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Part Time Convertible Two Wheel Drive with Regenerative Braking

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Abstract: ***The "Part time two-wheel drive with regenerative braking" is an innovative project which aims at reducing commuting costs incurred by people who travel on a daily basis and as well as aims to reduce the pollution caused by vehicles that are run by conventional fuels like Petrol and Diesel. In metropolitan cities like Delhi, Mumbai and Bangalore, rising levels of pollution is a menace for people living in these cities. Our project aims to reduce the pollution level by means of an electrical motor which draws energy from a cleaner source, i.e., electricity. If a situation arises, which forces the rider to use engine in case of low battery levels, HHO Kit makes sure that the pollution levels of the vehicle remain under harmless levels. A 2-stroke vehicle is being taken for the project in order to show a more drastic reduction in pollution levels, since the original emission of a 2-stroke vehicle is greater than that of 4 stroke vehicles. Through this project, we as engineers, take upon ourselves, the moral responsibility of reducing our carbon footprint on the planet. This project aims at achieving mainly 3 crucial things, i.e., reducing costs on fossil fuels, decreasing emissions caused by fuels and providing a backup for the commuter in case of fuel shortage or battery shortage***

Keywords: BLDC Motor, HHO Gas kit, Pulse Width Modulator, Emissions, 3 Phase Controller, Secondary Throttle.

I. INTRODUCTION

The part time convertible two-wheel drive with regenerative braking system is an innovative idea to counter the ever-increasing problem of rising fuel prices and increased expenditures due to fuel consumption. It is also equipped with an HHO Kit which helps the increased and efficient fuel burning, since it ensures complete combustion of fuel molecules, it also reduces the harmful by-products of fuel such as Carbon-dioxide, Hydrocarbons and Carbon Monoxide. HHO Kit utilizes water for the generation of gas, hence, the source is easily and freely available as 75% of earth is covered with water. The name "Part time convertible two-wheel drive" corresponds to the fact that this vehicle is part time convertible electric vehicle driven by a motor and powered by Lead Acid batteries. A three-phase controller is used to control the speed of the vehicle by means of a secondary throttle. This provides an alternative to commuting with energy from a clean power source. The inclusion of regenerative braking system is a boon to the riders in metropolitan cities clogged with traffic where rider needs to apply brakes at every other moment. Every time the rider applies brakes of his vehicles, the brake shoes absorb the friction energy from the hub and this energy is used to charge the vehicle batteries. Overall, this project not only concentrates on saving monetary resources, but it also takes the moral responsibility in the preservation of fossil fuels for our future generations. The Part time convertible two-wheel drive with regenerative braking is an attempt in a territory which no automobile giants have stepped their foot in. The Part time convertible two-wheel drive with regenerative braking takes the moral responsibility of reducing the overall carbon footprint of our society, and hence, is a step in the right direction.

II. PROBLEM STATEMENT

The data obtained from a United Kingdom (UK) based firm Statista (www.statista.com) suggests that about 1,75,89,511 two-wheeler vehicles were sold in India in the year 2016-2017. This amounts for a great amount of pollution in crowded areas. The Data from a Beijing based firm named aqicn.org suggests that, an Air Quality Index Value (AQI) of 500 was evident in Lajpat Nagar Delhi on Thursday 12/4/2018. AQI levels from 0-50 are regarded as good whereas 50-100 is considered as acceptable. Particulate Matter (PM) 2.5 and PM 10 particles were found to be beyond the safe level. To help reduce the pollution levels, HHO Kit and Electric motor as an alternative, play an important role. Just like every innovation in the field of engineering, this product aims to reduce the costs incurred while commuting, but apart from that, this product aims at taking a major responsibility, that is, to reduce the emission of harmful products like CO, CO_2, Hydrocarbons.

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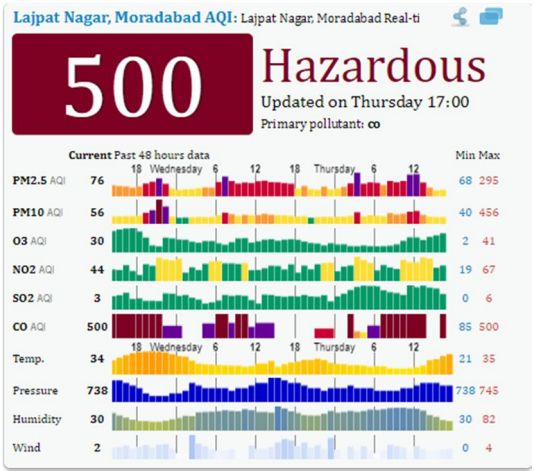

Fig 1. Delhi AQI Report

A. Objective

There are 3 main objectives behind taking up this project. They are as follows,

1) To save money on fuel costs.
2) To reduce emission levels from the vehicle engine.
3) To provide a backup in case of fuel shortage.

III. COMPONENTS USED

A. Tvs scooty es 1996 model

The vehicle's front wheel was removed and a 250 W BLDC Motor was attached to the front forks. The motor was first welded with 3 clamps to enable the mounting of a wheel rim on it. The wheel hub which contained the traditional drum brakes were disassembled and modified to fit in regenerative braking mechanism. The conventional brake shoes are replaced with cylinders that absorb frictional energy, these cylinders are attached to the end of motor shafts are fitted Mini Electric Motor which in reverse, acts as a dynamo, hence absorbing the frictional energy of the rotating hub and converting it to electrical energy.

Fig 2: TVS Scooty ES

B. Three Phase Controller

A 3 Phase controller is necessary to coordinate all the parts in the above-mentioned list. Controller is an ECU which helps to regulate the speed of the BLDC Motor through a secondary throttle. When the throttle is twisted, it sends signal to the controller, which is received and interpreted by the controller in such a way that, more voltage is supplied to the BLDC Motor, this in turn increase the speed of the motor. In absence of a controller, the motor will start to run at its maximum speed and will misbehave.

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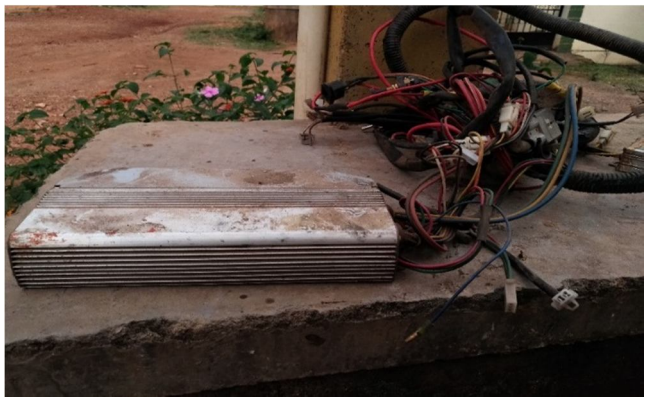

Fig 3: Three Phase Controller

C. Bldc Motor

A 250 W Brushless DC motor from the firm Electrotherm India Pvt Ltd. is used to drive the vehicle. 3 clamps are welded on the periphery of the motor to enable the mounting of the wheel rim. The motor wheel assembly is the mounted on the front fork. This motor provides a peak load output of 275 W at 1100 RPM and a rated power output of 250 W at 570 RPM. It can provide a torque of 5 N-m at 570 RPM. The motor consists of 800 primary windings. This motor can provide a maximum speed of up to 25km/hr., which takes 7-8 hours to charge fully and consumes 1.3 Units for the same. It can provide up to 70 km of distance on a full charge.

Fig 4: BLDC Motor

D. Regenerative Braking

In our case, a pair of 3V 0.2 A motors are used to replace the conventional brake shoes inside the brake drum. The motor end shaft is mounted with a pair of friction cylinders. When the rider applies brakes, these cylinders rub against the drum and absorb the frictional energy, this frictional energy is converted to mechanical energy of the friction cylinders and as a result the cylinders start rotating. Since they are connected to a motor, the motor in reverse acts as a dynamo and generates current. This generation of current is evident in an Ammeter. The generated current is stored chemically inside the 4 batteries that are used to run the BLDC Motor and in turn, the vehicle.

E. Lead Acid Batteries

4 Lead acid batteries of 12 V and 24 Ah are connected in series; thus 48 V of Voltage is obtained from these 4 batteries, 48V is necessary to make the motor run. If more storage is required, 2 batteries can be connected in parallel and can be treated as one, in this way, voltage is kept to 48V whereas current in Ah is increased. The connection in series is essential to increase the voltage of the battery assemblage to 48V. It can be shown by a circuit diagram in the following manner.

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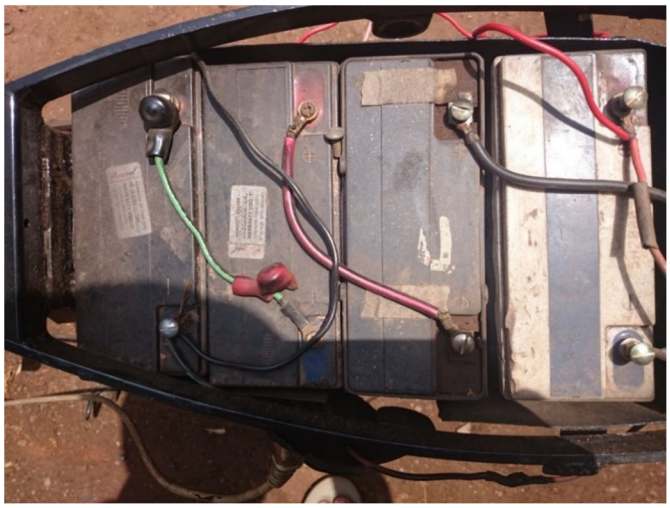

Fig 5: Battery Connections

F. Hho Kit

The idea behind an HHO system is a relatively simple concept. The system uses electricity from the car's alternator to run an electrical current through water that's been infused with an electrolyte, usually a form of salt. The electricity breaks the bond between the hydrogen molecules and the oxygen molecules, and the hydrogen and oxygen are released as gases. These gases are collected and used by the engine as fuel. The collected gas then is piped to the vehicle's engine and sucked in by the intake manifold. Electrolysis is the most common method adopted for the production of HHO gas. Distilled Water, Mineral RO water or any other pure form of water is used which has a TDS level below 300 PPM is used. Electrolytic salts like KOH or NaOH are dissolved in the water. Steel plates (SS 316 or SS 409) are immersed in the container containing this solution. One plate is anode and another plate is cathode. Positive current is passed through anode and negative current is passed through cathode, this current is strong enough to break the bond between Oxygen and Hydrogen molecules of water. There is no problem of evaporation since the current produce is barely enough to break the bond between Oxygen and Hydrogen molecules. After this process, the HHO Gas is collected on top the container surface which holds the Electrolytic plates.

Components of HHO Gas Kit:

1) HHO Cell
2) Power Controller
3) Safety Drye
4) Electrolyte Salts
5) Hose Pipes

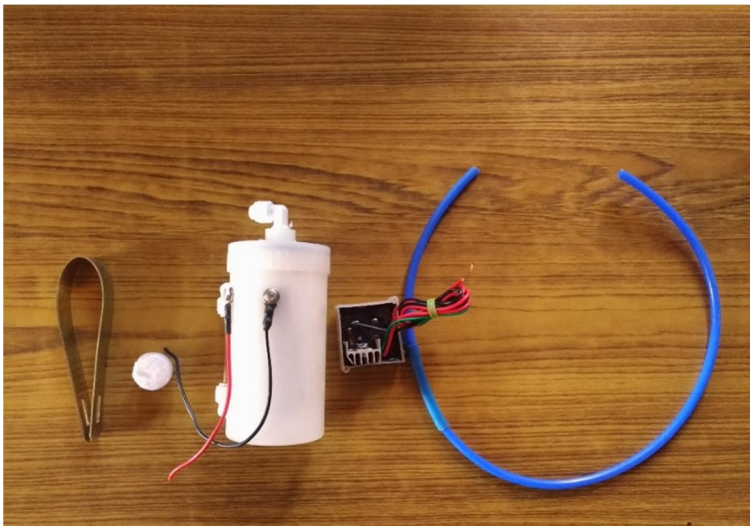

Fig 6: HHO Gas Kit

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G. Secondary Throttle

A secondary throttle is installed to the handle of the vehicle along with the conventional accelerator throttle of the vehicle. This secondary throttle is installed in series with the original throttle provided by the vehicle manufacturer. This is connected to the controller which in turn is connected to the BLDC Motor assembled inside the wheel. This forms an essential part of the Part time convertible 2-wheel drive, since it controls the speed of the motor and helps to vary it. Speed is changed by twisting the throttle. Greater the twist, greater the rise in speed.

Fig 7: Secondary Throttle

IV. HHO KIT CONNECTIONS

HHO Kit connections are made before fitting it to the vehicle. The HHO Cell is first connected to the power controller, then the HHO cell container is filled with the mixture of water and electrolytic salts (in this case KOH). Hose connections are made. The HHO Cell container is mounted on the chassis frame using the clamp provided with the kit. The hose running from the outlet of the HHO cell which in turn supplies the HHO Gas is connected to the hose which runs between engine and the carburetor. To ensure that the gas is being produced, the other end of the hose of HHO Cell should be dipped in a glass of water and the engine should be started, if the HHO gas is being generated, bubbles are formed inside the glass of water, else, nothing is evident. Hence this procedure can help us to identify a defective HHO Cell and can be replaced.

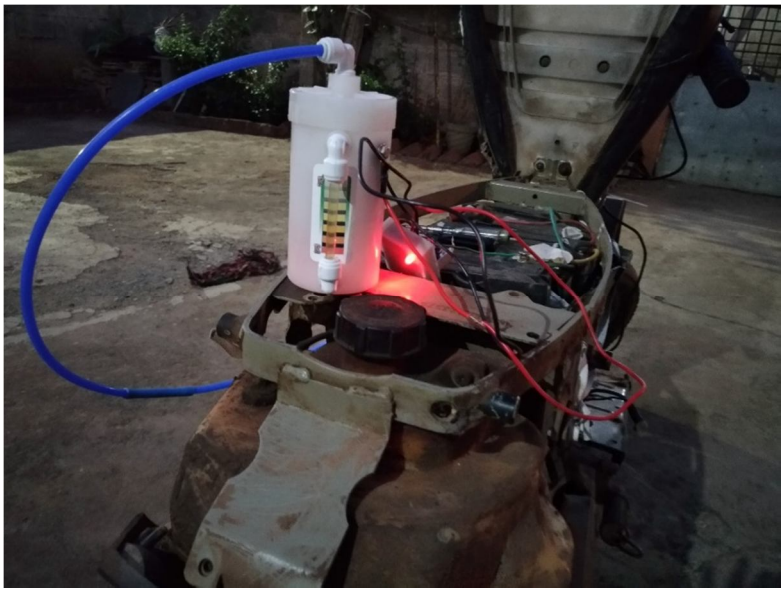

Fig 8: HHO Gas Kit Connections

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V. PERFORMANCE AND EMISSION ANALYSIS

The vehicle is tested on various parameters such as:

A. Cost of Electricity Vs Cost of Petrol

Serial No.	Electricity required(W)	Tariff Charges/unit (HESCOM 2018-2019 in Rs)	Total Distance on single charge (km)	Cost Incurred by using Electrical Motor (Rs)	Average mileage obtained from the engine (kmpl)	Cost of Petrol to run the vehicle for the same distance
1	1152	6.96	65	8.017	35	141.14

Table 1: Electricity vs Petrol

Hence this data shows us that the cost incurred while using the electrical motor is Rs. 133.213 lesser than that of the engine (Petrol). This amounts to about 94% of savings in the costs incurred to drive the vehicle for the same distance (in this case 65 kms).

B. Power Developed by Motor vs Power Developed by Engine

Power Developed by Motor (W)	Power developed by Engine(W)
250	2570

Table 2: Motor Power vs Engine Power

As the above data depicts, the BLDC motor can only produce about 10% of the total power produced by the Engine, which is a downside of this vehicle, but what it lacks in power, it makes up for it in efficiency.

C. Emission Comparison of Engine And Motor

	Engine (1100 RPM)	Motor
CO (Carbon Monoxide in % Vol)	2.727	NIL
CO_2 (Carbon dioxide in % Vol)	3.44	NIL
HC (Hydrocarbons in PPM)	623	NIL

Table 3: Emissions Engine vs Motor

D. Specific fuel Consumption (sfc) Vs rpm

The Engine was tested for Specific fuel consumption by marking a bottle with 10cc mark. It is then connected to the carburetor with a hose pipe and tested the fuel consumption for various speeds. The following table shows the results obtained.

Sl No.	RPM	Time taken for consumption of 10cc fuel (seconds)		Specific Fuel Consumption (kg/h)	
		Without HHO	With HHO	Without HHO	With HHO
1	655	28	32	0.0154	0.0134
2	798	22	25	0.0196	0.01727
3	1114	16	19	0.027	0.0227
4	1278	13	17	0.033	0.025
5	1347	9	13	0.048	0.0332

Table 4: SFC vs RPM

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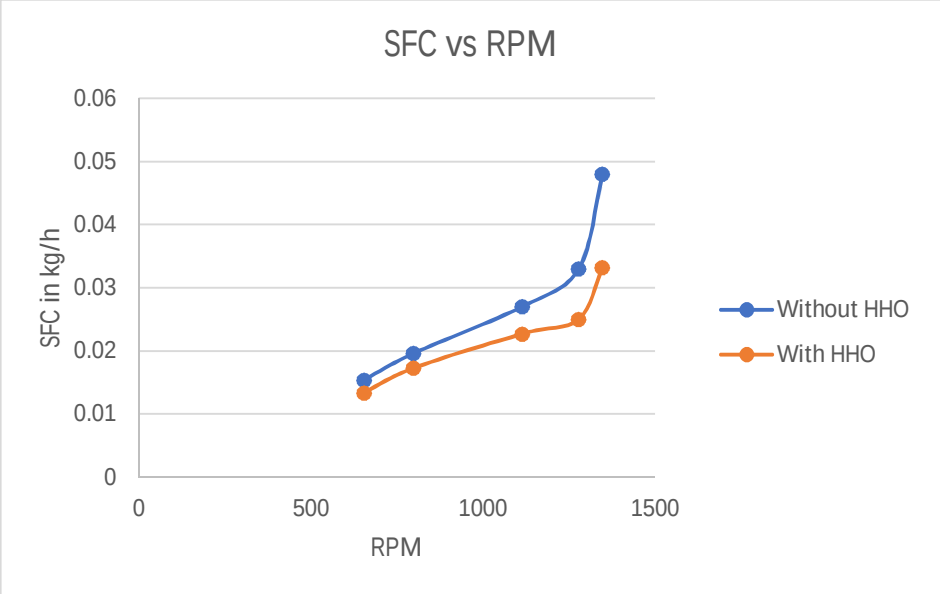

Fig 9: SFC vs RPM graph

The graph shows a maximum decrease in specific fuel consumption of upto 30.83% and an average decrease of 20% after the addition of HHO Kit.

VI. EMISSION ANALYSIS

Emission test is conducted at a local emission testing center. The emission of Carbon monoxide, Hydrocarbons and Carbon dioxide is obtained at various speeds of the engine. The data is tabulated and graphs are obtained as below.

A. Carbon Monoxide Emission

Serial No.	Speed in RPM	Carbon Monoxide Emission (% Volume)	
		Without HHO	With HHO
1	650	2.2	2.0
2	800	2.45	2.225
3	1100	2.727	2.621
4	1280	2.846	2.712
5	1350	3.121	2.92

Table 5: Carbon Monoxide Emission Comparison

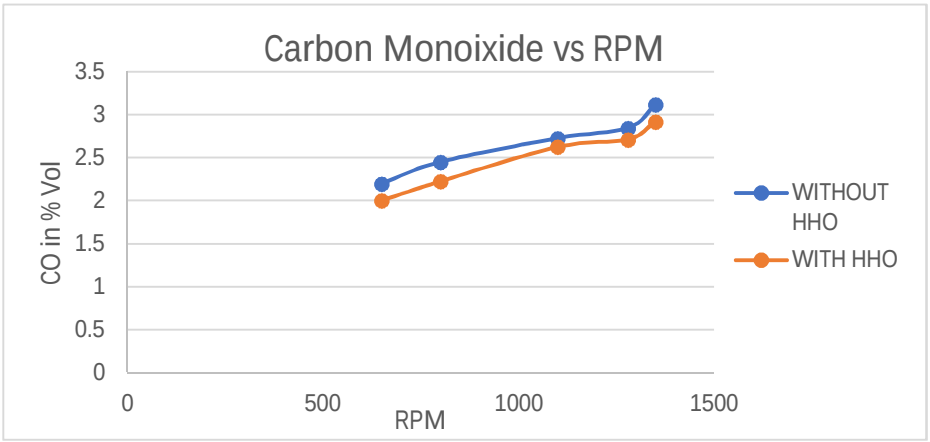

Fig 10: Carbon Monoxide vs RPM

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The above figure shows a maximum decrease in carbon monoxide efficiency of about 9.18% and an average decrease of about 6.64% after the addition of HHO Kit to the vehicle.

B. Hydrocarbon Emission

Serial No.	RPM	Hydrocarbon Emission (PPM)	
		Without HHO	With HHO
1	678	567	524
2	820	598	548
3	1098	623	589
4	1255	699	655
5	1380	724	685

Table 6: Hydrocarbon Emission Comparison

The above data shows a maximum reduction of hydrocarbon emission of upto 8.4% and an average reduction in hydrocarbon emission of 6.63% after the addition of HHO Kit to the vehicle.
The graph is shown as below

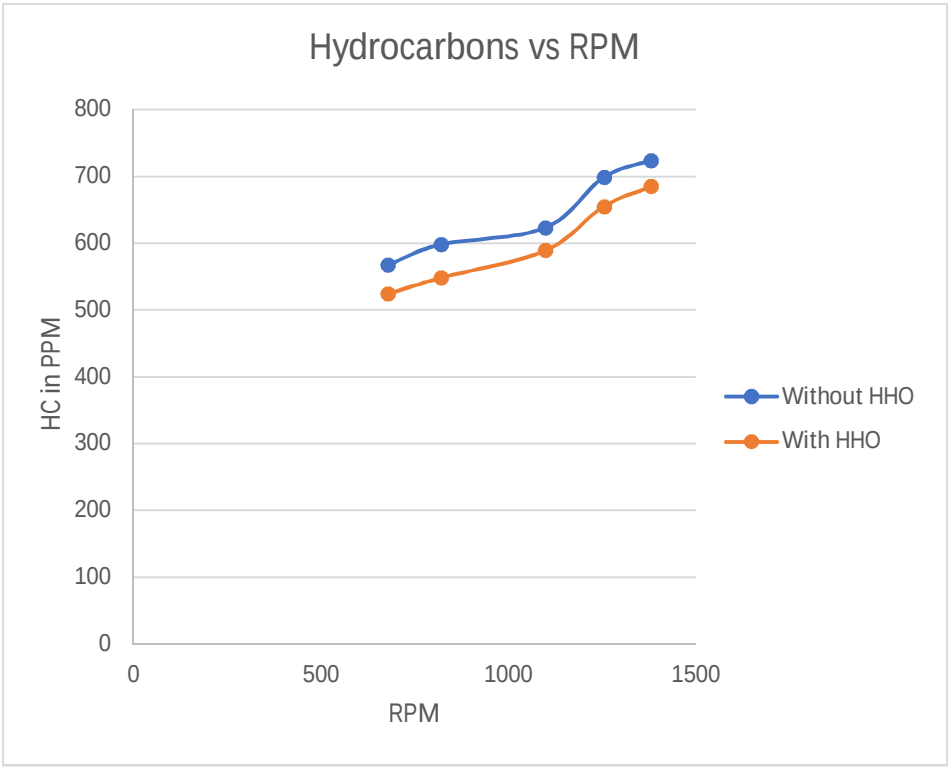

Fig 11: Hydrocarbons vs RPM

C. Carbondioxide Emissions

Serial No	RPM	Carbon dioxide Emission (% Volume)	
		Without HHO	With HHO
1	655	2.96	2.81
2	827	3.21	3.02
3	1112	3.44	3.28
4	1262	3.72	3.56
5	1365	4.41	3.93

Table 7: Carbon dioxide Emission Comparison

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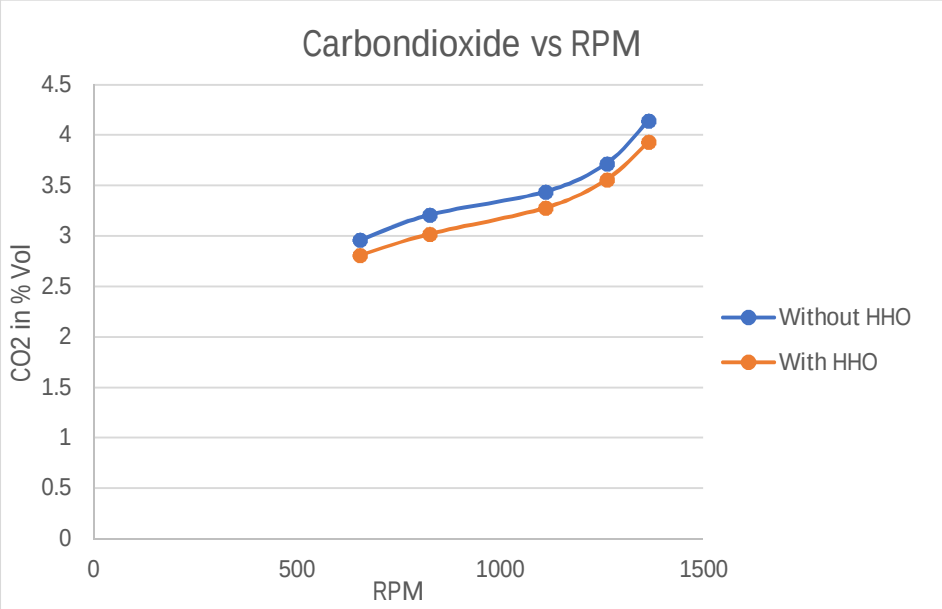

Fig 12: Carbon dioxide vs RPM

The above graph shows maximum decrease in Carbon dioxide emission of upto 6% and an average decrease of 5% after the installation of HHO Kit.

D. Consolidated Performance Results

Serial No.	Parameter	Decrease in Value	
		Maximum (%)	Average (%)
1	SFC (kg/h)	30.83	20
2	CO (% Vol)	9.18	6.64
3	HC (PPM)	8.4	6.63
4	CO_2 (% Vol)	5.99	4.9

Table 8: Consolidated Performance Results

VII. CONCLUSION

This project makes its best efforts to counter the need of preserving fossil fuel, reducing costs incurred on fossil fuels and curbing pollution in some of the most crowded areas of our country, yet, like all other things, it is not perfect. The inclusion of HHO Kit does help reduce emissions by a significant amount, but there are additional maintenance costs involved for that as well. The motor can barely match the power developed by the original 2 stroke IC Engine. The batteries are expensive as of now and need to be replaced every couple of years. Despite all these pros and cons of the vehicle, it does provide one crucial aspect in the field of Engineering, and that is hope, hope for a better design and a feasible way to obtain these individual parts. Hope to improve the efficiency further, with upcoming years, we as engineers will be innovating further to improve this product, and with better resources and even more capable infrastructure for research, there is tremendous scope for this product to lock horns with some of the greatest automobile giants in the Indian market. Even though most efforts in the field of engineering are done to save money, we have achieved that alongside another big achievement, that is, reducing pollution and reducing our carbon footprint on this planet. This is a moral responsibility we have taken upon ourselves with regards to this project.
Main improvements are:

A. Upto 30.83% decrease in Specific Fuel Consumptio
B. Upto 9.18% decrease in Carbon Monoxide Emission
C. Upto 8.4% decrease in Hydrocarbon Emission
D. Upto 6% decrease in Carbon Dioxide Emissions

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VIII. ACKNOWLEDGEMENT

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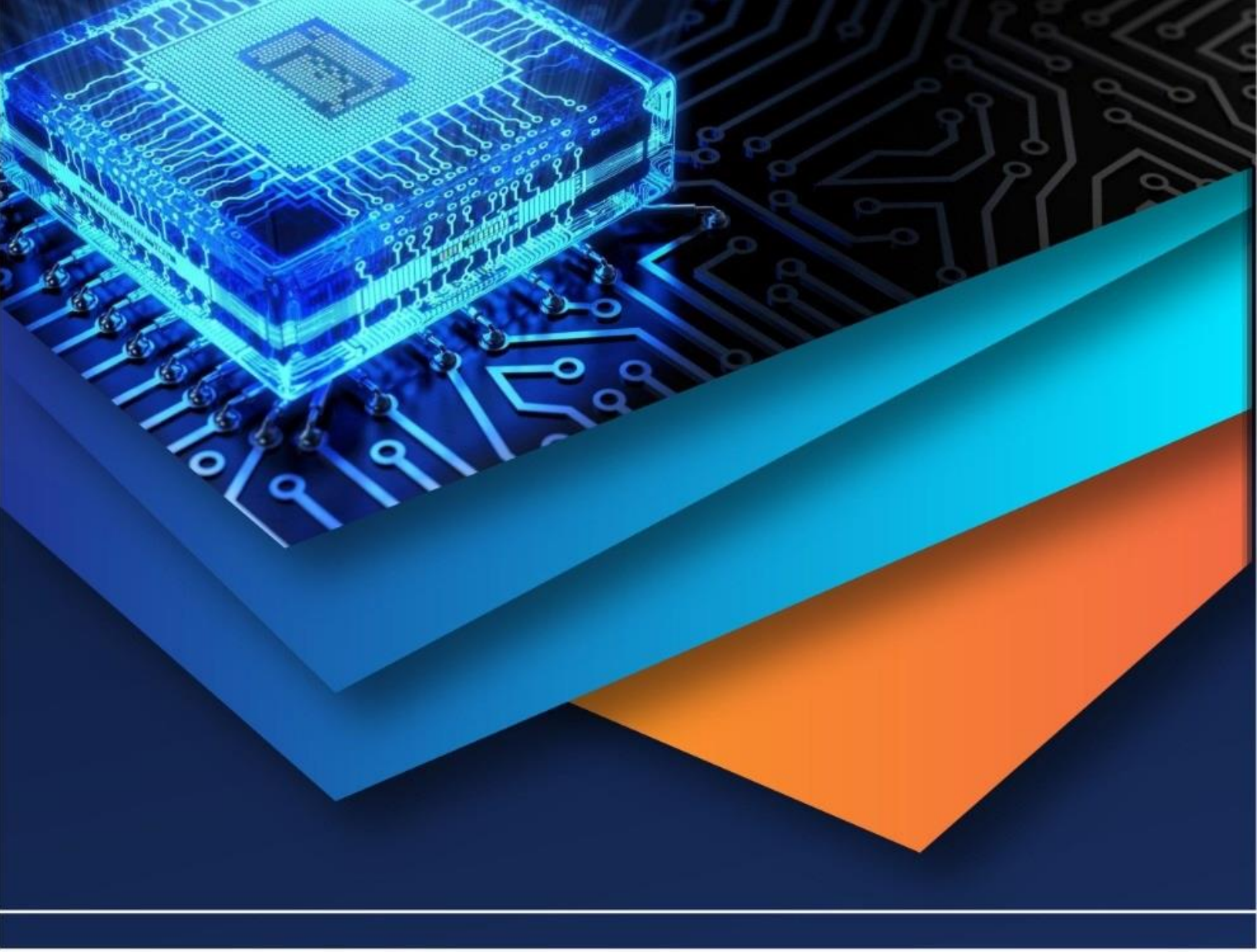

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