INVESTIGATION OF PERFORMANCE AND EMISSION ON A SINGLE CYLINDER DI-DIESEL ENGINE WITH A CATALYTIC CONVETER USING BIO-DIESEL

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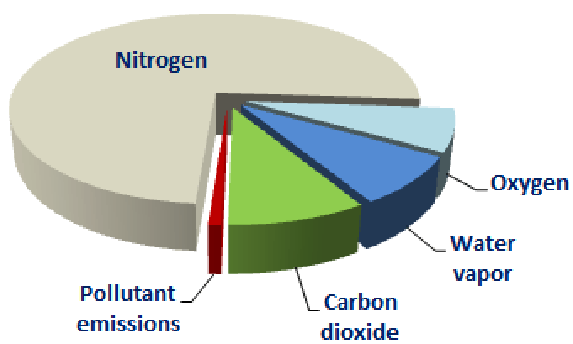
Abstract— There are approximately 700 million cars on the road every day in the world today, with that number expected to rise to close to 1300 million by 2030. This rise in vehicle numbers would deplete diesel, which is a nonrenewable source of energy and one of the main fuels used to power automobiles. Incomplete combustion products such as CO, HC, NOx, particulate matter, and others result from incomplete combustion in the engine. Several alternate systems are being considered to minimise diesel consumption and emissions, such as advanced engine configuration, fuel pretreatment, fuel additives, exhaust treatment and better combustion process tuning. Biodiesel is the best way to minimise diesel usage and to control automotive exhaust emissions among all forms of technology so far produced, both as a diesel replacement and catalytic converters based on noble group metals. This project deals with bio-diesel processing, mixing of the two combustibles to make mixtures and mixing characteristics as well as vehicle efficiency criteria for a bio-diesel mixture (B30, B50), exhaust emissions, autopower exhaust emission control in a catalytical converter, manufacture of a catalytic converter and experimental process using an aluminium group based metal catalyst.

Keywords — Blend, transesterification, redox, Catalytic Converter, aluminium group metal, reduction, oxidation.

INTRODUCTION

Diesel is one of the major fuels used in the modern world for running vehicles. Crude oil is expected to become extremely scarce and expensive to find and manufacture in this century. Despite the fact that engine fuel economy has significantly improved in recent years and will likely continue to improve in the future, the growing number of vehicles alone indicates that there will be a high demand for alternative fuel in the immediate future. There have always been some IC engines running on non-diesel oil fuels over the years. Their numbers, however, have been relatively small. Concerns over diesel engine emissions are another factor behind the production of alternative fuels for diesel engines. The large number of vehicles contributes significantly to the global air quality crisis. Automobile manufacturers began developing a treatment system for exhaust gases known as a catalytic converter for their vehicle models as a result of the strict rules and emission standards. Most traffic in vehicles is driven by gasoline, diesel and jet fuels which produce substantial amounts of carbon monoxide (CO) as well as unbranded hydrocarbons and nitrogen oxides (NOx) as



well as particulate matter (PM). The standard exhaust gas composition under engine operation conditions is composed of carbon monoxide (CO, 0.5% vol.), unburned hydrocarbons (HC, 350ppm), nitrogen oxides (NOx, 900ppm), hydrogen (H2, 0.17% vol.%), water (H2O, 10 vol.%), carbon dioxide (O2, 0.5% vol).

This paper discusses performance and emission ofdiesel engine using bio-diesel (B30, B50) and emission control using a metal coated (Al_2O_3) catalytic convertor.

CATALYTIC CONVERTER:

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A catalytic converter is a pollution control system that catalyses a reaction to transform harmful contaminants in exhaust gas to less toxic pollutants

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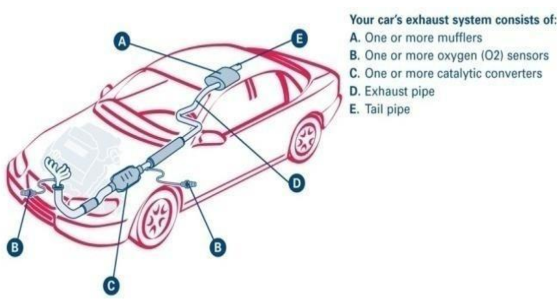

Fig1: catalytic convertor fitted to car

Placed in the thorough piping, a catalytic converter (CC) releases lethal exhaust gases containing unburned fuel, CO and NOx. Converting these gases into carbon, water, N2 and O2 would be the catalytic converter. This is considered one of the most effective instruments for mitigating the enormous pollutant content in our environment, since it eliminates approximately 80 percent of the incomplete combustion toxic gases generated by the engine.

HISTORY

The catalytic converter was invented by Eugene Houdry, a French mechanical engineer living in the US. John J. Mooney and Carl D. Keith subsequently designed a catalytic converter for the Engelhard Corporation and produced the first commercial catalytic converter in 1973. A obligatory reduction in NOx was introduced in 1979 and a three-way catalyst for CO, HC, and NOx was required in order to have been innovation and implementation.

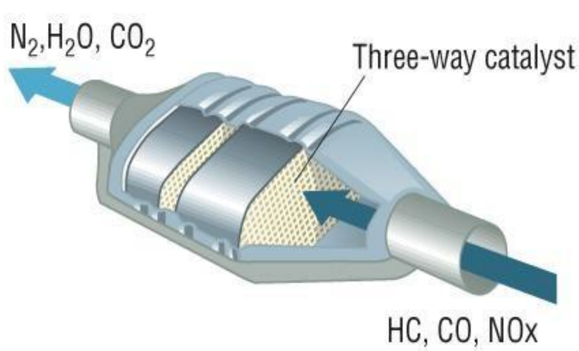

Fig2: Catalytic convertor

Over the past 30 years, catalytic converters have passed through many cycles and undergone phenomenal evolution. The ceramics are a single wave structure with many flow passages in most converters. They are available in a number of different shapes, including circle, triangle, hexagonal and sinusoidal. Early converters were using loose granular ceramic, with gas running between the springs.

CATALYST

These have base metal oxides, such as copper, chromium, nickel, and cobalt, and platinum (Pt), palladium (Pd) and rhodium noble metals (Rh). Although basic metal oxides are seen at higher temperatures to be effective, they sinter and deactivate when high-end gas exhaust temperatures are exposed. A 2:1 mass ratio of platinum to palladium is generally used as a catalyst for oxidation. For oxidation of CO, olefins, and methane palladium has a greater functional activity than Pt.

This paper examines the use of catalytic converters with AL2O3 as catalyst for exhaust gases.

BIO-DIESEL (B30, B50)

Biodiesel, also known as Methyl Ester, is a clean-burning, green fuel alternative to mineral diesel derived primarily from vegetable oils.

Since biodiesel's physical and chemical properties are somewhat close to those of regular diesel, it can be blended and used as a mixture with the same properties.

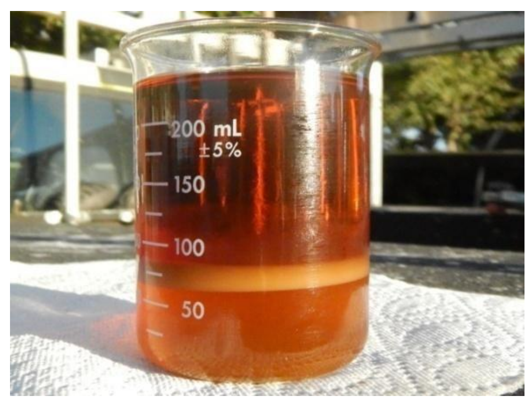

Fig3: Biodiesel

BIO-DIESEL PRODUCTION

There are three basic methods for producing biodiesel from oils and fats:

- Oil transesterification catalysed by a base.
- Oil transesterification catalysed by an acid.
- The oil is converted into fatty acids, which are then converted into biodiesel.

Transesterification is known as the reaction of

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triglyceride (fat/oil) to esters (biodiesel) and glycerol in an alcohol.

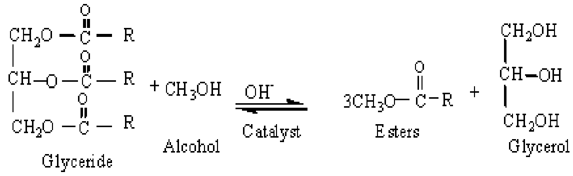

Fig4: R : Alkyl group

The isolation of the ester and glycerol layers after the reaction period indicates a complete transesterification reaction.

BLEND PREPARATION

The blend of bio diesel and pure diesel is prepared by mixing accurate quantity of methanol taken in a pipette and pouring in a beaker containing adequate quantity of pure diesel. Here "B" stands for blend and the number written along with it denotes the percentage by volume of bio-diesel present in themixture.

In present world blends upto a percentage of 50 to 70 are prepared and tested in various conditions. A blend with 5% by volume methanol and 95% by volume pure diesel is denoted as "B5". Similarly B30 and B50 contain 30% and 50% by volume methanol mixed with 70% and 50% pure diesel repectively.

Fig5: Biodiesel blends

LITERATURE REVIEW

N. Stalin and H.J. Prabhu: et al, 2007 conducted performance test on diesel engine using KARANJA bio-diesel blending with diesel and concluded thattorque, brake power and brake thermal efficiency reach maximum values at 70% load.

Praveen K.S. Yadav, Onkar Singh and R.P.Singh: et al, 2010 The findings of a A performance test on a compression ignition engine with a palm fatty acid biodiesel, including torque output, brake-specific fuel consumption and brake heat quality, shows that the B-40 dual combustion blend of fuel can be used without any alteration of the motor.

P.K.V.S.Subramanyeswararao, *et al,* 2014 investigated on back pressure for differentmodels catalytic converters by changing the lengths and diameters of the substrate. In his study, it is also seen that the increase in catalyst diameter would result in decrease of exhaust emissions. Comparison between catalytic converters with external air supply and without external air supply was done and concluded that NO emissions are lower in case of external air supply.

Narasimha Kumar et al., 2011: Research has been conducted to reduce emissions from a variable compression ratio, copper-coated spark ignition engine equipped with a catalytic converter containing a sponge iron catalyst that is powered on gasoline (blend of 20 percent ethanol and 80 percent gasoline by volume). Carbon monoxide (CO) and unburned hydrocarbons are the main contaminants released by spark ignition engines (UHC).

Mohiuddin and Nurhafez et al., 2007 carried out an experiment to investigate the The performance and conversion efficiency of TWCCs for the purpose of reducing fuel emissions, used in automotive exhaust lines. Two different cell density ceramic converters, substratum

EXPERIMENTAL SETUP

FABRICATION DATA

Funnel length=144mm
Angle=6 degrees
Overall length =542mm
Funnel outer diameter=48.1mm
Funnel inner diameter=42.1mm
Outer diameter of shell=160mm

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Inner diameter of shell=154mm
The inner diameter of the mesh is 148mm
Grid 8*8
Length=254mm
Operations performed are Galvanizing of inner mesh with aluminium oxide (Al2O3),Grinding, Fitting, Arc welding and Lathe machining

Mesh:-

Fig6: Mesh

Fabricating :-

Fig7: Fabrication of catalytic convertor

Welded assembly fitted to exhaust:-

Fig8:Catayltic convertor fitted to engine exhaust

ENGINE SPECIFICATIONS

Single cylinder DI-diesel engineStroke length=185mm
Diameter=87.5mm
Length of the cylinder=1100mmSpeed =1500 r.p.m

Fig9: Diesel engine test rig

FIVE GAS ANALYSER

This is mainly used to check the emissions generated by the engine. The five gas analyser is placed inside the exhaust of the catalytic convertor and the exhaust is completely blocked so that no air enters into the exhaust which thereby helps the five gas analyser to get accurate values for emissions. The five gases which this analyser works on is CO(carbon monoxide), HC(hydrogen carbide), CO_2(carbon dioxide), O_2(oxygen), NO_X(oxides of nitrogen).

Fig10: Five gas analyzer

EXPERIMENTAL PROCEDURE

Using this experimental setup we have conducted the test by using bio-diesel (B30,B50) with catalytic convertor. The catalytic convertor is fitted to the exhaust of the engine where the blend is used as a fuel for running the engine. First the engine is started and made to run at no load condition and the time taken for consumption for 10c.c fuel is taken and the same procedure is carried out at one fourth load, half

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load, three fourth load and full load. To get the emission values the outlet of catalytic converter is blocked and five gas analyser is connected to it.

Based on the values obtained the results are formulated below.

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Results and Discussions:

Performance curves of bio-diesel (B30) on single cylinder DI-diesel Engine

Table 1: performance of bio-diesel (B30)

LOAD	B.P.	T.F.C.	S.F.C.	Mech. eff.	Br. th. Eff.	Ind. The. Eff.
NL	0	0.22	∞	0	0	60.92
1/4 LOAD	0.94	0.35	0.37	37.30	22.78	61.27
1/2 LOAD	1.86	0.47	0.25	54.06	33.57	62.08
3/4 LOAD	2.77	0.59	0.21	63.67	39.82	62.94
FL	3.71	0.70	0.18	70.13	44.95	64.10

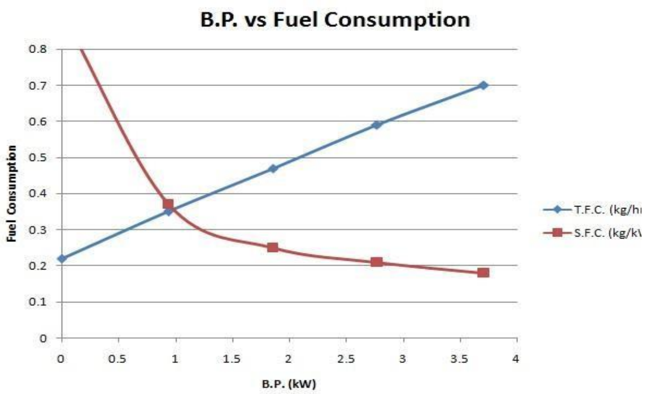

Fig11:Graphical representation of Brake power (B.P) vs TFC and SFC

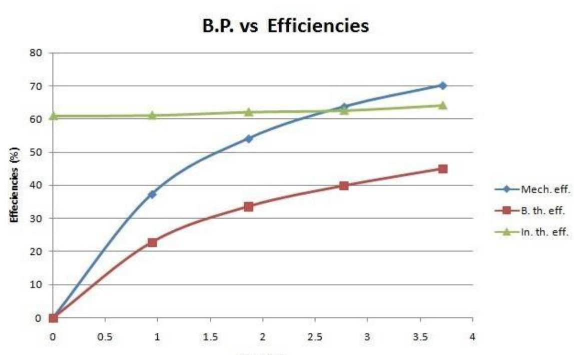

Fig12: Graphical representation of Brake power (B.P) vs efficiencies (mechanical eff., brake thermal eff., indicated thermal eff.)

Emissions using biodiesel (B30) using catalytic convertor

Table 2: emission using biodiesel (B30) with catalytic convertor

LOAD	CO	HC	CO_2	O_2	NO_X
NL	0.03	0.012	0.1	19	18
1/4 LOAD	0.18	0.016	2.8	16	108
1/2 LOAD	0.08	0.019	2.3	16	226
3/4 LOAD	0.06	0.024	4.6	15	886
FL	0.016	0.029	5.2	14	1048

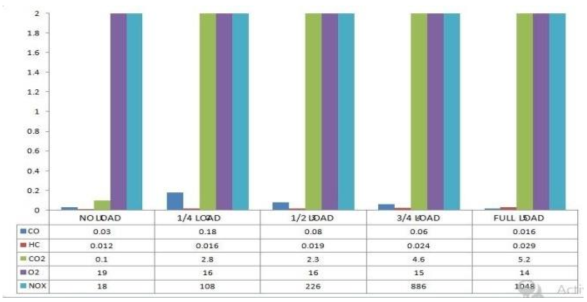

Fig13: Overall graphical representation of load versus emissions (B30)

Performance curves of bio-diesel (B50) onsingle cylinder DI-diesel engine

Table 3: performance of biodiesel (B50)

LOAD	B. P.	T.F. C.	S.F. C.	Mec h. eff.	Br. th. Eff.	Ind. The . Eff.
NL	0	0.38	∞	0	0	34.3 5
1/4LOA D	0.9 6	0.61	0.64	39.1 6	13.7 7	35.1 7
1/2 LOAD	1.8 6	0.82	0.44	56.0 2	20.2 8	36.2 0
3/4 LOAD	2.7 7	1.02	0.36	65.4 8	24.2 8	37.0 8
F L	3.7 1	1.20	0.32	71.7 6	27.6 4	38.5 2

Overall graphical representation of loadversus emissions

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(B50)

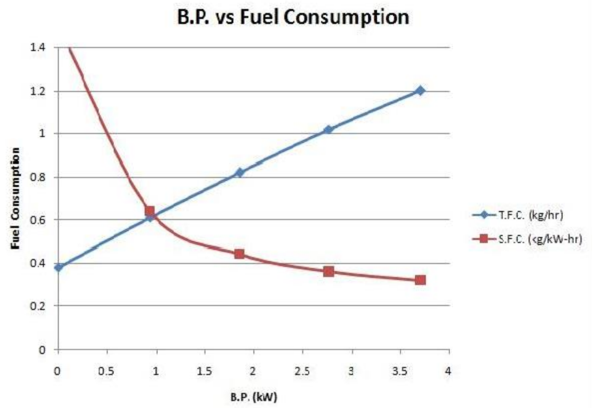

Fig14: Graphical representation of Brake power (B.P) vs fuel consumption (T.F.C and S.F.C.)

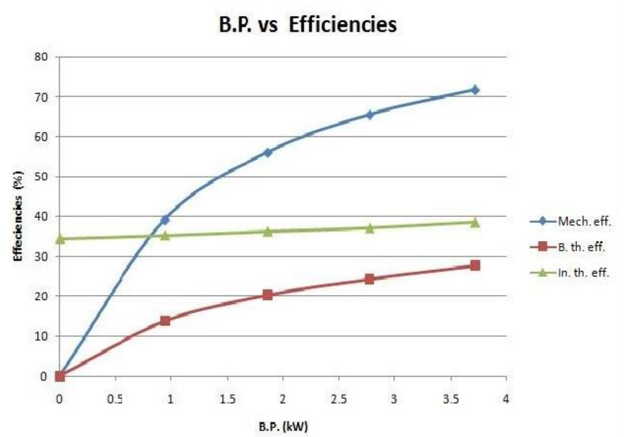

Fig15:Graphical representation of Brake power (B.P) vs efficiencies (mechanical eff., brake thermal eff., indicated thermal eff.)

Emissions using biodiesel (B30) using catalytic convertor

Table 4: emission using biodiesel (B50) with catalytic convertor

LOAD	CO	HC	CO_2	O_2	NO_X
NL	0.08	0.015	0.3	20	24
1/4 LOAD	0.26	0.021	3.5	18	120
1/2 LOAD	0.14	0.028	2.8	18	248
3/4 LOAD	0.09	0.03	5	17	930

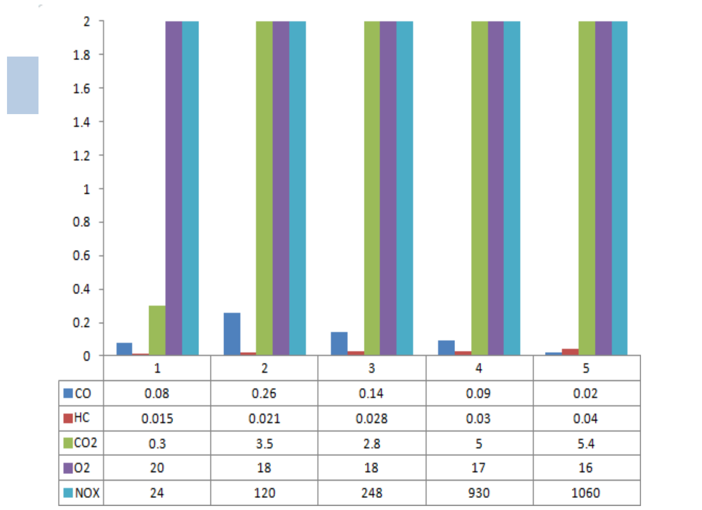

Fig16: Overall graphical representation of load versus emissions (B50)

CONCLUSIONS

The performance parameters for blends show a gradual increase in the efficiencies of the engine with increase in load. There is a slight increase in mechanical efficiency (η_{mech}) when using B50 when compared to B30, but the brake thermal efficiency ($\eta_{b.\ th.}$) and indicated thermal efficiency ($\eta_{in.\ th.}$) decreases for the same.

At full load:-

Mechanical efficiency (B30) = 70.13

Mechanical efficiency (B50) = 71.76 Break thermal efficiency (B30) = 44.95 Break thermal efficiency (B50) = 27.64 Indicated thermal efficiency (B30) = 64.10Indicated thermal efficiency (B50) = 38.52

On comparing the exhaust emission we find that NO_x emission-the major cause of environmental pollution-is reduced upto 60% when using AL_2O_3 coated catalytic converter (emission without use of catalytic converter being 1663 and 1737 for B30 and B50 at full load condition respectively). The emissions are well in accordance with the stringent norms of pollution control. Also the emission for B30is less compared to B50.

At full load:-

CO_2 emissions (B30) = 5.2

CO_2 emissions (B50) = 5.4

NO_x emissions (B30) = 1048

NO_x emissions (B50) = 1060

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Thus, B30 must be preferred for use in DI-Diesel engine along with metal coated catalytic converter to control the emissions.

FUTURE SCOPE

Further researches can be carried out using various other oils like Jetropa oil, Mahua oil, Castor seed oil etc. to replace diesel as sole fuel. Also by using catalysts like platinum, rhodium, palladium there can be furthermore reduction harmful exhaust emission values which thereby reduces release of toxic substances into the atmosphere.

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