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Control of Exhaust Emissions and Enhancement of Retention Time for Four Stroke Engine Using Nano-sized Copper Metal Spray

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Abstract - The approach here is to control the exhaust emissions from four stroke, single cylinder, and spark emission petrol engine having copper nano-particles coated on copper sieve as catalytic converter. AVL-422 gas analyzer was used for measurement and comparision for CO and unburnt hydrocarbon in the exhaust of the engine at various speeds and loads. In the present work, some alterations and modifications have been designed so as to increase the retention period of exhaust gases to provide more time for its oxidation and thereby to reduce harmful emissions.

Index Terms - S.I. Engine, catalytic converter, copper nano-particles, retention time

1 INTRODUCTION

THIS tremendous growth in the urbanization as well as commercialization has made the whole world is in the grip of severe environmental crisis. Air pollution can be defined as presence in atmosphere of one or more contaminants for such duration that is injurious to human health and animal or plant life. To predict the transport related air pollution Newer and newer models have been developed worldwide.

The oxidation of gasoline in the engine to CO_2 and H_2O is far from desired completely efficient process. Various laws and regulations were made to cope up with this problem. The emission standards limit the maximum amount of harmful substances that a car exhaust can release. The pollutants that are limited today by the regulations are hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter (PM). Among above pollutants CO is considered as most toxic pollutant, whose effective reduction can be achieved by using catalytic converter [1]. Unburnt hydrocarbons are present in exhaust emission due to incomplete combustion. The level of unburned hydrocarbons is specified as parts per million (ppm) carbon atoms. The total hydrocarbon emissions are used as a measure of the combustion efficiency. Treatment of the exhaust gas means that some cleaning action must occur after the exhaust gases leave the engine cylinders and also when they exit in the tail pipe and enter the atmosphere [2]. For this two methods are widely used, Air injection system and the Catalytic converter. In the present method, catalytic converters have been used. The C.C. is the leading pollution control device with magnetic and chemical properties yielding applications in biological nanosensors, optoelectronics, nanodevices, nanoelectronics, information storage and catalysis [3].Amongst main metals like Au, Ag, Pd, Pt, towards which nanotechnology research is directed, copper and copper based compounds are the most important . The metallic Copper plays a significant role in modern electronics circuits due to its excellent electrical conductivity and low cost nanoparticles [4]. Thus Copper will gain increasing importance as it is expected to be an essential component in the future nanodevices due to its excellent conductivity as well as good biocompatibility and its surface enhanced Raman scattering (SERS) activity [5]. Metallic copper nanocrystals homogeneously dispersed in silica layers have attracted great attention recently for the development of nonlinear optical devices [6].Such composite materials offer exciting possibilities of potential thin films device applications with novel function arising from size quantization effect. In the light of fast and growing applications of metallic copper nanoparticles, a reproductive method of synthesis with a specific size, well defined surface composition, isolable and redispersable properties remains a challenging task to a synthetic chemist. The ability to scale up the synthesis to bulk scale will gain increasing importance as more and more applications are being established. However, most of the synthetic methods either yielded particles of irregular shape with wide size distribution and required high temperature and pressure condition or produce particles with reduced catalytic activity and inability to reuse the particles.

In this paper, we have reported the synthesis of copper nanoparticles by reducing the copper ions with sodium borohydride [7-10]. The particle size has been varied by modulating the concentrations of reactants and capping agent. The catalytic activities of these particles of different sizes have been tested on the catalytic converter in S.I. engine. Catalytic converter based on spray of copper nano-particle [11-14] on copper sieve demonstrates superior performance. Nano-particle exhibit high temperature stability beyond that normally encounter in catalytic converter applications. Nano-particles less than 3–5 nm in diameter are catalytically active for several chemical

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reactions.

2 PROCEDURE

2.1 System Dsigning

The matrix as discussed above is designed and assembled as per the dimensions given in the Fig. 1. The arrangement was provided within the system to fix the wire gauge of copper. It is designed in such a way so that the area of cross section at the point where the wire gauge is fitted is about five times the area of cross-section of exhaust manifold of the engine. Wire gauge of mesh no. 20 is used and fitted with the help of nuts and bolts.

Engine Specifications are as follows:
RPM: 3 HP
FUEL: PETROL
NUMBER OF CYLINDERS: SINGLE
BORE: 70 mm
STROKE LENGTH: 70 mm

2.2 Calculation of Present Work

Radius of tail pipe	**2.70 cm**
Area of copper sieve	**30.5*30.5=930.25cm^2**
Area of tail pipe	**3.01* (2.70)^2 = 14.58 cm^2**
Area of tail pipe/ Area of copper sieve	**14.48/930.25=1/63.80**
Area of copper sieve	**63.80* 14.58 = 930.250**
Engine specification - Engine capacity **Engine speed**	**= 256.56 c.c. = 256.56 cm^3** **= 3000 rpm**
Volume of gas at outlet of tail pipe	**256.56 cm^3 * 3000/2 rpm = 769680 cm^3/minute.**
Velocity of gas at tail pipe outlet in cm/minute	**384480 cm^3 / minute** **4.44 cm^2 = 26395.06 cm/min**
Velocity of gas at tail pipe outlet in m/sec	**26395.06 * 10^{-2} = 4.39 m/sec** **60**
Velocity of car passes through copper sieve	**velocity of gas at tail pipe = 0.081 m/sec** **209.52**
Velocity of gas at tail pipe outlet in m/sec **Velocity of gas passes through copper sieve**	**= 4.39 = 6.46 m/sec** **0.68**
Finally velocity of gas passes through copper sieve	**Velocity of gas at tail pipe outlet** **6.46**

2.3 Preparation of Copper Nano-particles

In a typical procedure, 20 ml ethylene glycol (EG) solution (0.1M) of CuSO4·5H2O was mixed with 20 ml EG mixed solution of NaOH and N_2H_4·H2O under magnetic stirring. The molar ratio of N_2H_4·H2O / CuSO4 was 1.5 and the molar ratio of NaOH / CuSO4 was 0.05. The mixture solution was placed in a microwave oven (2.45 GHz, GalanzWP750) and reacted under medium power (750 W, working cycle of 18 s on and 12 s off) for 3 min. Upon irradiating for about 30 s, the mixture turned from light blue to black; at about 90 s, the mixture boiled at about 196°C. (The heating rate was then estimated to about 120 °C min^{-1}.) Then the mixture was irradiated for another 2 min to keep the mixture boiling. After cooling to room temperature, Cu nanoparticles were obtained by centrifuging and washing with ethanol several times.

Transmission Electron microscopic (TEM) analyses were performed with Morgagni 268D Transmission electron microscope operating at 80kB (Mega view III Camera CCD), all India Institute of Medical Sciences (AIIMS), New Delhi. Samples were prepared by drying a drop of the colloid on a TEM grid with the sample allowed to dry completely at room temperature. Approximately 100 nanoparticles from each sample were measured manually for size distribution. Triple distilled water was used for solution preparation.

2.4 Experimental Procedure

1. Connect the instrumentation power input plug to a 230 V, 50 Hz single phase AC supply. Now all the digital meters namely, RPM indicator, temperature indicator display the respective readings and also connect the inlet and outlet water connections to the exhaust gas calorie meter and engine.
2. Fill up the petrol to the fuel tank mounted side of the panel.
3. Check the lubricating oil level in the oil sump. Allow water to the engine and calorie meter and adjust the flow rate.
4. Start the engine with the help of self start arrangement.
5. Allow the engine to stabilize the speed, i.e., 2800 rpm or 3000 rpm by adjusting the accelerator.
6. Apply ¼ load, i.e. slowly vary the potentiometer.
7. Note down all the required parameters mentioned below:
(a) Speed of the engine in rpm.
(b) Load from spring balance.
(c) Time taken for 10 cc of fuel consumption.
(d) Manometer readings.
(e) Different temperatures from temperature indicator.
8. Load the engine step by step with the use of field excitation rheostat provided on the load bank such as,
(a) ½ load
(b) ¾ load
(c) Full load

3 RESULTS AND DISCUSSION

Emission parameters of a four stroke S.I. engine with and without catalytic converter are studied by changing load and speed as shown in Fig. 3-6. By studying various graphs for carbon monoxide and hydrocarbon in varying speed and load, the following results were obtained:

A) Figure 3a & 3b showed the effect of changing load on CO & HC percentage emission at 1500 rpm. It is clear from the figure that CO & HC emission at 0.25 load is somewhat higher than the moderate load (0.5 & 0.75 load) because the temperature outside the burning flame zone is much lower leading to formation of hydrocarbons also the air-fuel ratio is 10:1 leading to slow oxidation. As the load increases from 0.25 to 0.5 to 0.75, more amount of charge is supplied inside the cylinder and the oxidation process is accelerated. Finally when load increases from 0.75 to 1, emission of CO and HC increases from 1.3% to 1.6% and 1700 ppm to 1800 ppm respectively. On repeating the same step using catalytic converter the emission of HC and CO are found to be lowered.

B) At varying increased load with increasing speed it is found that emission of CO & HC decreases. Emission of CO decreases from 1.5% to 1.2% when speed increases from 1500 to 1800 rpm as shown in Fig. 4a & 4b

C) The emission of CO and HC decreases till the speed reaches to 2000 rpm, and on further increasing the speed the emission again increases as the port and spark timing did not match which results in incomplete combustion of fuel shown in Fig. 5a&b.

d)On repeating the above steps for 1500-2400 rpm using catalytic converter (Cu sieve) coated with copper nanoparticle, the emission of HC and CO are found to be lowered & more efficient than bulk copper.

2 CONCLUSION

The engine is designed to run at medium load (0.5 load) for a longer time due to less emission of HC and CO. At full load, emission of HC and CO is higher so it is not desirable to run engine at full load. The converter uses two different types of catalyst, reduction and oxidation catalyst. The idea behind the work is to create a structure that exposes the maximum surface area of catalyst to exhaust stream, also minimizing the amount of catalyst required. The exhaust gases pass through a bed of catalyst and the catalytic action takes place at surface of Cu which are porous and the the higher catalytic activity towards the oxidation of CO and HC could be due to the higher catalytic surface area of small nanoparticles.

ACKNOWLEDGMENT

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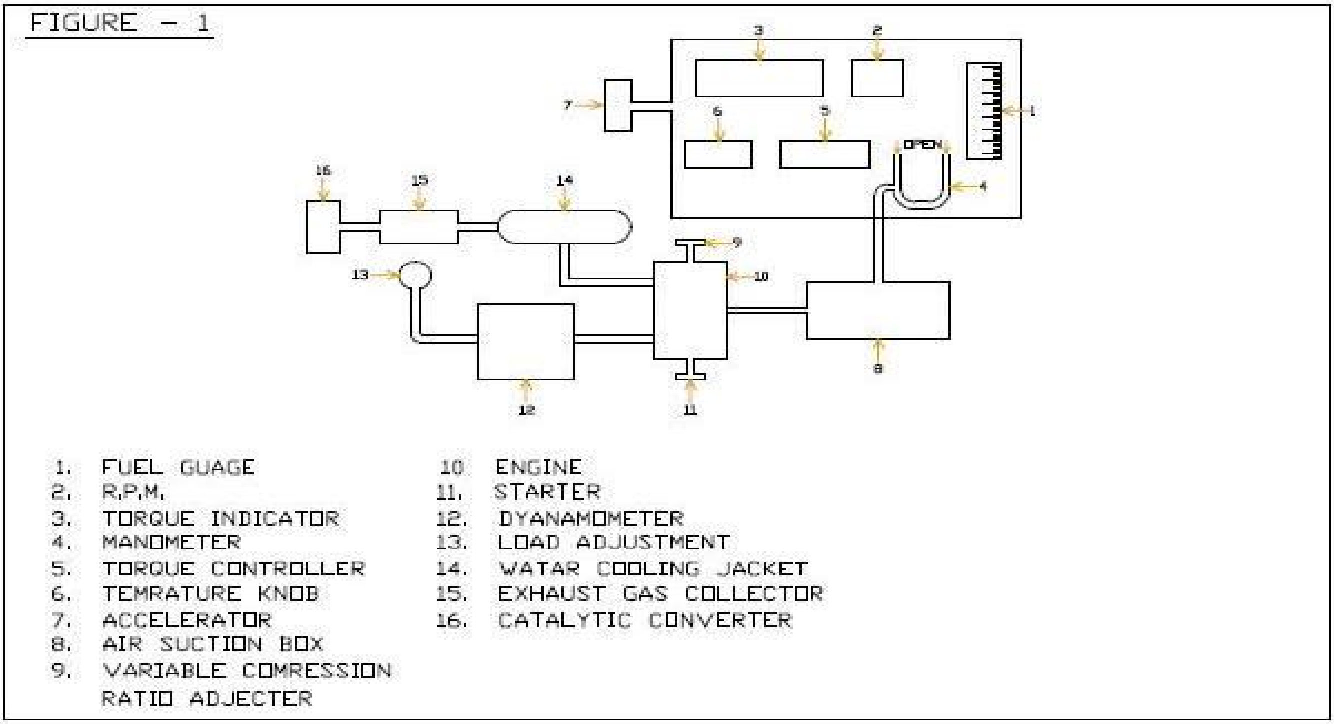
FIGURE CAPTIONS:

1) FIGURE 1



2) FIGURE 2

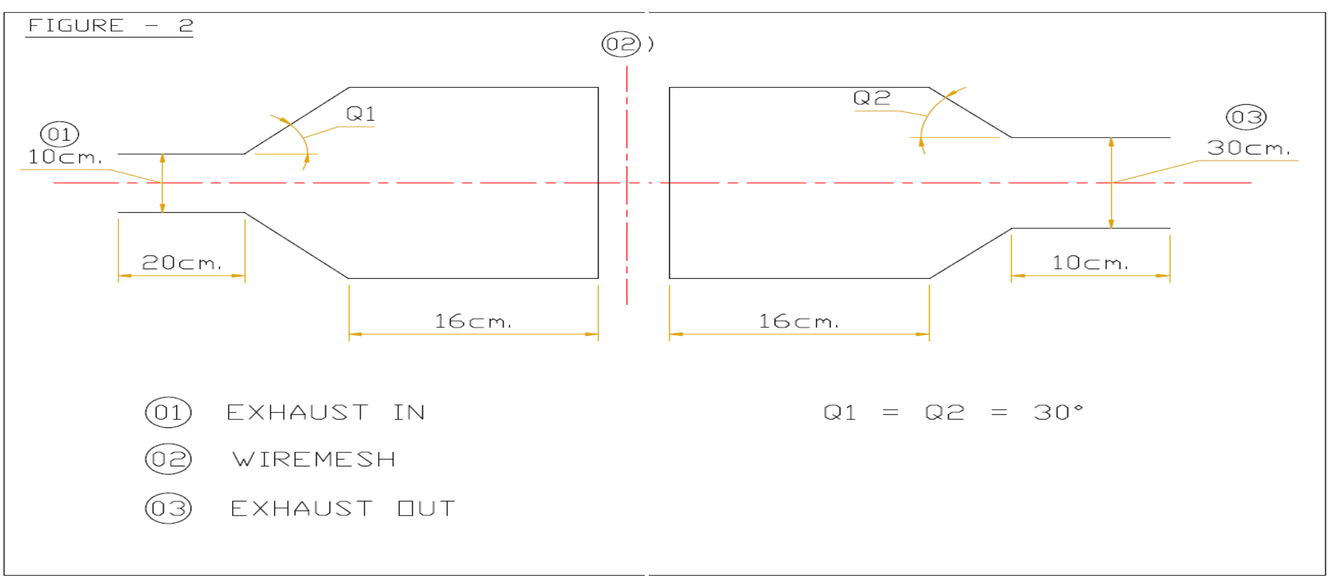


FIGURE 3: VARIATION OF CO WITH LOAD AT 1500 RPM

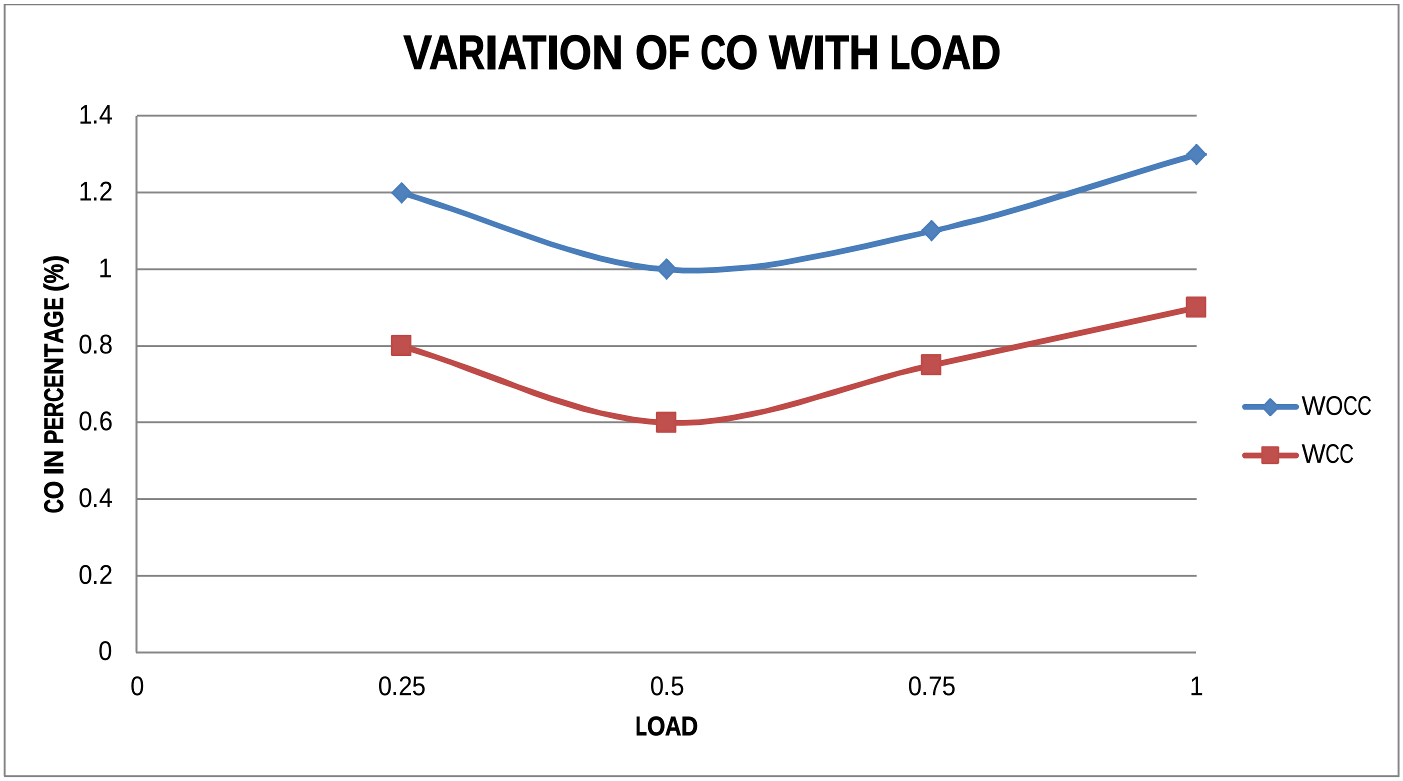


FIGURE 4: VARIATION OF CO WITH LOAD AT 1800 RPM

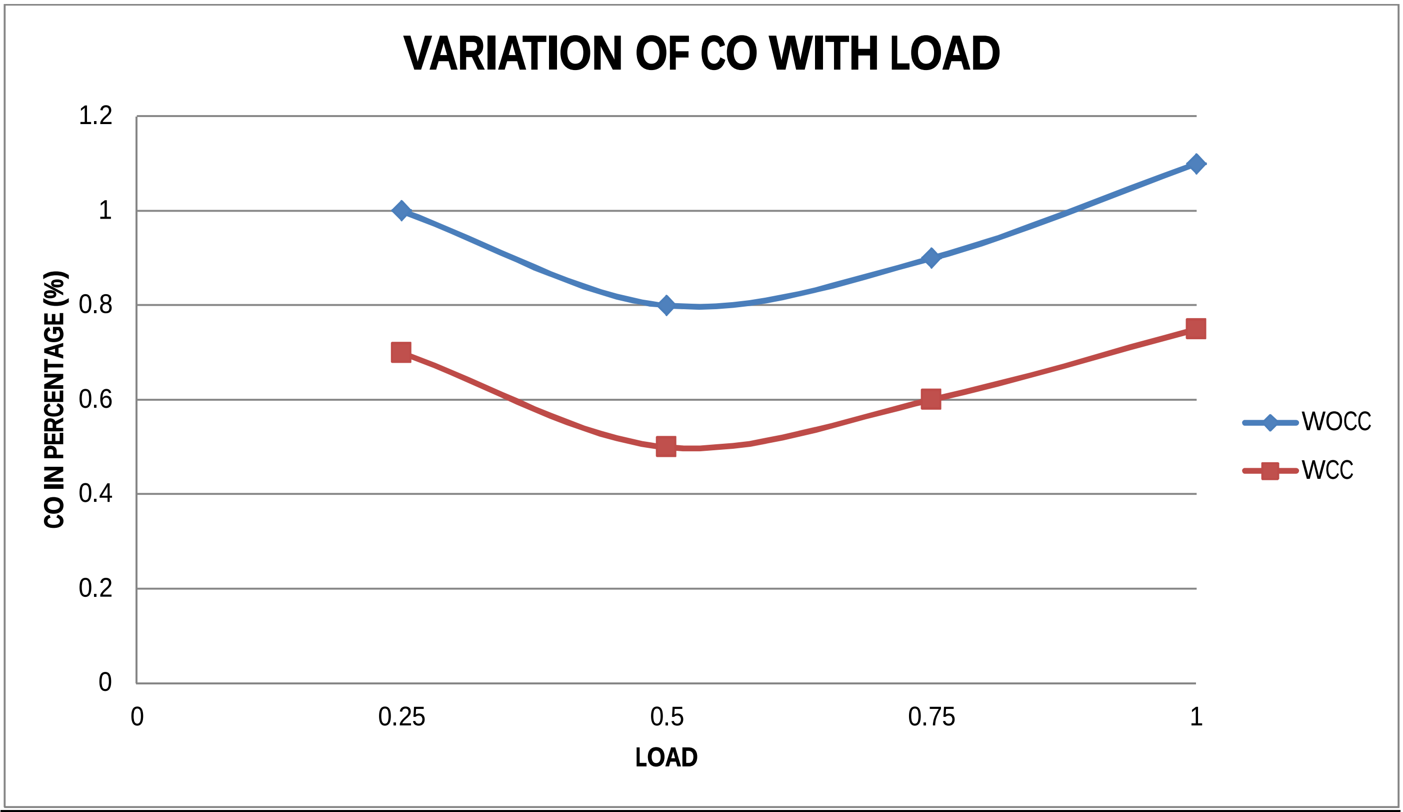


FIGURE 5: VARIATION OF LOAD WITH CO AT SPEED OF 2000 RPM

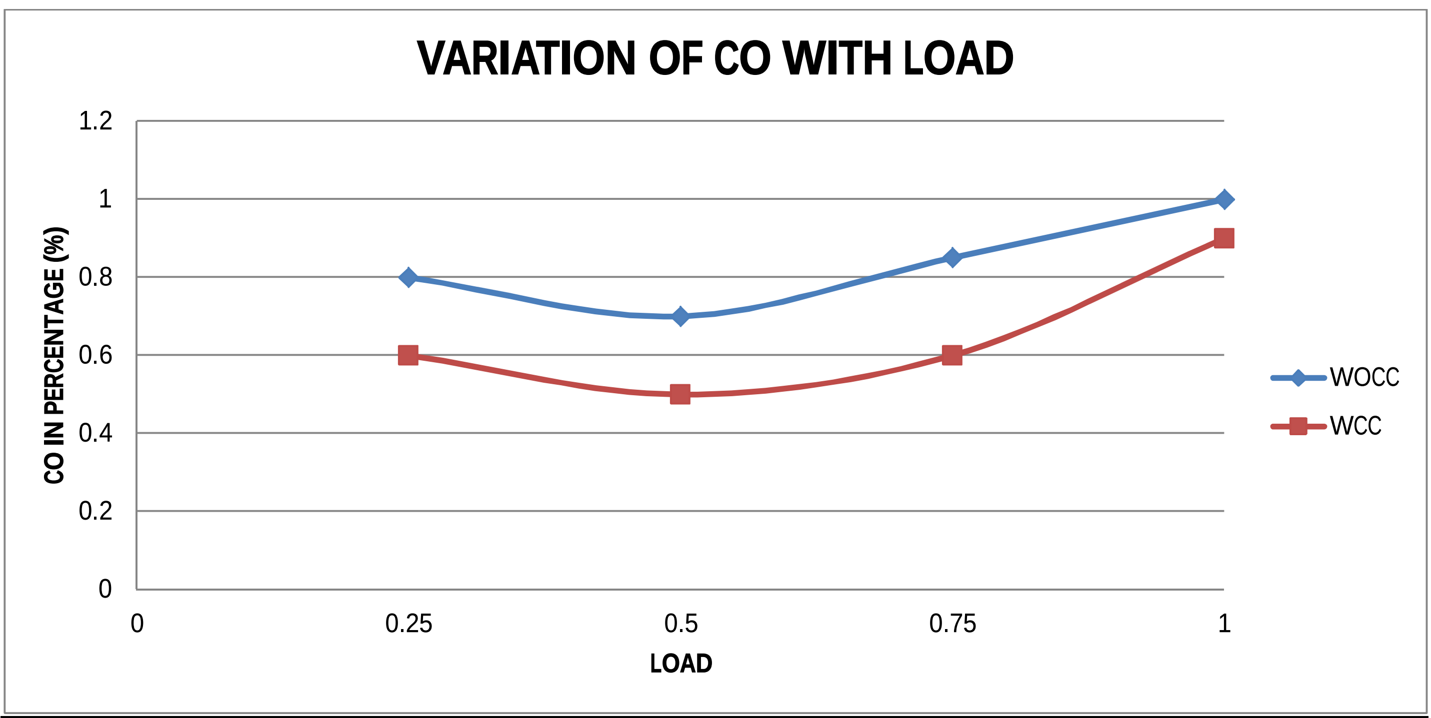


FIGURE 6: VARIATION OF LOAD WITH CO AT SPEED OF 2200 RPM

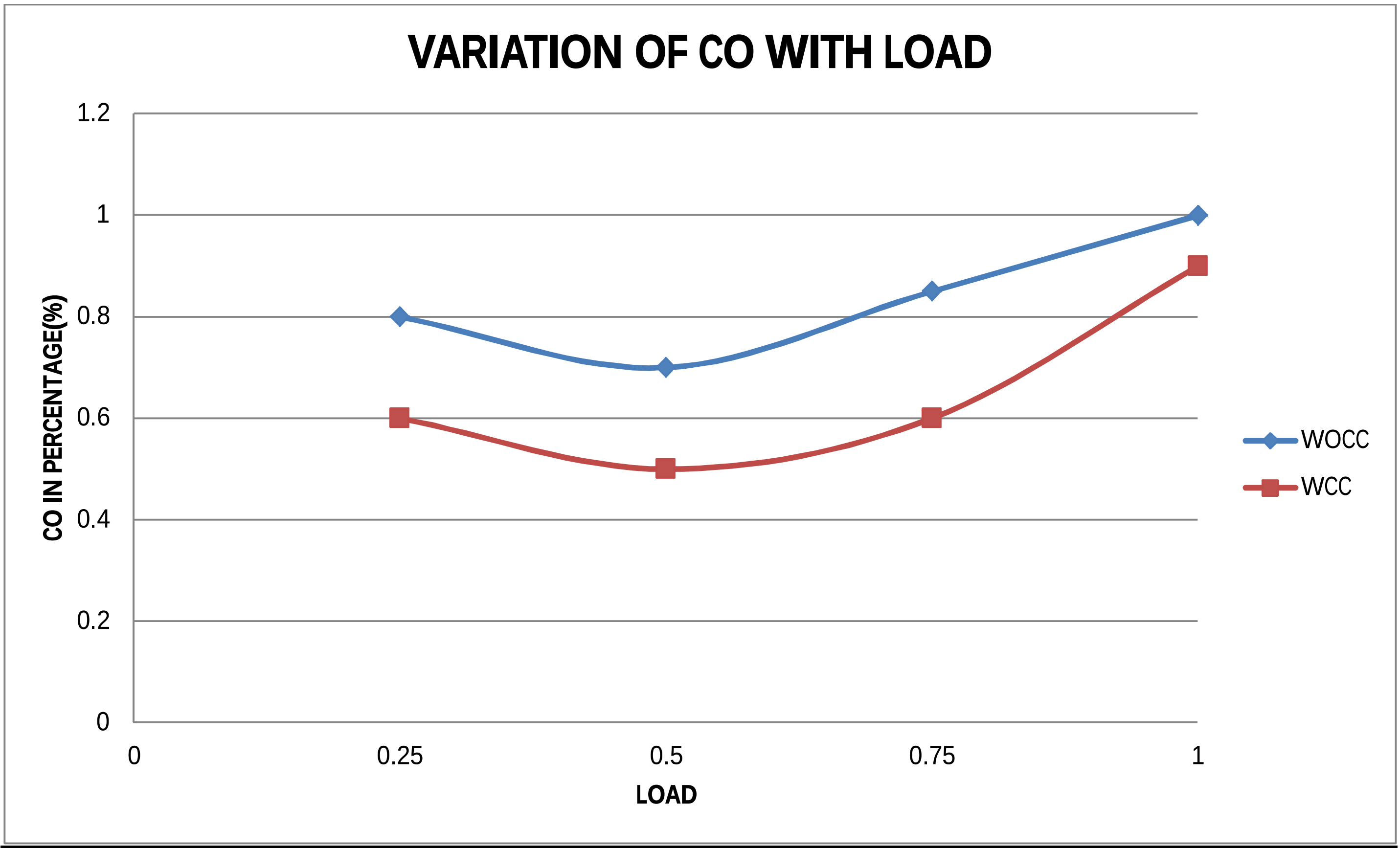


FIGURE 7: VARIATION OF HC WITH LOAD AT 1500 RPM

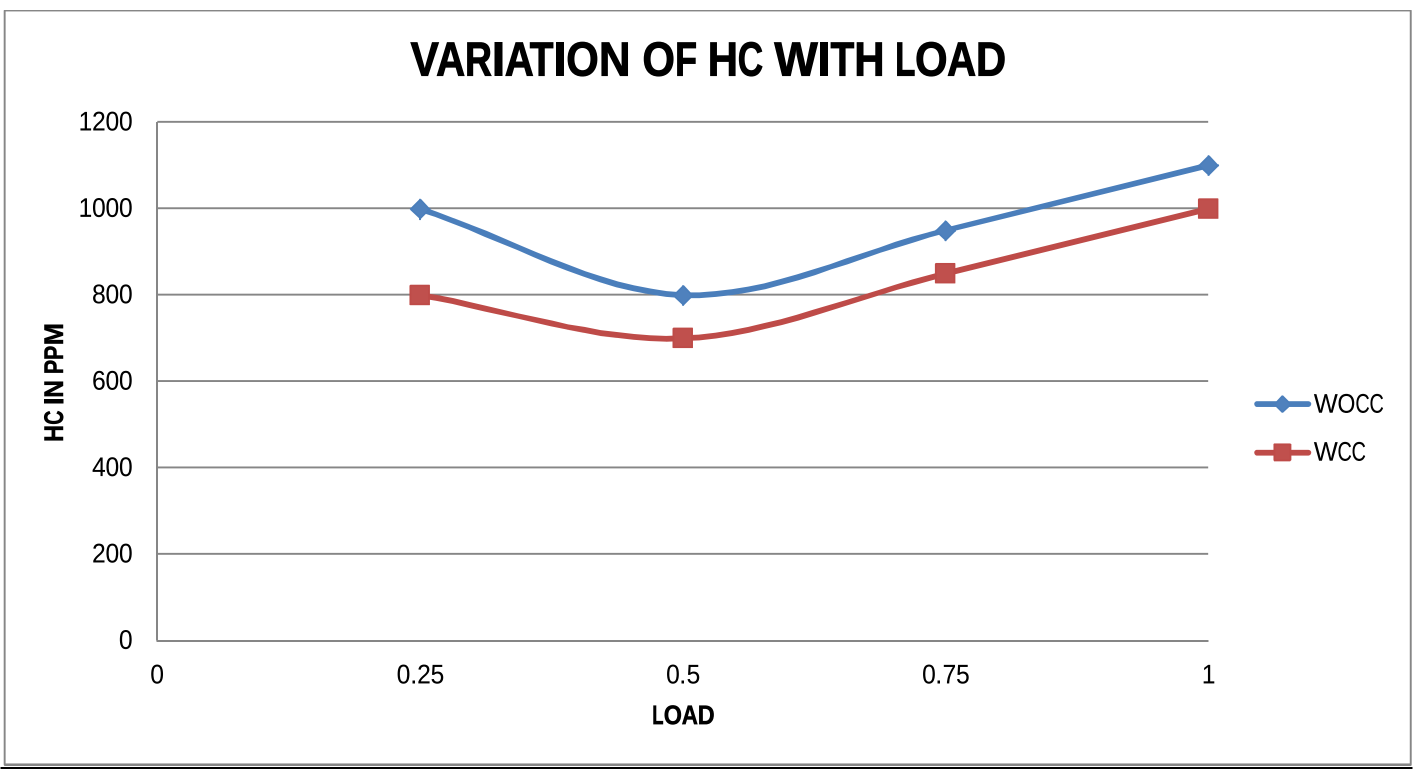


FIGURE 8: VARIATION OF HC WITH LOAD AT 1800 RPM

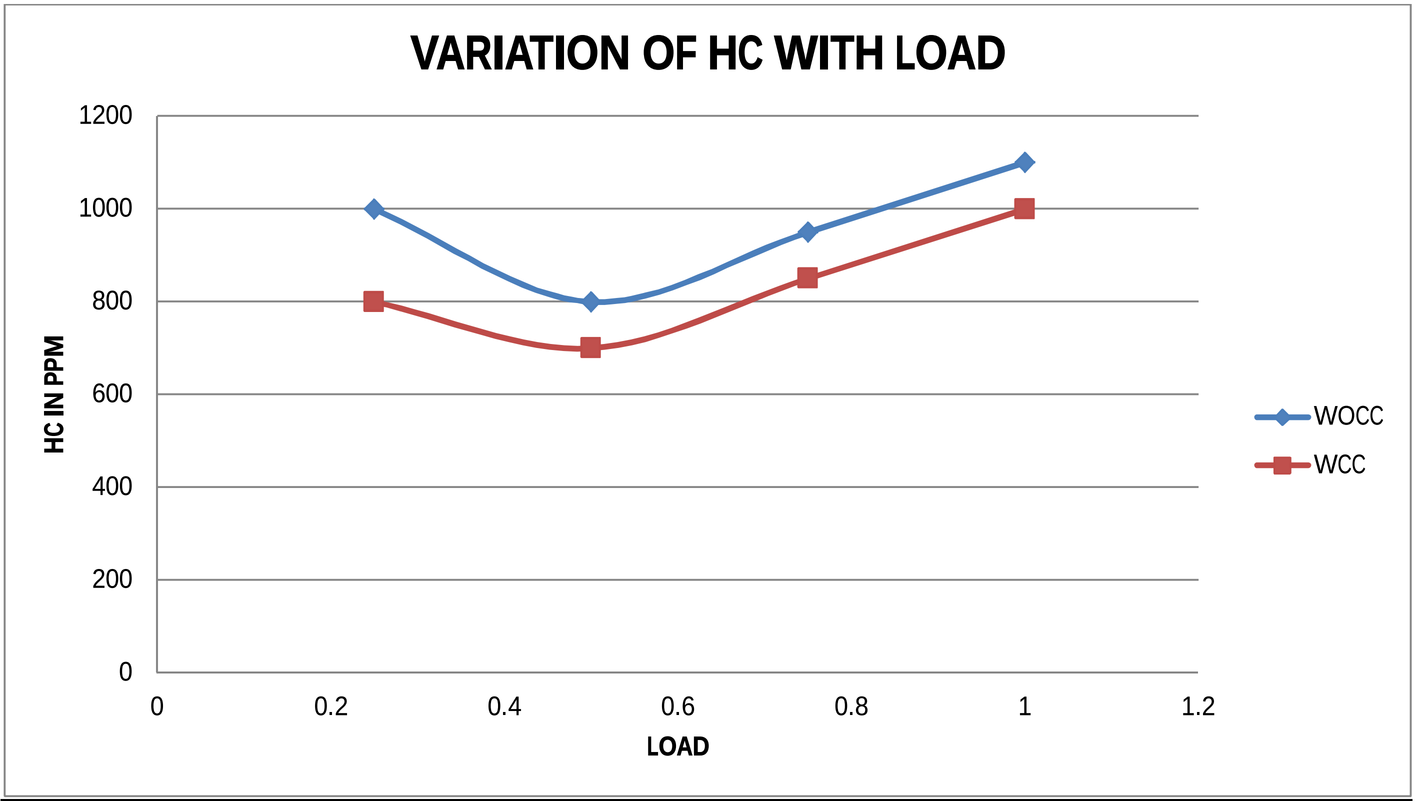


FIGURE 9: VARIATION OF HC WITH LOAD AT 2000 RPM

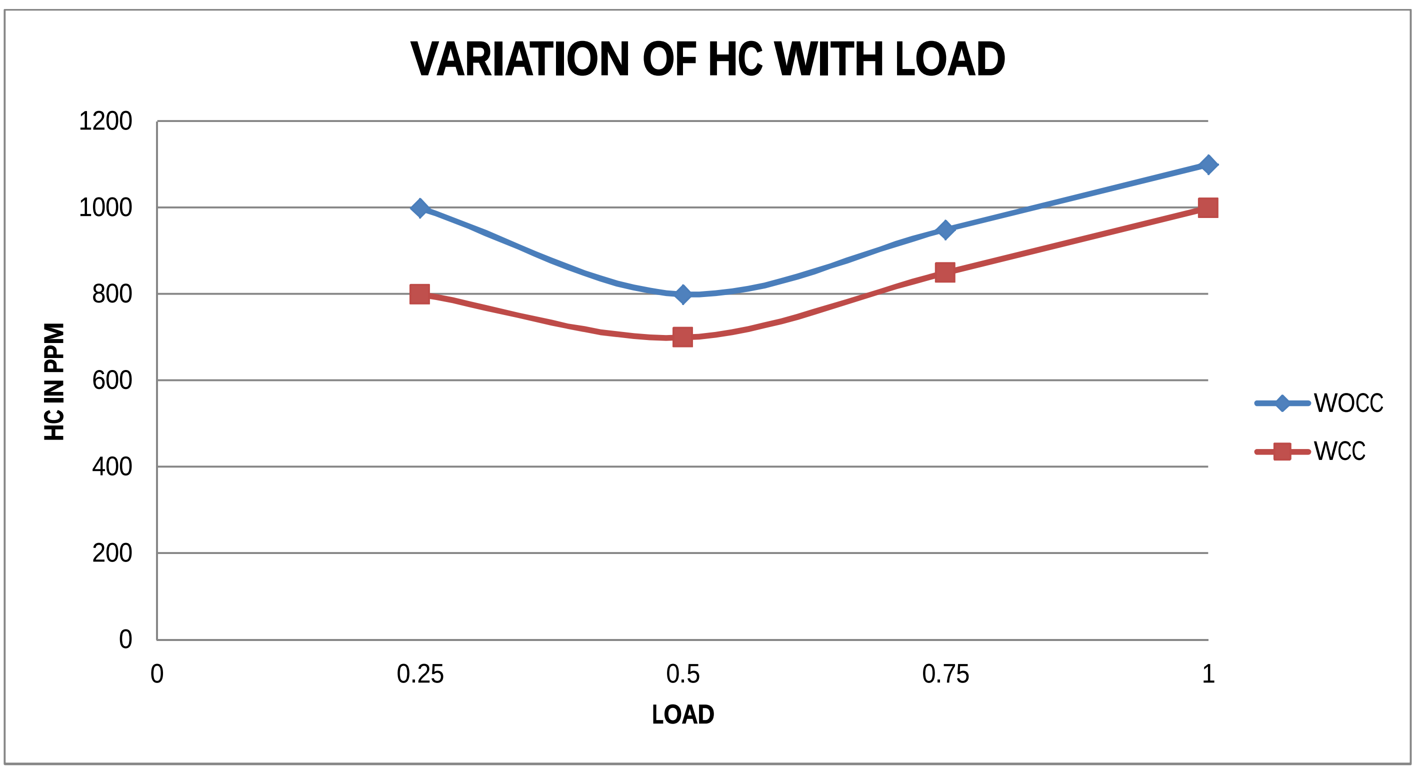
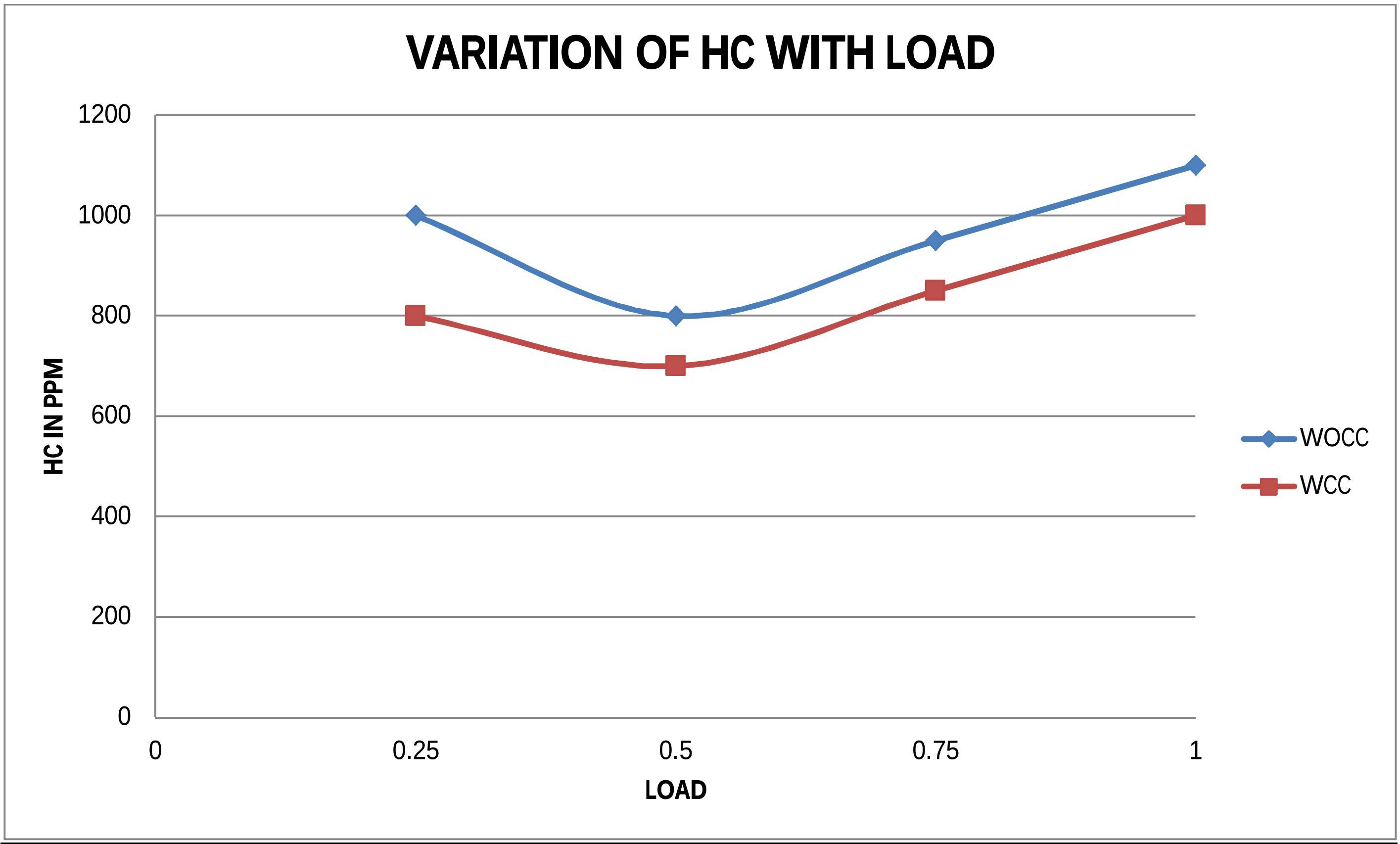


FIGURE 10: VARIATION OF CO WITH LOAD AT 2200 RPM


VARIATION OF HC WITH LOAD
HC IN PPM
1200
1000
800
600
400
200
0
0
0.25
0.5
0.75
1
LOAD
WOCC
WCC