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Performance and Analysis of Ethanol and EGR effect on the exhaust gases in compression ignition engine

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Abstract: Last few years world nations developments increase very rapidly by consumption of fuels so the emission of fuels widely damaged the world climate like the word "Global Warming" is became very popular in now days and this is because of emission of different fuels so controlling of emissions are very important and today different experiments are done for controlling of emissions. Today the consumption of Diesel becomes more especially in transportation and industries so for controlling of diesel emission I have used the Ethanol as additives and Exhaust Gas Recirculation (EGR) process combinedly.The Experiment is done on a single cylinder, 4-stroke, water cooled, kirloskar made diesel engine by mixing of ethanol in diesel by 10% and EGR at 10% , 15% and 20%.Exhaust Gas Recirculation process is really useful technique in controlling oxides of nitrogen in diesel engines but it's not give proper result at higher loads and higher percentage of recirculated gas because combustion tends to deteriorate at higher loads leading to reduced engine thermal efficiency and increased hydrocarbon and smoke emission so mixing of ethanol in diesel increase cetane index and kinematic viscosity. It has been observed from the different ratio of ethanol and EGR 10% Ethanol and 10% EGR is very effective from the others because it's increase thermal efficiency, decrease tremendous amount of NOx, decrease fuel consumption, decrease HC at lower load, decrease O_2intake in combustion chamber.only the disadvantages of ethanol is it's increase water content in combustion chamber and also increases little amount of CO and CO_2.

Keywords: Ethanol; EGR; Emissions; Combustion; Diesel engine

I. INTRODUCTION

Diesel engines are one of the major contributors to the pollutant emissions since they are widely used due to high combustion efficiency, reliability, adaptability and cost effectiveness. Diesel engine emission is very dangerous to human being and other living organism because of different emission such as Sulphur dioxide (SO_2), Carbon-monoxide (CO), Oxides of nitrogen (NOx), Hydrocarbon vapours, polycyclic organic compounds, aliphatic hydrocarbons and Smoke. This hazardous emission has deleterious effect includes, bronchitis, asthama, reduced ability of the haemoglobin to carry oxygen, heart attacks, eye and respiratory irritation, lungs cancer.[1]

The ethanol-Diesel emulsion technique is one of the techniques to be able to use ethanol without any modification in Diesel engines. Ethanol has advantages as it reduces the PM, CO, and NOx.[2,3,4]Other environmental benefits associatedwith ethanol blendeddiesel fuel include the improvement of biodegradability and the reduction in net emissions of greenhouse gases if ethanolis produced from biomass.[5] Considering the advantages ethanol has few limitations as it does not blend effectively with diesel.[6] Ethanol-diesel blends phase separate when exposed to small amounts of water and/or low temperatures. [7,8]

Exhaust Gas Recirculation (EGR) is a process to induce the exhaust gases in the combustion chamber. The exhaust gases mainly consist of carbon dioxide, nitrogen etc. and the mixture has higher specific heat compared to atmospheric air. Re-circulated exhaust gas displaces fresh air entering the combustion chamber with carbon dioxide and water vapor present in engine exhaust. As a consequence of this air displacement, lower amount of oxygen in the intake mixture is available for combustion. Reduced oxygen available for combustion lowers the effective air–fuel ratio. This effective reduction in air–fuel ratio affects exhaust emissions substantially. In addition, mixing of exhaust gases with intake air increases specific heat of intake mixture, which results in the reduction of flame temperature. Thus combination of lower oxygen quantity in the intake air and reduced flame temperature reduces rate of NOx formation reactions. [9,10]

EXPERIMENTAL SETUP AND METHODOLOGY

A single -cylinder constant speed diesel engine set was chosen to study the effect of EGR and ethanol on the performance and emissions. The specifications of engine are given in Table I and photograph of the engine setup is shown in Fig. 1.

In present study comparisons were made between Diesel, Diesel + 10% EGR, Diesel + 15% EGR, Diesel + 20% EGR, Diesel + 10% Ethanol +10% EGR, Diesel + 10% Ethanol +20% EGR.The load interval used to compare above mentioned groups at 0kg, 2kg, 4kg, 6kg, 8kg and 10kg. Diesel and 90 % Diesel+ 10% Ethanol used in present study were pretested and their properties were illustrated in Table II.

Here the partly cooled EGR process is used for the experiment and the quantity of EGR can be regulated by a control valve installed inthe EGR loop. An orifice was installed in the EGR loop to measure the flow rate of re-circulated exhaust gas. To measure the intake air flow rate manual method was used as per manufacture instruction. Suitable instrumentation for measurement of temperatures at several locations was done. Fuel consumption measurement was done using a gravimetric fuel consumption meter (Make: AG Measurements, India). Exhaust gas emission (Oxygen, CO and CO_2, HC and NOx) measurements were done by raw exhaust gas emission analyzer (Make:AROEquipmetpvt.Ltd. India. Model: GA 4040/GA 4050).

To achieve the objectives of the study, engine was run under normal operating condition and at different EGR rates and 10% ethanol mixing in diesel. The data for HC, NOx, CO, CO_2, exhaust gas temperature, and fuel consumption were recorded. Then, engine performance and emission patterns were compared. Optimum EGR rate was found on the basis of performance and emissions of the engine.

Table I. Test engine specifications.

Model	**Kilorskar**
Engine type	Single cylinder, water cooled, self-governed, vertical diesel engine
Rated power	5 HP or 3.7 kW
Rated speed	1500 rpm
Compression ratio	16 : 1
Bore x stroke	80 mm x 110 mm
Brake	Rope brake with spring balances and loading screw
Brake drum diameter	0.270 m
Belt thickness	0.006 m
Effective radius	0.138 m

Table II. Properties of Diesel and Diesel+ 10% Ethanol

Specification	Diesel	90 % Diesel+ 10% Ethanol
Kinematic viscosity @ 40^0 C	2.14 cSt	2.28 cSt
Acidity, inorganic	0.01 mgKOH/gm	0.02 mgKOH/gm
Ash	Nil	Nil
Flash point	60/73 ^{o}C	56/69 ^{o}C
Water content	Nil	73 mg/kg
Pour point	3.5 ^{o}C	2 ^{o}C
Density @ 15^o C	0.825 kg/cm^3	0.824 kg/cm^3
Sediments	Nil	Nil
Total sulphur	41 mg/kg	40 mg/kg
Carbon residue, Rams bottom	Nil	Nil
Copper strip corrosion test for 3 hrs @ 100^o C	1a	1a
Distillation, Recovery of 95% @ ^{o}C	359 ^{o}C	355 ^{o}C
Color index	1.6	2
Cetane index	77.61	80.92
Acidity, Total	0.02 mgKOH/gm	0.03 mgKOH/gm
Polycyclic Aeromatic Hydrocarbon	9 % by mass	14 % by mass

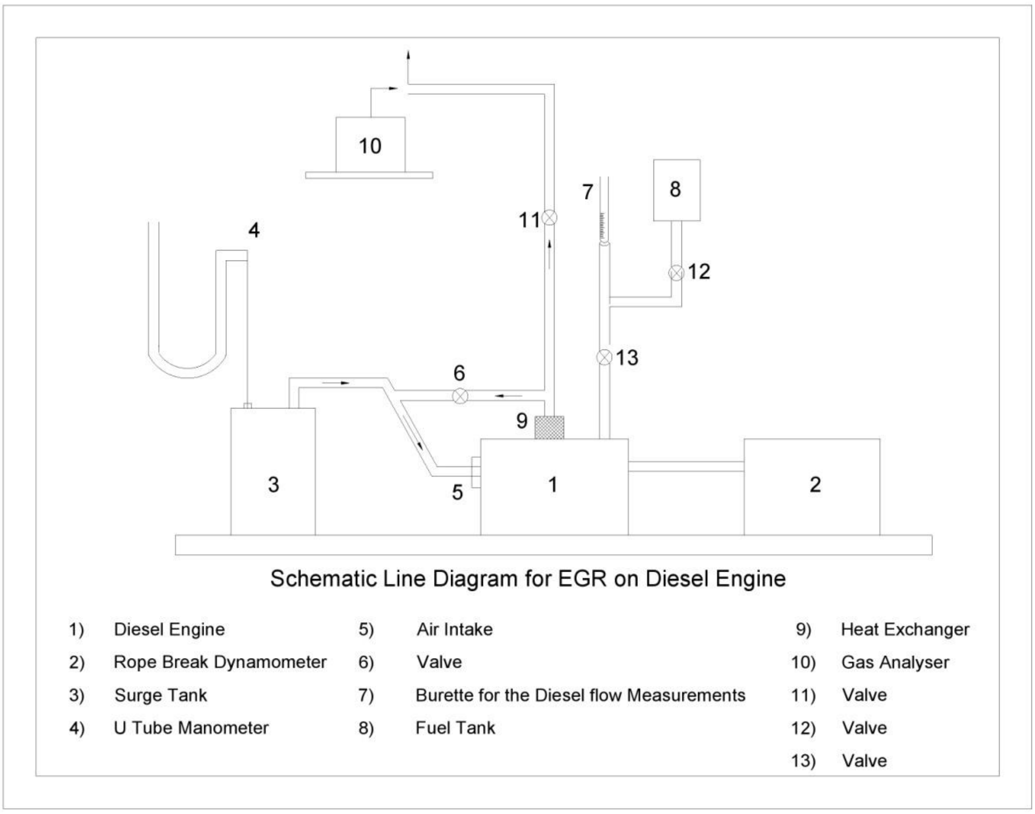

Fig 1.*Engine setup used for the experiment*

RESULTS AND DISCUSSIONS

Engine emissions characteristics

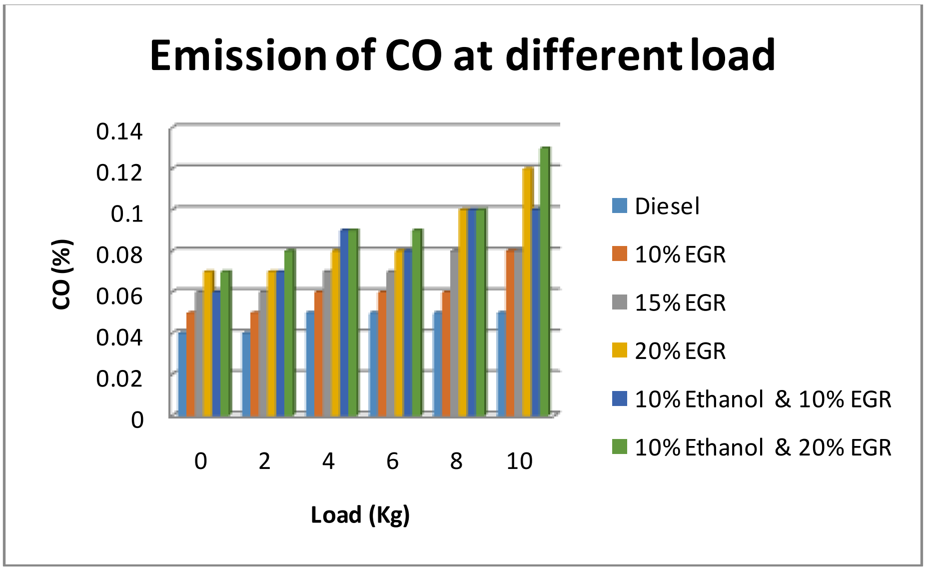

Fig. 2 Comparison of CO value in control and experimental groups at different load

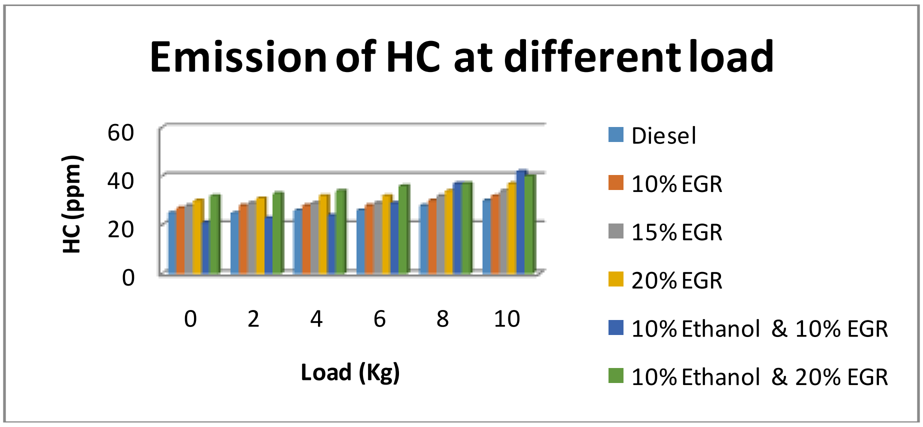

Fig. 3 Comparison of HC value in control and experimental groups at different load

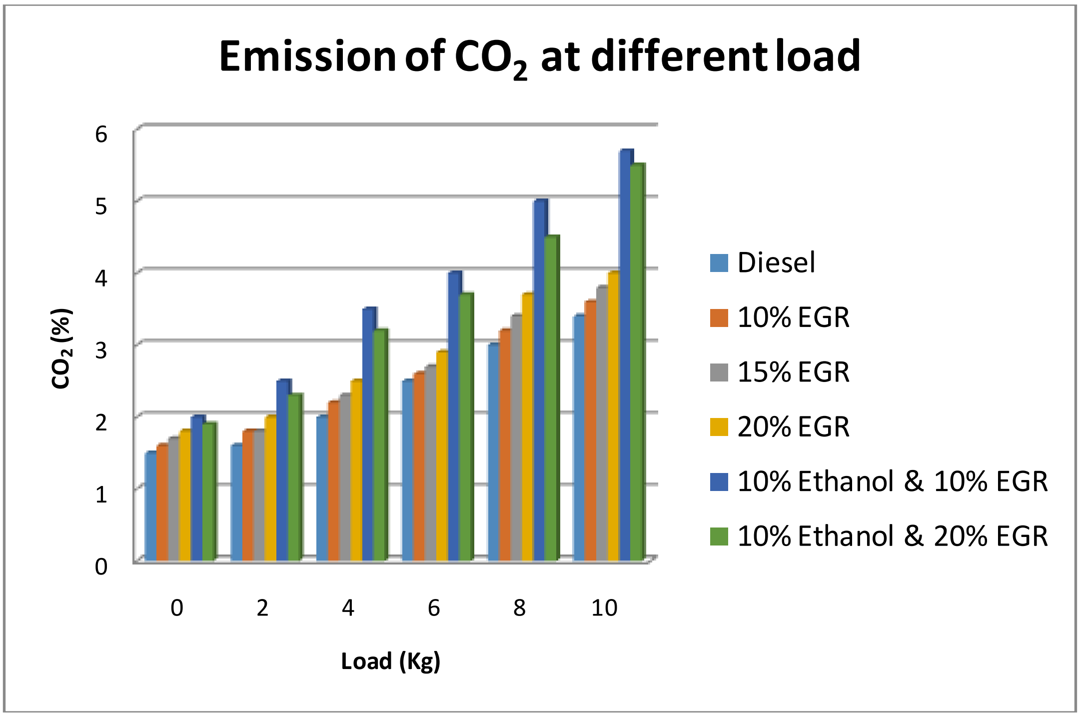

Fig. 4 Comparison of CO_2 value in control and experimental groups at different load

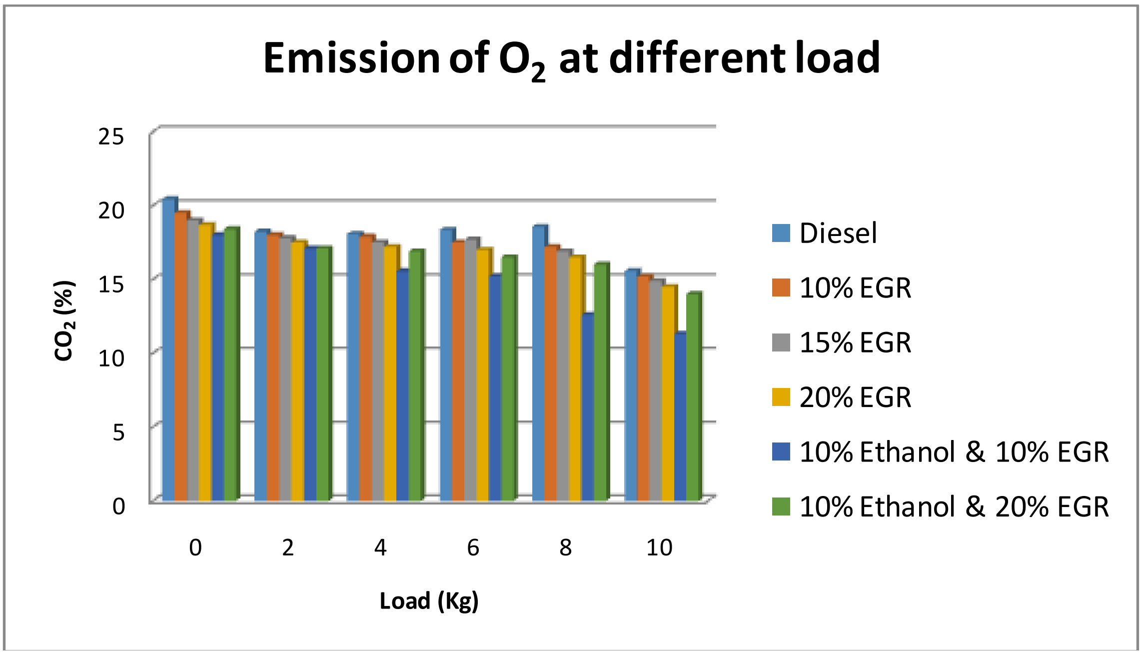

Fig. 5 Comparison of O_2 value in control and experimental groups at different load

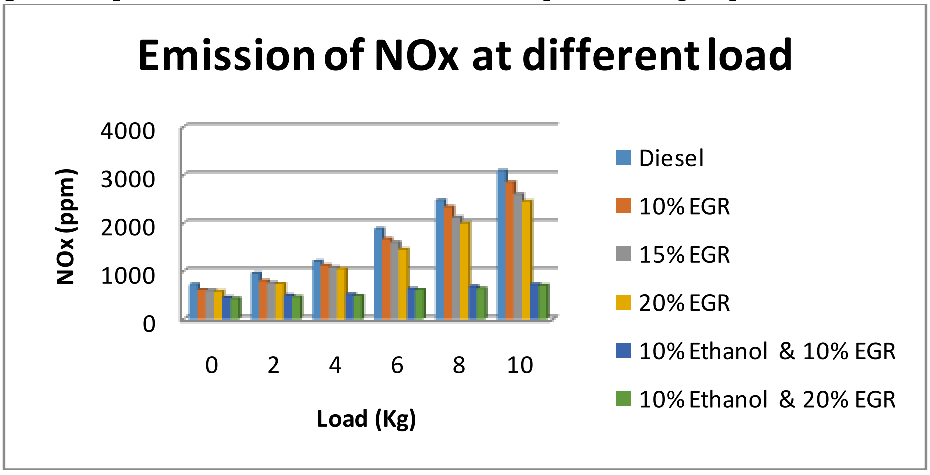

Fig. 6 Comparison of NOx value in control and experimental groups at different load

Fig. 2 shows effect of EGR on carbon monoxide emission which suggest that at part load CO increases gradually and at higher load CO decreases. It also suggested that when mixture of 10% Ethanol was used at different EGR values CO gradually increases.**Fig. 3**shows at part load emission of HC increases while decreases for EGR and 10% Ethanol respectively. For higher load HC increases for both EGR and 10% Ethanol mixture. Similar results was observes in previous reported study that HC and CO emissions increase with increasing EGR.[11]

Effect of EGR and 10% ethanol additive on CO_2 and O_2 are shown in **Figs. 4** and **5**, respectively. Emission of CO_2 gradually increases with increased EGR while higher percent of CO_2 was observed with additive of 10% Ethanol.Unburnt O_2 level was decreases for both EGR and additive mixture.

Fig. 6 shows the main benefit of EGR in reducing NOx emissionsfrom diesel engine.At 2kg load the emission of NOx was 950 ppm for diesel, 800 ppm for 10% EGR, 760 ppm for 15% EGR, and 740 ppm for 20% EGR. While mixture of 10% Ethanol and diesel was used considerably reduction of NOx was observed; for 10% Ethanol and 10% EGR it was 495 ppm and for 10% ethanol and 20% EGR it was 470 ppm. It was noted that higher NOx generation (63%), but when 10% EGR process was used NOx reduction was observed in92%. [12]Agarwal D and co-workers (2011)[11] has found that the degree of reduction in NOx at higher loadsis higher; which was observed in present experiment.

Engine performance

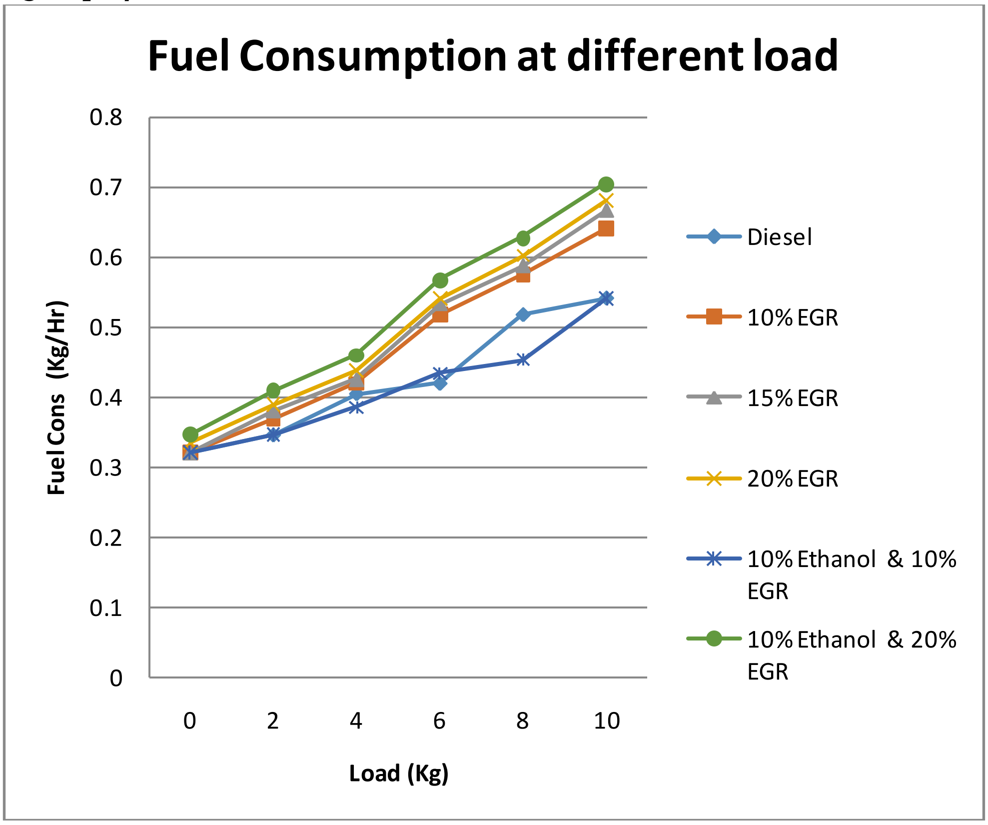

Fig. 7 Comparison of Fuel Consumptionvalue in control and experimental groups at different load

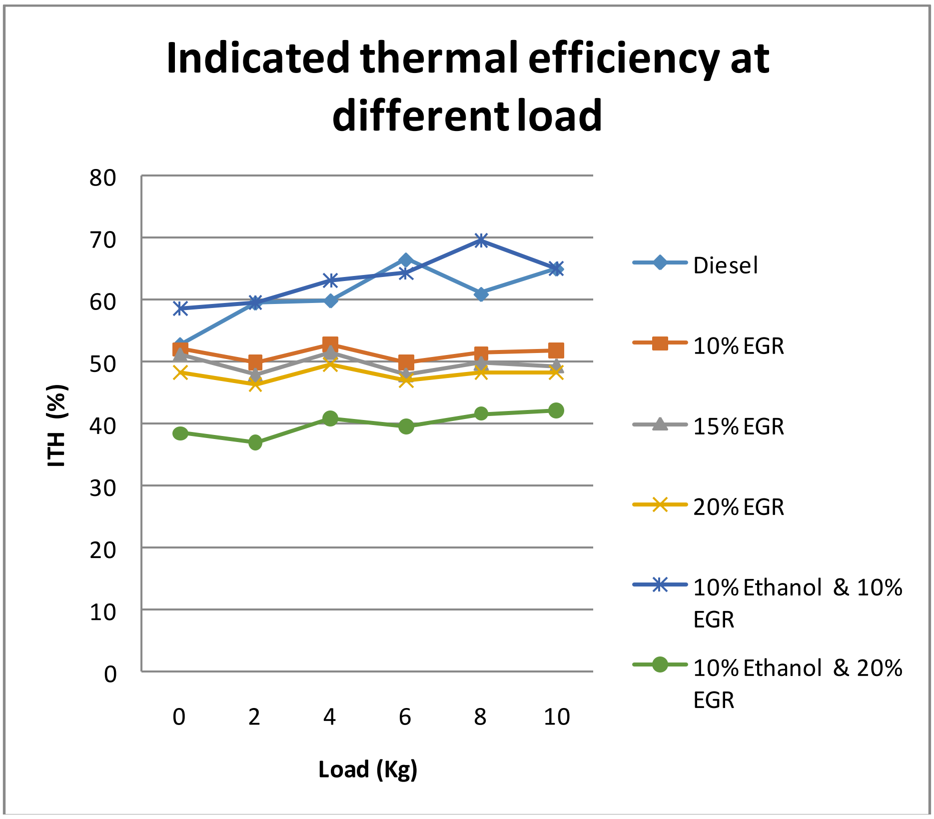

Fig. 8 Comparison of indicated thermal efficiency at different load

Fuel consumption and indicative thermal efficiency are shown in **Fig. 7** and **8**, respectively. Fuel consumption was little higher for different EGR percent. Fuel consumption level was comparatively lower for 10% Ethanol mixture at different EGR percent. Indicative thermal efficiency was lower for different EGR percent and also for 10% Ethanol and 20% EGR compared to diesel. The indicative thermal efficiency for 10% Ethanol and 10% EGR was higher for different EGR percent and also for 10% Ethanol and 20% EGR and comparable for diesel.

CONCLUSION:

From the Experiment reading it has been concluded that the 90% diesel + 10% ethanol + 10% EGR process is very effective by the others because it gives highly NOx reduction, very low fuel consumption and O_2 requirement, very good thermal efficiency only problem is little higher of CO, CO_2, HC.

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