Modeling, Analysis and Design of Cost Effective Cylindrical Wire-Plate Electrostatic Precipitator Using PV Array

V. Mahalakshmi, S.P. Vijayaragavan

Abstract— ***The ultimate aim of our work is to design an Electrostatic precipitator with an help of a PV array which will help up us to develop a model in which the PV array will serve as an input base. Here we are going to use cylindrical wire-plate type Electrostatic Precipitator. H-Bridge inverter and high frequency Transformer-Rectifier which we are using here gives the actual DC supply to our newly designed EP unit. Here the entire design of the EP unit which works on solar is done with the help of Matlab Simulink and results are being declared.***

Keywords— ***Electrostatic Precipitator (EP), H-Bridge inverter, Step-up transformer, Potential difference, Electrostatic preceptors***

1. INTRODUCTION

Nowadays the present research is going on in the field of electrostatic precipitator. Here we are going to design a new modeling technique of electrically charged particles in a model plate and a single wire-plate electrostatic precipitator (EP). Here particle concentrations plays a vital role in finding the flow of particles between the plate and the electrostatic needle. The two model predictors used are k means and poison distribution equations. These two determine the actual electrostatic concentration between the particles. The proposed model and the existing methodology parameters such as electric field, charging kinetics and particle concentration is taken into account and it is applied to precipitators. The present study is different from the earlier study were a homogeneous electric field or an infinite turbulent diffusivity are directly proportional to each other. The electric field is calculated by the migration particle which will help out in the particle distribution and energizing. The proposed model can be implemented in a a full-fledged EP model with no limitations on the particle concentration. Here the particle size plays a vital role in determining the electric charge distribution between the needle and electrostatic plate.

Here we are going to design very cheap rated electrostatic precipitator which is been generated from the medical waste. Here the DC Supply is given by H-Bridge inverter and a high frequency transformer. Voltage source inverter which we are using helps in converting dc power which s been generated from solar panel and converted into AC power.

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2. DC SOLAR POWERED TO HVDC CONVERTER

The following figure.1 is the circuit diagram of our projected design. The main components includes solar panel, Step-Up high frequency transformer, H-bridge inverter, and a High voltage Bridge rectifier. The input voltage which is been generated by the solar panel is been converted into AC current by using inverter that is present in the system. The output which is been driven from the inverter is feded to the high voltage transformer rectifier which helps in producing high voltage DC to Electrostatic Precipitator.

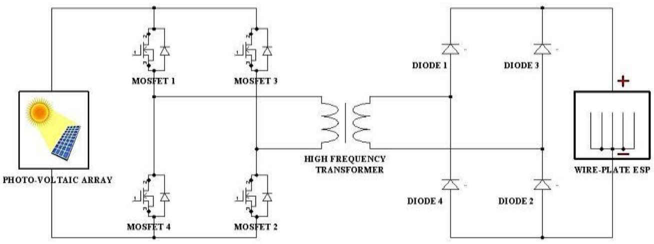

Fig.1. Circuit Diagram of power supply to EP model

The following Figure 2 is the simulink figure of high voltage power source to the EP unit. We are using Matlab simulink as tool to design this. Here the MOSFET switch which is been used helps in providing high frequency voltage to the system. Swapping frequency of the MOSFET switch will be 10KHz.

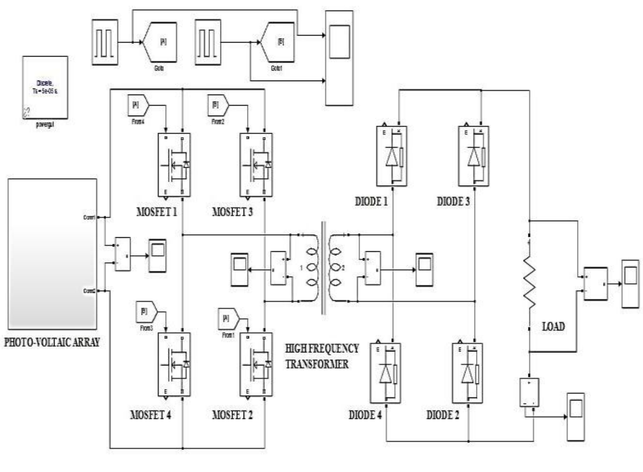

Fig.2. Simulink Diagram of power supply to EP model

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3. MODELING OF CYLINDRICAL WIRE-PLATE ESP IN COMSOL MULTIPHYSICS

3.1 Operation value

The whole work of the Electrostatic Precipitator is mostly depending on the applied voltage and current that is given to the system. The corona release relative of EP model is given by [10]

$$I = AV\,(V - V_c) \tag{1}$$

Where V-applied voltage, A-constant, Vc-corona starting voltage

Here the corona starting voltage and the corona onset field (E_C) is assumed by the subsequent equations [11]

$$V_c = E_c r_w \ln\left(\frac{d}{r_w}\right) \tag{2}$$

$$E_c = 3.126 \times 10^6 d_r \left[1 + 0.0301\left(\frac{d_r}{r_\omega}\right)^{0.5}\right] \tag{3}$$

If the applied voltage of the system is increased then the electric field asset among wire and plate will be increased [11].

$$E_s = 6.3 * 105\left(\frac{273P}{T}\right)^{1.65} \tag{4}$$

Where T-absolute temperature in Kelvin ,E_s-Electric field strength, P-Pressure.

3.2 Particle Charging

The element accusing is really an significant work in the EP model. Here the corona discharge is been produced as a result of particle charging [10].

$$q(t) = q_\infty \frac{\frac{t}{\tau}}{1 + \frac{t}{\tau}} \tag{5}$$

Where q_∞-saturation charge, t-charging time, r-time constant of the field charging

3.3 Transmitting Velocity of charged particles

The transmitting velocity is called as the velocity of the emotional elements. These particles move near the gathering plate in the EP Model. The Coulomb force of a emotional particle is given by [10]

$$F = qE \tag{6}$$

F-Coulomb force (N) q-positive charge (C) and E-electric force (V/m).

3.4 Collection Efficiency of EP model

The combined collection efficiency (η) of EP model is assumed by [10]

$$\eta = 1 - \exp\left(\omega_e - \frac{eA}{Q}\right) \tag{7}$$

Where, ω_e-migration velocity and (A/Q)-specific collection area, A-area of collection electrode and Q-gas flow rate. The following figure 3 is the 3D model of cylindrical wire plate ESP.

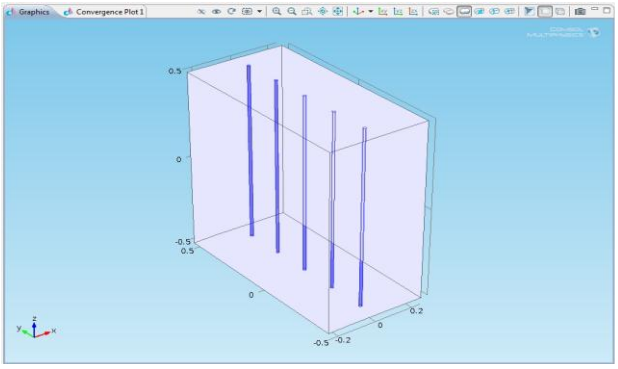

Fig.3. Cylindrical Wire- Plate Electrostatic Precipitator

3.5 Electrical Field and Potential Distribution of Needle plate Configuration

It is found from the fig 4 the potential distribution is always high in the wire region and it will be null value in the crosswise plates. The dark yellow color exposed in figure 4 has got the estimation of -70000 V. With the help of this color we have found that a high potential exists in the cylindrical wire. The red color tells us if zero is the potential.

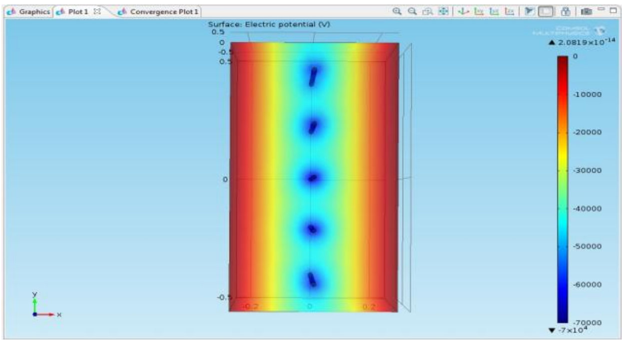

Fig.4. Potential Distributions from wire to plate at -70kV

When input voltage is given to the wire, a strong electric ground is been generated in between wire and plates. When the functional voltage attains the corona onset voltage, we can see contemporary is graceful among wire and plate. It is found that electric field concentration is straight comparative to the applied voltage.

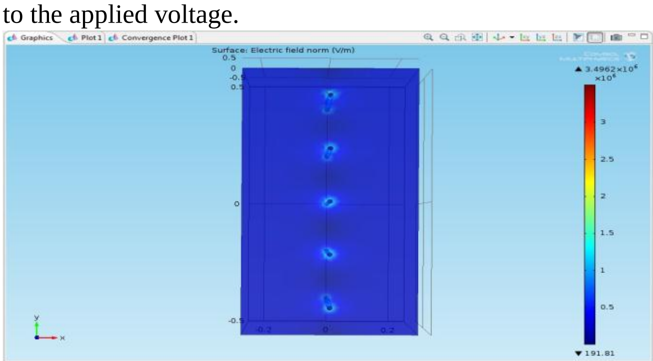

Fig.5.Electric field for -70kV

The following fig 6 characterizes the potential circulation of plate in EP model. When comparing it is found that electric potential distribution will increase if there is increase in the actual applied voltage.

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The electric potential of the system is indicated by blue color in the following graph.

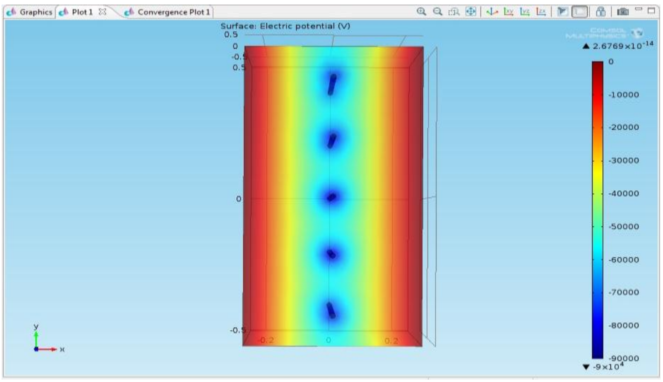

Fig.6. Potential Distributions between needle and plate

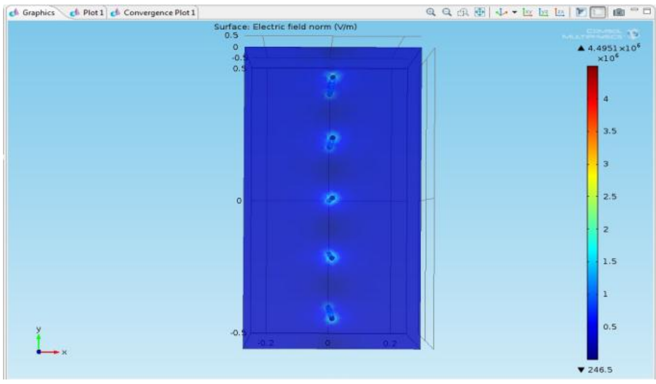

Fig.7.Electric field for -90kV

This following table 1 represents the electric field concentration and electric potential at different charging points.

Type of ESP	POTENTIAL DIFFERENCE (V)				ELECTRIC FIELD INTENSITY(V/m)		
	Voltage Applied	IN Wire	Plate Spacing	Ground Plate	IN Wire	Plate Spacing	Ground Plate
Wire-Plate ESP	**-90kV**	-90kV	-39000V	0	$3.49*10^6$V/m	26000V/m	0.5162V/m
Needle-Plate ESP	**-90kV**	-90kV	-37000V	0	$3.1*10^6$V/m	22000V/m	0.3162V/m

Table.1. Results of EP Model simulation

4. SIMULATION RESULTS AND DISCUSSION

The following Fig 8 is the High DC output voltage which is been gotten from the above Fig.2. Simulink Diagram. The next Fig. 9 is the output current of the exact electrostatic precipitator (EP) model.

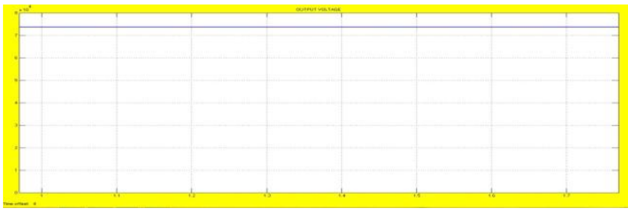

Fig.8. High Voltage DC between Needles to plate

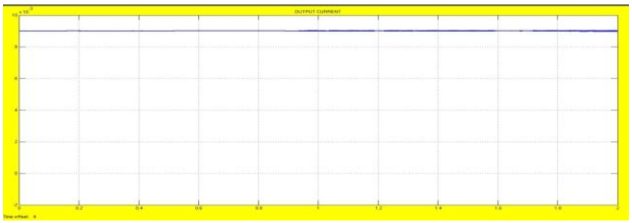

Fig.9. Current flowing from Needles to plate

The figure 10 represents the primary winding voltage of the transformer. The dc voltage that is been fashioned from the solar panel is been inverted by using voltage source inverter and the voltage is given to the prime winding of the transformer.

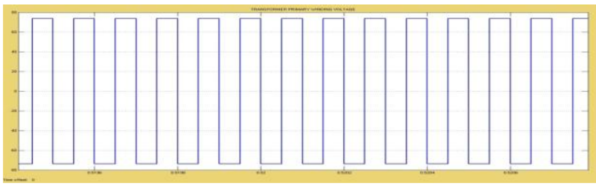

Fig.10. Primary Winding Voltage of the Transformer

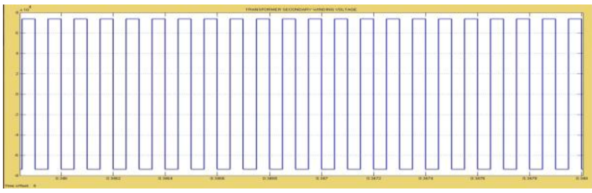

Fig.11. Secondary Winding Voltage of the Transformer

The pulse signal which s been generated from the PIC microcontroller is given as input to the mosfet driver. Here the amplification of the pulse signal takes place and fed to the MOSFET terminals. The MOSFET adjustment is usually functioned in the range of 10 KHz frequency. The pulse signal generated and its corresponding simulink is been represented in figure 12.

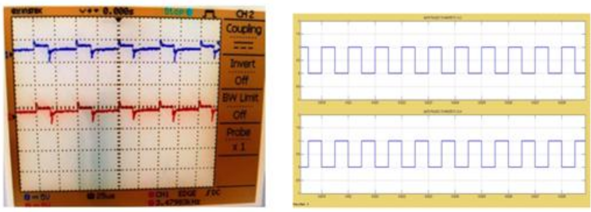

Fig.12. Pulse signal generation

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CONCLUSION

Here we have developed an low cost high efficient electrostatic precipitator model using MATLAB software. It is based on solar panel as input component. When following the above parameters we can build up a good EP model which can be easily implemented in all areas in a good efficient manner.

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