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Effect of EGR (Exhaust gas recirculation) on performance and emission of CI (Compression ignition) engine fuelled with blend

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***Abstract*— In this experimental study, the effect of methanol/diesel with different mixing ratios (M10 and M20) along with different EGR rate (EGR10 and EGR15) was tested over to enhance the performance and emission of a single-cylinder direct injection compression-ignition engine at different compression ratio and the result were compared with the conventional engine The tests with/without methanol blends were performed on a hydraulic dynamometer while running the engine at the speed of 3000 rpm at different varying engine load, In this tests measure engine performance parameter like engine torque, brake specific fuel consumption, brake thermal efficiency and exhaust emission. After experimental study to measure engine torque, brake specific fuel consumption, brake thermal efficiency and exhaust emission in which BSFC was decrease and brake thermal efficiency was increase in performance parameter while in emission parameter CO, CO_2, O_2, HC, NOx and exhaust gas temperature were reduced in exhaust gas.**

Keywords- compression ignition engine, exhaust gas recirculation methanol blend, engine performance, exhaust emission

I. INTRODUCTION

The increasing industrialization and vehicles in the world lead to a steep rise in the demand of petroleum products [1]. Petroleum based fuels are stored fuels in the earth. There are limited reserves of these stored fuels and they are irreplaceable [2]. With our known reserves and the growing rate of consumption, it is feared that they are not going last long [3]. These finite resources of petroleum and highly concentrated in certain regions of the world has given rise to frequent disruptions and un-certainties in its supply as well as price all over the world. Although accelerating consumptions will create a challenge before the world that a new types of fuels should replace the conventional fuels [4]. Petroleum fuel vehicles discharge significant amount of pollutants like CO, HC, NOx, and soot [5]. Due to these reasons, alternative fuel technology will become more common in the coming decades [6]. The burning question with steady increase in energy consumption coupled with environmental pollution has promoted research activities in alternative and renewable energy fuels. [7]

To study different alternative fuels, among these in alcoholic family methanol is one of the most widely used fuel. Methanol (CH_3OH) has many advantages, which has made it an attractive non-petroleum-based alternative fuel for the automotive industry in many countries [8].Methanol can be easily synthesized from natural gas or from gasification of coal or biomass [9]. It has excellent combustion properties. Along with methanol fuel EGR circuit was fitted to the engine through valve [10].EGR has good tendency to reduce NOx emission because it lowers the flame temperature [11].

II. TEST ENGINE AND EXPERIMENTAL SETUP

2.1 Test engine

The engine performance experiments were carried out on a single-cylinder, four-stroke, water-cooled compression-ignition diesel engine. The engine specifications are shown in Table 1.

2.2 Test fuel

Test fuel for these experiments was chemco chemical industrial methanol; its purity was above 99%. The physical and chemical properties of the gasoline, methanol and different blend percentage used are shown in Table 2.

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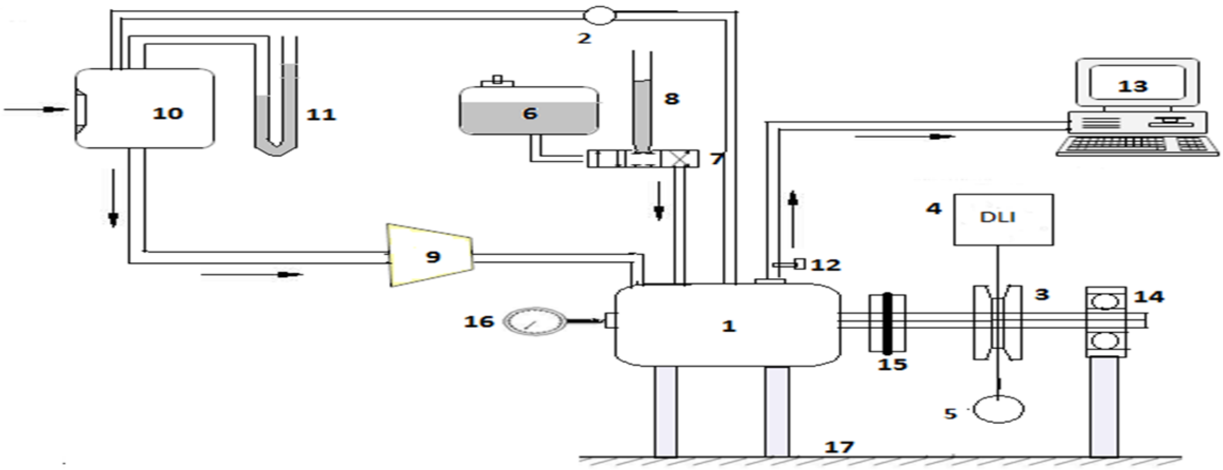

Fig. 2.2 schematic diagram of experimental setup

1. Engine 2.EGR valve 3.Hydraulic dynamometer 4.Digital load indicator 5.Load setting valve 6.Fuel tank
7. Three way valve 8. Fuel beret 9.Air-filter 10.Air-box 11.Manometer 12.Exhaust temperature indicator
13. Exhaust gas analyzer 14. Support bearing 15.Universol-joint 16.Techometer 17.Engine base

Table1. Engine Specification

Items	Engine
Mark	Fieldmarshal
Engine type	Four stroke, single cylinder
Displacement (cm^3)	359 cc
Bore (mm)	82 mm
Stroke (mm)	68 mm
Compression ratio	18.5:1
Fuel system	Direct injection
Cooling system	Water-cooling
Engine power H.P/Kw	5.0/3.7
Grade of oil	SAE20W40

Table2. Property of methanol/diesel blend

Fuel blend	Boiling point ˚c	Lower C.V (Kcal/KG)	Flash point ˚c	Kinematic viscosity 27˚c	Specific-gravity 28˚c
Diesel	154	10799	40	1.7cst	0.835
M10% blend	-	10530	0.463	13.751	0.825
M20% blend	-	10208	0.496	12.900	0.815
Pure methanol	64	5542	12	1cst	0.785

2.3 Experimental setup and procedures

The experimental setup, shown in Fig. 2.2, consists of a test engine, hydraulic dynamometer, fuel and air flow meters and various measuring equipments. Hydraulic dynamometer is directly coupled to the engine output shaft to measure engine torque, fuel consumption was measured in burette which is attached with the engine inlet and note down the volume of methanol burned during a specified period of time [12] In test ring air box type air supply system is used along with EGR circuit which supply the air to engine intake manifold and also indicated it's pressure on manometer [13]. In the experiment non contact type digital tachometer is use and digital temperature indicator for temperature at engine exhaust.

Fig. 2.3 experimental setup

All the tests were performed at part load (0 kg, 4.40 kg, 6.90 kg, 9.10 kg and 11.70 kg) at 3000 rpm, all the data for engine torque, engine power, specific fuel consumption and exhaust gas temperature was collected. The test was performed before fill up sufficient methanol/diesel blend in tank, then engine is start and engine picks up speed with continues supply of cooling water in brake drum. Load the engine with load setting valve. Then open burette-filling cock, take sufficient methanol/diesel blend in burette and note down time required for 50 ml fuel consumption, at that time note down brake drum speed with tachometer and manometer difference and note down temperatures on display. The tests were performed at different stages with different compression ratio.. At the first stage, the engine was tested at diesel and at other stage with the use of varying methanol blend (M10, M20) along with different EGR rate (EGR10, EGR15) and take reading. The normal reading was taken at normal compression ratio while other blended readings were taken at higher compression ratio.

III. RESULT AND DISCUSSION

3.1 performance parameter

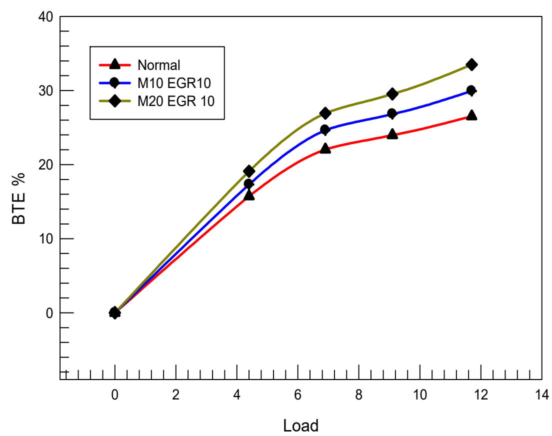

Fig.3.1.1 effect of diesel and methanol blend on BTE at various engine loads.

So in figure 3.1.1 indicate the brake thermal efficiency is increase. As the load is increasing brake thermal efficiency is increasing [14]. This is because for the same brake power time required to and the calorific value is decreasing so BTE is increasing. The best result we got at full load with 20% methanol and 80% diesel by volume along with 10 % of exhaust gas recirculation.

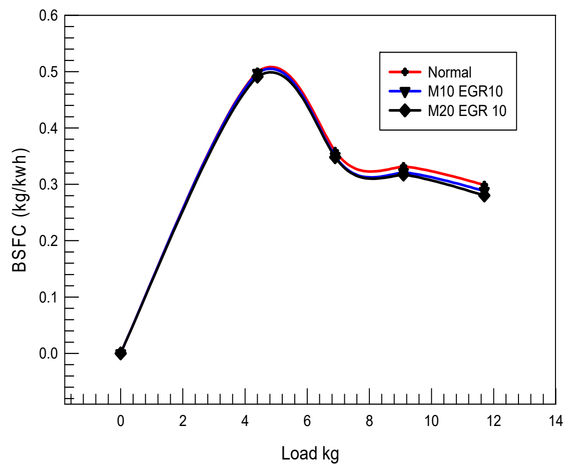

Fig.3.1.2 effect of diesel and methanol blend on BSFC at various engine loads.

As shown in fig 3.1.2 compare with the normal compression ratio methanol 20 % diesel 80% by volume at higher compression ratio give better result in brake specific fuel consumption.

Parameter	Normal CR	Higher CR			
		M10	M10	M20	M20
		EGR 10	EGR 15	EGR 10	EGR 15
CO (% by vol)	0.10	0.06	0.07	0.06	0.07
HC (ppm)	69	60	62	57	57
NO_x (ppm)	360	340	338	348	345
EGT (K)	689	683	682	685	683

3.2 emission parameter

The tendency of methanol is to reduce the exhaust emission like CO, CO2, HC [15]. When methanol is blended with the diesel in combustion chamber fuel get proper amount of oxygen so fuel burnt properly and reduce the carbon parameters in the exhaust [16].

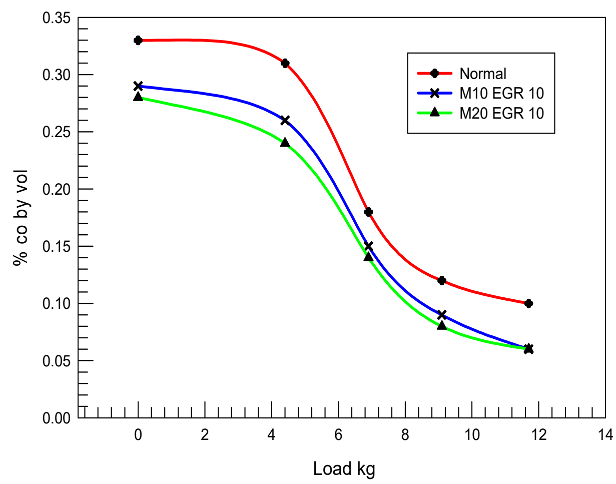

Fig.3.2.1 effect of diesel and methanol blend on CO at various engine loads.

So, in fig 3.2.1 methanol blend with diesel at higher compression ratio give better result compare to conventional engine. The best result we get into the 20% methanol blend in diesel by volume.

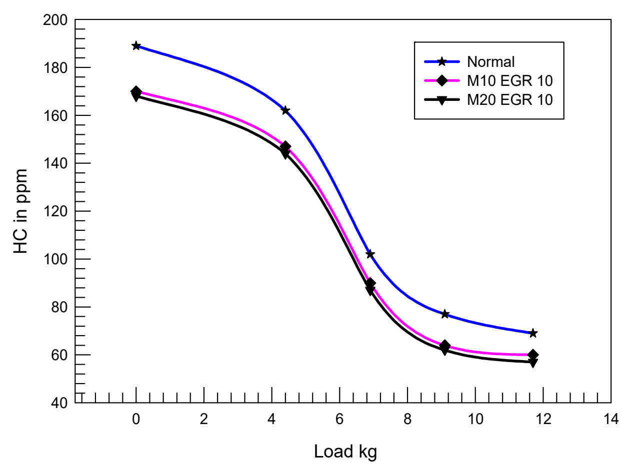

Fig.3.2.2 effect of diesel and methanol blend on HC at various engine loads.

As in fig.3.2.2 At higher compression ratio HC reduced in exhaust. The effect of EGR is not significant in HC emission.

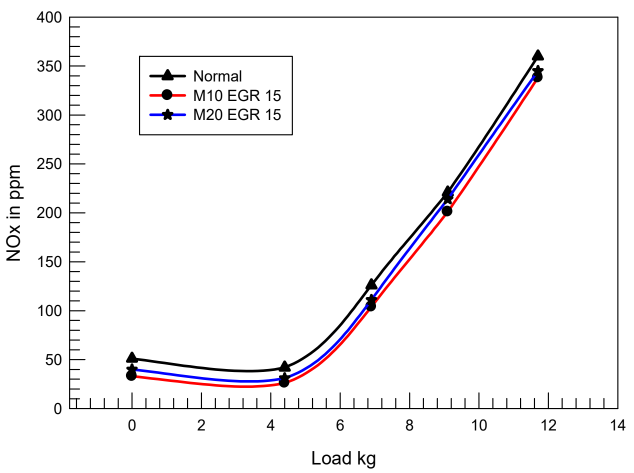

Fig.3.2.3 effect of diesel and methanol blend on NO_x at various engine loads.

Exhaust gas recirculation reduced the peak flame temperature [17]. EGR reduced the emission of NOx in exhaust [18]. NOx emission reduce more in 15% EGR compare to 10% EGR when methanol blend percent is constant hence M10 with EGR15 give better result as shown in figure 3.2.2

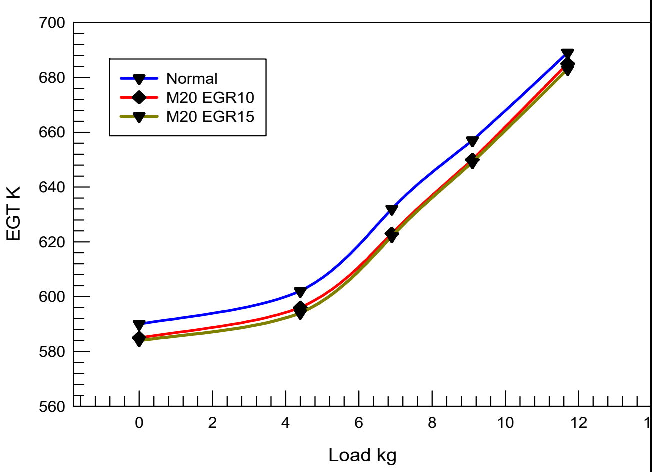

Fig.3.2.4 effect of different rate on EGT at various engine loads.

For constant methanol blend percentage the effect of EGR is more on exhaust gas temperature. As in fig.3.2.4 M20 EGR 15 gives better result compare to M20 EGR10.

IV. Result and Discussion

The summary of all the results after experimental study is as follows:

1. Using 10% methanol/diesel blend to in engine performance increase brake thermal efficiency up to 12.85% and 20% methanol/diesel gives increase in brake thermal efficiency up to 26.23%.
2. BSFC reduce 3.57% in 10% methanol/diesel while 4.28% in 20% methanol/diesel.
3. Using 10% methanol/diesel blend gives reduction in CO emission up to 30% and in 20% methanol/diesel reduction is up to 40%
4. Hydrocarbon in exhaust reduces 13.04% in 10% methanol/diesel and 17.39% reduce in 20% methanol/diesel.
5. In NO_x emission 3.33% reduction is in 20% methanol/diesel while 5.55% in 10% methanol/diesel blend.
6. For the same methanol blending percentage exhaust gas temperature reduces 4°C in 10% EGR while 6°C in 20 % EGR.

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