PERFORMANCE OF CRDI DIESEL ENGINE POWERED WITH PYROLYSIS OIL UNDER THE INFLUENCE OF EXHAUST GAS RECIRCULATION.

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ABSTRACT

This paper investigates the performance of Common rail Direct Injection (CRDI) diesel engine operated with blends of tyre pyrolysis oil (TPO) with diesel and ethanol under the influence of exhaust gas recirculation (EGR). The experiments were carried out at a rail pressure of 900 bar with 10^{o} bTDC and at constant speed of 1500 rpm. The EGR varied in 15%, 20% and 25%. With obtained result were made comparison without EGR. It was found slight lower in BTE. NOx was reduced up to 09% for EGR of 15%. Beyond 15% of EGR, BTE showed poor performance and emissions HC and CO were increased.

KEY WORDS: CRDI, Injection timing, Injection pressure, Pyrolysis oil, EGR, NOx

INTRODUCTION

The pollution emitted from the automobile especially diesel engine have a severe effect on living beings and on environment. Emission of oxides of nitrogen (NOx) was the major pollutant given out by the diesel which will adverse effect like acid rain, smog, asthma, nausea [1]. With rapid increase in the consumption of diesel, it make burden on foreign exchange of developing countries like India. Hence energy security cause a huge threat part from increase in price of oils. Therefore it is necessary to search of alternative fuels which are easily available. In this regard various resources were analyse during the past decade but it was all limited to laboratory level. This was because of emission of NOx from the alternative fuels. Various methods were used to reduce the NOx by using injection strategies such injection timing, injection pressure and using different types of nozzle holes [2] and exhaust gas recirculation [3]. In EGR system, portion of exhaust gases are recirculated back to intake manifold where it gets mix up with fresh air which is being inducted into the Combustion chamber [4].

The diesel engine was analysed with EGR in the range of 5 and 15% and was observed lower NOx for 15% EGR without compromising in the power output [5].

The use of EGR in transient state is a challenge due to fluctuations in the recirculation system, which can cause peaks of NOX and soot emissions [6]. It was showed that the use of EGR in a diesel engine increased the premixed phase of combustion. Peak heat release rate was reduced at high loads and increased at low loads. Ignition delay and combustion duration were also increased [7]. A EGR rate of 40% achieved extremely low levels of NOX emissions, but with increased emissions of PM, specific fuel consumption and engine noise levels. Agarwal et al. [8] noticed that diesel engines tolerate high EGR rates at low loads, since there is high oxygen concentration in these conditions, compared to high loads. With increasing load, inert gases are predominant in the exhaust, causing increased soot emissions due to reduced availability of oxygen. With EGR rates up to 20% a slight increase of fuel conversion efficiency at low loads was observed, explained by re-burning of hydrocarbons that enter the combustion chamber with the recirculated exhaust gas [9]. The authors reported reduced exhaust gas temperature, increased intake charge temperature and reduced fuel conversion efficiency with increasing EGR rate. EGR increased exhaust CO and THC emissions, and gas opacity, due to the dilution effect, and reduced NOX emissions, due to reduced flame temperature. A direct-injection diesel engine operating at constant speed with up to 30% of EGR rate achieved a reduction of up to 30% of NOX emissions, decreased exhaust gas temperature and increased ignition delay, opacity and CO emissions [10]. Investigation the effects of using EGR cooling systems. The use of hot EGR increases in-cylinder pressure, which can decrease thermal efficiency losses due to a faster combustion, but cold EGR achieves lower NOX levels [11-12]. It was showed that, at constant EGR rate, the temperature of the recirculated exhaust gas causes different effects on engine performance. These effects depend on operating conditions, with positive and negative aspects using hot or cold EGR [13].

TYRE PYROLYSIS OIL:

Pyrolysis is an endothermic process that induces the thermal decomposition of feed materials without the addition of any reactive gases, such as air or oxygen. The thermal efficiency of this process is approximately 70%, and can increase to 90% with the use of pyrolytic products as fuel.This tire pyro lytic oil is obtained from the scrap tire. The scrap tire is one of the very common and important solid wastes all over the world. Scrap tire production shows increasing trend due to increasing number of vehicle in both developed and underdeveloped countries [2]. Nearly 1 billion of waste vehicle tires are accumulated each year [3]. By this accumulated tires pyrolytic oil is produced which carries 85.54% C, 11.28% H, 1.92% O, 0.84% S, and 0.42% N [4]. In our experiment fixed bed pyrolysis process is used to produce tire pyrolytic oil. In addition, chemical products such as benzene, toluene, xylene and limonene can be obtained from waste vehicle tire obtained pyrolysis liquid products. The properties of tyre oil is shown in the table 1.

Table 1 Properties of base fuels

Property	Method	Ethanol (E)	TPO (T)	Diesel (D)
Density (kg/m^3)	ASTM D-4052	789	935	819
Kinematic viscosity (cst)	ASTM D-445	1.21	3.2	2.94
Flash point (□C)	ASTM D-9390	14	41	57
Fire point (□C)	ASTM D-9390	18	51	64
Calorific value (kJ/kg)	ASTM D-2015	26843	41430	44189
Cloud point (□C)	ASTM D-4052	-7	4	2
Pour point (□C)	ASTM D-2500	≤ -35	<-8	-16
Cetane number	ASTM D-613	8	44	52
Carbon residue %	ASTM D-524	-	0.5	0.35

EXPERIMENTAL METHODOLOGY

In the underlying phase of work, experimentation was done to check the execution and emanation of CRDI engine fuelled with various mixes of TPO, Ethanol and Diesel. With different combinations of mixture, IT was shifted from 25^o before top dead centre (bTDC) to 5^o after top dead centre (aTDC) with keeping up the IP of 600 bar at 80% and 100% load. A DELTA 1600 S Exhaust Gas Analyzer was utilized to gauge fumes outflows, for example, CO, HC, and NOx. Smoke outflows were measured with Hartridge Smoke meter.
Assist examinations were led on the CRDI engine fuelled with TPO and its blend with diesel and ethanol, to get best IP that yield better execution where IPs were changed from 600 bar to 1000 bar keeping an improved IT of 10^{o}bTDC.

SCHEMATIC DIAGRAM OF ENGINE SETUP USED

Figure 1 shows the schematic diagram of the CRDI test rig.

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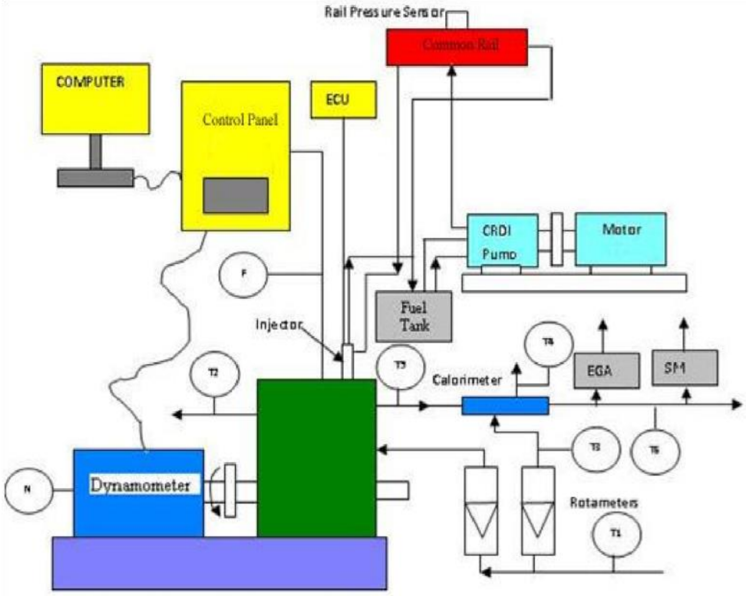

T1, T3 – Inlet Water Temperature, T2 – Outlet Engine Jacket Water Temperature

T4 – Utlet Calorimeter Water Temperature, T5 – Exhaust Gas Temperature before Calorimeter

T6 - Exhaust Gas Temperature after Calorimeter, F – Fluid Flow differential pressure Unit

N – Speed Encoder, EGA – Exhaust Gas Analyser, SM – Smoke Meter

Fig. 1 Schematic diagram of the CRDI experimental test rig

RESULT AND DISCUSSION

The CRDI engine was analysed with the utilization of PPO and its blends with diesel and ethanol for a load of 80% and 100%. The pressure of the rail was maintained at 600 bar and 1500 rpm in order to optimize IT. Once IT is optimized, next step was varied the pressure of rail from 600 to 1000 bar to optimize the IP.

Performance: Brake thermal efficiency

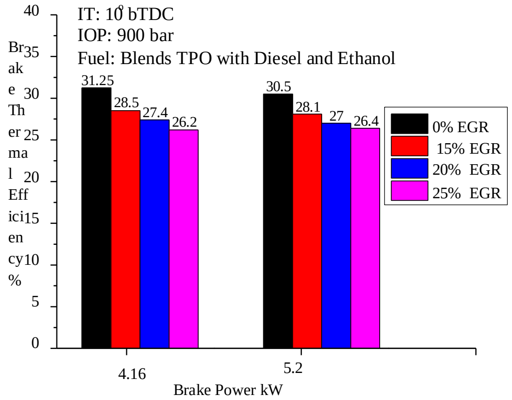

Fig.1 Variation of BTE under the influence of EGR

Figure 1represents the variation of brake thermal efficiency with effect of EGR at 80% and 100% load. EGR with 15% showed better performance for the selected blend. Further increase in the EGR reduces the BTE. This may be due to the more unburnt gases into the CC. At 100% load, there is slight in the drop of BTE which may be due to unavailability of excess air. As the rate of EGR was increased the BTE was decreased. This may be due to slow down of combustion process and reduces the burning rate. Smoke Opacity:

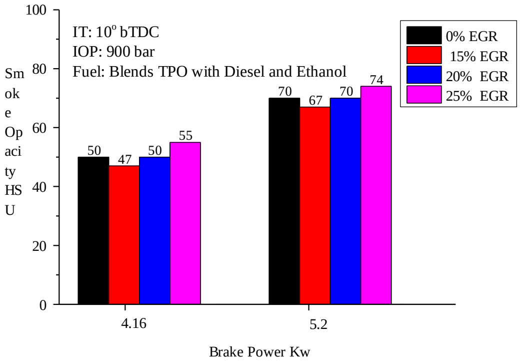

Fig.2 Variation of Smoke Opacity under the influence of EGR

Figure 2represents the variation of brake thermal efficiency with effect of EGR at 80% and 100% load. EGR with 15% showed better performance for the selected blend. Smoke was least for EGR with 15% compared to other values. It can be observed with increase in load and EGR rate the smoke opacity increases. This may be due to more fuel was burnt at higher load to yield high power output [14].

Carbon Monoxide emission:

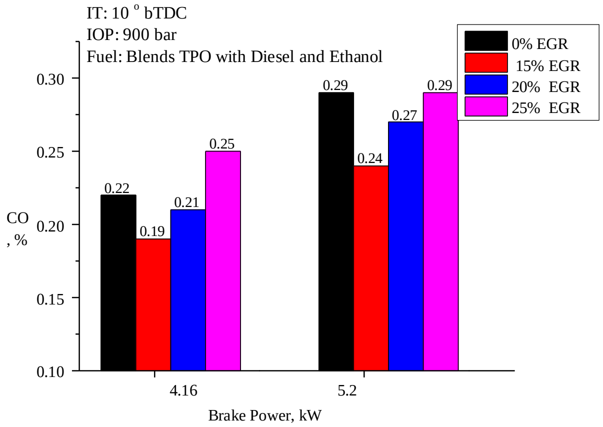

Fig.3 Variation of CO under the influence of EGR

Figure 3represents the variation of brake thermal efficiency with effect of EGR at 80% and 100% load. EGR with 15% showed better performance for the selected blend.CO was low at 15% EGR. EGR prevents CO oxidation due to lower oxygen concentration and as a result, CO emission increases slightly with increasing EGR rates

HC Emissions:

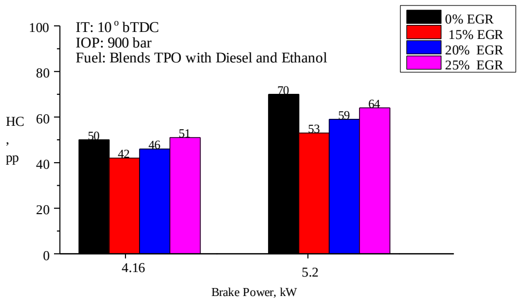

Fig. 4. Variation of HC under the influence of EGR

Figure 4 represents the variation of brake thermal efficiency with effect of EGR at 80% and

100% load. EGR with 15% showed better performance for the selected blend. Increase in EGR rates causes lower flame temperatures which results in the formation of larger flame quenching zones where combustion cannot happen easily [15].**NOx Emissions:**

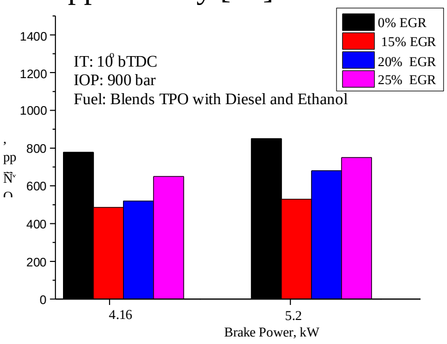

Fig. 5. Variation of HC under the influence of EGR

Figure 4 represents the variation of brake thermal efficiency with effect of EGR at 80% and 100% load. EGR with 15% showed better performance for the selected blend.EGR rates decreases the flame temperature and oxygen concentration leading to lower NOx emissions.

CONCLUSIONS:

The effect of EGR on CRDI engine fuelled with blend of Tyre Pyrolysis oil in terms of performance and emissions reveals the following conclusions.

- BTE decreases with increase in the rate of EGR.
- Emission of NOx was reduced by 38% when the EGR rate was 15%. Smoke opacity increase with increase in the rate of EGR.
- HC and CO emissions increased with increasing EGR rates

In summary, EGR with 15% shown better results in terms performance and emissions.

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