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Research Article

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To Alleviate the Release of Detrimental Chemicals by using Smoke Collecting Device

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Abstract A simple smoke collecting device (SCD) was constructed in order to test the efficiency of collecting smoke particles. The SCD uses an electric charge (corona discharge) to remove certain impurities-either solid particles or liquid droplets from air or other gases in smokestacks. SCD is working by controlling emission gas from chimney to be passed in a room that has negatively charged electrode plates by giving a negative pole of direct current (DC) which has a high voltage about 20-50 KV. smoke or emission gas from burning results will be negatively charged when passing a negatively charged electrode/plate. The process of collecting smoke with this method uses static electricity, so it is called smoke collecting device (SCD). The system used in this experiment was made from a row of PVC pipes. This SCD is suitable for small and medium-sized enterprises (SMEs) to alleviate the release of detrimental chemicals such as polycyclic aromatic hydrocarbon (PAHs) into the atmosphere.

Keywords SCD (Smoke Collecting Device), Electrostatic precipitator, Corona Discharge, High Voltage Dc Supply

Introduction

Smoke collecting device, also called electrostatic air cleaner, a device that uses an electric charge (corona discharge) to remove certain impurities—either solid particles or liquid droplets—from air or other gases in smokestacks and other flues. The precipitator functions by applying energy only to the particulate matter being collected, without significantly impeding the flow of gases. Originally designed for recovery of valuable industrial-process materials, pollution control devices are used for air pollution control, particularly for removing harmful particulate matter from waste gases at industrial facilities and power-generating stations. If released into the atmosphere, such particulates reduce visibility, can contribute to climate change, and lead to serious health problems in humans, including lung damage and bronchitis. Smoke collecting device can capture fine particles (i.e., those that are smaller than 2.5 microns [0.0001 inch] in diameter), which are especially dangerous if released because they can be drawn deep into the lungs and can trigger inflammatory reactions.

Figure 1: Section view of SCD project

Corona Discharge

A corona discharge is an electrical discharge caused by the ionization of a fluid such as air surrounding a conductor carrying a high voltage. It represents a local region where the air (or other fluid) has undergone electrical breakdown and become conductive, allowing charge to continuously leak off the conductor into the air. A corona occurs at locations where the strength of the electric field (potential gradient) around a conductor exceeds the dielectric strength of the air.

Literature Review

The air pollution currently become the crucial problem and have impact environment especially for health. One of the sources considered as the cause of pollution is the fuel burning either in solid (wood, coal, and charcoal), liquid (liquid fuel), and gas fuel (Karwall et al. 2018). Ships that are using HFO (High Fuel Oil) as its fuel consist of high sulphur concentration, heavy metal, polycyclic aromatic hydrocarbons (PAHs) and other concentrations of poison materials (kennedy, 2019).

It has to be known that, ship which using HFO cause air pollution due to PM (Particular Matter) emission. then, PM actually has its own characteristic based on the particle size and aerodynamic characteristic. For coarse particle or PM10 has particle size amounts < 2.5 μ. Based on the several explanations, the ships which using diesel engine often cause emission gas with PM10 and PM25 size (Kennedy, 2019).

Smoke collecting device (SCD), this tool is working by providing electric capacity in gas stream, so the electric capacity will be separated from gas stream (Nobrega & Falaguasta, 2003: 275—284).

Smoke collecting device (SCD) working process

SCD is working by controlling emission gas from chimney to be passed in a room that has negatively charged electrode plates by giving a negative pole of direct current (DC) which has a high voltage about 20-50 KV. The higher the strains will increase the fly ash collecting. Particulate or smoke or emission gas from burning results will be negatively charged when passing a negatively charged electrode/plate. Furthermore, the negatively charged emission gas is passed through a metal plate that is positively charged so that the emission gas will be attracted and attached to the metal plate. The process of collecting dust with this method uses static electricity, so it is called smoke collecting device (SCD) or electro static gas/dust collector. In creating SCD, it is needed electric domain with high strains by using main component as like negative discharge electrode and positive metal sheet collector. At first, the strains using AC electric source amounts 380 V and is increased by step up the transformer up to 55 KV. Then, it is put in line with DC (Direct Current) using rectifier. The difference strains polarization can cause huge electric domain and sometime also emerged fire bow if passing through these two metal sheets. This occurrence is caused by electron jump or ion from negative pole to positive pole which is being mediated by gas or ash from burning result.

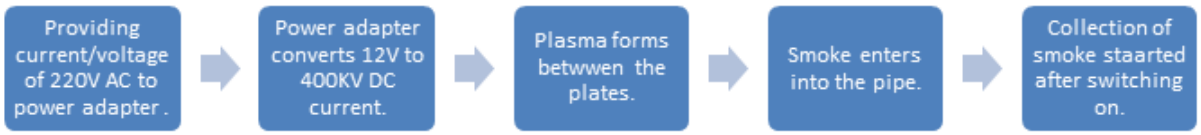

Figure 2: Working process of SCD

Study of Components

1. Electrodes

• The electrode plate/wire produces a high amount of corona discharge. Their main function is to generate a high-intensity electric field and ionize the particles in the flue gas. • Collecting electrodes are made of sheet metal. They attract the particulate matter.

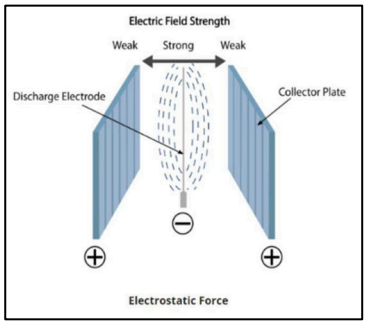

Figure 3: Electrodes

2. Power Supply/Transformer Unit

High voltage DC is required to charge the discharge electrodes to produce the corona effect. To do that, first, the voltage is first stepped up using a high voltage transformer.

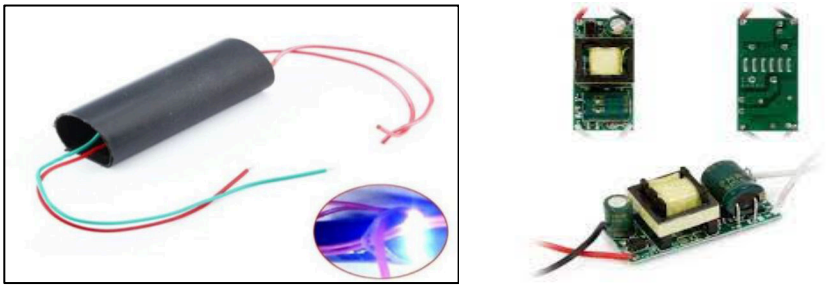

Figure 4: Power supply/transformer

3. Insulator

An electrical insulator is used in an electrical system to prevent unwanted flow of current to the earth from its supporting points. The insulator plays a vital role in the electrical system. An electrical insulator is a very high resistive path through which practically no current can flow.

4. Housing

An encloser in which the arrangement of the plate and wiring take place.

Figure 5: Housing of the project/complete SCD view

5. *Hose pipe*

A flexible tube used for conveying gases/air/smoke etc.

6. *Vacuum motor*

A DC motor is used to make a vaccum pump for intake of smoke

Figure 6: Vacuum hose pipe

Testing of SCD

- To prove the theory behind our SCD, we hooked up our power supply to a small SCD constructed out of a small PVC pipe, electrode plates, transformer and insulator.
- To test this, we hooked up the negative lead and the positive lead to the electrode plates. Once connected, we lit small incense on fire that produced a constant flow of smoke upwards.
- When the power supply was turned on, the flow of smoke was immediately stopped and the smoke particles began collecting on the negative electrode plate. The experimental setup to determine collection efficiency of the SCD. The SCD was connected to the wood combustion furnace where 4 kg of rubber-wood was burned. The input voltage for the SCD was 12V-DC, which is equivalent to the output of 10KV-DC.
- The collection efficiency (η) can then be calculated from inlet to outlet are the mass concentrations of particles at the inlet and exit of the SCD. The large variation of the velocity is due to the fact that the flow was natural. The condition of isokinetic sampling was approximately achieved.
- The variation does not significantly affect the loss or gain of the sample of smoke particles is very low (~ 2.5 microns). The first 10 samplings were performed in each 10 seconds when device is off and then 10 samplings in each 10 seconds after the device is on.

Calculation table

Table 1: Air Quality Index

S. No.	Without SCD		With SCD	
	Time	Reading(ppm)	Time	Reading(ppm)
1	12:34:50	13.29	12:37:10	15.38
2	12:35:00	13	12:37:20	14.82
3	12:35:10	13.55	12:37:30	11.22
4	12:35:20	14.25	12:37:40	10.26
5	12:35:30	14.67	12:37:50	9.84
6	12:35:40	15.64	12:38:00	9.48
7	12:35:50	16.42	12:38:10	8.5
8	12:36:00	16.98	12:38:20	7.43
9	12:36:10	17.27	12:38:30	6.26
10	12:36:20	17.83	12:38:40	6.18

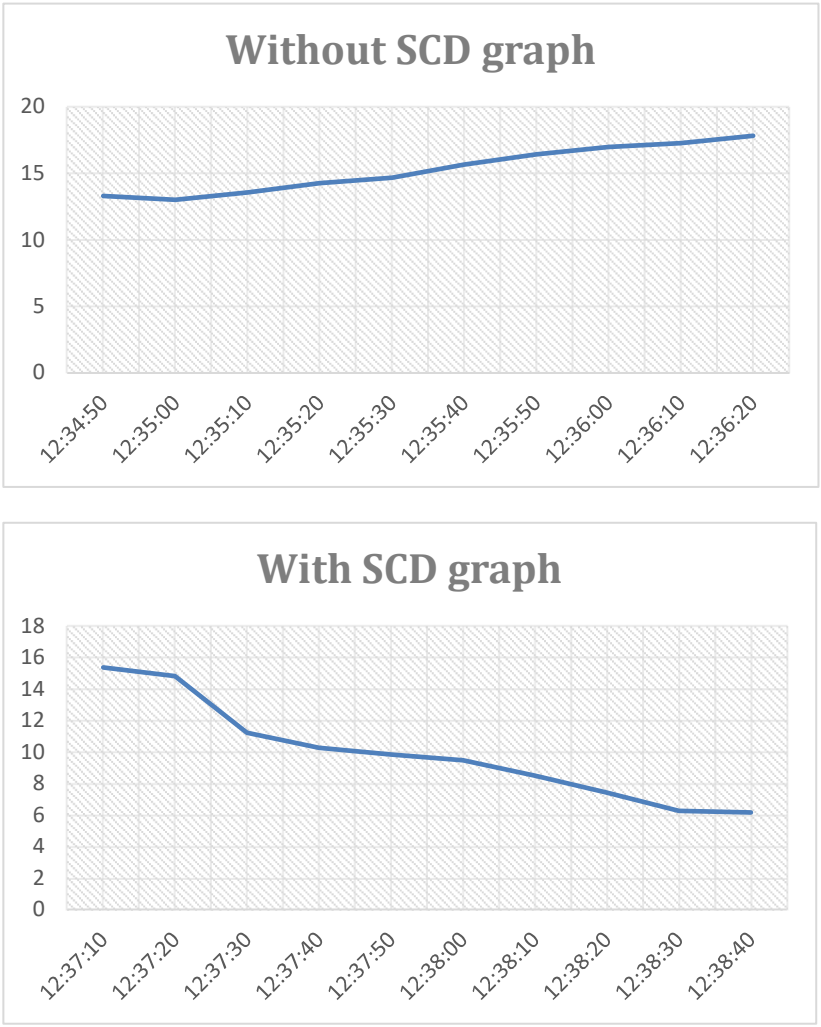

Figure 7: Air quality index graph

Conclusion

The maximum collection efficiency of the designed SCD was found to be approximately 65% during the initial period. The collection efficiency decreased as the dust loading increased. Results show that the gap between the collection plate electrodes has a greater influence on efficiency than the distance between the wire electrodes. In practice, the minimal distance between the collection plate electrodes should be about 12-14mm for safe and efficient operation. The efficiency was reduced from 65% to 50%. which corresponds to about one hours of operation. The efficiency of the cleaning system increased after 60 minutes. The efficiency is sufficient to alleviate emissions of detrimental chemicals like PAHs into the atmosphere.\

Costing estimate

The overall cost of making and testing of the project is in between 5000 rupees.
Costing of electrical equipment's – 2000 rupees
Pipes and outer casing – 2300 rupees
Miscellaneous costing – 260 rupees

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