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Study the Effect of The Initial Temperature of Diesel Fuel Upon Engine Performance, By Using CI Engine.

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Abstract

In my work , I investigates the effect of initial temperature of diesel fuel upon engine performance and emissions by using CI engin , with different diesel fuel cetane number (56 , 54 , 53) , from the results it showing us that the brake power is increasing with the engine speed and the increasing is (64.66 %) at maximum load with respect with brake power at minimum load ,also measuring the brake torque and it is found from the results the brake torque is increasing with the engine speed at minimum and maximum load and from the results it is found that the brake torque is increasing about (63.902 %) when compare it with brake torque at minimum load ,fuel consumption(kg/hr) is increasing with the engine speed but decreasing when increasing cetane number with the following values (6.631%,7.843%,9.15%) for cetane number (53,54,56) , and the brake specific fuel consumption also decreasing about (6.065%,6.98%,8.654%) for Cetane number (56,54,53) respectively , the thermal efficiency it is found to be increased with the engine speed and for different fuel cetane number with the following percentage (5.96%,6.837%,8.498%) for Cetane number (53, 54 , 56) respectively, The (CO_2) emissions is increased with the engine speed and when the Cetane number increased about (11.35%,9.457%,11.065%) for cetane number (56,54,53) respectively , The (CO) emissions is decreased when the Cetane number increased about (24.165%,20.581%,21.7%) for Cetane number (56,54,53) respectively , The (HC) emissions is decreased by increasing fuel Cetane number about (8.695%,10%,9.586%) for Cetane number (53 , 54 , 56) respectively.

Keywords: Cetane number, Fuel Consumption, Brake specific fuel consumption, Engine speed.

1- Introduction.

1.1 Diesel Fuel.

Diesel fuel is obtainable over range of molecular weights and physical properties, various methods are used to classify it,some using numerical scales and some designating it for various uses.For convenience, diesel fuels for IC engines can be divided into two extreme categories, light diesel fuel which has a molecular weight of about (170) and can be approximated by the chemical formula ($C_{12.3}\ H_{22.2}$), and heavy diesel which has a molecular weight of about (200) and can be approximated as ($C_{14.6}H_{24.8}$). Most diesel fuels used in engines will fit in this range, light diesel fuel will be less viscous and easier to pump, will generally inject into smaller droplets [1].

1.2 Cetane Number.

In a compression ignition engine,self-ignition of the (air-fuel)mixture is a necessity, the correct fuel must be chosen which will self-ignite at the precise proper time in the engine cycle.It is therefore necessary to have knowledge and control of the ignition delay time of the fuel.The property that quantity this is called the (Cetane Number), the larger the cetane number, the shorter is the ignition delay and the quicker the fuel will self-ignite in the combustion chamber environment. A low cetane number means the fuel will have a long ignition delay .cetane numbers are established by comparing the tested fuel with two standared reference fuels. The fuel component (n-cetane) (hexadecane) , ($C_{12}\ H_{34}$) , is given the cetane number value (100), while heptamethylenonane (HMN), ($C_{16}\ H_{34}$) is given the value of (15). The cetane number (CN) of other fuels is then obtained by comparing the (Ignition delay) of that fuel with the (Ignition delay) of a mixture blend of the two reference fuels with:

CN of fuel = (percent of n-cetane) + 0.15 (percent of HMN)..(1-1).

The normal cetane number range for vehicle fuel is about (40 to 60) for a given engine injection timing and rate, if the cetane number of the fuel is low , the ignition delay will be too long .When this occurs, more fuel the desirable will be injected into the cylinder before the first fuel particles ignite, causing over large, fast pressure rise at the start of combustion .This results in low thermal efficiency and a rough-running engine (long ignition delay of fuels with cetane numbers below (40) causes in a very rich fuel-air mixture in the cylinder when ignition finally occursThis results in unacceptable levels of exhaust smoke, and these fuels are illegal by many emission laws). If the [CN] of the fuel is high, combustion will start too soon in the cycle. Pressure will rise before (top dead center) and more work will be required in the compression stroke. Cetane number is the most important single fuel property which affects the exhaust emission, noise and start ability of a diesel engine. In general, the lower the cetane number, the higher are the hydrocarbon emissions and noise levels, cetane fuels increase ignition delay so that start of combustion is nearer to top dead center [2].

1.3 Ignition Delay and Cetane Number.

An increase in temperature, pressure, engine speed, or compression ratio will decrease the ignition delay time. Fuel droplet size, injection velocity, injection rate, and physical characteristics of the fuel seem to have little or no effect on the ignition delay time. At higher engine speeds, turbulence increased, wall temperature is higher and ignition delay is decreased in real time. However (ID) is almost constant in cycle time, which results in a fairly constant crankshaft angle position for the combustion process at all speeds. It is important to use fuel with the correct cetane number for a given engine cycle and injection process. If the cetane number is low , ignition delay will be too long , and more-than desirable amount of fuel will be injected in to the cylinder before combustion starts.then, when combustion does start , a greater amount of fuel will be quickly consumed and the initial cylinder pressure rise will be greater,Then when combustion does start , a greater amount of fuel will be quickly consumed and the initial cylinder pressure rise will be greater,If the cetane number is high , combustion will start too early before (top dead center) , with a resulting loss in engine power.Ignition delay time is inversely proportional to cetane number .

$$\text{Ignition Delay} \quad \alpha \quad 1/CN \ldots\ldots\ldots\ldots\ldots (1\text{-}2).$$

(The use of a fuel with too low cetane number results in accumulation of fuel in the cylinder before combustion causing " diesel knock " , and too high cetane number will cause rapid ignition and high fuel consumption).The increasing temperature of fuel injection will cause large spray droplets and incomplete combustion , fuel is injected into combustion chamber in an atomized spray at end of the compression stroke, after air has been compressed to (31-45) bar and has reached a temperature, due to compression , of at least (500℃) . This temperature ignites the fuel and initiates the pistons power stroke, the fuel is injected at high pressure (137) bar to ensure good mixing [3].

2- Literature Summury.

Effect of Fuel Cetane Number on Engine Performance and Emissions.

A . M . Icekes, et.[4], 2009, studied the effect of fuel cetane number on a premixed diesel combustion mode, they demonstrated how variation in fuel cetane number affect the detailed combustion behaviour of a direct injection diesel engine. The testing was conducted under light load conditions on a modern single cylinder engine fulled with a range of ultra low sulphar fuels with cetane number ranging from 42 to 53. Fuel cetane number was found to affect the ignition delay and accordingly, combustion phasing and gaseous emissions.

Yakup Icingur et.[5], 2001, investigated the effect of fuel cetane number and injection pressure on the direct injection diesel engine performance and emissions . In this experimental study, the effects of different fuel cetane numbers (CN) and fuel injection pressures on a diesel engine emissions and on the performance were investigated . For this purpose, the fuels with (46.51 , 54.5 ,and 61.5) (CN) were tested in a four - cycle four - cylinder (Direct injection) diesel engine, measurements were conducted for each of the injection pressure (100 , 150 , 200 , 250) bar. The change of engine performance for the different (CNs) was also tested at full load condition and the results showed that (CO) emissions are reduced about (5%). The fuel (CN) is increased for the standard injection pressure, but the smoke value increased dramatically when the injection pressure was reduced to (100)bar in contrast with the lower pressure smoke that decreased when the injection pressure was increased to (250 bar). Increases in engine torque by (5 %) and power output by (4%) were observed at the max torque speed of (2500 rpm), when the cetane number was increased from (46 to 54.5). However when increasing (CN) above (54.5) no significant increase in the engine performance was observed.

Wu Yu, et.[6], 2011, studied the effect of cetane number (CN) improver on the performance and emissions, including particulate number concentration and size distribution, of a turbocharged, common-rail diesel engine fueled with biodiesel-methanol. Two volume fractions (0.3% and 0.6%) of CN improver were added to BM30 (30% of methanol in the biodiesel-methanol blend) in the experiment. The results showed that, compared with those of biodiesel-methanol blend, the peak value of cylinder pressure increaseses. the second peak of heat release rate decreases. the start of second heat releaseis advanced. and the fuel economy and thermal efficiency are improved when CN improver is added to biodiesel-methanol blend. Besides, CO and HC emissions decrease, and smoke emissions increase slightly.

Renato Cataluña et.[7], 2010, investigated the effect of ignition delay time in diesel engines on the formation of particulate matter, using fuel formulations with different sulfur concentrations from various sources. The (CN) of diesel fuels has a determining effect on PM and unburned hydrocarbon (HC) emissions, the increase in ignition delay time observed in fuels with low (CN) shifts the maximum pressure to angle above 20 degree after the top dead center while simultaneously reducing the maximum temperature in the combustion chamber. This reduction in maximum temperature has a favorable effect because of reducing the cracking reactions of the high molecular weight fractions , thus reducing the emissions of particulate matter . On the other hand , with the increase in CN the maximum pressure after the top dead center was observed at angles smaller than 20 degree, providing a greater torque. This in turn translates into lower specific fuel consumption, increasing the thermal cracking reaction which favors the formation of particulate matter and increases the speed of oxidation reactions, reducing the emissions of unburned hydrocarbon. The presence of sulfur in the fuel slightly increases the particulate emission, but the determining effect on particulate matter emissions is tied to the CN, which determines the maximum pressure in the combustion chamber .Overall, it was observe that increasing the CN by one number increases the particulate matter emissions by 8% and reduces the hydrocarbon emissions by 4%.

3- Experimental Work.

The experimental work was done on a diesel engine type (Fiat) .

3.1 Compression Ignition Engine.

The engine used in the experimental work is a compression ignition engine (C.I. engine) type (FIAT) model (TD313), 4 cylinders, 4 strokes; the displacement volume for this engine is (3.666L). The engine was coupled to a hydraulic dynamometer to measure the brake torque. Figure (1-1) shows the experimental rig of (C.I. engine), and table A-1 lists the main technical specifications of this engine.

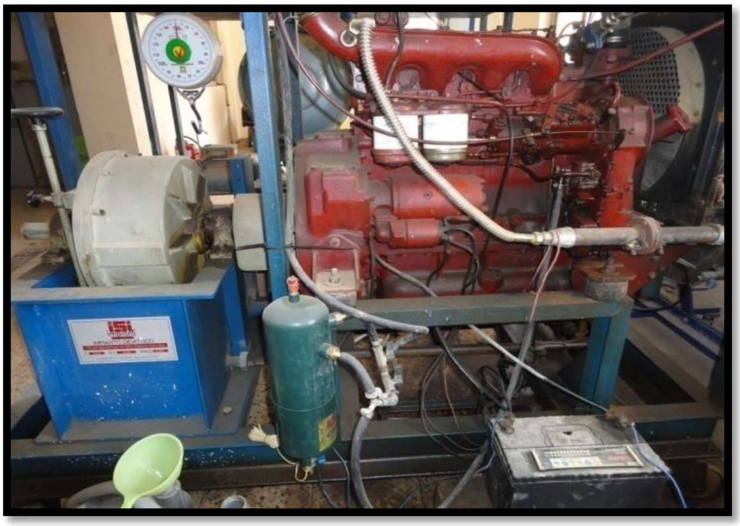

Fig. (1-1) Diesel Engine Type Fiat.

Table (A-1) Main technical specifications of compression ignition engine (C.I. engine).

FIAT diesel engine	
Engine type	4-cylinder , 4-stroke
Engine model	Fiat , TD 313 , Diesel engine rig
Combustion type	Direct Injection , water cooled, natural aspirated
Displacement	3.666 Lit.
Valve per cylinder	two
Bore	100 mm

Stroke	110 mm
Compression ratio	17.667
Fuel injection nozzle	Hole nozzle 10 nozzle holes Nozzle hole dia. (0.48m) Spray angle= 160^{o} Nozzle opening pressure=40Mpa

3.1.1 Measuring Parameters.

The following parameters are measured for the diesel engine:-

1- Brake torque (N.m).

2- Engine speed (rpm).

3- Fuel consumption (kg/hr).

4- Air consumption.

5- Emission (Gas Analyzer).

3.1.2 Measurement of brake torque.

The hydraulic dynamometer, Fig (1-2), type (isilingegner iadidattica) was used to measure the brake torque of (C.I. engine) by using friction fluid. Water was used as the friction fluid . The dynamometer consists of an inner rotating member or impeller coupled the output shaft of the engine. This impeller rotates in a casing filled with water. The output can be controlled by regulating the gates which can be moved in and out to partially or wholly obstruct the flow of water between the impeller and casing. The equation (1-3) in (Appendix A) was used to calculate the brake power.

Fig. (1-2) Hydraulic Dynamometer.

$$Bp = \frac{2\pi * N * Tb}{60 * 1000} \quad kW \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1\text{-}3).$$

3.1.3 Measurement of engine speed (rpm).

The measuring of the engine speed of compression ignition engine (C.I. engine) was done through the speed gauge of the engine, figures (1-3) shows the engine speed gauge.

Fig. (1-3): The engine speed gauge.

3.1.4 Fuel consumption.

The glass tube, as shown in Figures (1-4), was used to measure the fuel consumption of the (C.I. engine). This glass tube has a constant volume (100) ml, a stop watch was used to measure the fuel consumption of this volume, and fig (1-5) shows the three tanks used in the test that contain diesel fuel with different fuel cetane numbers and, two tank for cetane number of (53, 54) and the main tank of the engine filled with cetane number (56). The equation (1-4) was used to calculate the fuel consumption.

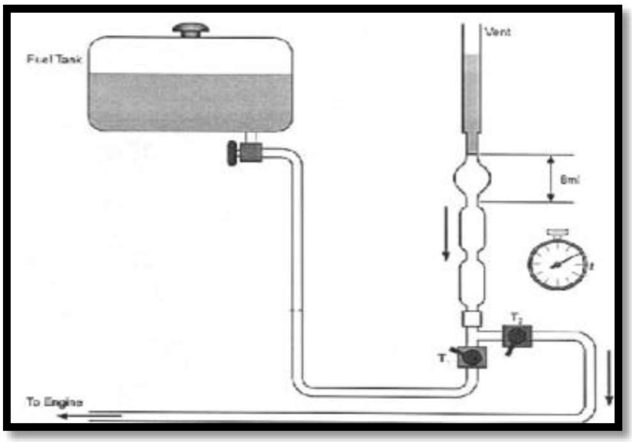

Fig. (1-4).

Fig. (1-5) show us the three tanks used for different fuel cetane number.

$$\dot{m}_f = \frac{V_F}{time} \times \rho_F \quad {}^{kg}/_{sec} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1\text{-}4).$$

Where:

V_F = volume of fuel consumption.

3.1.5 Air consumption.

The air supplied to compression ignition engine was measured by using air box, orifice and the manometer used to measure the pressure differential between the atmosphere and pressure inside the air box. The equation (1-5) in was used to calculate the air consumption see fig. (1-6).

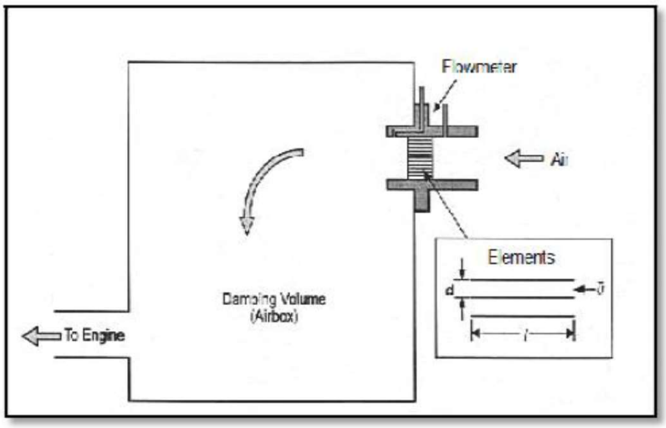

Fig. (1-6).

$$\dot{m}_{air} = \frac{12\sqrt{h_o}}{3600} \times \rho_{air} \ \frac{kg}{sec} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1\text{-}5).$$

3.1.6 Emissions.

The exhaust gas analyzer type (Flux 2000 Italy) was used to analyze the emissions of exhaust, as shown in Fig (1-7). The analyzer detects the CO-CO_2-HC- O_2 contents. The gases are picked up from the vehicle exhaust pipe by means of a probe. They are separated from water moisture through the condensate filter, and then they are conveyed into the measuring cell. A ray of infrared light, generated by a transmitter, is sent through the optical filters on to the measuring elements. The gases in the measuring cell absorb the ray of light at different wavelengths, according to their concentration. The H_2, N_2, and O_2 gases due to their molecular composition (they have the same number of atoms) do not absorb the emitted ray. This prevents measuring the concentration through the infrared system. The CO, CO_2 and HC gases, thanks to their molecular composition, absorbs the infrared rays at specific wavelengths (absorption spectrum). However, the analyzer is equipped with a chemical kind sensor through which the oxygen which the oxygen percentage (2) is measured.

Fig. (1-7)

3.2 Experimental procedure.

1-Preparing the engine for working until get the steady state operation condition and read the result for engine speed (1100 rpm to 2500rpm) .

2- Preparing the fuel samples from AL-Doura refinery in Baghdad for different fuel cetane numbers (56 , 54 , 53).

4- Results and Conclusion.

4.1 Effect of engine load on the brake power of the engine.

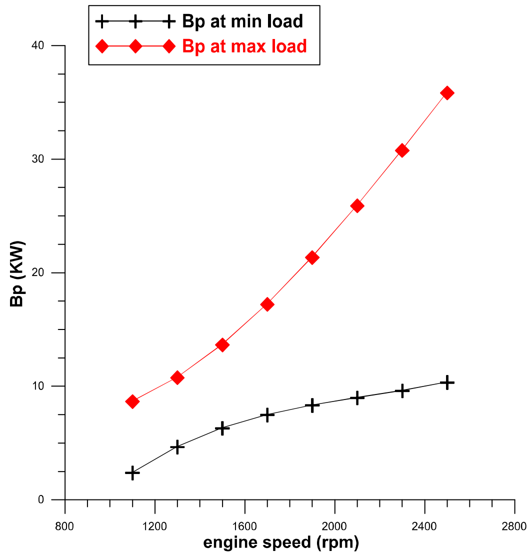

Fig. (1-8) Effect of engine speed on the brake power of the engine at minimum and maximum load.

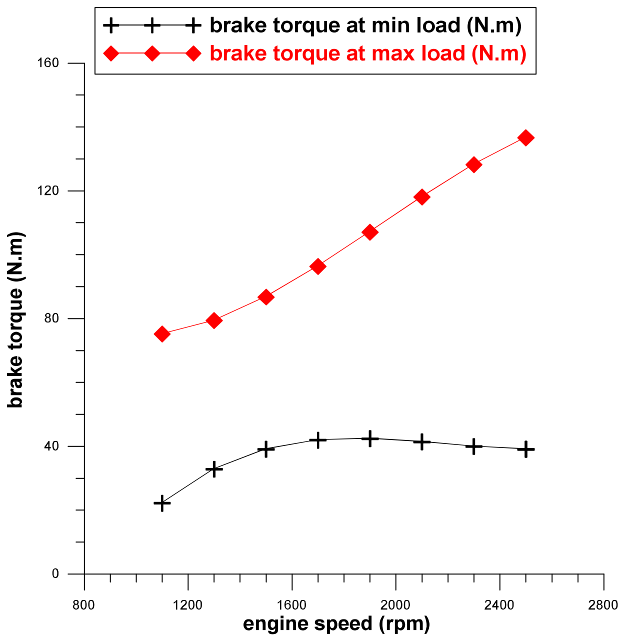

Fig. (1-9) Brake torque of the engine for different speed of the engine.

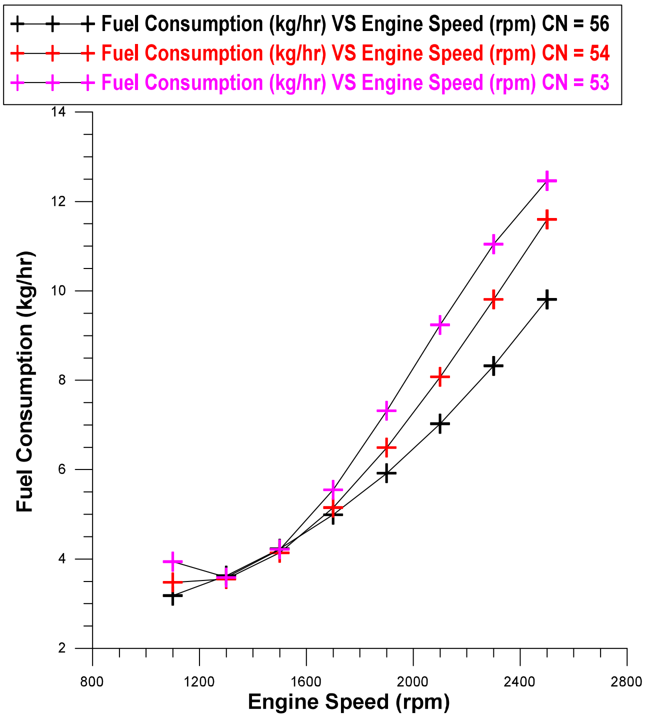

Fig. (1-10) showing the fuel consumption for different fuel cetane number

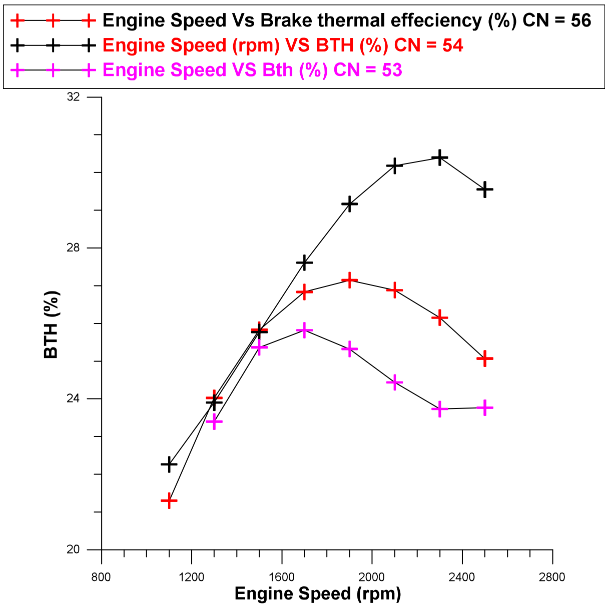

Fig. (1-11) showing the brake thermal efficiency for different fuel cetane number.

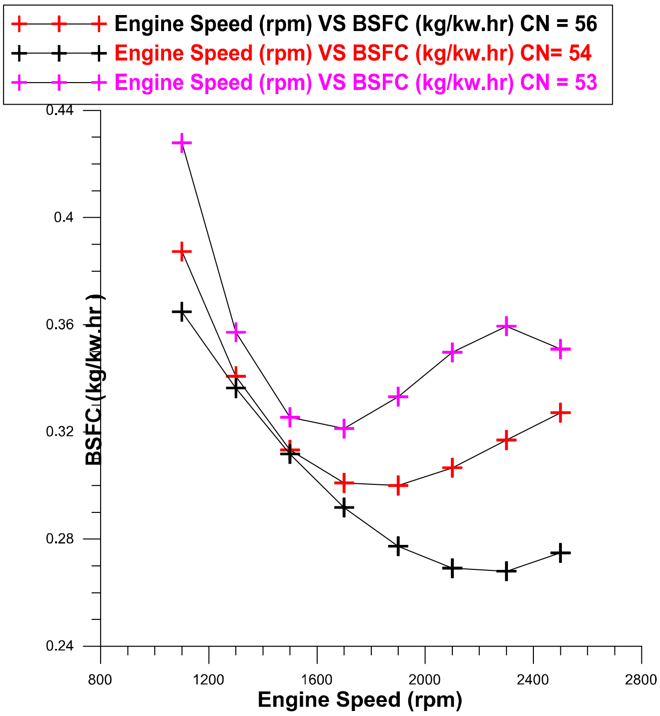

Fig. (1-12) showing the brake specific fuel consumption for different fuel cetane number for different engine speed.

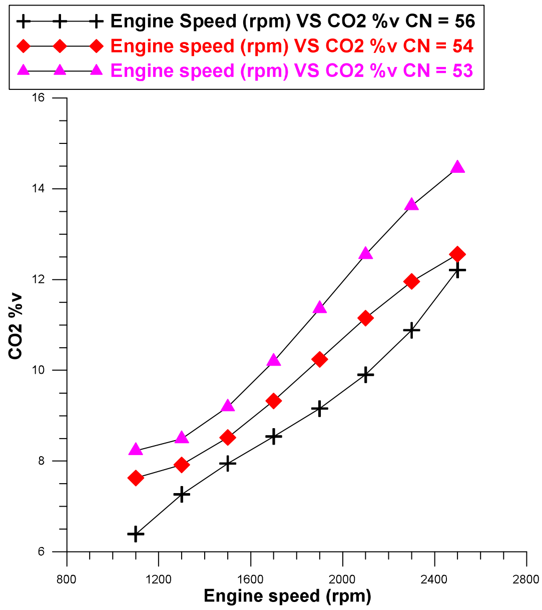

Fig.(1-13) showing the CO_2 Emissions for different fuel cetane number for different engine speed.

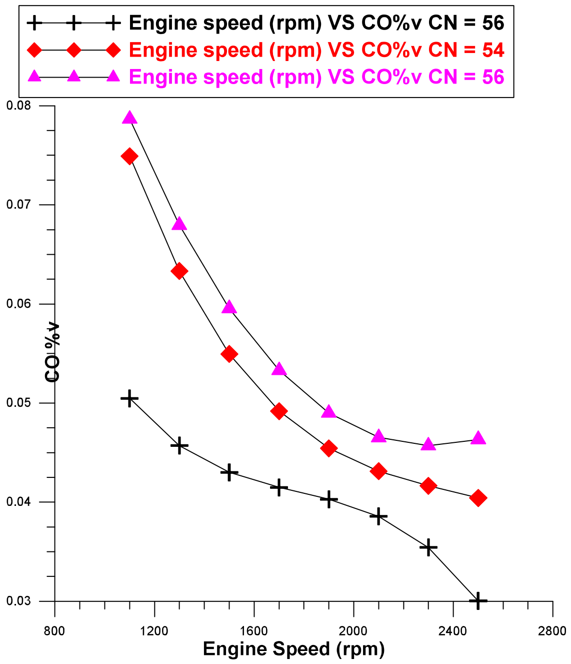

Fig. (1-14) showing the CO Emissions for different fuel cetane number for different engine speed.

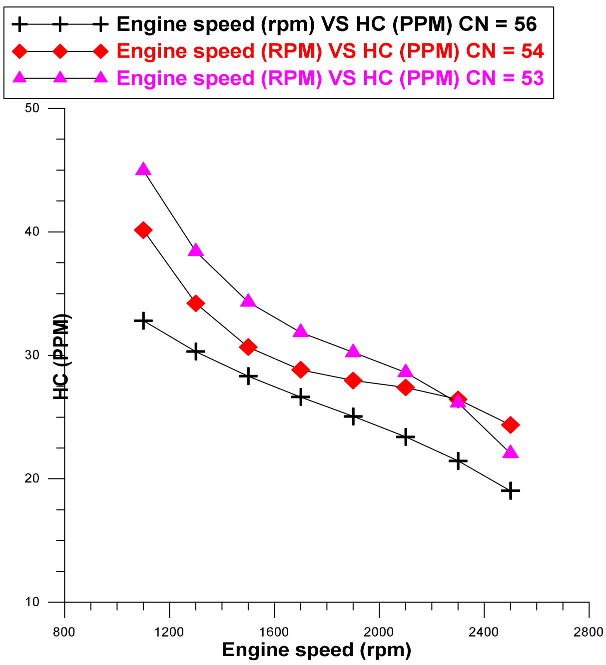

Fig. (1-15) showing the HC Emissions for different fuel cetane number for different engine speed.

The conclusions from the above figs are:

1- The brake power increase with the engine speed and the increase in bp at max load is (64%) than the bp at min load and this is can be shown from fig (1-8).

2- The brake torque is increase with the engine speed and this is can be shown from fig (1-9) .

3- From fig (1-10) show the fuel consumption for different engine speed and for different cetane number of fuels and show us that the fuel with high cetane number have the lowest fuel consumption so fuel of cetane number (56) it is the more economically than the other fuels.

4- From fig (1-11) show the brake thermal effeciency for different engine speed and for different cetane number of fuels and show us that the fuel with high cetane number have the highest brake thermal efficiency so fuel of cetane number (56) it is the more economically than the other fuels.

5- From fig (1-12) show the specific fuel consumption for different engine speed and for different cetane number of fuels and show us that the fuel with high cetane number have the lowest brake specific fuel consumption so fuel of cetane number (56) it is the more economically than the other fuels.

6- From fig (1-13) show the CO_2 Emissions for different engine speed and for different cetane number of fuels and show us that the fuel with high cetane number have the lowest CO_2 emissions so fuel of cetane number (56) it is the more economically than the other fuels.

7- From fig (1-14) show the CO Emissions for different engine speed and for different cetane number of fuels and show us that the fuel with high cetane number have the lowest CO emissions so fuel of cetane number (56) it is the more economically than the other fuels.

8- From fig (1-15) show the HC Emissions for different engine speed and for different cetane number of fuels and show us that the fuel with high cetane number have the lowest engine HC engine so fuel of cetane number (56) it is the more economically than the other fuels.

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