Selective Catalytic Reduction for NOx Level Reduction in Diesel Engines Fueled by Jatropha Oil

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ABSTRACT

The anaerobic treatment of wastewater has contributed to the field of environmental protection. Complex Experiments were studied to study the percentage reduction of NOx levels in conventional engine with jatropha oil with varied injection pressure at recommended injection timing and compared with conventional diesel engine. The NOx levels were studies at various values of BMEP. The effect of other parameters like void ratio, catalyst temperature, space velocity on nitrogen oxides in the exhaust was also studied. The NOx emission levels were controlled by means of selective catalytic reduction technique using the lanthanum ion exchanged zeolite, called catalyst-A and urea infused ion exchanged zeolite, called catalyst-B with different values of injector pressures in conventional engine with crude jatropha oil at peak load operations. The NOx levels were found to be decreased 25-30% using selective at analytic technique.

KEYWORDS: Alternate fuels, Brake thermal efficiency, Catalytic reduction, Exhaust gas temperature.

I. INTRODUCTION

The search for alternative fuel has become inevitable as increasing the vehicle population sand increasing the usage diesel fuel more in agriculture purpose. Increasing the pollutions and increasing the cost has another burden to the Government. Alcohols like ethanol and methanol are alternative resources of fuels can be effectively used in spark ignition engine as they have high octane number and highly volatile fuels. However, they pose problems when they are used in diesel engines, as they have low cetane numbers (less than 10) and high latent of evaporation. That too most of the alcohol produced in India is diverted for Petro–chemical industries. Several researchers experimented with different vegetable oilon conventional engine and their performance was found to be poor due to their high viscosity and low cetane number[1]–[5].

The performance of the vegetable oils in conventional engine can be improved by introducing the concept of Low Heat Rejection(LHR) combustion chamber. In this, the flow of heat will be restricted in all directions when the combustion takes place. Ceramic coated inside the cylinder makes the engine hot by restricting the heat through the heat(LHR1).Maintaining the air gap in the piston and air gap in the liner makes the engine hot by restricting the heat through liner and through the piston(LHR2).The combined insulations of LHR1 and LHR2 is further restrict the heat and makes the engine very hot(LHR3).

Wallace et al studied the performance of the engine with air gap insulated piston with an air gap of 2mm. Wallace et al. also studied the performance of the insulated piston engine in which air gap thickness was maintained at 2-mm. [4]. The major finding was increase of particulate emissions due to reduction of air–fuel ratios from 18.27 to astonishingly small 12.76, which was inadmissible in practice.

Karthikeyan et al. studied the performance of the engine with the air gap in the piston and air gap in the liner with 2mm.The air gap insulated piston, crown and the piston were joined by the studded design[5]. They reported that particulate emissions were increased at all loads when compared with conventional engine. Investigations were continued with bio-diesel in engine with high grade Low Heat Rejection combustion chamber.[Kesava Reddy *et al*, 2012; Janardhan*et al*, 2012; Chowdary*et al*, 2012].They reported that exhaust emissions were increased along with the Brake Thermal Efficiency.

In this section author made an attempt reducing the exhaust emissions with Selective Catalytic Reduction Technique in the diesel engine using crude jatropha oil.

II. MATERIALS AND METHOD.

Fig.1 Shows experimental setup for conducting the test with diesel and with crude jatropha oil in a conventional engine with piston diameter 80mm and a stroke of 110mm.The output of the engine 3.68kw and speed of 1500 rpm. The compression ratio 16:1and nozzle had 3 hole and 0.25mm. The manufacturer recommended injection time 27^0bTDC, injector pressure 190bar and direct injection type arrangement. Fuel consumption can be measured with burette and air consumption can be measured with air box method. Water cooling system, in which inlet temperature of water was maintained at 80^{0}C by adjusting the water flow rate. The engine oil was provided with a pressure feed system. No temperature control was incorporated, for measuring the lube oil temperature. The injector opening pressures were varied from 190 bar to 270 bar (in steps of 40 bars) using nozzle–testing device. The maximum injection pressure was restricted to 270bars due to practical difficulties involved. The exhaust gas temperature (EGT) and water outlet temperature was measured with thermocouple made of iron and iron-constantan connected to exhaust gas temperature indicator and water outlet temperature indicator. NOx were recorded using Netel Chromatograph. Catalyst-A was prepared[7] by using 500 grams of zeolite and 2N solution of lanthanum salt was stirred for 5-6 hours at $70\text{-}80^{0}$C. Ion exchanged zeolite was extracted by filtration and activated by calcinations in an oven for 3 hours at 400^{0}C and was cooled in furnace to retain mechanical properties. Recovered Ionized exchanged zeolite was placed in a cylindrical pipe whose diameter 120mm and length 600mm.Using gravity feed dosing system Catalyst-B was prepared by infusion of urea on lanthanum exchanged zeolite. Urea was injected into exhaust gases with the help of nozzle before it pass on to Catalyst-A. NOx emissions were controlled with the help these two catalysts.

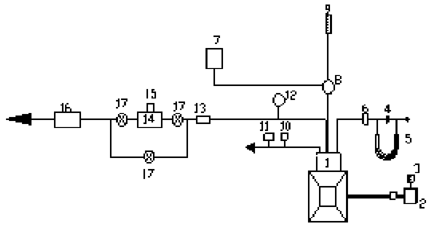

Fig.1. Experimental Setup for Pure Diesel Operation

1.Engine, 2.Electical Dynamo meter, 3.Load Box, 4.Orifice meter, 5.U-tube water manometer, 6.Air box, 7.Fuel tank, 8. Pre-heater, 9.Burette, 10.Outlet jacket water temperature indicator, 11.Outlet-jacket water flow meter, 12. Exhaust gas temperature indicator, 13. AVL Smoke meter. 14. Catalytic chamber, 15. Nozzle, 16.Netel Chromatograph NOx analyzer. 17. Control valve.

III. RESULTS AND DISCUSSIONS

Table 2.Showsthe variation of NOx levels with diesel and crude jatropha oil at different operating pressures with and without catalytic converters A&B. The comparison was made in fig.2 at peak load operation of the engine. It was known that NOx levels in diesel was found to be more compared to the crude jatropha oil operation in conventional diesel engine at different operating pressure. It was due complete combustion of fuel. In case of crude jatropha oil due to high viscosity of the fuel, sauter mean diameter of the atomized fuel drop is large, fuel will splash on to the cylinder walls that causes temperature comedown in the cylinder, gives high duration of combustion and lower heat release. As pressure increases from 190 to 230,230 to 270bar in diesel fuel, oxygen availability causes improves the combustion, most of the heat utilized into useful work, NOx levels were reduced. But in case of crude jatropha oils, due to high viscosity of the oil, sauté mean diameter of the fuel more that makes the improper mixing with oxygen.

It results into improper combustion, fuel conversion efficiency thereby increases the combustion temperatures which improves the NOx levels.

Table.2. Performance of Biodiesel in Conventional diesel Engine with Catalytic Converter

Injection timing	NOx levels (ppm) at peak load			
(ºbTDC)				
	Fuel/Catalyst	CE		
		Injection pressure (bar)		
		190	230	270
	Diesel/ (No catalyst)	850	810	770
27	CJO/(No catalyst)	650	700	750
	CJO/(Catalyst-A)	260	280	300
	CJO/(Catalyst-B)	390	420	450

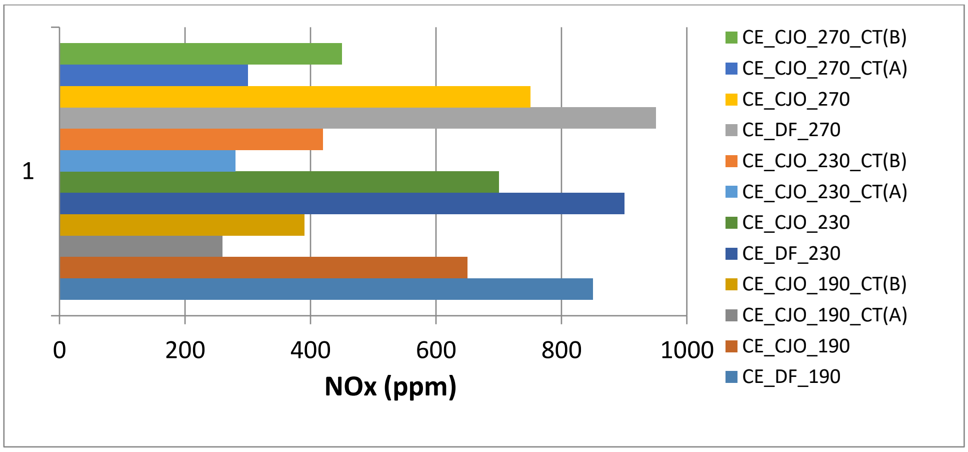

Fig.2. Variation of NOx Levels of Diesel fuel and crude jatropha oil without and with catalytic converters A&B

Fig.2. Shows the NOx levels was found to be more in conventional engine with diesel fuel at 270 bar. Due to increase of oxygen availability, every atomized fuel particle having associate with oxygen particle leads to combust successfully produce good power. This gives higher temperatures prevails in the combustion chamber leads to increase higher NOx levels.

It was found from Fig.2, NOx levels will be reduced 60% with using Catalyst-A and 40% reduced with Catalyst-B catalytic convertors on exhaust emissions using crude jatropha oil. It was known from the graph in Fig.3. catalyst–A and catalyst-B were become efficient when the void ratio 0.6 value. The parameter void ratio is defined as volume occupied by catalyst to volume of catalytic chamber. Beyond this value the effect of catalyst activity become decrease. It was due the exposure of catalyst to the exhaust gases.

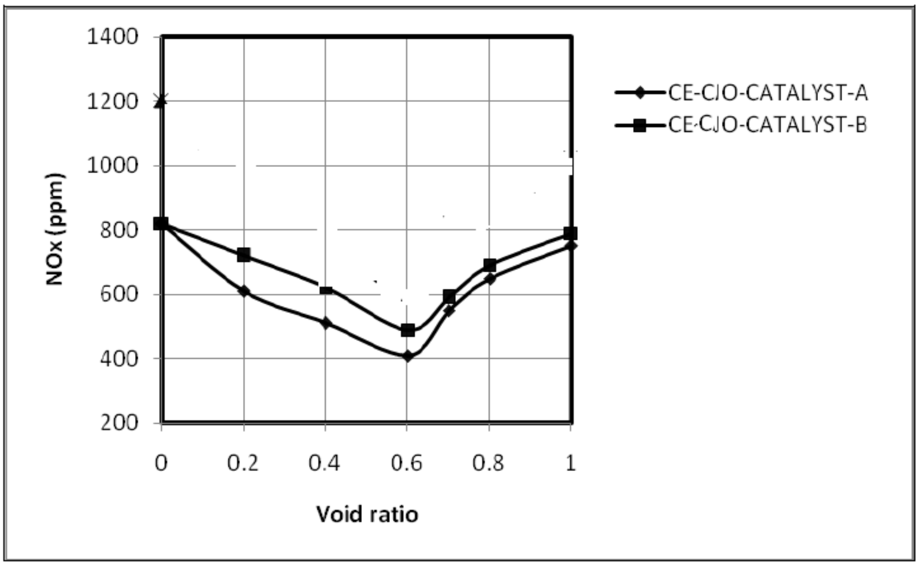

Fig.3.Variation of NOx levels with void ratio with different catalyst with conventional engine with CJO operation at peak load operation

From Fig.4. It was known that with crude jatropha oil on conventional engine, with catalyst-A, the % reduction of NOx found to be 50-60% at about 175^{0}C with catalyst-B and It was with catalyst-A found to be 40-50% at a temperature about 300^{0}C

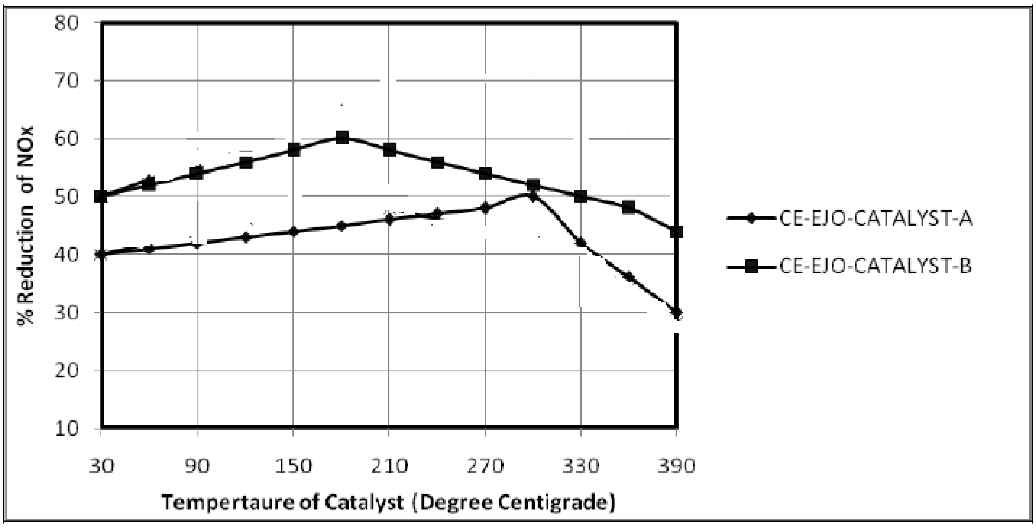

Fig.4.Variation of % reduction of NOx levels with temperature of the different catalysts with CJO operation in conventional engine at peak load operation.

IV. CONCLUSIONS

From the results NOx levels were reduced 60% using Catalyst-A and 40% reduced using Catalyst-B. Catalyst can efficiently works when void ratio become 0.6

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