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Air Pollution Controlled Prototype Modelling of Electrostatic Precipitator for Small Scale Industries

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Abstract: Electrostatic precipitator (ESP) is efficient pollution control equipment. This paper aims in designing of a low cost and portable ESP for small scale industries for controlling the pollution. A prototype of two stage ESP is developed with low cost, less weight and easily available materials. Which can be used in boilers, hospitals and cooking purposes. A pollution test is conducted on the prototype for verifying SO_2 and CO_2 emission by installing this ESP and verified.
Keywords: Electrostatic precipitator, air pollution control, SO_2, CO_2

INTRODUCTION

As the technology increases the number of market as well as industries increases [1]. On manufacturing various products the industries are emitting the pollution out into the environment [2]. These pollutants creates health hazards to the humans and animals, increases the global warming, depletion of ozone layer, creation of acid rain etc. [3, 14]. The Government have announced the permissible outlet of pollutants into the atmosphere for every industries [4]. If the industries are going to emit the pollutants in more then the industry need to pay fine [5, 6]. There are various methodologies followed by the industries to control the emission of particulates into the atmosphere depending upon the size of the particulates size [15, 16]. The particles having size above 10µm can be easily captured using filtering and cyclone formation, but the particles below 10µm it is difficult to collect, for collecting these particles the best methodology is using Electrostatic Precipitator (ESP) [7, 8]. Using static electricity from an electrode, it ionises the particulates matter and using another electrode it collects the ionised particles, ionisation of particles is done by production of corona around the electrode with very high voltage [9, 10, 32].

ESP operation

At atmospheric conditions, a non-uniform electric field has to be generated with a small diameter electrode; pulsating or continuous voltage supply is applied to it and a grounded collection electrode to collect [11]. The particulates are passed through an electric field [18-22, 24-30] where they initially receive an electric charge and then as a charged particle, are deflected across the field to be collected on an earthed plate [12]. In practice, for large gas flow rates, the single stage precipitator normally takes the form of a series of vertical parallel plates usually termed as receiving or collecting electrodes which for convenience are normally at earth potential, having discharging elements positioned midway between the plates and insulated from them [13].

Aim of the work

To design a low cost portable Electrostatic Precipitator which can be used in houses, smiths etc. It is a dry electrostatic precipitators can be used for collecting dry particles like cement, ash, machine shops and chemical plants for removing oil mists, dyes and colours, bacteria & fungus in the medical field, air conditioning systems for sanitizing air, to recover the materials in the flow of gas.

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Experimental Setup

Electrostatic precipitator is a device that removes suspended dust particles from a gas or exhaust by applying a high voltage electrostatic charge and collecting the particles on charged particles.

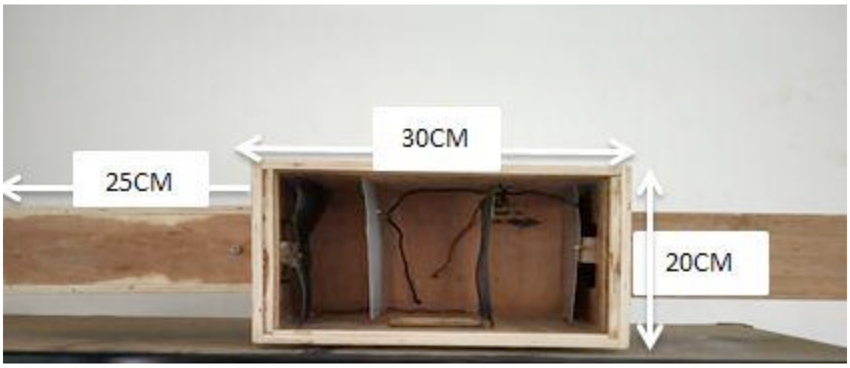

Figure 1. Experimental model of ESP

Discharge electrodes

Discharge electrodes were formed with the help of mesh to apply the high voltage on the particles.

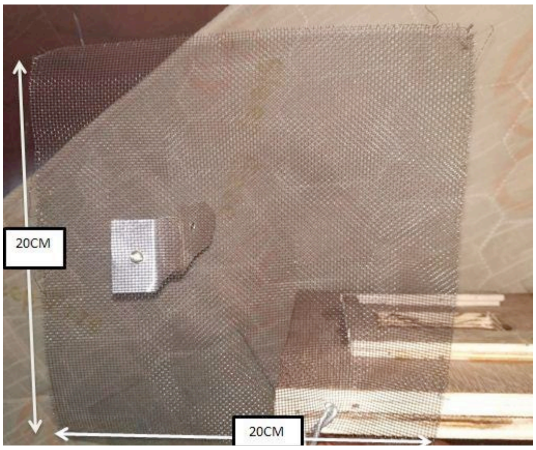

Figure 2. Discharge électrodes

Collection electrodes

Collection electrodes collect charged particles; it is made up of aluminium. Shown in the Figure

Figure 3. Collection electrodes

Collection electrodes were usually positively charged for collecting the ionized dust particles usually made of an alloy steel for special flue gas stream conditions where corrosion of carbon steel plates would occur. Collection electrodes in this proposed project are made up of aluminium the charged dust particles move towards the positive plates and deposited on positive plates. Here, the extra electron from the dust particles will be removed on positive plates, and the particles then fall due to gravitational force. Aluminium or other material plates are light weight, corrosion resistant and impermeable which makes them suitable in ESPs [17, 23, 31].

Wooden cabin

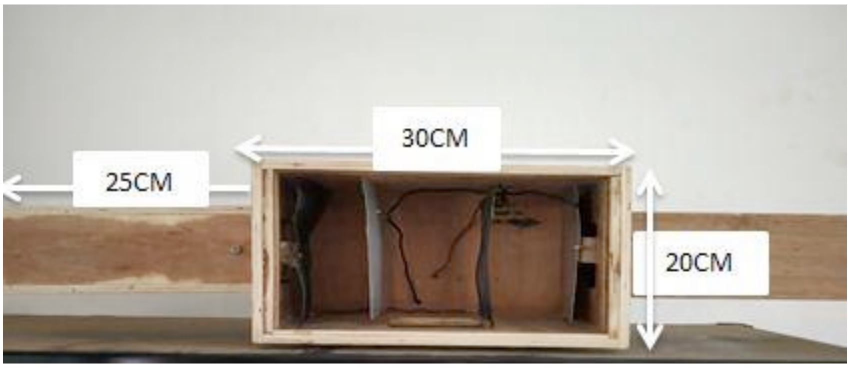

Figure 4. Wooden cabin

A wooden cabin is used to accommodate the discharge and collection electrodes , wooden pipes and Hooper cabin is made up of plywood which makes them economic ,environmental friendly ,durable. Inlet and outlet wooden pipes are installed in both sides of the cabin.

Hooper

Hooper is used to collect the dislocated particles from the collecting plates**.**

Figure 5. Hooper

The hopper is designed with 60° inclination to collect the dust particles without getting spread. Usually a rapping mechanism is available with the hoppers to apply a vibration for removing the dust particles.

Table 1. Components Specifications

Sl .no	Components	parameters	Numbers
1	Wooden cabins	30*20*22cm	1
2	Inlet and outlet pipes	20*15*12cm	2
3	Discharge electrodes	20*20cm	2
4	Collection electrodes	20*20cm	2
5	Hooper	15*15cm with 60°	1
6	High voltage supply :	Input : DC 3V-7.2V Output : 20kV-40kV High voltage bipolar discharge distance – 10mm-20mm High voltage bipolar discharge distance – 10mm-20mm.	1

RESULT AND DISCUSSION

Generally ESP should have an efficiency of 95%. Our original testing procedure was conducted by using IOT based air purifier sensor.

Step

- Contaminated air was made as input of IOT base sensors (which senses SO_2, CO_2) similarly precipitated output of ESP fed to the sensors.
- Graphical output of the sensors in both cases are verified.

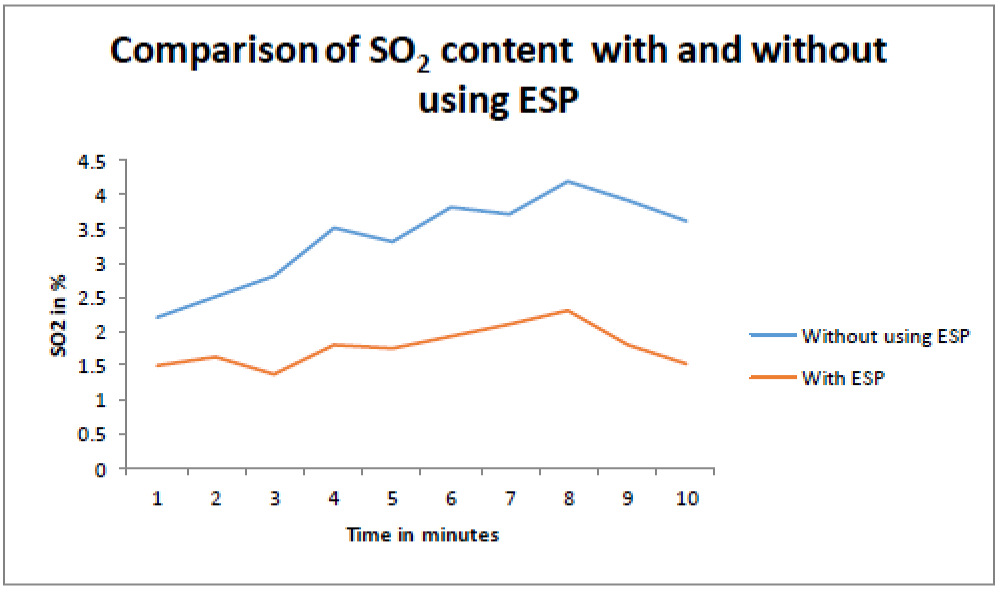

Figure 6. Graphical output of SO_2 content

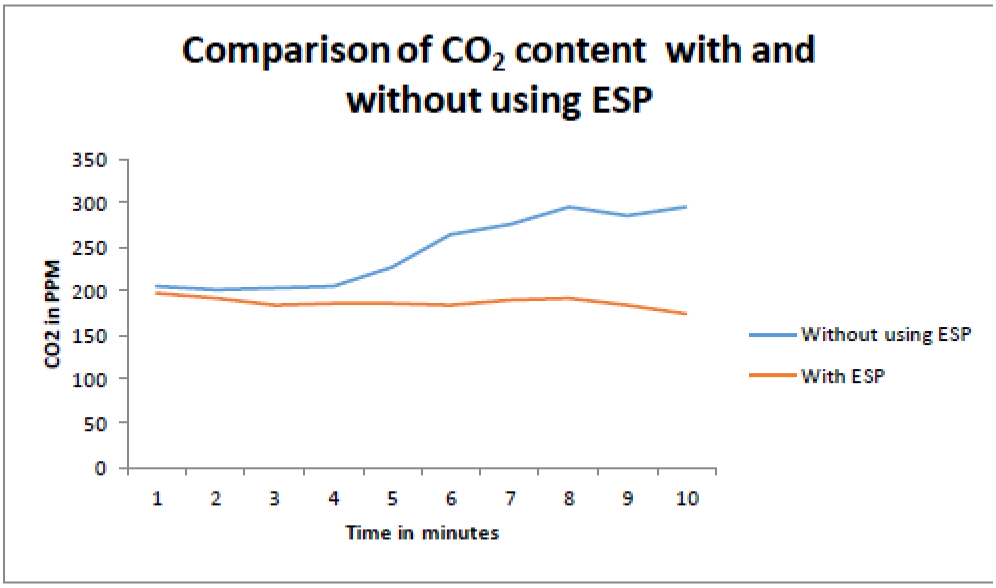

Figure 7. Graphical output CO_2

Graphical analysis

Normal value of SO_2 in an atmospheric air is in the range of 1.5-2% but in contaminated air it in the range of 2.5%.by analyzing the graphical representation of precipitated output, SO_2 is in the range of 1.5-1.9 ppm which is below the prescribed emission norms.

Similarly CO_2 content of the contaminated and precipitated air was compared and result was verified (as shown in the fig).

Cost of estimation

Table 2. Cost Estimation

SL .NO	COMPONENT	UNIT	PRICE (Rupee)
1	Plywood	4*4cm	1500
2	Aluminium plate	2*2cm	80
3	Wire mesh	2*2cm	50
4	High voltage DC supply	kV	2000
5	Exhaust Fan	2	100
6	Aluminium wire	1m	30
7	Nuts and screws	As required	10
8	fuse carrier	1	50
9	Fevicol and flex	1	50
10	Glass	30*20 cm	120
		Total cost	**3940**

Benefits

• The efficiency for the removal particles/pollutants is high up to 99%, over a wide range of particle sizes.

• Electrostatic precipitators are efficient in collecting dry pollutants.

• Operating cost of electrostatic precipitators are low and in the long run they are economically feasible.

• More flexible

Limitations

• Due to the corona effect power loss may occur.

• Wet particles cannot be removed.

CONCLUSION

This portable ESP is low cost and efficient in collecting the dust particles. It does not any additional requirements for installing. The polluted gas outlet can be directly connected to the inlet of the ESP, due to the presence of a draught fan, the air will be automatically for into the electrodes. Since the Hooper is removable type cleaning will be easier. Installing this kind of ESP is possible for all middle level people, so the pollution in the atmosphere can be reduced drastically.

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REFERENCES

[1] Moorthy, C. Ganesa, G. UdhayaSankar, and G. RajKumar. "A Design for Charging Section of Electrostatic Precipitators by Applying a Law for Electric Field Waves." *Imperial Journal of Interdisciplinary Research* 3.6 (2017): 842-844.

[2] Ayturan, Yasin Akın, Ali Öztürk, and Zeynep Cansu Ayturan. "Modelling of PM10 Pollution in Karatay District of Konya with Artificial Neural Networks." *Journal of International Environmental Application and Science* 12.3 (2017): 256-263.

[3] Parker, Ken R. "Why an electrostatic precipitator?." *Applied Electrostatic Precipitation*. Springer, Dordrecht, 1997. 1-10.

[4] McDonald, Jack Raymond, and Alan H. Dean. "Electrostatic precipitator manual." (1982).

[5] Jedrusik, Maria, ArkadiuszSwierczok, and RyszardTeisseyre. "Experimental study of fly ash precipitation in a model electrostatic precipitator with discharge electrodes of different design." *Powder Technology* 135 (2003): 295-301.

[6] Mainelis, Gediminas, et al. "Design and collection efficiency of a new electrostatic precipitator for bioaerosol collection." *Aerosol Science & Technology* 36.11 (2002): 1073-1085.

[7] Rothenberg, Larry, Alan Viosca, and Igor Krichtafovitch. "Electrostatic air filter design and assembly." U.S. Patent Application No. 15/653,440.

[8] Phillips, James R., et al. "Design of a Second Generation Electrostatic Precipitator for Martian Atmospheric Dust Mitigation of ISRU Intakes." *2018 AIAA SPACE and Astronautics Forum and Exposition*. 2018.

[9] Sander, Sören, Steffen Gawor, and UdoFritsching. "Separating polydisperse particles using electrostatic precipitators with wire and spiked-wire discharge electrode design." *Particuology* 38 (2018): 10-17.

[10] Cheremisinoff, PaulN. *Air pollution control and design for industry*. Routledge, 2018.

[11] Khaled, Usama, et al. "Experimental and analytical study on the performance of novel design of efficient two-stage electrostatic precipitator." *IET Science, Measurement & Technology* 12.4 (2018): 486-491.

[12] Arif, S., et al. "The influence of design parameters on the occurrence of shielding in multi-electrode ESPs and its effect on performance." *Journal of Electrostatics* 93 (2018): 17-30.

[13] Bacher, Christian, et al. "Discharge electrode geometry and energy efficiency in a one-stage wire–tube electrostatic precipitator operating at high concentrations of submicron liquid aerosol." *Environmental technology* (2018): 1-13.

[14] Ayturan, Yasin Akın, Zeynep Cansu Ayturan, and Hüseyin Oktay Altun. "Air pollution modelling with deep learning: a review." *International Journal of Environmental Pollution and Environmental Modelling* 1.3 (2018): 58-62.

[15] Moorthy, C. Ganesa, G. Udhaya Sankar, and Graj Kumar. "What Is The Polarity Of An Electromagnetic Wave?." *Indian J. Sci. Res* 13.1 (2017): 255-256.

[16] Moorthy, Ganesa. "Application of Raman Spectroscopy to Pollution Control Using Wave Numbers." *International Journal of Environmental Pollution and Environmental Modelling* 2.1 (2019): 44-47.

[17] Udhaya Sankar, G., C. Ganesa Moorthy, and G. RajKumar. "Smart Storage Systems for Electric Vehicles–A Review." *Smart Science* 7.1 (2019): 1-15.

[18] Moorthy, C. Ganesa, G. Udhaya Sankar, and G. RajKumar. "Temperature of Black Holes and Minimum Wavelength of Radio Waves." *International Journal of Scientific Research in Science, Engineering and Technology* 4.4 (2018): 1104-1107.

[19] Moorthy, C. Ganesa, G. Udhaya Sankar, and G. Rajkumar. "Two Expressions for Electrostatic Forces and For Magnetic Forces to Classify Electromagnetic Waves." *Imperial Journal of Interdisciplinary Research* 3.10 (2017): 706-709.

[20] Vallikkodi, M., G. Udhaya Sankar, and P. Vishnukumar. "An Innovative Interpretation for Parallel Universe." *Imperial Journal of Interdisciplinary Research* 3.5 (2017).

[21] Moorthy, C. Ganesa, G. Udhaya Sankar, and G. Rajkumar. "Rotating Bodies Do Have Magnetic Field." (2016).

[22] Moorthy, C. Ganesa, G. Udhaya Sankar, and G. RajKumar. "LIGOs Detected Magnetic Field Waves; not Gravitational Waves." *Imperial Journal of Interdisciplinary Research* 3.8 (2017): 268-269.

[23] Udhaya Sankar, G., C. Ganesa Moorthy, and G. RajKumar. "A suggestion for a good anode material synthesized and characterized." *Discov* 54 (2018): 249-253.

[24] Sankar, G. Udhaya. "Climate change challenge–photosynthesis vs. hydro-electrolysis principle." *Climate Change* 3 (2016): 128-131.

[25] Sankar, G. Udhaya. "A Survey on Wavelength Based Application of Ultraviolet LED." *computing* (2007).

[26] UdhayaSankar, G., C. GanesaMoorthy, and G. RajKumar. "Global Magnetic Field Strengths of Planets From A Formula." (2016).

[27] Moorthy, C. Ganesa, and G. Udhaya Sankar. "Planck's Constant and Equation for Magnetic Field Waves." *Natural and Engineering Sciences* 4.2: 107-113.

[28] Moorthy, C. Ganesa, G. Sankar, and G. Rajkumar. "Simplified Interpretation for Einstein's Energy Mass Relation." *Imperial Journal of Interdisciplinary Research* 3 (2017).

[29] Moorthy, C. Ganesa, G. Udhaya Sankar, and G. Raj Kumar. "Why Do Distant Planets Have Speedy Winds." *Mercury* 3: 0-24055556.

[30] MOORTHY, C. G., SANKAR, G. U., & KUMAR, G. A VELOCITY INDEX FOR EXISTENCE OF ATMOSPHERE IN A PLANET. Mercury, 4(47.4), 10-8937.

[31] Udhaya Sankar, G., C. Ganesa Moorthy, and G. RajKumar. "Synthesizing graphene from waste mosquito repellent graphite rod by using electrochemical exfoliation for battery/supercapacitor applications." *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* 40.10 (2018): 1209-1214.

[32] Moorthy, Ganesa, G. RajKumar, and S. Sekar. "New Design for Charging Section of Electrostatic Precipitators Using Thermocouple Principle for Air Pollution Control." *International Journal of Environmental Pollution and Environmental Modelling* 1.4 (2018): 116-119.