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The Analysis of Active Carbon Life Time as an Adsorbent of Dust/Particulate through Cyclone Ventilator Modification

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Abstract

The presence of air pollutants in a room can cause health problems both in the long run and short term. One of the indicators of indoor air pollution is dust/particulates. Air pollution comes from incomplete combustion activities from households, cigarette smoke, household industries, building materials, etc. The purposes of this study are to analyze the life time of activated carbon for dust filtration after passing through the cyclone ventilator modification; to analyze its effectiveness in lowering dust levels; to analyze its efficiency rate in lowering dust levels, and; to evaluate the ability of the cyclone ventilator modification to reduce the dust levels. The research design was a pre-experimented research in the form of One Group Pretest-Posttest design. The independent variable was the cyclone ventilator while the dependent variable was dust. The data collections of the dust were conducted 100 times, before and after the air passed through the cyclone ventilator. The data analysis employed was the paired t-test. The results showed a decrease in temperature of 1.18^{o} C after the installation of the indoor air purifier at an average air speed of 8.51 m/s. Before passing through the indoor air purifier, the average dust level reached 0.29 mg/m^2. Meanwhile, the average dust level after passing through the ventilator decreased to 0.0039 mg/m^2. The average percentage of dust level reduction was 98.68%. The paired t-test analysis indicated p=0.000, meaning that there was a significant decrease of dust level after the air passed through the air purifier. The life time of the activated carbon for dust filtration had not reached its saturation point after 400 hours. This ventilator was highly effective as it could reduce dust level by more than 80% for 400 hours. Meanwhile, the efficiency was evident from the effectiveness of the ventilator in lowering the dust level at a relatively low cost since the operation did not require electricity. The conclusion of the study was that this cyclone ventilator modification had an excellent capability as indicated by its life time rate as well as its effectiveness and efficiency in lowering indoor dust levels. It is recommended that the cyclone ventilator modification be applied in an effort to promote healthy indoor air quality for both households and home industries.

Keywords: *dust, life time, effectivity and efficiency, indoor air purifier, cyclone ventilator modification*

Introduction

Air pollution causes various impacts on all aspects of life, including the health of humans, animals, plants and the impact on materials. The impacts on human health include respiratory disorders, emotional disturbances, anorexia, mental depression in the respiratory center and central nervous system. Among many materials that cause air pollution, particles/dust belong to the groups that require serious attention because of the magnitude of the impact that can be generated, both on living things and other physical environments. In this case, the particle/dust is a solid object that occurs due to a mechanical process (reduction break up) to a solid mass which is still influenced by the force of gravity. Particles/dust can be inhaled through the respiratory tract. Particles larger than 0.6 µ will be retained in the upper respiratory tract while those below 0.3 µ will follow the Brownian motion, i.e., going in and out and only those with the size between 0.3 µ to 0.6 µ will arrive at the lung alveoli.

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Referring the Minnesota Department of Health in Saragih[1], the main problem of indoor air pollution is that it holds more pollutant concentration than in outdoor. The occurrence of indoor air quality problems is generally caused by several factors, including the lack of ventilation, the contaminants being in the room, and contamination from the outside of the room[2]. Furthermore, Saragih[1], stated that the presence of indoor air pollutants can cause health disturbances both in the long run and in short term where the air pollution sources can come from the kitchen in households, smoke, building materials, etc.

The purposes of this study were to analyze the life time of the activated carbon for dust filtration after passing through the cyclone ventilator modification; to analyze its effectiveness to reduce the dust level; to analyze its efficiency rate in lowering the dust level, and; to evaluate its ability to lower the dust level.

Method

The experimental design employed in the research is One Group Pretest Posttest Design. The difference between these two measurement results was considered as a treatment effect.

The research location was at PT. Kalimaya Surabaya as a home industry that produced home furnishings and home construction which had the potential to generate particle/dust. Location of research was The Laboratoriy of Health Polytechnic of Surabaya.

The sampling was determined to be 100 times which were before and after the treatments, taking into account of the ability and necessities of the researchers to measure the life time of the indoor air purifier. Ability here meant the cost factor, the ability of the personnel in dividing their daily activities and the routine tasks they must conduct.

The material used was a 105 µm of active carbon from coconut shells (obtained from 140-sized mesh), while the cyclone ventilator modification consisted of the following components: 1) the cyclone/turbine ventilator, 2) the activated carbon reactor. The specifications of the air-chamber device (cyclone/turbine ventilator) and the active carbon reactor were as follows: 1)material: alluminium; 2) diameter: 45cm=16"; 3) Dimensions: 75 x 68 x 68 cm (HxLxW); 4) Weight: 4.5 kg to 8.5 kg; 5) Suction Capacity: 42.39 m^3/min; and last 6) the media thickness: 20 cm.

Figure 1. Active Carbon and Cyclone Ventilator Modification

The data obtained would then be collected, processed and analyzed using descriptive and analytical statistics with paired t-test which was included in the parametric statistical test. The use of paired t-test was to test the effectiveness of the treatment with determined variables, i.e. the level of CO and CO gas before it passed the air purifier (pre-test) and the level of CO and dust after passing the room air purifier (post-test). The collected data was numeric so that it was presented as mean, SD, maximum and minimum.[3]

Findings and Discussion

Air Speed Rate

The results of the air flow rate measurement are presented in graphical form as follows:

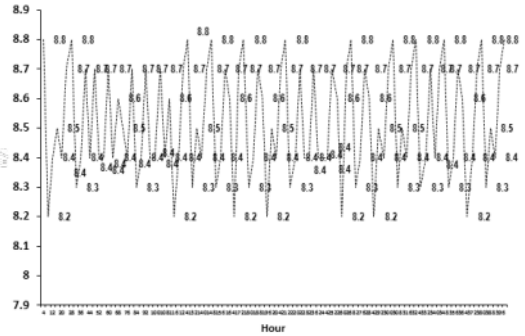

Figure 2. Air Flow Rate Measurement Results

Through the air flow rate meter with a span of 60 minutes for the reading, the average air suction capability of the cyclone ventilator was capable of sucking air at 8.51 m/s. This condition exceeded the natural room air flow rate in the as required by The Regulation of the Minister of Health of the Republic of Indonesia Number 1077 of 2011 concerning Guidelines for Restoring Air in the House Room[4], ranging 0.15 - 0.25 m/sec. This requirement is in conformity with the Decree of the Minister of Health No. 261 / MENKES / SK / II / 1998 concerning Health Requirements for the Work Environment[5] which requires that the ventilation

rate should be between 0.15-0.25 m/sec.

Room Temperature

Table 1. The Result of Room Temperature Measurement Before and After the Installation of the Cyclone Ventilator Modification

No	Before Installation		After Installation		Temperature Difference after Installation (°C)
	Date of Measurement	Temperature (°C)	Date of Measurement	Temperature (°C)	
1	August 15, 2016	27.05	Sept 2, 2016	25.89	1.16
2	August 16, 2016	27.15	Sept 3, 2016	26	1.15
3	August 18, 2016	27.35	Sept 5, 2016	25.90	1.45
4	August 19, 2016	27.0	Sept 6, 2016	25.85	1.15
5	August 20, 2016	27.0	Sept 7, 2016	26	1
6	August 22, 2016	27.24	Sept 8, 2016	25.97	1.27
7	August 23, 2016	27.01	Sept 9, 2016	25.98	1.03
8	August 24, 2016	27.06	Sept 10, 2016	26	1.06
9	August 25, 2016	27.09	Sept 13, 2016	25.78	1.31
10	August 26, 2016	27.10	Sept 14, 2016	25.86	1.24
Average		27.11	Average	25.93	1.18

The results of the temperature measurements before operating the ventilator indicated the highest temperature measurement of 27.35 ºC, while the lowest temperature before operating the ventilator was at 27 ºC with the average temperature measured at 27.11 ºC. After the ventilator operated, the highest temperature reached 26 °C while the lowest temperature amounted to 25.78 ºC with the average room temperature recorded at 25.93 ºC. From the results above, it was found the average difference of temperature decrease after the installation of the cyclone reached 1.18 ºC. This was due to by the movement of the air passage through the cyclone. In accordance with the Decree of the Minister of Health No. 261 / MENKES / SK / II / 1998 concerning Health Requirements for the Work Environment[5], a working space requires temperature ranges between 18-26 ºC. This indicated that with the installation and operation of the cyclone ventilator, the room temperature became eligible. The comfort of the room air temperature that met the requirements was expected to increase the workers' performance.

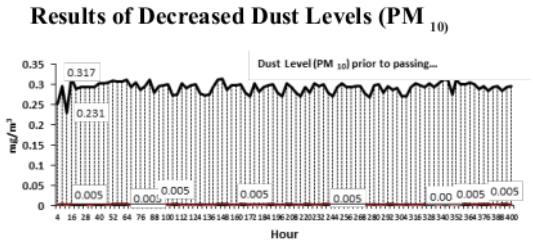

Figure 3. The Distribution of Dust Level Measurement Results (PM 10) Before and After the Cyclone Ventilator

The measurement results of the dust levels (PM 10) before the air passed through the cyclone ventilator showed the highest levels of 0.317 mg/m³ while the lowest reached 0.231 mg/m³. Meanwhile, the measurement of the dust level (PM10) after passing the cyclone ventilator recorded the lowest dust level of 0.003 mg/m³ and the highest level at 0.005 mg/m³ at the end of the measurement (400 hours) on the 50th day.

Furthermore, the amount of the percentage decrease in the dust level (PM10) and the performance of the filtration media (coconut shell-activated carbon) as the absorption media which would be employed as a reference in the calculation of paired t-test, effectiveness, lifetime and efficiency of the cyclone ventilator to lowering the dust level (PM10) in the generator room of PT. Kalimaya Surabaya.

The research results indicated that as long as the ventilator had operated with the span of 50 days with the exposure of the air pollution of the room derived from the operational genset for 8 hours each day, the dust levels (PM10) decreased at the highest rate of 98.97% while the lowest was 98.25%, resulting an average decline of 98.68%.

The results showed that the cyclone ventilator's ability to reduce the indoor dust level (PM10) did not form a declining trend line, but a fluctuating graphic line instead. This occurred because the dust parameter (PM10) had an average diameter of ≤ 10 µm, while the active carbon used as the adsorbent media had an average diameter of ≤ 125 µm. Thus, the absorption process did not work well enough. The dust (PM10) was adsorbed into the pores of the activated carbon mainly had the diameter of <25 nm, thus, when the pores of the activated carbon had been covered by the dust (PM10) which had the diameter of <25 nm, other adsorbents such as CO and dust (PM10) would pass through the effluent.

The fluctuating study results were also due to the varied dust particle sizes (PM10) so that they formed new layers on the initial surface because it was not adsorbed into the adsorbent media. This caused the cyclone ventilator use activated carbon as the adsorbent media to better reduce the dust parameter (PM10).

In this study, the life time assigned to the cyclone ventilation was equal to reducing the amount of dust (PM10) up to 50%. Based on the results of this research, with 50 days of exposure to air pollutants originating from the generator set lasting 8 hours each day, the ventilator's ability to reduce the amount of dust (PM10) was still above 98%. Thus, the 50-day testing period had not resulted in the cyclone ventilator to reach its life time and it could still operate to reduce dust (PM10) even more than 50 days.

The Evaluation of the Indooe Air Purifier (Cyclone Ventilator Modification)

The physical condition evaluation of the cyclone ventilator included: 1) the cyclone ventilator was made of aluminum, causing it not easy to rust and could be used for long period of time; 2) the ventilator did not require routine maintenance because based on the research, the ventilator could be used up to 50 days with the equipment condition could still operate properly; 3) the cyclone ventilator could operate on weak wind stream and could adjust to strong wind stream; 4) the cyclone ventilator could move because of the differences in the air pressure coming from indoor and outdoor. This could happen because the hot air contained in the room would move out into cooler air through the cyclone ventilator.

Conclusion

1. The life time of the activated carbon used in the the cyclone ventilator modification could reach 400 hours without showing any indications of experiencing a period of saturated filtration media in reducing air pollutants (dust parameter).

2. The effectiveness of the cyclone ventilator modification in reducing the dust levels (PM10) by the filtration media still indicated the efficiency level of 98% although it had been tested for 400 hours. The cyclone ventilator modification had been proven to be highly efficient. The indicators were from the aspects of effectiveness, necessity energy, and economic factor.

3. The performance evaluation of the indoor air purifier/cyclone ventilator modification was evident in the ventilator's reliability during the operation and its outcome (life time, effectiveness and efficiency).

Suggestions

1. Further research needs to investigate whether the cyclone ventilator modification is equally effective in lowering other contaminants.

2. Further studies on the media used can be

conducted because the media used already reacted to dust or other pollutants.

3. The media on the cyclone ventilator modification in lowering the dust has met the quality standards of the air quality in the work environment of 0.15 mg/m$^{3(5)}$. Therefore, it is necessary for further detailing various diameters of smaller media so that the surface area gets broader.

Additional Informations

Source of Funding-Authors

Conflict of Interest-No

Ethical Clearance-Yes

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