, crushed, finely ground, and blended to the correct chemical composition [11].

### 2.3. Technical assessment

**2.3.1. Fogging methods.** The process of fogging is used in a variety of applications to control humidity, temperature, and improves air quality. Fogging systems incorporate a high-pressure pump and a spray nozzle designed to produce water droplets smaller than the diameter of a human hair, even as small as 5 microns (5 millionth of a meter). In this research, the first step to mitigate the widespread of cement dust is designing the tools to catch the smooth dust particles using fogging method, as shown in Figure 1.



**Figure 1.** Scheme of fogging method

**2.3.2. Dust catcher laboratory test.** In this study, materials and dust catcher will be tested in the laboratory scale with the variables are the independent variable is the velocity of the water going into the sprayer ( $V_a$ ), while the fixed variables are the diameter of the nozzle ( $D_n = 1.40$  mm), the distance between the sprayer with chimney simulator ( $L = 1.0$  m), airspeed in column ( $V_u = 510$  m per min), the distances between the top end of the chimney with the gauge ( $Z = 100$  cm).

#### 2.4. Data analysis

The effect of fogging methods on dust emission catcher for each grain type and grain flow rate was determined using ANOVA analysis with a 5% level significance. The effectiveness of the dust catcher using fogging methods was determined by calculating the percentage reduction in dust emission, that is:

$$\% \text{ reduction (efficiency)} = 100\% - 100 \times \frac{\text{avg. dust caught fog}}{\text{Avg. before fogging}} \quad (1)$$

The data processing is carried out by calculating the mass of cement dust that can be caught by the fog from the cement dust catcher with the fogging method. Based on the mass of cement dust that can be caught by the fog, it can be determined the performance of this method of dust catcher.

### 3. Results and discussion

Determination of the performance of the tool is done by calculating the work efficiency of the dust catching method of this fogging method is presented in Table 1 and 2.

**Table 1.** Dust mass before and after passing through the dust catcher

No.	Air velocity at Sprayer (ml per min)	The measurement sequence to	Cement dust mass ( $\mu\text{g}$ )	
			before fogging	after fogging
1	350	1	24,810	8,217
		2	24,928	8,222
		3	24,697	8,219
2	250	1	23,313	8,042
		2	23,591	8,091
		3	23,108	8,065
3	170	1	22,241	7,867
		2	22,289	7,882
		3	22,233	7,893
4	110	1	21,131	7,691
		2	21,073	7,699
		3	21,203	7,698
5	50	1	18,651	7,522
		2	20,620	7,536
		3	19,636	7,530

Sources: Primary data, in 2018

**Table 2.** The Efficiency of Fogging method with air velocity variation

No	Air velocity at Sprayer (ml per min)	The measurement sequence	Dust caught ( $\mu\text{g}$ )	Efficiency (%)
1	350	1	16,592	66.88
		2	16,707	67.02
		3	16,478	66.72
2	250	1	15,271	65.50
		2	15,499	65.70
		3	15,043	65.10
3	170	1	14,374	64.63
		2	14,408	64.64
		3	14,340	64.50
4	110	1	13,440	63.60
		2	13,375	63.47
		3	13,505	63.69
5	50	1	11,130	59.67
		2	13,084	63.45
		3	12,106	61.65

Source: Data processing; 2018

Table 1 shows that more dust was caught with higher velocity of the water sprayer. 350 ml per min caught 24,697 to 24,928  $\mu\text{g}$  dust, while it was only 18,651- 20,620  $\mu\text{g}$  with the velocity of 50 ml per min. The order of dust caught according to water spray velocity is 350>250>170>110>50 ml per min. Fogging reduce dust concentration in the air. Based on Table 2, the bigger the water velocity in the sprayer ( $V_a$ ), the more dust were caught due to the particles have relatively low settling velocities in air, ranging from 0.001 to 0.25 m per s [6]. However, if the water speed is too high then the results are still in the form of water, not fog. If what is being served is still in the form of water, cement dust that can be captured by water is still a relatively large size (greater than 30  $\mu\text{m}$ ). However, if those who have been sprayed are already in the form of fog, the fog will be able to capture the cement dust until the size is very fine (nanometre size). This is because the size of the fog is much smaller than the size of the water. The smaller the size, the larger the surface area, and the larger the surface area, the fog will be able to capture cement dust to a very fine size. The ability to capture cement dust with a very fine size is the advantage of fogging method. So, the purposes of industrial transformation and green production (ITGP) will be success as policy integration for promoting green industry [12]. The method of fogging is compared with wet scrubber tools that use water to capture cement dust. Therefore, in this study, the variable speed of the water that will be flowed into the water spray is sought to produce a perfect mist without being mixed with water and with a maximum amount of fog.

While analysis of the quality of the fog that is associated with a variable dispersed. The water velocity in the sprayer ( $V_a$ ) are as follows:

- 350 ml per min: The spraying is not fog but mist. The dust particle weight difference at the bottom and top were big.
- 250 ml per min: The results released by the nozzle at a water speed of 250 ml per min are still water droplets that have not been able to catch fine dust particles.
- 170 ml per min: At this speed there is a change in shape from water droplets to fog. This condition still not optimal to catch the fine dust particles.
- 110 ml per min: The water speed of 110 ml per min is the optimal speed for catching fine dust particles in the chimney, due to the nozzle was able to spray the fog.
- 50 ml per min: There is a decreasing in efficiency to catch fine dust particles due to the fog produced from the nozzle was damaged at a water speed of 50 ml per min.

Based on this analysis, the best conditions for variable water velocity in the sprayer ( $V_a$ ) can produce a perfect mist without mixing with water, which occurs at 110 ml per minute. The existence of cement dust catcher method of fogging which is installed on the cement factory chimney, so that the cement dusts, especially the fine ones which are included in the flow of exhaust gas which exits the chimney of the cement plant, will be captured by the fog. According to Grudnig [13], fog method is incorporating system of water spraying using two-phase of nozzles. In operating conditions, variable water velocity in sprayer ( $V_a$ ) can produce a perfect mist without mixing with water, which occurs at 110 ml per minute, with an efficiency of 63.89%, meaning that if the dust catcher is installed in cement factories. By that, there is a reduction in dust coming out of the factory chimney through a significant flow of exhaust gas. This will affect the quality and temperature conditions as IPCC [2] said will be increase 2°C per decade caused by industrial sector. This is possible because one of the factors that influence air quality and temperature is the amount of dust in the air. The smaller the mass of dust exposed to the air, the cleaner the air quality and the smaller air temperature increasing so that climate conditions can be maintained.

#### 4. Conclusion

Fogging method with water speed variable can reduce the dust emissions especially smooth dust. This is to mitigate widespread of dust emission in the air as a pollutant and one of warming global factors causing climate change.

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