GREENV: GREEN AND HEALTHY ENVIRONMENT THROUGH MINIMIZING CARBON CONTAMINANTS BY EXHAUST GASES

SUBMITTED BY

RAJA SHEHRYAR IQBAL

SHAKEEL AHMED

ABDUL BASIT

SUPERVISOR

Dr. JAVED AHMED KHAN TIPU

DEPARTMENT OF MECHANICAL ENGINEERING

INTERNATIONAL ISLAMIC UNIVERSITY

ISLAMABAD, PAKISTAN

2023

GREENV: Green and Healthy Environment Through Minimizing Carbon Contaminants by Exhaust Gases

APPROVAL SHEET

SUBMITTED BY

Raja Shehryar Iqbal (829-FET/BSME/F19)

Shakeel Ahmed (832-FET/BSME/F19)

Abdul Basit (845-FET/BSME/F19)

Submitted for the partial fulfillment of the Degree of Bachelor of Science in Mechanical Engineering

Supervised by: ______________________________

Dr. Javed Ahmed Khan Tipu

Co-Supervisor by: ____________________________

Dr. Muhammad Arif

Approved by: ________________________________

Dr. Adnan Aslam Noon

GREENV: Green and Healthy Environment Through Minimizing Carbon Contaminants by Exhaust Gases

By

RAJA SHEHRYAR IQBAL

SHAKEEL AHMED

ABDUL BASIT

A thesis
presented to the International Islamic University,
Islamabad in partial fulfillment for the degree
requirement of
Bachelor of Science
in
Mechanical Engineering

2023

Islamabad, Pakistan

AUTHOR'S DECLARATION

We hereby declare that no portion of the work referred to in this report has been submitted in support of an application for another degree or qualification of this of any other university or other institute of learning. If any act of plagiarism found, we are fully responsible for every disciplinary action taken against us depending upon the seriousness of the proven offence, even the cancellation of our degree.

Signature of Students

829/FET/BSME/F19

832/FET/BSME/F19

845/FET/BSME/F19

ABSTRACT

Our project GREENV is a combination of two words, GRE for "GREEN" and ENV for "Environment" which means "Green Environment". Our purpose is to establish a green & healthy environment under the agenda of the 13th Sustainable Development Goal (SDG) which is Climate Action. Therefore, GREENV comes along with a unique solution to combat climate crises as we are manufacturing GREENV devices that are installed on the tailpipes of diesel vehicles, generators, chimneys...etc for the collection of carbon soot particles present in exhaust gases, that are the root cause. The uniqueness is that these captured soot particles are then reused to make Carbon Tiles and Carbon Ink. There are catalytic converts and Diesel Particulate filters that are installed within the vehicles' system whose purpose is to capture soot particles and to emit clean smoke. The difference between them and in our device GREENV is that in Catalytic converters & in Diesel Particulate Filter, they burned out the collected carbon soot particles at the moment while in our device we do not burn the captured carbon soot particles, instead of that, we reused them to make carbon tiles and carbon ink. Our target audience is government institutions, factories, industries, and all stakeholders which will help us to implement our GREENV devices on public transport buses, cars, industries, factories...etc under the agenda of the 13th sustainable development goal (SDG) which is climate action.

Keywords: Greenv, Climate Change, Green, Healthy, Environment

Acknowledgement

In performing our final year project, we had to take the help and guideline of some teachers, who deserve our greatest gratitude. This project's completion brings us a great deal of information and joy. We are grateful to **Dr. Javed Ahmed Khan Tipu,** Lecturer in the Department of Mechanical Engineering, for providing us with a solid thesis guideline throughout the course of multiple discussions. We also want to express our sincere gratitude to everyone who helped us write this thesis, both directly and indirectly.

Also, a big thank you to **Dr. Muhammad Arif,** whose enthusiasm for students' underlying structures had a lasting impact and who introduced us to the work methodology. Numerous people, particularly our classmates, provided insightful comments and ideas on this project, which inspired us to better our senior project. We would like to thank everyone who contributed directly or indirectly to the completion of our thesis.

Table Of Contents

List of Figures

CHAPTER 1 INTRODUCTION

1.1 Project Title

Greenv: "Green & Healthy Environment through minimizing carbon contaminants by exhaust gases. GREENV is a combination of two words, GRE for "GREEN" and ENV for "Environment" which means "Green Environment". Our purpose is to establish a green & healthy environment under the agenda of the 13^{th} Sustainable Development Goal (SDG) which is Climate Action.

1.2 Background

Now a day, Diesel Vehicles, Factories, Chimneys, Electric Generators, oil & gas industries and many more industries & equipment's emit a lot of carbon soot particles through their exhaust gases from tail-pipes. Carbon soot particles contribute to air pollution and have detrimental effects on human respiratory health. Inhaling these particles can lead to various health problems, including asthma, wheezing, and serious conditions such as carcinoma and lung cancer. Unfortunately, there is currently no effective method for the proper disposal of carbon soot particles.

Air pollution occurs when the atmosphere is contaminated by excessive amounts of harmful substances, including gases, particulates, and biological molecules. This pollution can lead to diseases, allergies, and even fatalities in humans, while also posing risks to other organisms and damaging the natural or built environment. Both human activities and natural processes can contribute to the occurrence of air pollution.

An air pollutant is a substance that has negative effects on both human health and the ecosystem. These pollutants can take the form of solid particles, liquid droplets, or gases, and they can originate from natural sources or human-made sources. Air pollutants are typically categorized into two types:

1. Primary pollutants: These are directly emitted into the air from specific processes. Examples include ash from volcanic eruptions, carbon monoxide from vehicle exhaust, and sulfur dioxide released by factories.
2. Secondary pollutants: Unlike primary pollutants, secondary pollutants are not emitted directly into the air. Instead, they form through chemical reactions or interactions among primary pollutants. Ground-level ozone serves as a prominent example of a secondary pollutant.

It is essential to address and mitigate air pollution through various measures to protect human health, safeguard ecosystems, and preserve the environment for future generations.

1.2.1 Sources of Air Pollution:

Pollutants are released into the atmosphere from various locations, activities, or factors. These sources can be broadly categorized into two major groups.

Anthropogenic (man-made) Sources

The release of pollutants into the atmosphere is primarily associated with the combustion of various fuel types. These sources can be categorized as follows:

Stationary sources: This includes smoke stacks from fossil fuel power stations, manufacturing facilities, waste incinerators, furnaces, and other heating devices that burn different fuels.

Mobile sources: This category comprises motor vehicles, marine vessels, and aircraft, all of which emit pollutants during their operation.

Controlled burn practices: Controlled or prescribed burning is a technique employed in agriculture and forest management. It involves deliberately burning vegetation to stimulate the germination of desirable forest trees and promote forest renewal.

Volatile compounds: Pollutants can be released from the fumes of paints, hair spray, varnish, aerosol sprays, and other solvents containing volatile compounds.

Landfill emissions: Waste deposition in landfills produces methane, which is a potent greenhouse gas and air pollutant.

Military activities: Military resources such as nuclear weapons, toxic gases, germ warfare, and rocketry can also contribute to air pollution.

These various sources collectively contribute to the release of pollutants into the atmosphere, highlighting the need for comprehensive pollution control measures and sustainable practices to minimize their impact on human health and the environment.

Natural Sources

Various sources contribute to air pollution, and they can be categorized as follows:

Natural sources: Dust generated from large land areas with minimal vegetation is a natural contributor to air pollution.

Animal emissions: Methane, a greenhouse gas, is emitted during the digestion of food by animals.

Radon gas: Radon is released through radioactive decay within the Earth's crust and can contribute to air pollution.

Wildfires: Smoke generated from wildfires can release harmful pollutants into the atmosphere.

Vegetation emissions: In certain regions, vegetation can emit significant amounts of volatile organic compounds (VOCs), which have environmental implications.

Efforts should focus on implementing measures to mitigate the release of these pollutants into the air, as well as finding sustainable alternatives that minimize the impact on human health and the environment.

Particulate Matter

Soot, the particulate matter captured by this device, consists of fine black particles primarily composed of carbon. It is produced through the incomplete combustion of fossil fuels. These soot particles are incredibly small, often smaller than dust or mold, with a diameter about 1/30th the size of a person's hair. Due to their size, they can penetrate deep into the lungs and pose significant health risks.

Recent research conducted at Stanford University indicates that particulate matter, including carbon soot, contributes to approximately 15 to 30% of global warming (Jacobson 2007a, b). Carbon soot is characterized as a substance with eight parts carbon to one part hydrogen (Srivastava and Agarwal 2011). Its true density is estimated to be 1.84 ± 0.1 g/cm3, while the bulk density ranges from 0.02 to 0.4 g/cm3 (Choi et al. 1994).

Incomplete combustion of petroleum products, wood, fuel oil, plastics, and household waste are the primary sources of carbon soot. Diesel emissions from vehicles, domestic heating, and wildfires also contribute to carbon soot emissions (Bølling et al. 2009). Polycyclic aromatic hydrocarbons, which are generated from liquid or gaseous fuels, are among the key components of carbon soot (Srivastava and Agarwal 2011).

Addressing and minimizing carbon soot emissions is of utmost importance, and this can be achieved through the adoption of cleaner combustion technologies, the promotion of sustainable energy sources, and the implementation of effective pollution control measures. By reducing carbon soot emissions, we can mitigate its adverse impact on both human health and the environment.

Figure 1: Glaciers Absorbing Sunlight

In addition to its impact on air quality, particulate matter, including carbon soot, also poses a threat to cultural heritage. It stains and deteriorates stone inscriptions, sculptures, statues, and monuments, diminishing their aesthetic and historical value. Furthermore, the transportation of soot by wind and ocean currents to the polar ice caps in the Arctic and Antarctic regions has catalyzed the melting of these ice caps by absorbing sunlight (Jacobson 2004, 2005).

To preserve our cultural heritage and address climate concerns, it is crucial to reduce carbon soot emissions not only for the benefit of human health but also to protect valuable artifacts and mitigate the effects of climate change on our planet's ice caps. This requires concerted efforts in pollution reduction, renewable energy adoption, and sustainable practices.

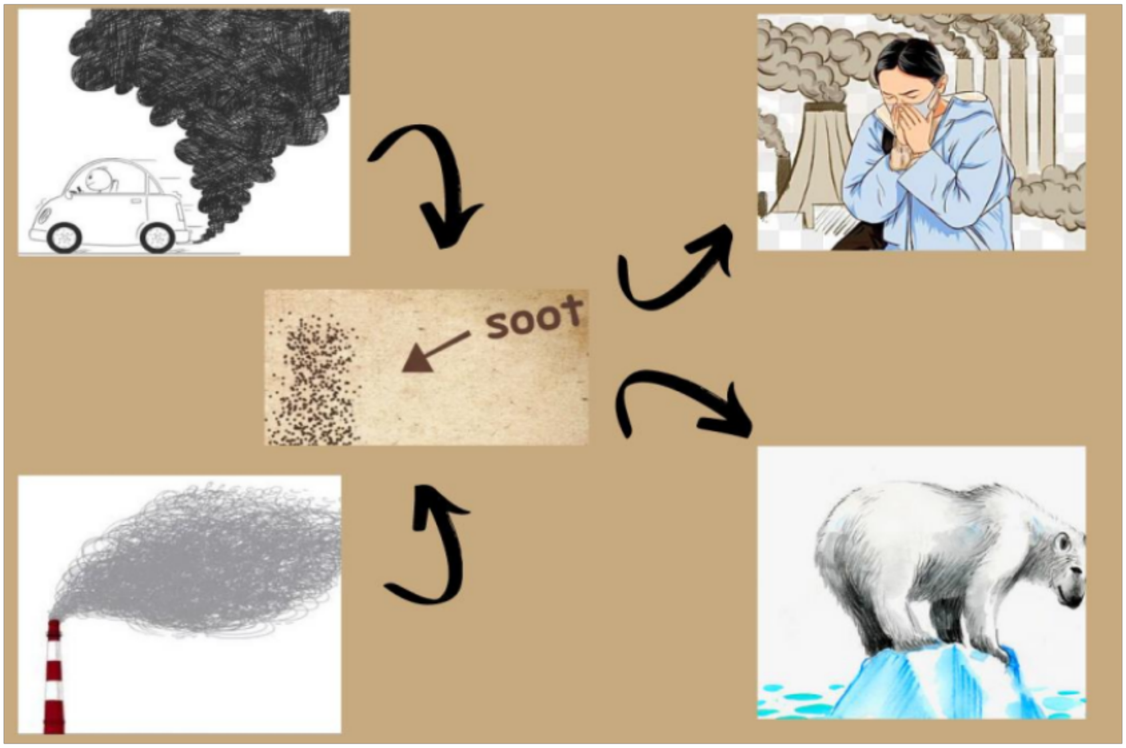
When snow is covered with soot, it absorbs a greater amount of the Sun's energy and heat compared to pristine, white surfaces that reflect the Sun's rays. As global warming progresses, many snow- and ice-covered regions are already experiencing melting. As glaciers and ice sheets melt, they tend to accumulate more dirt and soot, further intensifying their darkening effect. This additional soot contributes to the warming process by making icy surfaces darker and increasing their absorption of solar energy. Similar to how wearing a black shirt outdoors absorbs more solar energy and keeps you warmer than a white shirt, soot particles on snow effectively absorb sunlight. Thus, they enhance the warming effect as ice melts.

1.3 Problem Definition

The problem we are trying to solve is to reduce air pollution and then convert it into carbon ink & carbon tiles. It is a sustainable idea in which we are going to collect carbon black (Soot) also called particulate matter (PM 2.5) from automobile engine emissions by using a carbon collecting device and reuse that carbon black (soot) to form different carbon products. As we all know the world is facing a serious problem regarding air pollution, thus we will work on sustainable project to reduce air pollution. Most of carbon black (Soot) coming from diesel engines exhaust emission (generators and automobiles) tail pipes, Chimneys, biomass burning, including wildfires, residential heating and industry. Developing countries in Asia, Africa and Latin America emit more than 75 percent of global black carbon (Soot) emissions, mainly from cook stoves and the burning of solid fuels like coal and wood for heating, which especially affects the health of women.

Air pollution, both outdoors and indoors, causes millions of premature deaths each year. The deaths are mainly caused by the inhalation of particulate matter. Black carbon, a component of particulate matter, is especially dangerous to human health because of its tiny size. But black carbon not only has impacts on human health, it also affects visibility, harms ecosystems, reduces agricultural productivity and exacerbates global warming which cause melting of glaciers

Figure 2: Carbon Soot Problems



Microscopic particle can penetrate deep into the lungs and have been linked to a wide range of serious health effects, including premature death, heart attacks, lungs cancer, strokes, as well as acute bronchitis and aggravated asthma among children. Therefore, due to these reasons, we are collecting this carbon black through exhaust emissions and then use it to make carbon ink & carbon tiles to create green impact on our society.

1.4 Project Scope

Our project is unique and great as to make a Green & Healthy Environment by reducing carbon contaminants through exhaust gases, is not only beneficial for humans but for all the creatures and stakeholders of society & Planet. Our uniqueness is that the device "GreenV" which we design and manufacture is the first one in Pakistan that will install on the tailpipes of Diesel Vehicles, Factories, Chimneys, Generators, industries…etc. for the collection of Carbon Soot Particles (PM 2.5), causing Global Warming, Climate Change, Air Pollution, SMOG, and Health diseases.

The carbon soot particles collecting devices are available at International Level but not available in Pakistan. Therefore, we are manufacturing carbon soot particles collecting device to make it economically sustainable and more efficient for Pakistan. The device will be equally applicable to the industrial and logistic industries.

As we all know that Pakistan is facing serious Climate Crises, due to which floods across Pakistan have been caused and devastating the whole life cycle. Thus, we came up with an impactful, unique, and problem-solving idea that will mitigate the Climate Crises in Pakistan.

Along with this, we also have following benefits that our project will solve following hot problems:

1. Air Pollution.
2. Carbon Soot Particles (PM 2.5)
3. Climate Change
4. Global Warming
5. SMOG
6. Health & Respiratory diseases caused by Carbon Soot Particles.
7. Climate & Flood Crises in Pakistan.

Therefore, the scope of our project is very vast as it is directly reducing the air pollution while indirectly reducing the global warming, climate change, smog, health diseases that are causing because of it. As government & organizations are working on the mitigation & awareness of the climate crises, since it is a matter of lives of millions of peoples & all the natural habitat.

1.5 Need Assessment

Every year 7 million People died due to Air Pollution globally. Out of which, 1.3 million people died annually in Pakistan. The Air Pollution becomes the 4th major cause of deaths in recent years. The root cause of Air Pollution is the Carbon Soot Particles (PM 2.5) emitted by the exhaust gases through the tailpipes. Carbon Soot Particles (PM 2.5) are not only causing Air Pollution but also contributing towards Global Warming, Climate Change, SMOG and Health Diseases.

According to a recent study at Stanford University, particulate matter or carbon soot particles (PM 2.5) accounts for about 15 to 30% of global warming. As we all know that Pakistan is facing a serious problem regarding Global Warming, Climate Change, Air Pollution & Smog, due to which floods across the Pakistan have been caused because of abnormal melting of glaciers, and unusually heavy rains, devastating the whole life cycle.

Therefore, the need of our project is very demanding in order to tackle the issues like global warming, air pollution, smog, climate change and health diseases. Since, we all know that Pakistan is facing a serious problem regarding Global Warming, Climate Change & Air Pollution, due to which floods across the Pakistan have caused because of abnormal melting of glaciers, unusual heavy rains and it results in devastation of the whole life cycle.

As young professionals and youth of Pakistan, our project GREENV and all other projects related to climate change are the need of day in order to protect the habitat from climate change & save humans & environment from different diseases caused by particulate matter such as lungs cancer, asthma, etc and to control the carbon emissions for the development of green and healthy Pakistan.

CHAPTER 02: LITERATURE REVIEW

Air pollution poses a significant challenge in our modern era, impacting both climate change and public health negatively. It contributes to increased rates of illness and death, primarily due to various pollutants. Particulate Matter (PM), comprising small particles, can infiltrate the respiratory system and lead to respiratory and cardiovascular ailments, reproductive and central nervous system issues, and even cancer. Ground-level ozone, originally beneficial in the stratosphere, becomes harmful and affects the respiratory and cardiovascular systems. Nitrogen oxide, sulphur dioxide, Volatile Organic Compounds (VOCs), dioxins, polycyclic aromatic hydrocarbons (PAHs), carbon monoxide, and heavy metals like lead are all hazardous air pollutants associated with respiratory disorders such as Chronic Obstructive Pulmonary Disease (COPD), asthma, bronchiolitis, lung cancer, cardiovascular events, central nervous system dysfunctions, and skin conditions. Furthermore, environmental pollution and climate change have consequences on the spread of infectious diseases and the occurrence of natural disasters[1].

Black carbon, a component of soot, is a potent absorber of solar radiation in the atmosphere. It is primarily emitted from human activities, with a higher concentration in tropical regions. Transported over long distances, it mixes with other aerosols to form extensive atmospheric brown clouds. Black carbon emissions rank as the second largest contributor to global warming after carbon dioxide due to its strong absorption, regional distribution aligned with solar irradiance, and its role in the formation of atmospheric brown clouds. In the Himalayan region, black carbon's solar heating significantly impacts the melting of snowpacks and glaciers. These atmospheric brown clouds reduce surface solar radiation and the deposition of black carbon on snow and ice surfaces accelerates their melting, particularly in the Arctic [2]

Precipitator type (parameters)	Charging device (voltage, current, current density)	Collection electrodes geometry	Dust particle size and charge (resistivity)	Gas flow rate (velocity, residence time)	Dust loading (particle concentration)	Collection efficiency (reduction ratio)
Tubular ESP, 6 m high (3 m^2 total cross section)	Barbed discharge electrode (−75 kV)	Cylindrical	Cement dust	8600 m^3/h (0.8 m/s)	128 g/m^3	99.9% (outlet 86 mg/m^3)
Electrocyclone, 50 mm dia.	Wire-cylinder precharger	Cylindrical (1600 kV/m)	SiO_2 1–20 μm	4–12 m^3/h		75% (55% for uncharged)
Electrocyclone 75 mm dia., 240 mm height	Wire cylinder, 330 μm wire (−4 to −9 kV)	Cylindrical	Fly ash > 1 μm	36–1300 m^3/h (0.5–30 m/s surface velocity)	8–23 g/m^3	92% (72% for uncharged 10 μm)
Electrocyclone 480 mm dia., 3280 mm height	Wire cylinder	Cylindrical	Diesel engine soot	470 m^3/h	1 g/m^3	50–80%
Two-stage tubular ESP, 100 mm dia., 450 mm length	Co-axial corona triode charger, 25 μm silver wire (6–12 kV), (+2 kV—grid), (3.7 μA, 10^7/cm^3 ion concentration)	Cylindrical (2 or 3 kV)	Particles in ambient air 0.3–13 μm, 15e; PSL 18–255 nm; NaCl 4-11 μm	1 m^3/h (1 s)	0.5–3 μm/m^3	96% (particles in ambient air); 99.7% (PSL); 99.9% (NaCl)
Electrocyclone, 430 mm dia., 3.1 m long	Wire cylinder, 10 mm stainless steel wire with 10 mm long barbs, pulse excitation (93 or 105 kV, 50–100 pulse/s, 30 μs pulse width), (30 mA)	Cylindrical	Dust particles ($NH_4Cl + NH_3 + H_2O$) 3.1 μm (mean)	15,000 m^3/h	50 g/m^3	90% (93 kV pulse), 92.6% (105 kV pulse) (75–80% for 62–70 kV dc; or 42.5% uncharged)

Figure 3: Table of ESP Features

Above table provides different diameters of stainless-steel electro cyclones and electrostatic precipitators, along with their respective high voltage charge rods. These are used for particle separation. The diameters listed in the table represent various sizes of the electro cyclones, impacting their efficiency in separating particles. The high voltage charge rods create an electric field within the electro cyclone, aiding in the attraction and separation of charged particles. The selection from the table is based on the desired particle separation efficiency, system requirements, and operating conditions [3].

Experiments performed using a lab-scale tubular electrostatic precipitator (ESP) to investigate its effectiveness in reducing particulate matter (PM) emissions. The experiments involved using a small diesel engine as the source of smoke and PM. Opacity and particle concentration were measured, and a correlation between opacity and particle concentration was established. The study examined the influence of various operational factors on the ESP's voltage-intensity (VI) curves, such as voltage polarity, discharge electrode diameter, humidity, electrode temperature, and fouling. The findings demonstrated that negative voltages resulted in high collection efficiencies and short test durations. The article also emphasized the significance of avoiding structures that connect discharge and collection electrodes in the flue gas to prevent electrical issues caused by fouling [4].

The combustion of fuel in ships main engines contributes to air and sea pollution. To mitigate air pollution from industrial burning, electrostatic precipitators (ESPs) are commonly employed to remove gas pollutants using an electric field. This research aims to develop an ESP concept for reducing pollutants from ship engine emissions. Experimental methods were utilized to evaluate the effectiveness of the ESP. The results demonstrate that the use of the ESP significantly reduces nitrogen dioxide (NO2) levels from 7.70 mg/Nm3 to 3.85 mg/Nm3. Additionally, sulphur dioxide (SO2) levels decrease from 72.3 mg/Nm3 to 39.6 mg/Nm3, resulting in a 50% reduction in NO2 and a 45.2% reduction in SO2 emissions [5].

Ashutosh Kulkarni and his team developed a retrofit electrostatic precipitator for automobile engines using stainless steel grade 202 casing, 0.5mm mild steel wire mesh, and 1mm Galvanized iron plates. The device efficiently collects solid particulate matter, with 2.556g/hr from a running petrol engine [6].

Ibrahim Adabara and his research team developed a simple wire-plate electrostatic precipitator (ESP) to assess the effectiveness of capturing smoke particles generated from the combustion of rubber-wood, which serves as a biomass energy source. The ESP comprised a collection cylinder electrode and two wire electrodes positioned between the cylinders. A high-voltage neon transformer enabled a maximum input voltage of 10.5 kV (DC) for the Wheatstone bridge circuit. The gap between the cylinder and the spacing between the wires were adjustable. Field tests conducted in a furnace revealed that the device could operate for approximately one hour before requiring electrode cleaning. The collection efficiency gradually decreased as the dust loading increased during the wood burning process. Initially, the ESP achieved a peak efficiency of around 80%. Interestingly, the separation distance between the collection plate electrodes exerted a more significant influence on efficiency compared to the gap between the wire electrodes [7].

A research team led by Arinto Y.P. Wardoyo in 2020 developed a particulate filtering system based on electrostatic principles to target fine particles with a diameter less than 2.5 μm. The system utilized aluminium anodes and cathodes as electrostatic electrodes, which were integrated into a motor vehicle muffler. Performance testing involved measuring particle concentrations before and after using the filters at four different electrostatic voltages: V1 (100 Volt), V2 (200 Volt), V3 (300 Volt), and V4 (400 Volt). The results demonstrated the filter's ability to effectively reduce fine particle concentrations, achieving efficiency rates of 50%, 60%, 62%, and 68% for V1, V2, V3, and V4, respectively. The filter's performance was directly influenced by the applied voltage and the duration of the test. Overall, the study confirmed the high efficiency of the filter in reducing fine particle concentrations, with the voltage playing a significant role in its performance throughout the testing period [8]

Muhsin Kılıç and his team conducted a study involving a numerical simulation model and analytical method to evaluate the particle collection efficiency and transport phenomena in an electrostatic precipitator (ESP). The ESP involves complex physical processes, including turbulent flow, corona discharge ionization, particle movement, and electric charge displacement. Ions attach to suspended particles, causing them to become charged. These charged particles then move towards the collection plate and adhere to it. The numerical model considers gas flow, electrostatic field, and particle motion. The study investigated the collection efficiency of a wire-plate ESP for particle diameters ranging from 0.02 to 10 μm. The results showed significant variations in electric field strengths and current densities across the solution domain. Changing the supply voltage and charging wire diameters had a notable impact on the charges acquired by the electrostatic field and particle collection efficiencies. Additionally, the distance between the charging and collecting electrodes and the fluid inlet velocity influenced the particle collection efficiency. The study examined and discussed the influence of different ESP working conditions and particle dimensions on its performance [9], [10].

Juraj Drga, Nikola Cajová, and Bystrík Cervenka conducted a study to enhance the efficiency of particulate matter (PM) capture through electrostatic precipitation. Their focus was on designing a cost-effective electrostatic precipitator (ESP) suitable for small heat sources. The innovation involved creating two variants of the device based on a tubular ESP principle, incorporating additional elements to increase collecting electrode area and the number of charging electrodes. Computational fluid dynamics (CFD) analysis was utilized to assess the impact on pressure drop and gas flow velocity. The authors also evaluated the economic feasibility of the precipitators and made design adjustments to optimize energy consumption. The results showcased the promising direction for improving PM emission control equipment. The novel design significantly increased the collection area compared to conventional precipitators, demonstrating its potential for effective PM capture [11].

CHAPTER 03: DESIGN METHODOLOGY

Air pollution, particularly caused by exhaust gases from vehicles, generators, and diesel engines, is a significant contributor to global warming and climate change. To address this issue, the project aims to capture air pollution from exhaust tailpipes and convert it into valuable products, promoting a circular economy. The project consists of two main components: the GREENV Device and the High Voltage Regulator Module. This design description will provide detailed insights into both

Figure 4: GREENV DEVICE

components and their functioning.

3.1 Design Description

3.1.1 GREENV Device

The GREENV Device is a crucial component designed to capture air pollution from exhaust tailpipes and reduce carbon soot particles using electrostatic force. It features a 12-inch stainless steel hollow cylinder with thick rubber insulation and a bakelite handle for safety and easy handling. The device incorporates two stainless steel grids, with one being positively charged to attract carbon soot particles. A copper rod running along the device repels the particles, while a negatively charged cylinder attracts and accumulates them. The adjustable outer grid securely clamps the device to tailpipes of different diameters. Through this design, the GREENV Device efficiently captures and removes carbon soot particles, contributing to a

Figure 5: GREENV Device View

greener and healthier environment.

3.1.1.1 Design

The GREENV Device is meticulously designed, featuring a durable stainless-steel hollow cylinder with a thickness of 1mm and a diameter of 4 inches. This high-quality material ensures the device's longevity and resistance to harsh environments. To enhance safety, the cylinder is effectively insulated from the outside using thick rubber, minimizing the risk of electric shock and protecting users during operation. Additionally, the inclusion of a Bakelite handle on the outer side of the device adds a practical element, enabling easy and comfortable handling. The handle's sturdy construction further enhances the device's overall robustness, allowing users to securely grip and maneuver the GREENV Device as needed. Through thoughtful design considerations, the GREENV Device not only prioritizes functionality and efficiency but also places utmost importance on user safety and ease of use.

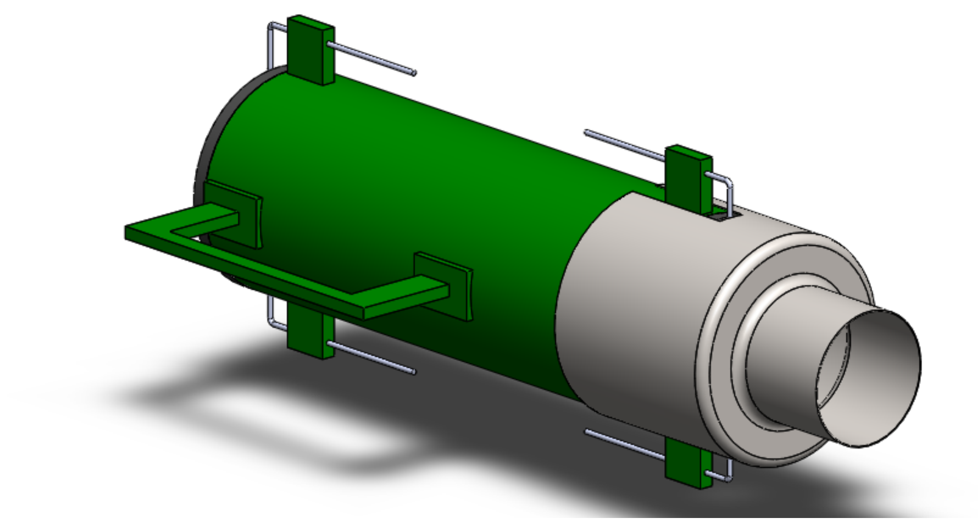


Figure 6: SOLIDWORKS MODEL

3.1.1.2 Internal Components

The design of the GREENV Device includes two stainless steel circular grids positioned at each end. These grids play a crucial role in the capture process. The grid closer to the tailpipe is specifically designed to acquire a positive charge, which is achieved through the integration of the voltage module. This positive charge is essential for attracting and capturing carbon soot particles effectively. Running along the axis of the device is a copper rod securely attached to the center of the positive grid. To prevent undesired charge transfer between the copper rod and the second grid, an insulating material is strategically implemented. This insulation ensures that the electrostatic forces operate as intended, maintaining the effectiveness of the particle capture process. The careful arrangement of these components within the GREENV Device optimizes its ability to capture and contain air pollution efficiently.

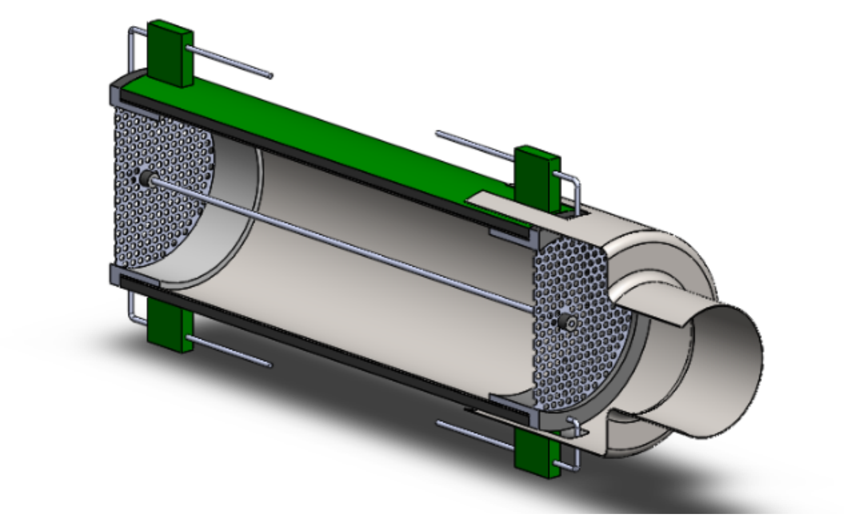


Figure 7: Cross-Sectional View

3.1.1.3 Slidable Outer Grid:

The GREENV Device features an adjustable outer grid that offers flexibility in its positioning. This grid can be easily moved in and out of the device, allowing for precise alignment and optimal performance. To ensure electrical safety and prevent unwanted contact, the outer grid is insulated from its outer surface. Additionally, a reliable clamp mechanism is incorporated to provide a secure attachment to tailpipes of varying diameters. This clamp mechanism utilizes hard insulated rubber, which not only facilitates a snug fit but also enhances the overall stability of the device. By allowing for adjustability and employing effective insulation and a robust clamp mechanism, the GREENV Device guarantees a reliable and secure connection to different tailpipe sizes, accommodating various machinery and vehicles with ease.

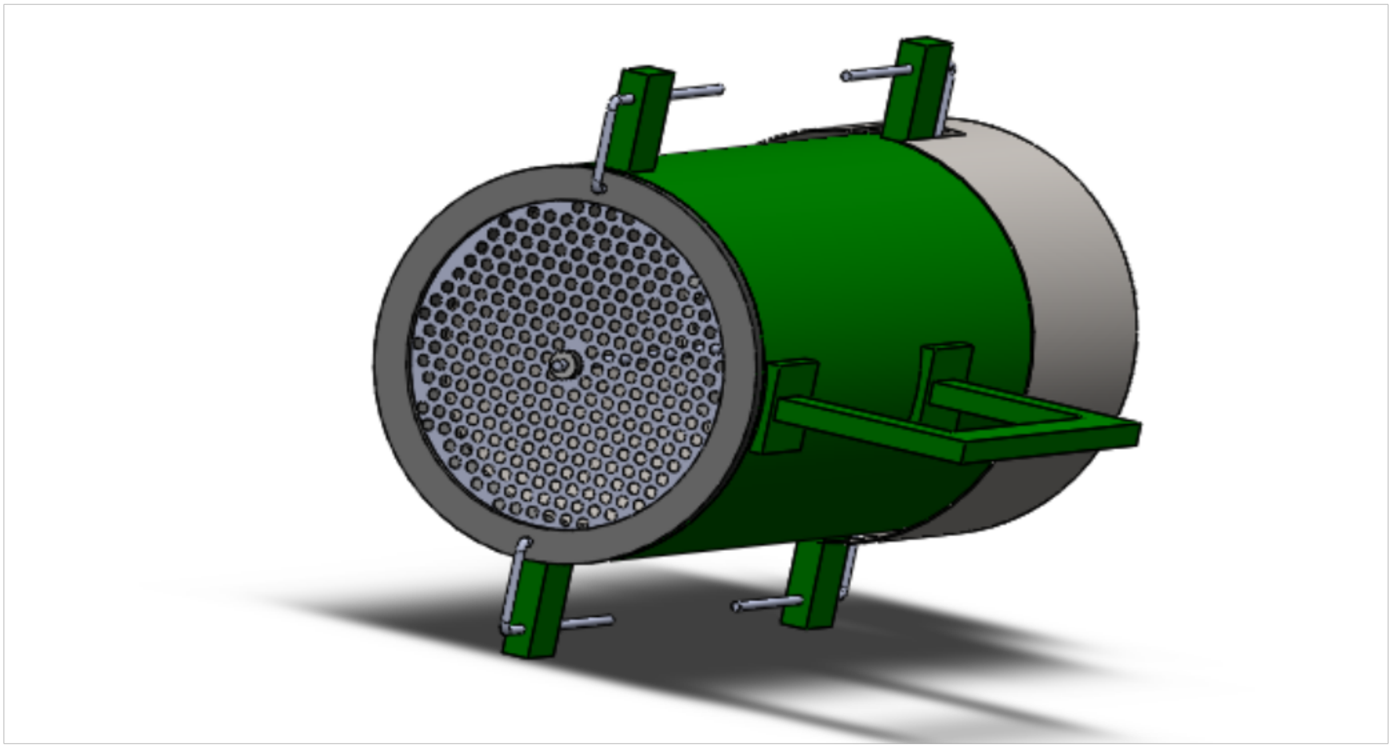


Figure 8: Slidable Outer grid

3.1.1.4 Working Principle:

When the exhaust enters the GREENV Device from the clamp end, a fascinating electrostatic phenomenon unfolds. The carbon soot particles present in the exhaust, initially uncharged, undergo a transformation. As they pass through the positively charged grid, the particles acquire a positive charge themselves. This charge reversal is facilitated by the attractive forces between the positively charged grid and the carbon soot particles.

As the positively charged particles move further into the device, they encounter the copper rod running along the device's axis. The presence of the positively charged copper rod generates a repulsive force that acts upon the carbon soot particles. This repulsion prevents the particles from clinging to the rod, enabling them to continue their journey deeper into the device.

Meanwhile, the GREENV Device employs a negatively charged cylinder, created by the voltage module, positioned parallel to the copper rod. This negatively charged cylinder exerts a powerful electrostatic force of attraction on the positively charged carbon soot particles. This force draws the particles toward the internal surface of the device, despite the repulsion from the copper rod.

As a result of this interplay between forces, the positively charged carbon soot particles accumulate on the internal surface of the GREENV Device. The accumulation occurs due to the strong attraction exerted by the negatively charged cylinder, effectively capturing and containing the air pollution within the device.

By harnessing the principles of electrostatic force, charge distribution, and careful positioning of positively and negatively charged components, the GREENV Device successfully achieves its objective of capturing carbon soot particles from exhaust emissions. This innovative design plays a vital role in reducing air pollution and contributing to a greener environment.

3.1.2 High Voltage Regulator Module:

The High Voltage Regulator Module plays a vital role in the project, converting the 12V battery input into a gradual potential difference of up to 30 kilovolts (kV). This is accomplished through a well-designed circuit, including a flyback transformer and safety features such as an insulated enclosure, voltage regulation knobs, and an ON/OFF switch. The module enables precise control and reliable operation, facilitating the effective functioning of the GREENV Device in capturing carbon soot particles from exhaust emissions.

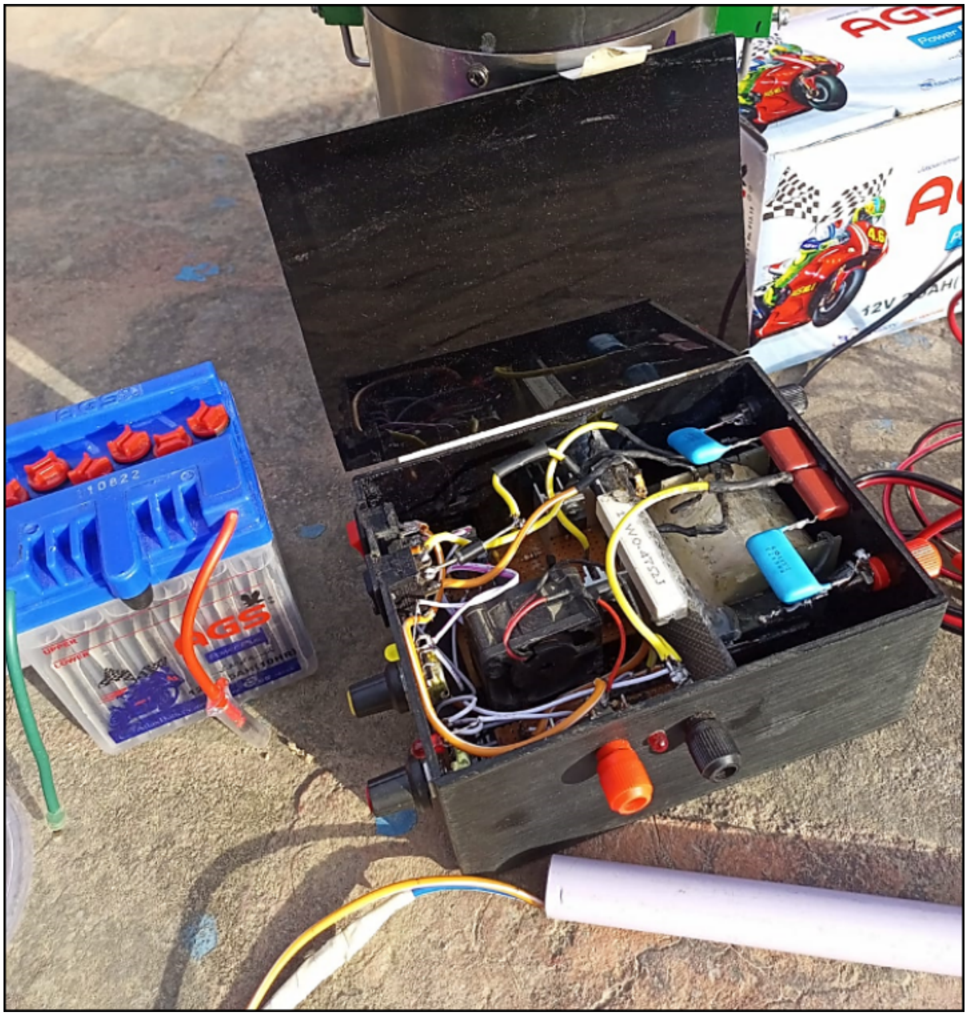


Figure 9: High Voltage Module Regulator

3.1.2.1 Circuit Design:

The High Voltage Regulator Module utilizes a sophisticated circuit design to attain the desired potential difference. Central to the circuit is a flyback transformer that facilitates the conversion of polarity between AC and DC. Additionally, the circuit incorporates components that effectively reduce the current from amperes to milliamperes, resulting in an amplified output potential difference. To ensure safety and protection, the entire circuit is enclosed within a sturdy and well-insulated box constructed from Bakelite material. This enclosure safeguards against potential electrical hazards and provides a secure operating environment for the module.

3.1.2.2 Control Features:

The High Voltage Regulator Module is designed with a range of control features to ensure precise and safe operation. These features enhance the flexibility and usability of the module. Located conveniently outside the circuit box, the module includes a voltage regulation rotary knob and a frequency regulatory knob. These knobs allow operators to make adjustments to the output voltage and frequency, enabling fine-tuning of the module's performance to meet specific requirements.

By integrating these control features, the High Voltage Regulator Module offers operators a comprehensive range of options to regulate and customize the output voltage and frequency. This promotes flexibility, efficiency, and safety in the operation of the module, supporting its seamless integration with the GREENV Device and the overall goal of capturing carbon soot particles from exhaust emissions to create a greener and healthier environment.

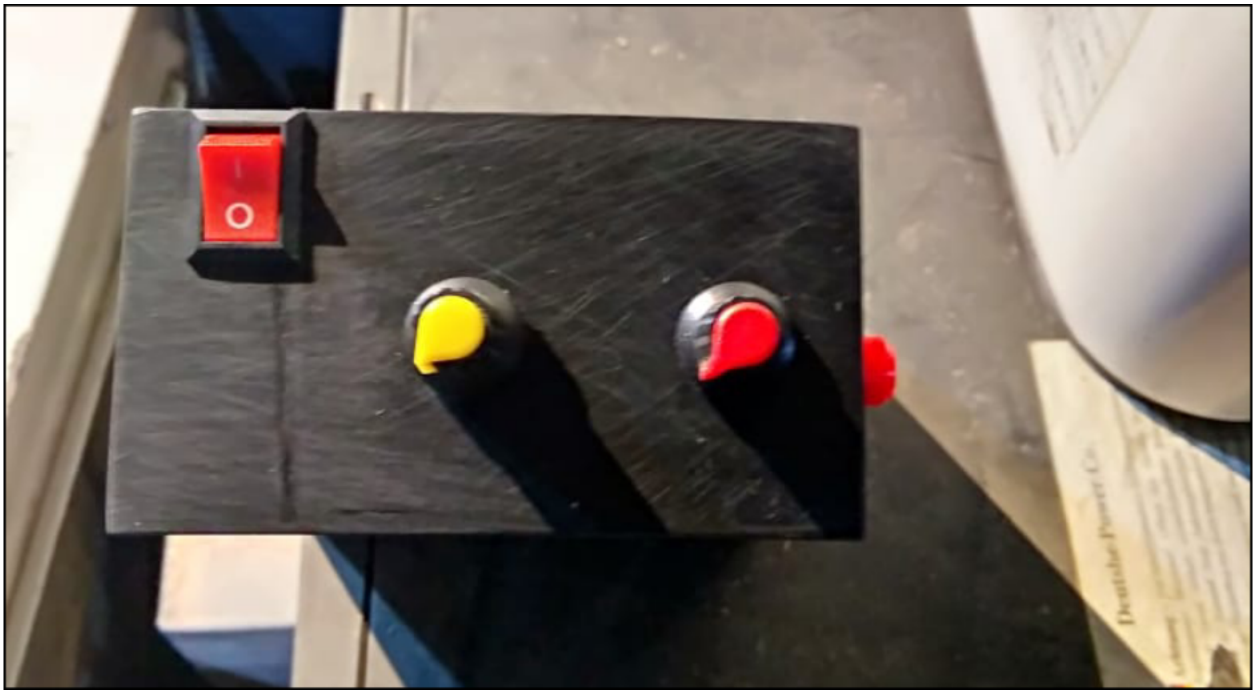


Figure 10: Control Buttons

3.1.2.3 Measurement:

To measure the potential difference generated by the High Voltage Regulator Module, a high-voltage testing probe is required. This probe is specifically designed to handle high voltages safely and accurately. By connecting the positive terminal of a standard digital multimeter to the copper rod and the negative terminal to the stainless-steel cylinder through a knob or similar connection point, the potential difference can be measured. This setup allows for the precise monitoring and verification of the output voltage produced by the module. Using a digital multimeter as the measuring instrument ensures reliable and convenient measurement of the potential difference, providing valuable feedback on the performance and stability of the module.

3.2 Design Parameters

3.2.1 GREENV Device Parameters:

3.2.1.1 Dimensions and Construction:

The GREENV device was 12 inches long and consisted of a stainless-steel hollow cylinder with a thickness of 1mm. The cylinder had a diameter of 4 inches and was made of stainless-steel material. To ensure insulation, the cylinder was wrapped with thick rubber material. A bakelite handle was added to the outer side of the device for

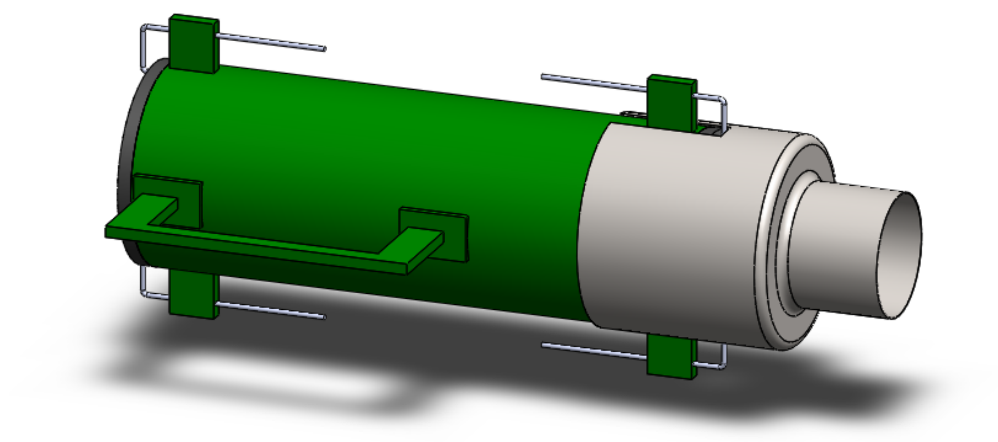


Figure 11: Body of Stainless Steel

convenient handling.

3.2.1.2 Electrostatic Charging Mechanism:

Inside the GREENV device, there were two stainless steel circular grids. The grid located closer to the tailpipe was positively charged using the voltage module. A copper rod was attached to the center of this grid, extending along the axis of the device. The rod was carefully insulated from the second grid, allowing the charge to be confined to its intended path.

3.2.1.3 Slidable Outer Grid and Insulated Inner Grid:

The GREENV device featured an outer grid that could be slid in and out. The inner grid, which was insulated from its outer surface, was positioned at a distance of 2 inches from the 12-inch negatively charged cylinder. A specially designed clamp mechanism was incorporated to securely fasten the device to tailpipes of different diameters. The clamp mechanism had a layer of hard insulated rubber to prevent short-circuiting, as the bodies of vehicles and individuals were negatively charged.

3.2.1.4 Carbon Soot Particle Accumulation:

As the exhaust gases entered the device through the clamp end, the carbon soot particles within the exhaust were positively charged by the internally positioned positively charged grid. The positive copper rod, running along the axis, repulsed these charged particles. Simultaneously, the negatively charged cylinder exerted an electrostatic force of attraction, causing the particles to accumulate on the internal surface of the device.

3.2.2 High Voltage Regulator Module Parameters:

3.2.2.1 Potential Difference Generation:

The high-voltage regulator module was responsible for generating a potential difference of up to 30 kilovolts (kV). Despite having a normal 12V battery input, the module was designed to convert the input voltage and gradually increase it to the desired output potential difference. A complex circuit, including a flyback transformer, was developed to achieve this.

3.2.2.2 Current Reduction Circuit:

To enable the desired potential difference, a circuit was implemented to reduce the current from amperes to milliamperes. This reduction was necessary to increase the output potential difference effectively. The circuit, enclosed within a well-insulated Bakelite material box, contained various components to regulate and control the flow

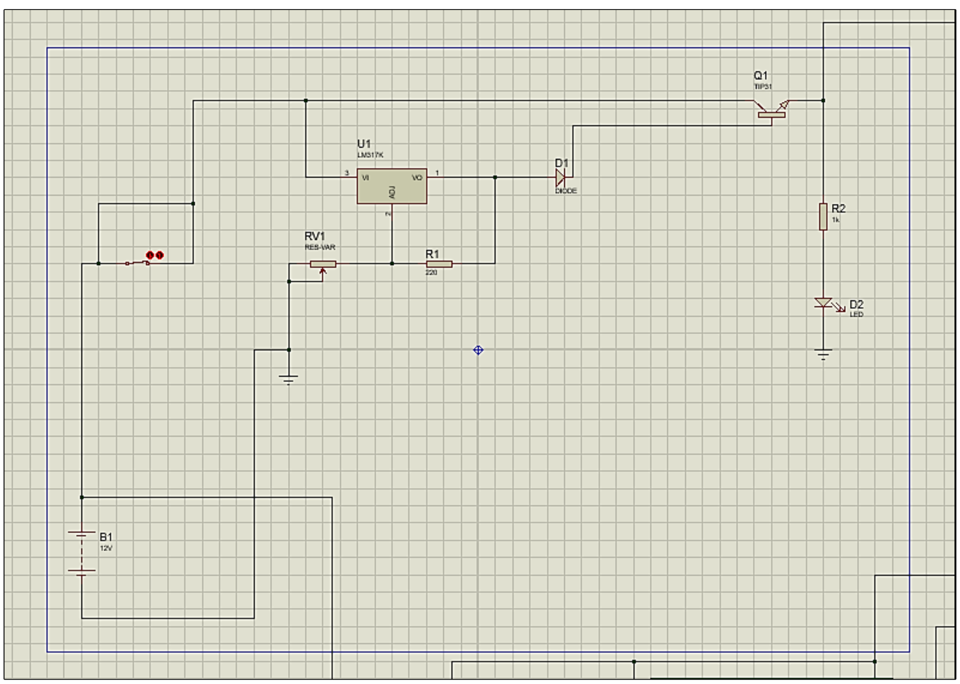


Figure 12: Circuit Diagram on Live-Wire

of electricity.

3.2.2.3 Control Features and Safety Measures:

The module featured a voltage regulation rotary knob and a frequency regulatory knob on the exterior of the circuit box. Additionally, a shifter from low voltage to high voltage and an ON/OFF switch were included for safety purposes. A high-voltage testing probe was integrated into the design to facilitate the measurement of the potential difference using a standard digital multimeter.

3.2.2.4 Terminal Connections:

In order to complete the system, the positive terminal of the high voltage regulator module was connected to the copper rod within the GREENV device. This ensured that the positively charged carbon soot particles captured by the device would be properly managed. The negative terminal, controlled by a knob, was directly connected to the stainless-steel cylinder of the GREENV device, completing the circuit.

3.3 Material Selection

3.3.1 GREENV Device:

3.3.1.1 Stainless Steel (Hollow Cylinder):

The GREENV device features a 12-inch-long stainless-steel hollow cylinder with a thickness of 1mm and a diameter of 4 inches. Stainless steel is chosen for its excellent properties such as high strength, corrosion resistance, and heat resistance.

Figure 13: Stainless-Steel (for Hollow Cylinder)

It can withstand the high temperatures and corrosive nature of exhaust gases emitted from vehicles, generators, and diesel engines. The chosen grade of stainless steel should be resistant to oxidation and chemical degradation caused by the exhaust gases to ensure the longevity and effectiveness of the device.

3.3.1.2 Rubber (Insulation):

To insulate the stainless-steel cylinder from the external environment, thick rubber is utilized. The rubber material used should have high-temperature resistance and be capable of providing effective electrical insulation. It ensures that the device remains electrically isolated from the surrounding components and minimizes any potential safety hazards. The rubber insulation also acts as a protective barrier, safeguarding the users from accidental contact with the charged components inside the device.

Figure 14: Rubber Insulation

3.3.1.3 Bakelite (Handle and Clamp):

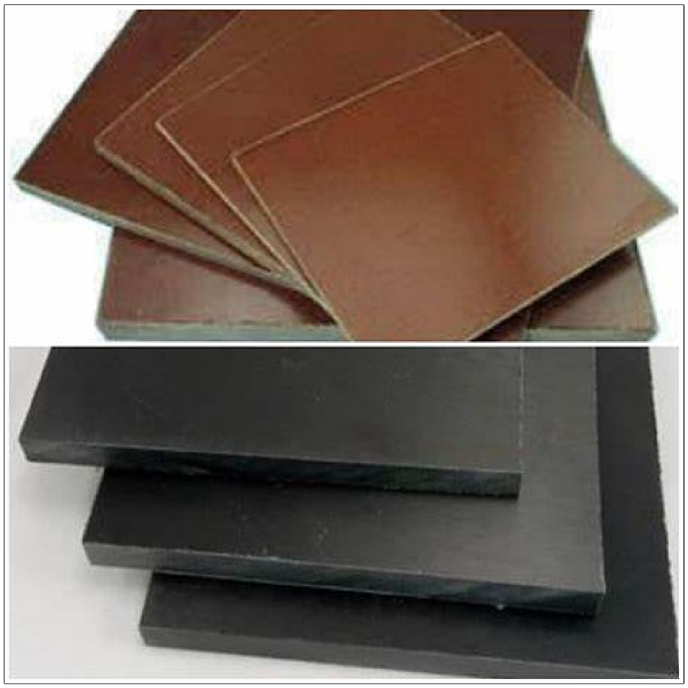


Figure 15: Bakelite Insulator

The GREENV device incorporates a handle and a clamp mechanism made of Bakelite. Bakelite is a type of thermosetting plastic known for its excellent electrical insulation properties and high mechanical strength. It offers superior electrical insulation, making it suitable for handling the device during installation and operation. The bakelite handle provides a safe and insulated grip for users, while the clamp mechanism allows the device to be securely attached to tailpipes of various diameters. It ensures that there are no issues of short-circuiting between the device and the negatively charged vehicle or machinery bodies.

3.3.1.4 Copper (Rod and Grids):

Inside the GREENV device, there are two stainless steel circular grids located at both ends. The grid closer to the tailpipe is positively charged, and a copper rod is attached to its center. Copper is selected for its excellent electrical conductivity, which allows for efficient charging, repulsion of particles, and accumulation of charged particles on the internal surface of the device. The copper rod, running along the axis of the device, serves as a conductor for the positive charge and facilitates the repulsion of positively charged soot particles. It ensures effective particle capture and deposition on the internal surfaces of the device for further processing.

3.3.2 High Voltage Regulator Module:

3.3.2.1 Bakelite (Enclosure):

The high-voltage regulator module is enclosed in a box made of bakelite. Bakelite, as a thermosetting plastic, exhibits exceptional electrical insulation properties, making it an ideal choice for encasing the circuitry of the module. It can withstand high voltages without compromising the integrity of the enclosure. The bakelite enclosure ensures that the circuit components and wiring are protected from external elements and minimizes the risk of electrical shock to users. It also provides mechanical strength and stability to the module.

3.3.2.2 Various Circuit Components:

The high-voltage regulator module comprises various circuit components that are essential for generating the desired potential difference. These components may include resistors, capacitors, diodes, transistors, integrated circuits, and other necessary electronic components. The specific materials used for these components will depend on their individual characteristics and requirements, such as conductivity, temperature resistance, and voltage rating. Copper is commonly used for wiring due to its excellent electrical conductivity. Ceramic materials are often employed for capacitors due to their stability and high dielectric constant. Silicon is a common choice for diodes and transistors due to its semiconductor properties.

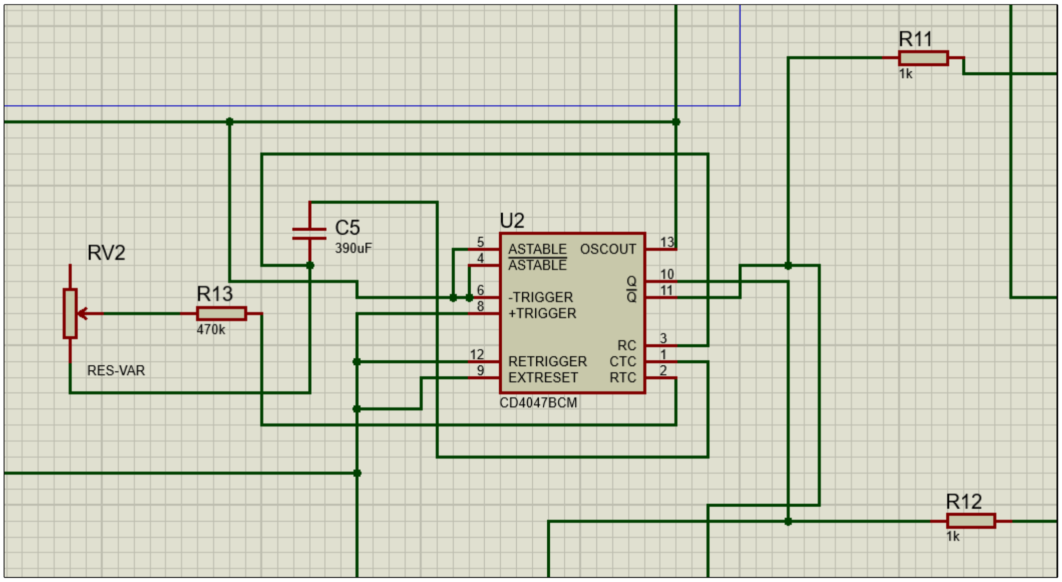


Figure 16: Circuit Components

3.3.2.3 Flyback Transformer:

The high-voltage regulator module incorporates a flyback transformer to achieve the desired voltage transformation. The core of the flyback transformer is typically made

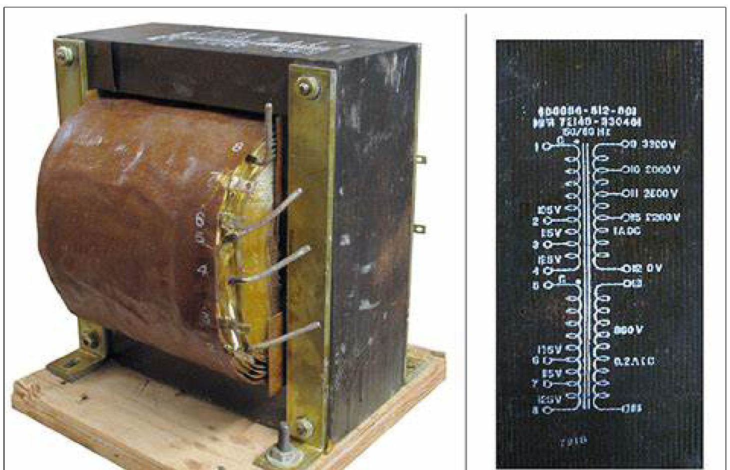


Figure 17: Flyback Transformer

of a ferrite material. Ferrite materials possess high magnetic permeability, which allows for efficient energy transfer and voltage transformation within the transformer. The ferrite core helps to concentrate and control the magnetic fields, enabling effective voltage conversion from the input battery voltage to the required high potential difference. The specific type and composition of the ferrite material used in the core will depend on factors such as the desired operating frequency, power requirements, and efficiency of the transformer.

3.4 Design Calculations

3.4.1 GREENV Device:

3.4.1.1 Calculation of Surface Area:

To determine the surface area of the GREENV device, we need to calculate the area of the stainless-steel hollow cylinder. The formula for calculating the surface area of a cylinder is:

Surface Area = $2\pi rh + 2\pi r^2$

Where:

r is the radius of the cylinder (half the diameter)

h is the height or length of the cylinder

For example, if the diameter of the cylinder is 4 inches (radius = 2 inches) and the length is 12 inches, the surface area would be:

Surface Area = $2\pi (2)(12) + 2\pi (2)^2$

Surface Area = $48\pi + 8\pi$

Surface Area = 56π square inches

3.4.1.2 Calculation of Electrostatic Force:

The electrostatic force between the negatively charged cylinder and the positively charged carbon soot particles can be calculated using Coulomb's Law:

Electrostatic Force = (k * q1 * q2) / r^2

Where:

- k is Coulomb's constant
- q1 and q2 are the charges of the interacting objects
- r is the distance between the charges

The force will depend on the charge on the particles, which can vary. The value of k is approximately 8.99 x 10^9 N m^2/C^2.

3.4.1.3 Clamp Mechanism Design:

The design of the clamp mechanism should ensure a secure attachment to tailpipes of various diameters. The clamp should have sufficient clamping force to hold the GREENV device in place without damaging the tailpipe. The clamping force can be calculated using the formula:

Clamping Force = Coefficient of Friction * Normal Force

Where,

The coefficient of Friction is the friction coefficient between the clamp and the tailpipe

Normal Force is the force applied perpendicular to the surface (weight of the GREENV device)

The selection of appropriate materials and the consideration of factors such as friction coefficients and safety margins are crucial in the design of the clamp mechanism.

3.4.2 High Voltage Regulator Module:

3.4.2.1 Calculation of Voltage Step-Up Ratio:

To achieve a potential difference of 30 kilovolts (kV) from a 12V battery input, a step-up ratio needs to be determined. The step-up ratio can be calculated using the formula:

Step-Up Ratio = V_{out} / V_{in}

Where:

- Vout is the desired output voltage (30 kV)
- Vin is the input voltage (12V)

In this case, the step-up ratio would be:

Step-Up Ratio = 30,000 V / 12 V = 2500

This means that the module needs to step up the voltage by a factor of 2500.

3.4.2.2 Calculation of Current Reduction:

To reduce the current from amperes to milliamperes, appropriate resistors and circuits should be designed. The specific calculations for current reduction will depend on the circuitry and components used. Ohm's Law (V = I * R) can be applied to determine the resistor values necessary to achieve the desired current reduction.

3.4.2.3 Calculation of Power Dissipation:

Power dissipation is an important consideration to ensure that the components within the high voltage regulator module can handle the power requirements. Power dissipation can be calculated using the formula:

Power Dissipation = Voltage Drop * Current

Where:

Voltage Drop is the voltage difference across the component

Current is the current flowing through the component

Proper component selection and heat dissipation measures should be implemented to handle the power dissipation in the high voltage regulator module. The power dissipation can be calculated using the formula:

Power Dissipation = Voltage Drop * Current

For example, if a component within the module has a voltage drop of 10 volts and a current of 100 milliamperes (0.1 amperes), the power dissipation would be:

- Power Dissipation = 10 V * 0.1 A
- Power Dissipation = 1 Watt

It is important to ensure that the selected components can safely handle the power dissipation to prevent overheating and damage.

3.4.2.4 Calculation of Flyback Transformer Turns Ratio:

The turns ratio of the flyback transformer is crucial for achieving the desired output voltage. The turns ratio can be calculated using the formula:

Turns Ratio = Vout / Vin

Where:

- Vout is the desired output voltage (30 kV)
- Vin is the input voltage (12V)

For instance, if the desired output voltage is 30 kV and the input voltage is 12V, the turns ratio would be:

Turns Ratio = 30,000 V / 12 V = 2500

This means that the secondary winding should have 2500 turns for every turn in the primary winding.

3.4.2.5 Calculation of Voltage Regulation and Frequency Control:

The voltage regulation and frequency control knobs on the module can be designed to adjust the output voltage and frequency as needed. The specific calculations for voltage regulation and frequency control will depend on the circuitry and components used. These adjustments can be achieved through the incorporation of variable resistors, capacitors, or frequency control circuits.

3.5 Drawing

This report aims to provide an overview of the drawing and design considerations for the GREENV device and the high-voltage regulator module. These two components play a crucial role in capturing carbon soot particles from exhaust gases and generating the necessary high potential difference for effective operation. Proper drawing and design practices are essential to ensure the functionality, safety, and reliability of these components.

3.5.1 GREENV Device Drawing and Design:

The GREENV device is designed to seamlessly retrofit onto exhaust tailpipes, capturing carbon soot particles emitted from vehicles, generators, and diesel engines. The drawing and design of the GREENV device involve several key considerations:

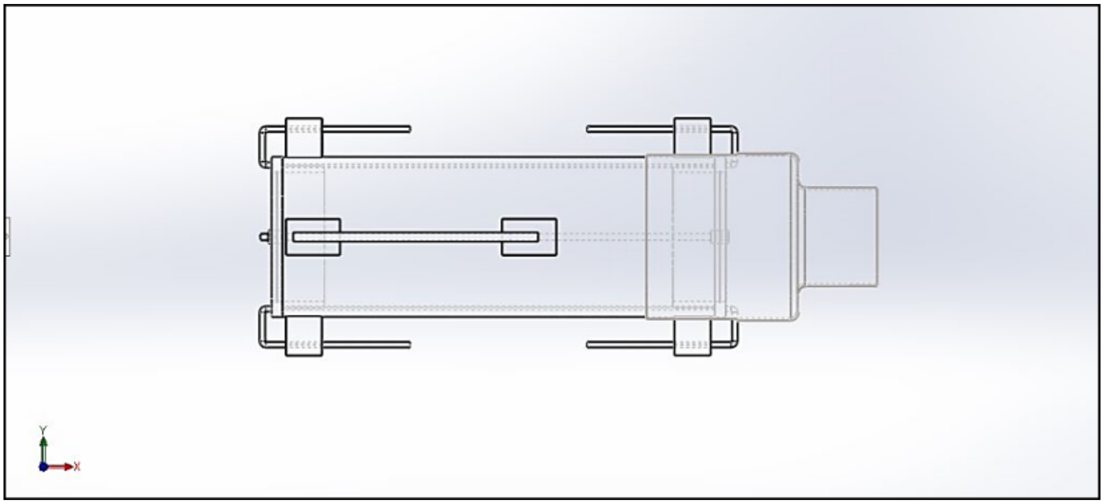


Figure 18: Isometric View

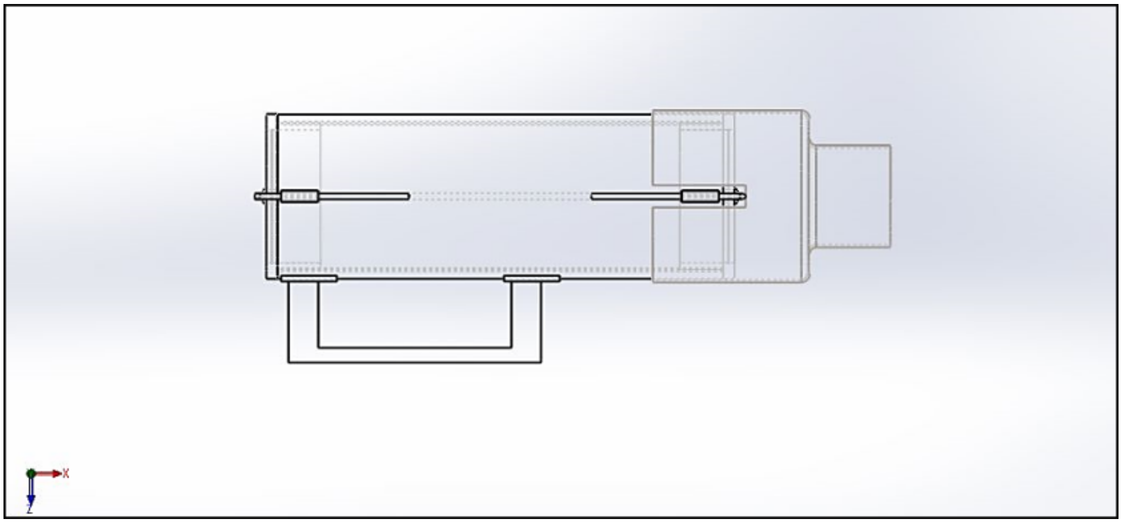


Figure 19:Back View

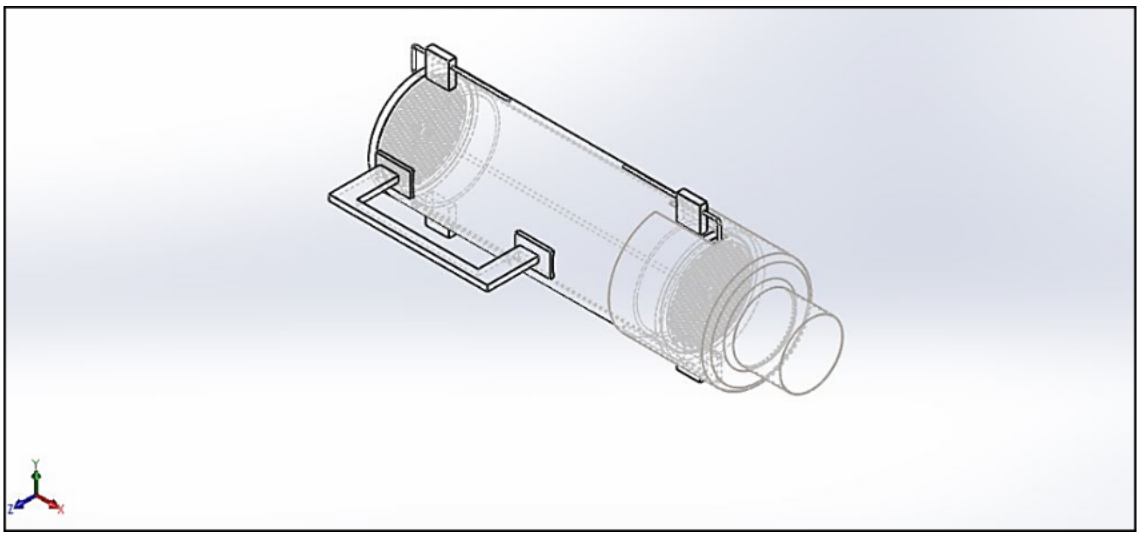
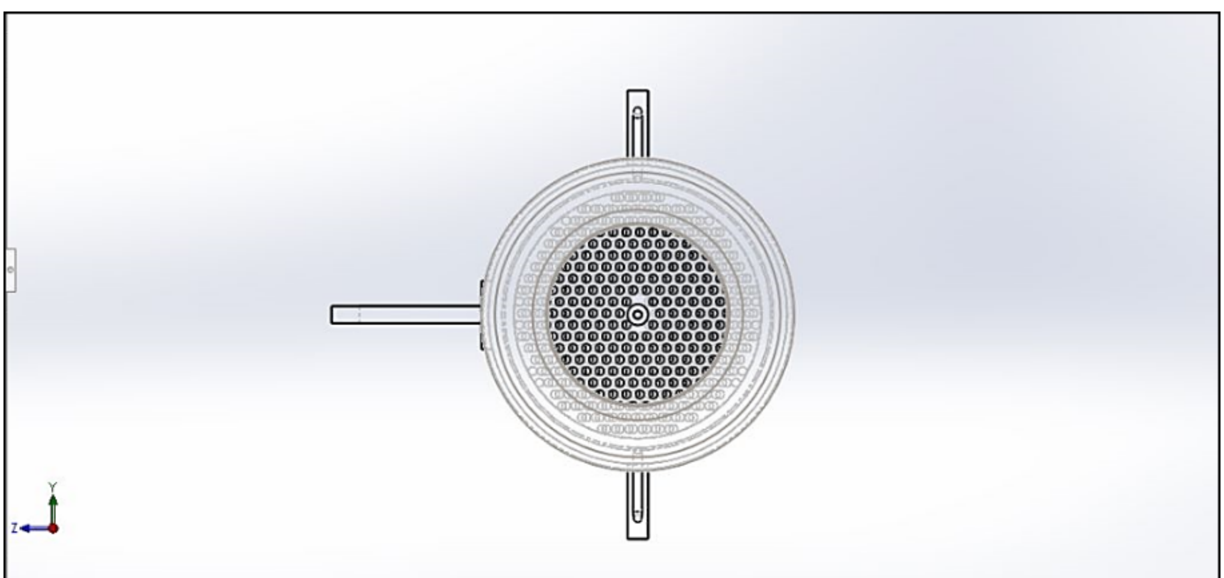


Figure 20: Front View



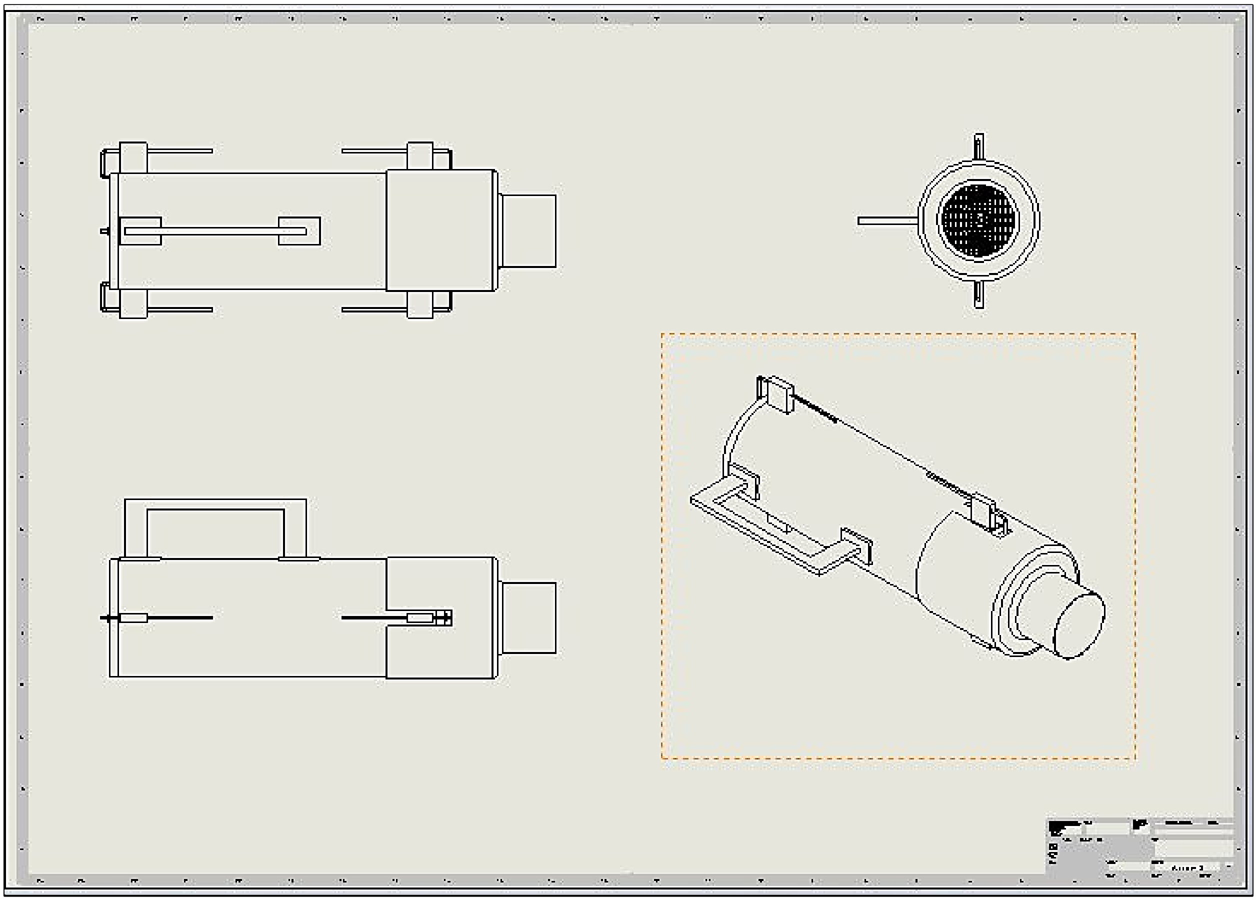


Figure 21:Drawing Views

3.5.2 High-Voltage Regulator Module Design:

The high-voltage regulator module is responsible for generating the required potential difference of up to 30 kilovolts (kV) from a 12V input. The drawing and design considerations for this module include:

3.5.2.1 Livewire Circuit

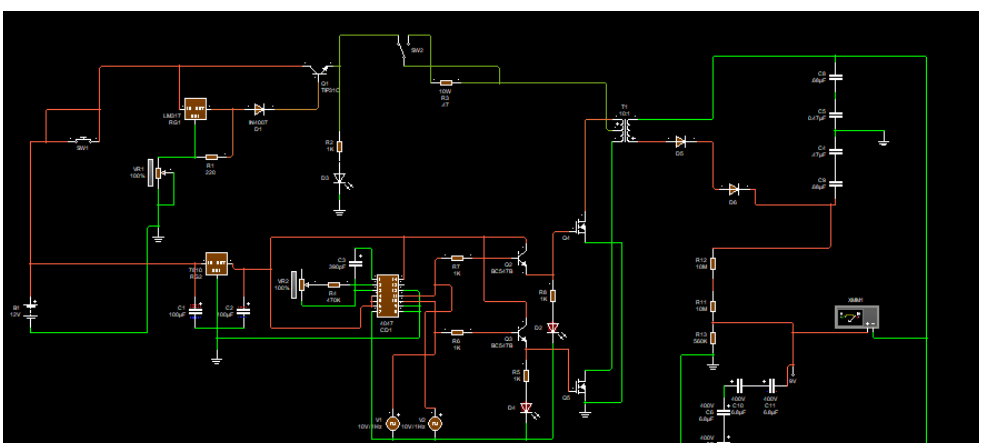


Figure 22:Livewire Circuit ON

3.5.2.2 Proteus Circuit:

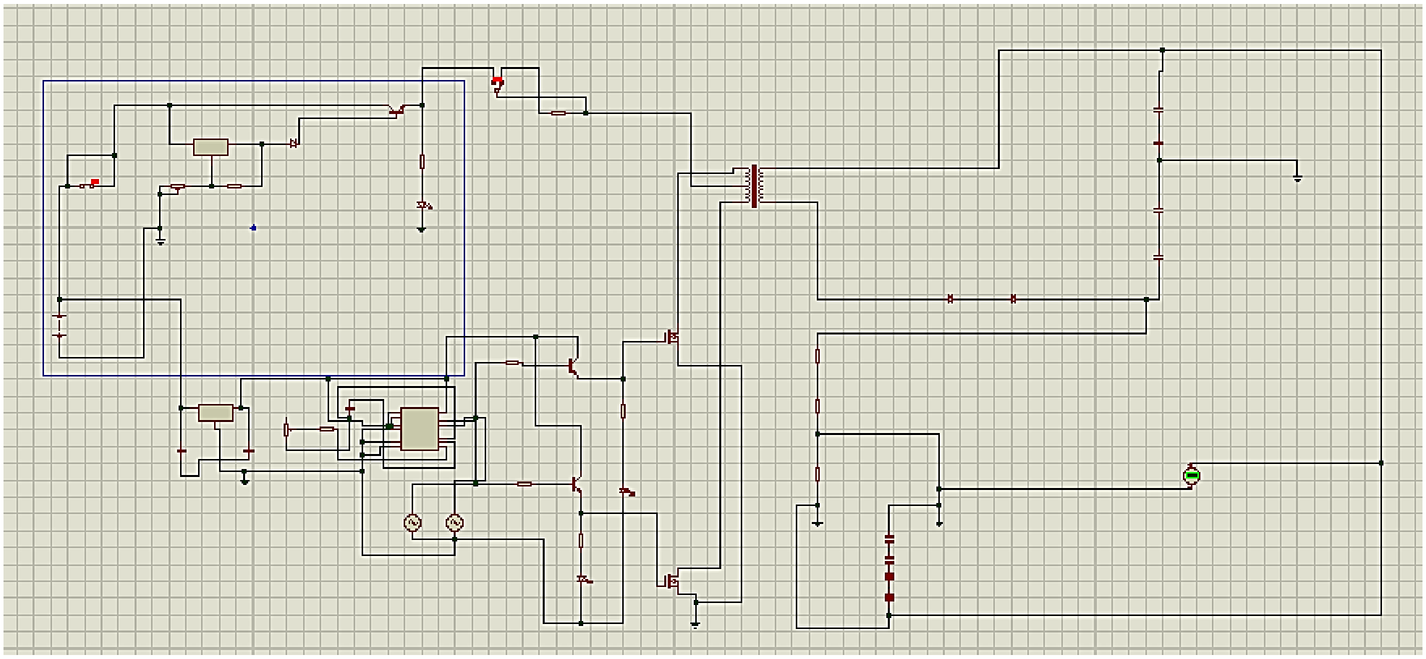


Figure 23:Proteus Circuit

CHAPTER 04: EXPERIMENTATION, RESULTS AND ANALYSIS

4.1 Experimentation

4.1.1 Testing of High Voltage Regulation Module on Paint Droplets and Paper Ash Particles

This high-voltage module is capable of regulating the voltage from 0 to 85 kilo-volts. This range is divided into 2 subranges (0 to 50 kV and 50 to 85 kV). These sub-ranges can be activated with the help of a switch to interconvert between high voltage and low voltage.

Upon completing this module, we started testing its working, regulation, and electrostatic ability. In order to perform the experiment, we used two steel electrodes

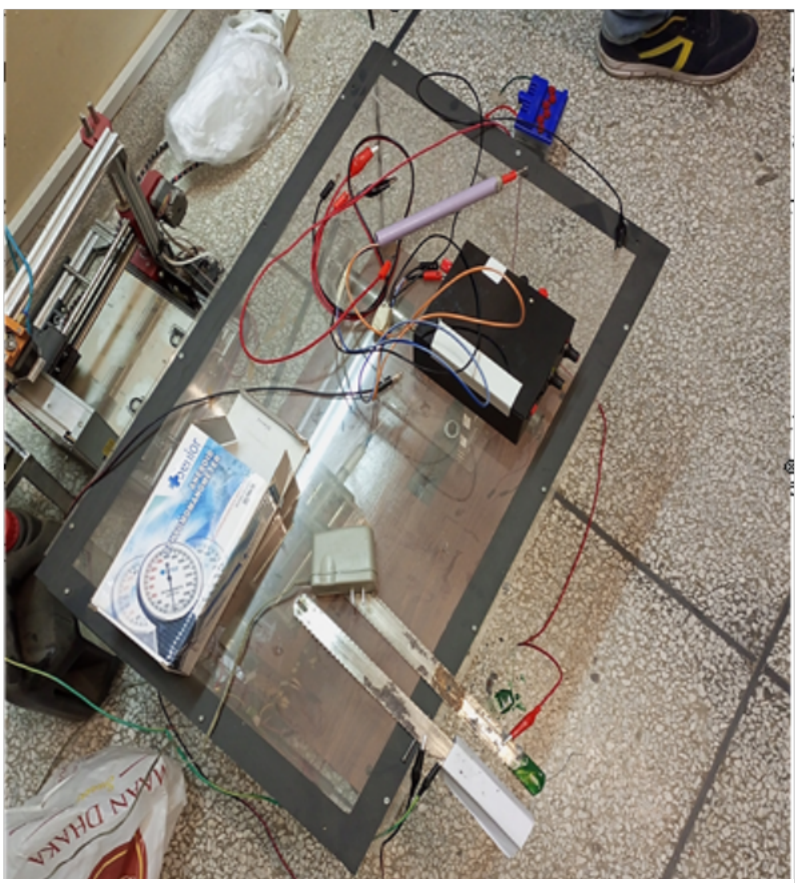


Figure 24:Experiment Setup

(anode and cathode) to connect the output terminals of the module. A multi meter was connected via an HT probe to read the voltage coming out of the module and the experiment had been performed under 2 different combinations.

In the first combination, we put one end of the anode in a paint box and placed it straight on a table like a cantilever beam, where the paint droplets started dipping off

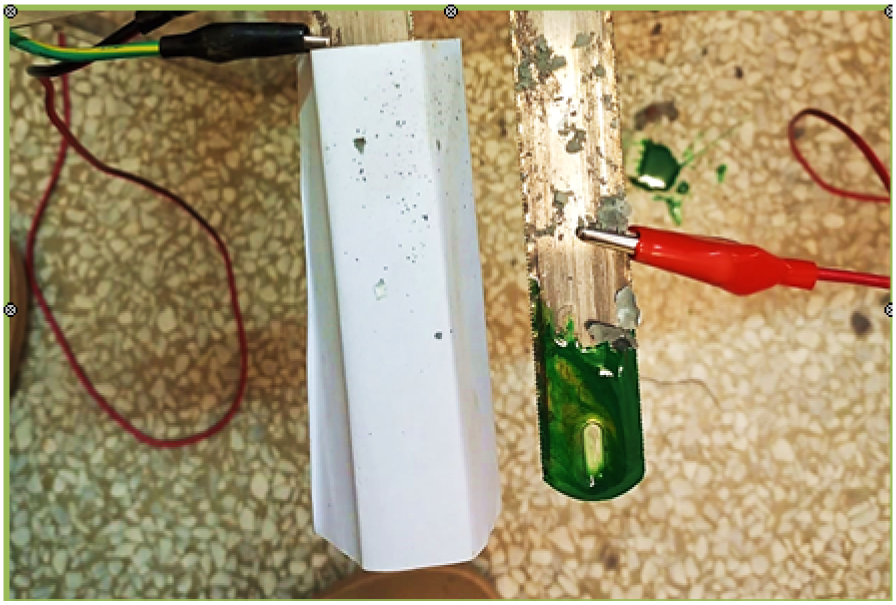


Figure 25:Charged Steel Electrodes

from its surface. A white paper was wrapped around the surface of the cathode and it was also placed parallel to the anode with a perpendicular spacing of 1 inch.

In the second combination, every condition remained the same but instead of dipping the anode in paint, we put some paper ash particles on the flat surface of the anode.

The experiment proceeds as follows:

- First of all, a 12V battery was connected to the input supplies of the module.
- The positive terminal of the module was connected to the anode and the negative terminal to the cathode.

- The main switch was turned on and set the other switch at the low voltage range.
- Voltage started increasing, by rotating the regulation knob in the clockwise

Figure 26: Collected Ash Particles

direction.

Observations from the experiment:

1. **Paint droplets:** - At a voltage of 35 kV, the paint droplets on the anode's surface start experiencing a force of attraction from the cathode. This force of attraction increases as the voltage is further increased.
2. **Paper ash particles:** - Similarly, with ash particles on the anode's surface, the particles start traveling from the anode to the cathode at a voltage of 32 kV. These ash particles get deposited on the white-wrapped paper around the cathode's surface. As the voltage is further increased, the force of attraction between the electrodes also increases.

4.1.2. 2nd PHASE OF TESTING (MOTOR BIKE)

The testing process for the motorbike silencer using the high-voltage regulation module is as follows:

1. **High-voltage regulation module:** The high-voltage regulation module plays a crucial role in this setup. It generates a corona charge, which is a high-voltage electrical discharge that occurs in the presence of a strong electric field. This corona charge is created by applying a high voltage (up to 30 kV in this case) to the module. The strong electric field generated by the corona charge is instrumental in attracting and capturing particles present in the surrounding environment.

2. **Corona charging and soot particle capture:** As the exhaust gases pass

Figure 27:Testing on Motor-Bike

through the motorbike silencer, they carry various particulate matter **PM 2.5**, including black soot particles. When the high-voltage module being regulated the corona charge keeps increasing accordingly and it attract and captures these soot particles.

3. **Stainless steel circular plate:** stainless-steel circular plate is mounted on motorbike silencer. Inner surface of this plate serves as a collection surface for the captured soot particles. As the soot particles deviate due to the electric field, they get stick with the stainless-steel plate due to opposite charge between rod and circular plate.

4. **Filtering and residue collection:** Over time, as the exhaust gases pass through the silencer, soot particles are being repelled by rod and continue to get accumulate on the stainless-steel circular plate. This process acts as a filter, preventing the majority of the soot particles from being expelled into the atmosphere. Instead, the particles remain adhered to the plate's surface.

5. **Cleaner exhaust output:** By capturing and collecting the black soot particles, the high-voltage regulation module significantly reduces the amount of soot expelled in the exhaust gases. This results in a cleaner exhaust output, with a reduced emission of harmful particulate matter into the environment.

   This process acts as a filter, leading to a cleaner exhaust output by reducing the emission of soot particles into the environment.

4.1.3 3rd Phase of Testing (Diesel Bus)

The testing process for the motorbike silencer using the high-voltage regulation module is as follows:

1. **High-voltage regulation module:** The high-voltage regulation module is utilized to generate a corona charge by applying a high voltage (up to 30 kV) to the module. This corona charge creates a strong electric field that attracts and captures particles present in the surrounding environment, including soot particles.

2. **Corona charging and soot particle capture:** As the exhaust gases from the bus pass through the silencer, they carry particulate matter, including black soot particles. The high-voltage module, with the corona charge active, generates a strong electric field around it. This electric field attracts and captures the soot particles present in the exhaust gases.

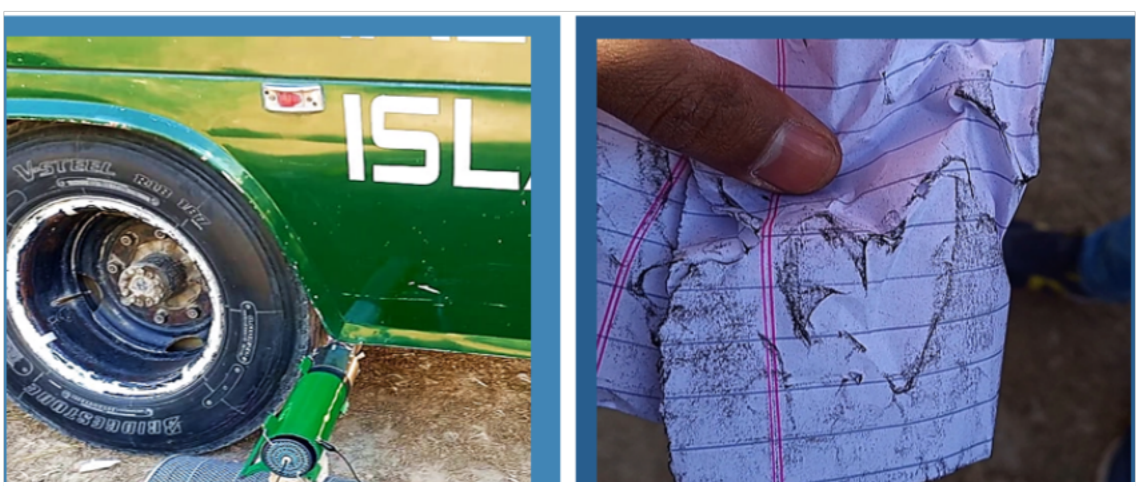


Figure 28: Testing on Diesel Bus

3. **Stainless steel circular plate:** Similar to the motorbike silencer testing, a stainless-steel circular plate is mounted inside the bus silencer. The inner surface of this plate serves as a collection surface for the captured soot particles. Due to the opposite charge between the rod and the circular plate, the soot particles are repelled by the rod and get stuck to the surface of the stainless-steel plate.

4. **Filtering and residue collection:** During the testing process, as the exhaust gases pass through the bus silencer, the soot particles are attracted to the high-voltage module and repelled by the rod, causing them to accumulate on the stainless-steel circular plate. Over time, the plate acts as a filter, preventing the majority of the soot particles from being released into the environment. Instead, they adhere to the surface of the plate.

5. **Cleaning with paper:** After the 1-minute testing period, the cleaning process is performed using paper. The paper is used to wipe the surface of the stainless-steel circular plate, removing the accumulated soot particles. The presence of the soot on the paper confirms the effectiveness of the high-voltage regulation module in capturing and collecting the particles.

6. **Cleaner exhaust output:** By capturing and collecting the black soot particles, the high-voltage regulation module significantly reduces the emission of soot in the bus's exhaust gases. This leads to a cleaner exhaust output and contributes to a reduction in the release of harmful particulate matter into the environment.

4.1.4 4th Phase of Testing (GAS ANALYZER)

The Testing process performed on a gas analyzer when a GREENV device is mounted on the exhaust tailpipe of a diesel engine. The objective is to measure the emissions of hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO2), and nitrogen oxides (NOx) and observe the impact of the GREENV device on reducing these emissions.

1. **Testing setup:** The gas analyzer, capable of measuring various emissions including HC, CO, CO2, and NOx, is measuring exhaust gases ratios of a diesel

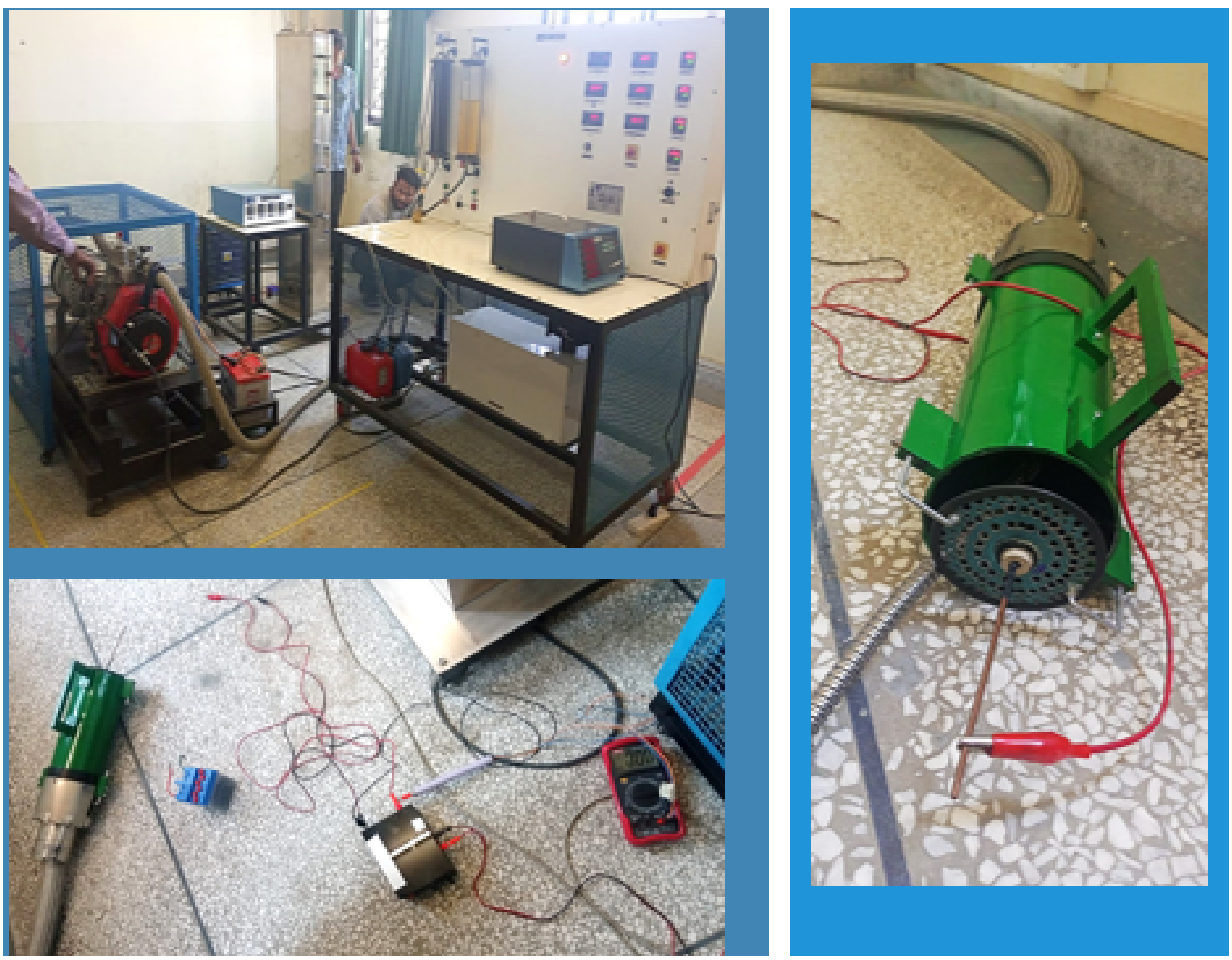


Figure 29:Experimental Setup in Lab

engine. Initially, the engine is started without any additional devices attached to the tailpipe.

2. **Baseline emissions measurement:** The gas analyzer measures and displays the levels of HC, CO, CO2, and NOx emitted by the diesel engine without the GREENV device. These readings serve as the baseline for comparison.

3. **Mounting the GREENV device:** The GREENV device, designed to reduce emissions, is mounted on the exhaust tailpipe of the diesel engine. It uses electrostatic filter to minimize the release of pollutants.

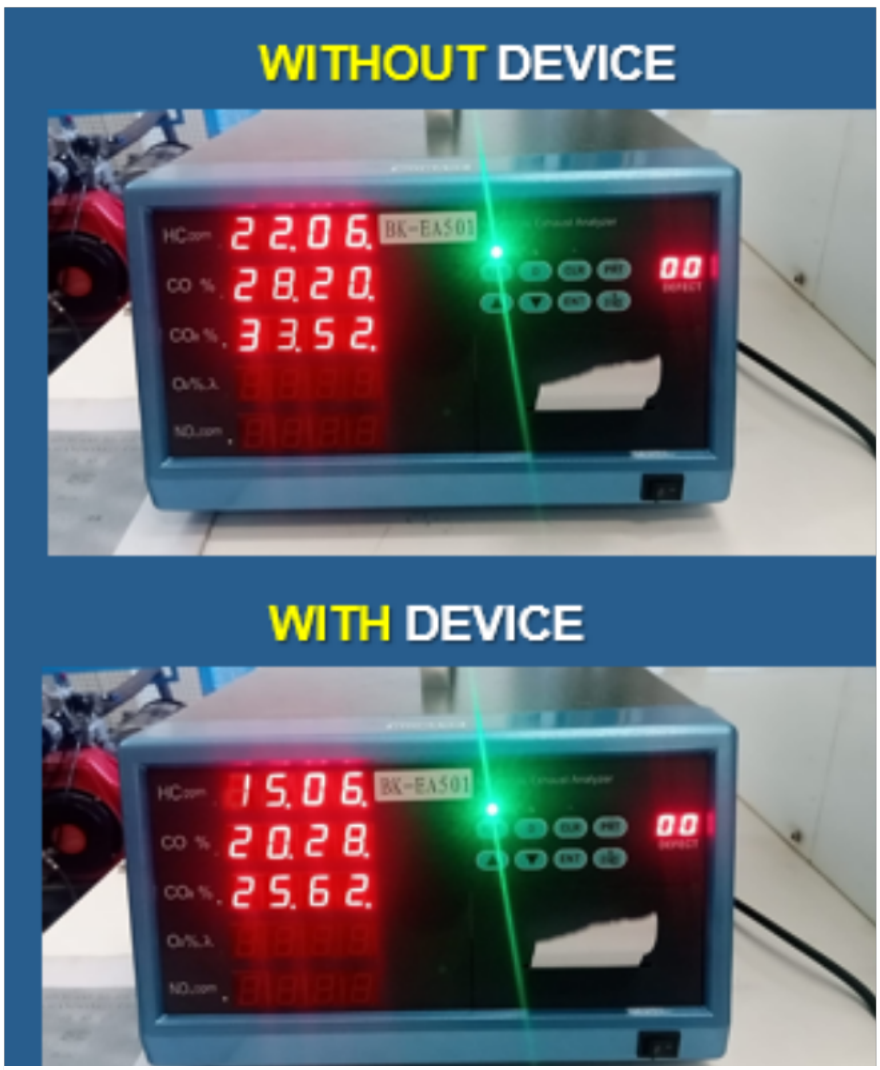


Figure 30:Results With & Without GREENV Device

4. **Emissions measurement with the GREENV device:** After mounting the GREENV device, the gas analyser continues to monitor the emissions of HC, CO, CO2, and NOx. The readings are observed and compared to the baseline measurements taken without the device.

5. **Analysis of results:** Upon analysing the emissions measurements, it is clearly visible that the levels of HC, CO, CO2, and NOx are significantly reduced when the GREENV device is attached to the exhaust tailpipe. The specific reduction in emissions will depend on the effectiveness and design of the GREENV device.

6. **Explanation of emission reduction:** The GREENV device utilizes its high voltage charge to facilitate the removal of harmful components from the exhaust gases. This can lead to a reduction in the levels of hydrocarbons, carbon monoxide, carbon dioxide, and nitrogen oxides emitted by the diesel engine.

7. **Environmental impact:** The reduction in emissions achieved by the GREENV device has positive environmental implications. It helps to lower air pollution and improve air quality by minimizing the release of pollutants into the atmosphere.

In summary, the testing process involves connecting a gas analyser to a diesel engine and measuring the emissions of HC, CO, CO2, and NOx. By mounting the GREENV device on the exhaust tailpipe, it is observed that the emissions levels are significantly reduced compared to the baseline measurements. The GREENV device incorporates technologies that contribute to the conversion or removal of pollutants, leading to a cleaner and more environmentally friendly exhaust output.

CHAPTER 05: CONCLUSION & FUTURE RECOMMENDATION

5.1 Conclusion

In our project, "Green and Healthy Environment by minimizing carbon contaminants through exhaust gases," we successfully tackled rising air pollution, which leads to global warming and climate change. By introducing the innovative GREENV device and high-voltage regulator module, we achieved remarkable results in capturing air pollution from exhaust tailpipes and utilizing it for the production of valuable products, contributing to a circular economy.

The GREENV device, a 12-inch stainless steel cylinder, played a crucial role in capturing carbon soot particles emitted by vehicles, generators, and machinery. By utilizing the principle of electrostatic force, the device attracted and accumulated these particles on its internal surface. With its retrofittable design, the GREENV device could be easily attached to exhaust tailpipes, making it a practical solution for reducing air pollution.

To support the functionality of the GREENV device, we developed a high-voltage regulator module capable of generating a high voltage potential difference. This module featured a complex circuit design, including a flyback transformer, which efficiently converted AC to DC and vice versa. With safety features and regulation controls, the module ensured stable and controlled operation, enabling the effective functioning of the GREENV device.

5.2 Future Recommendations

- This project is working on DC supplies of battery. If an AC supply can be prepared that can work on AC voltage input, then this device can be attached to generators as well and we are already working on it.
- Collaborate with relevant stakeholders, such as government bodies, environmental organizations, and industries, to promote the adoption of the GREENV device as a standard emission control technology and explore incentives for implementation.
- Further enhance the design of the GREENV device to accommodate a wider range of exhaust tailpipe sizes and types, ensuring its compatibility with various vehicles, generators, and machinery.
- Invest in research and development to identify additional valuable products that can be produced using the captured carbon soot particles, expanding the possibilities for a sustainable circular economy.
- Raise awareness through targeted campaigns, education programs, and public engagement initiatives to highlight the detrimental effects of air pollution, the significance of emission reduction technologies like the GREENV device, and the importance of individual and collective actions to combat climate change.

REFERENCES

[1] I. Manoalides, E. Stavropoulou, A. Stavropoulos, and E. Bezirtzoglou, “Environmental and Health Impacts of Air Pollution: A Review,” *Frontiers in Public Health*, vol. 8. Frontiers Media S.A., Feb. 20, 2020. doi: 10.3389/fpubh.2020.00014.

[2] V. Ramanathan and G. Carmichael, “Global and regional climate changes due to black carbon,” *Nature Geoscience*, vol. 1, no. 4. Nature Publishing Group, pp. 221–227, Apr. 2008. doi: 10.1038/ngeo156.

[3] A. Jaworek, A. Krupa, and T. Czech, “Modern electrostatic devices and methods for exhaust gas cleaning: A brief review,” *Journal of Electrostatics*, vol. 65, no. 3. pp. 133–155, Mar. 2007. doi: 10.1016/j.elstat.2006.07.012.

[4] D. Patiño, B. Crespo, J. Porteiro, E. Villaravid, and E. Granada, “Experimental study of a tubular-type ESP for small-scale biomass boilers: Preliminary results in a diesel engine,” *Powder Technol*, vol. 288, pp. 164–175, Jan. 2016, doi: 10.1016/j.powtec.2015.11.006.

[5] A. Y. Lusiandri, A. E. Kristiyono, and K. L. Waskito, “The Application of Electrostatic Precipitator (ESP) as Pollutant Reduction in Ship,” *Research, Society and Development*, vol. 8, no. 12, p. e148121650, Sep. 2019, doi: 10.33448/rsd-v8i12.1650.

[6] A. Kulkarni, V. Melavanki, V. Pavate, and Z. Riyazahmed Abbunavar, “RETROFIT ELECTROSTATIC PRECIPITATOR FOR AUTOMOBILES,” *International Research Journal of Engineering and Technology*, 2019, [Online]. Available: www.irjet.net

[7] I. Adabara, A. H. Shuaibu, A. S. Hassan, and A. S. Hassan, “Design and Implementation of an Electrostatic Precipitator and Its Cleaning System for Small Scale Combustion Multiple Placement of Solar, Wind and Biomass Energy Based DG’s Using WEF Algorithm View project Wireless Power supply system View project Design

and Implementation of an Electrostatic Precipitator and Its Cleaning System for Small Scale Combustion.”

[8] A. Y. P. Wardoyo, H. A. Dharmawan, M. Nurhuda, and A. Budianto, “A high voltage electrostatic filter for particulate matter PM2.5 capture applied in motor vehicle exhaust system,” in *Journal of Physics: Conference Series*, Institute of Physics Publishing, Jun. 2020. doi: 10.1088/1742-6596/1528/1/012001.

[9] M. Kılıç, M. Mutlu, and A. F. Altun, “Numerical Simulation and Analytical Evaluation of the Collection Efficiency of the Particles in a Gas by the Wire-Plate Electrostatic Precipitators,” *Applied Sciences (Switzerland)*, vol. 12, no. 13, Jul. 2022, doi: 10.3390/app12136401.

[10] J. Porteiro, R. Martín, E. Granada, and D. Patiño, “Three-dimensional model of electrostatic precipitators for the estimation of their particle collection efficiency,” *Fuel Processing Technology*, vol. 143, pp. 86–99, Mar. 2016, doi: 10.1016/j.fuproc.2015.11.010.

[11] J. Drga, M. Holubčík, N. Čajová Kantová, and B. Červenka, “Design of a Low-Cost Electrostatic Precipitator to Reduce Particulate Matter Emissions from Small Heat Sources,” *Energies (Basel)*, vol. 15, no. 11, Jun. 2022, doi: 10.3390/en15114148.