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

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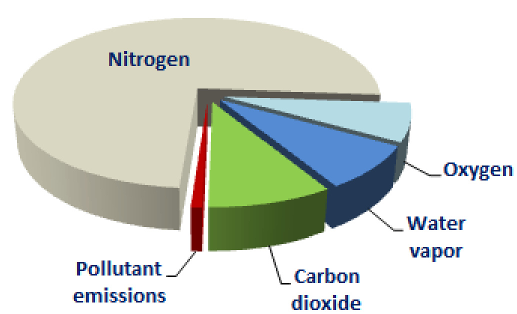
Abstract— **In present world there are approximately 700 million vehicles running everyday on road which is projected to grow close to 1300 million by the year 2030. This increase in number of vehicles will deplete diesel which is one of the primary fuel used to run vehicles and is non renewable source of energy. Also due to incomplete combustion in the engine, there are a number of incomplete combustion products CO, HC, NO_x, particulate matters etc. A numbers of alternative technologies like improvement in engine design, fuel pre-treatment, fuel additives, exhaust treatment or better tuning of the combustion process etc. are being considered to reduce the consumption of diesel and to reduce the emission levels of the engine. Among all the types of technologies developed so far, use of bio-diesel as diesel substitute and catalytic converters based on noble group metal are considered the best way to reduce the use of diesel and control automotive exhaust emissions respectively. This project work discusses production of bio-diesel, proportion of mixing the two fuels to form blends, properties of blend, automotive performance parameters of a Di-diesel engine using bio-diesel blends (B30, B50), exhaust emissions, automotive exhaust emission control by aluminium group metal based catalyst in catalytic converter, fabrication of a catalytic convertor, experimental procedure carried out to get results and conclusion.**

Index Terms— **Blend, transesterification, redox, Catalytic Converter, aluminium group metal, reduction, oxidation.**

I. INTRODUCTION

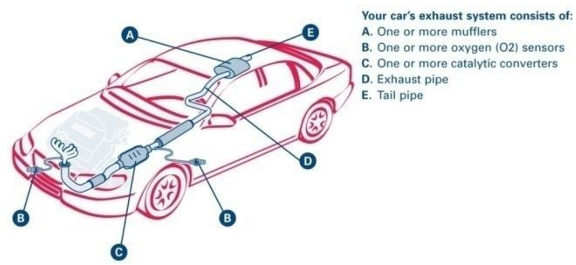
Diesel is one of the major fuels used in the modern world for running vehicles. Probably in this century, it is believed that crude oil will become very scarce and costly to find and produce. Although fuel economy of engine is greatly improved from the past and will probably continue to be improved, increase in number of automobiles alone dictates that there will be a great demand for alternate fuel in the near future. All these years there have always been some IC engines fuelled with non-diesel oil fuels. However, their numbers have been relatively small. Another reason for motivating the development of alternate fuels for the diesel engine is concern over the emission problems of diesel engine. The large number of automobiles is a major contributor to the air quality problem of the world. Due to the stringent rules and emission standards, automotive manufacturers begun to develop a treatment device for exhaust gases known as catalytic converter for their vehicle models. Most vehicular transportation relies on combustion of gasoline, diesel and jet fuels with large amount of emission of carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NO_x) and particulates matter (PM). Typical exhaust gas composition at the normal engine operating conditions are: carbon monoxide (CO, 0.5 vol.%), unburned hydrocarbons (HC, 350 ppm), nitrogen oxides (NO_x, 900 ppm), hydrogen (H_2, 0.17 vol.%), water (H_2O, 10 vol.%),carbon dioxide (CO_2, 10 vol.%), oxygen (O_2, 0.5 vol.%), water vapour, particulate matter etc.



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

1.1 CATALYTIC CONVERTER

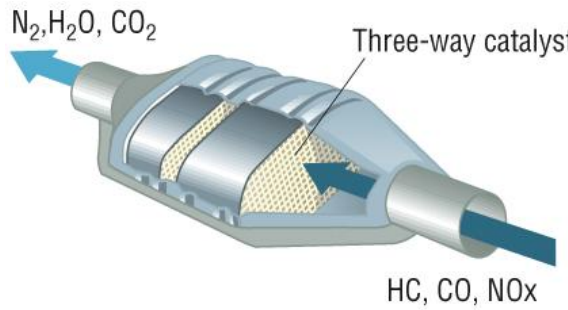
A catalytic converter is an emissions control device that converts toxic pollutants in exhaust gas to less toxic pollutants by catalyzing a reaction (oxidation or reduction).



A catalytic converter (CC) is placed inside the tail pipe through which deadly exhaust gases containing un burnt fuel, CO, NOx are emitted. The function of the catalytic convertor is to convert these gases into CO2, water, N2 and O2. It is said to be one of the most effective tool to fight against the overwhelming pollutant contents in our environment, as it reduces almost 80% of the harmful gases resulting from the incomplete combustion of the engine.

1.1.2 HISTORY

The catalytic converter was invented by Eugene Houdry, a French mechanical engineer who lived in the United States. The catalytic converter was later on further developed by John J. Mooney and Carl D. Keith at the Engelhard Corporation creating the first production catalytic converter in 1973. Beginning in 1979, a mandated reduction in NO_x required the development and use of a three way catalyst for CO, HC and NO_x.



Catalytic converter has gone through many processes and remarkable evolution for the past 30 years. In most converters, the ceramic is a single honeycomb structure with many flow passages. The passages comprise of many shapes, including square, triangular, hexagonal and sinusoidal. Early converters used loose granular ceramic with the gas passing between the packed spheres.

1.1.3 CATALYST

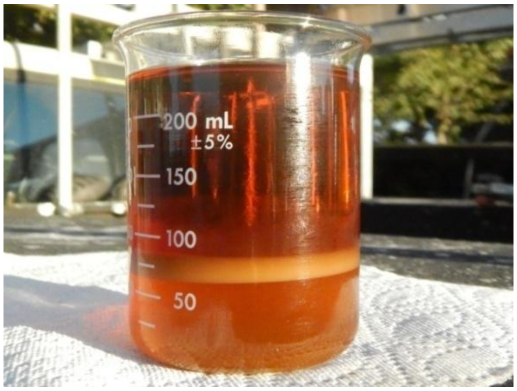
These include oxides of base metals e.g. copper, chromium, nickel, cobalt etc. and the noble metals platinum (Pt), palladium (Pd) and rhodium (Rh). Base metal oxides although found to be effective at higher temperature, they sinter and deactivate when subjected to high-end exhaust gas temperature.A mixture of platinum and palladium in 2:1 mass ratio is usually employed as oxidation catalyst. Palladium has higher specific activity than Pt for oxidation of CO, olefins and methane.

This paper covers the investigation of exhaust gases using catalytic converter with AL_2O_3 as catalyst.

1.2 BIO-DIESEL (B30, B50)

Biodiesel or Methyl Ester as it's also known, is a clean burning and renewable fuel alternative to mineral diesel made predominantly from vegetable oils.

Biodiesel's physical and chemical properties are very similar to normal diesel, so it can be mixed and used as a blend with same characteristics.



1.2.1 BIO-DIESEL PRODUCTION

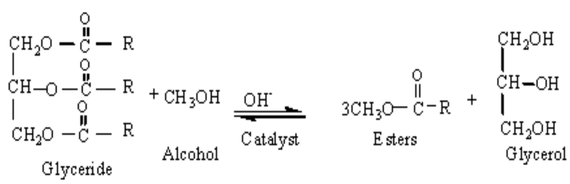
There are three basic routes to biodiesel production from oils and fats:

● Base catalyzed transesterification of the oil.

● Direct acid catalysed transesterification of the oil

● Conversion of the oil to its fatty acids and then to biodiesel.

The Transesterification process is the reaction of a triglyceride (fat/oil) with an alcohol to form esters(biodiesel) and glycerol.



R : Alkyl group

A successful transesterification reaction is signified by the separation of the ester and glycerol layers after the reaction time.

1.2.2 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 the mixture.

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.

B10 B20 B30 B40 B50

II. 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 that torque, 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 conducted performance test of palm fatty acid bio-diesel on compression ignition engine and the results obtained in the study of torque output, brake specific fuel consumption and brake thermal efficiency indicate that dual fuel combination of B-40 can be used in diesel engines without any modifications in the engines.

P.K.V.S.Subramanyeswararao, *et al*, 2014investigated on back pressure for different models 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: Investigations have been carried out for reducing pollutants from a variable compression ratio, copper-coated spark ignition engine fitted with catalytic converter containing sponge iron catalyst run with gasohol (blend of 20% ethanol and 80% gasoline by volume).The major pollutants emitted from spark ignition engine are carbon monoxide (CO) and unburnt hydrocarbons (UHC).

Mohiuddin and Nurhafez, *et al*, 2007 conducted an experiment to study the performance and conversion efficiencies of ceramic monolith three-way catalytic converters (TWCC) employed in automotive exhaust lines for the reduction of gasoline emissions. Two ceramic converters of different cell density, substrate © December 2015 | IJIRT | Volume 2 Issue 7 | ISSN: 2349-6002

III. EXPERIMENTAL SETUP

3.1 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
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 (Al_2O_3),Grinding, Fitting, Arc welding and Lathe machining

Mesh:-

Fabricating :-

Welded assembly fitted to exhaust:-

3.2 ENGINE SPECIFICATIONS

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

3.3 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).

IV. 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 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.

V. RESULTS

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

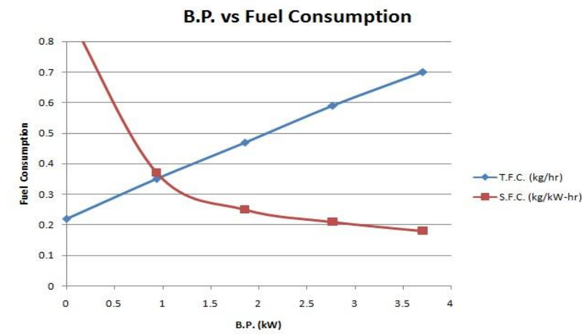
LOAD	B.P.	T.F.C.	S.F.C.	Mech. eff.	Br. th. Eff.	Ind. The. Eff.
NL	0	0.22	∞	0	0	60.92
1/4 LOAD	0.94	0.35	0.37	37.30	22.78	61.27
1/2 LOAD	1.86	0.47	0.25	54.06	33.57	62.08
3/4 LOAD	2.77	0.59	0.21	63.67	39.82	62.94
FL	3.71	0.70	0.18	70.13	44.95	64.10

Table 1: performance of bio-diesel (B30)

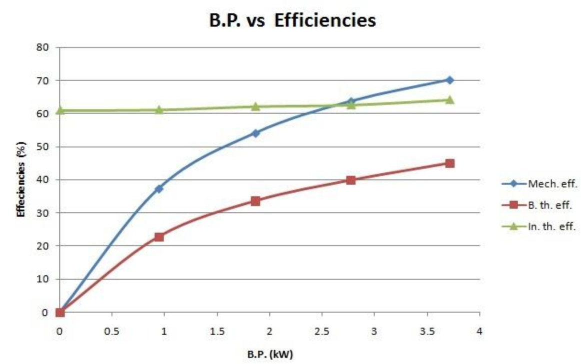
Specifications:
Calorific value=42438 kj/kgK
Specific gravity=0.491

Engine specifications:
l=185mm
D=87.5mm
L=1100mm
N=1500 r.p.m

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



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

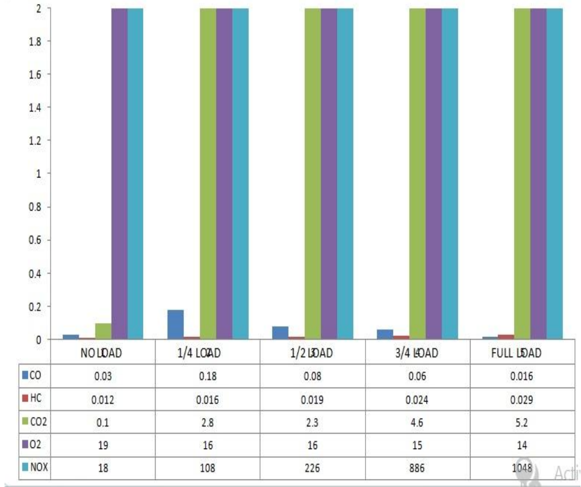


5.2 Emissions using biodiesel (B30) using catalytic convertor

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

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

5.2.1 Overall graphical representation of load versus emissions (B30)

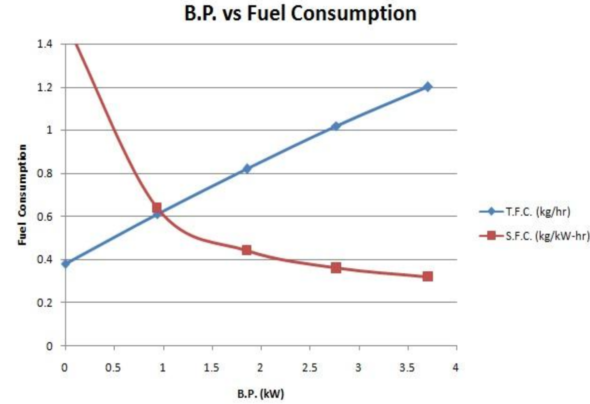


5.3 Performance curves of bio-diesel (B50) on single cylinder DI-diesel engine

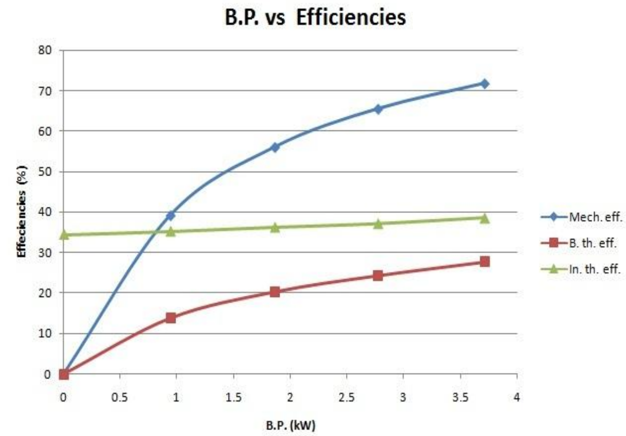
LOAD	B. P.	T.F. C.	S.F. C.	Mec h. eff.	Br. th. Eff.	Ind. The . Eff.
NL	0	0.38	∞	0	0	34.3 5
1/4LOA D	0.9 6	0.61	0.64	39.1 6	13.7 7	35.1 7
1/2 LOAD	1.8 6	0.82	0.44	56.0 2	20.2 8	36.2 0
3/4 LOAD	2.7 7	1.02	0.36	65.4 8	24.2 8	37.0 8
F L	3.7 1	1.20	0.32	71.7 6	27.6 4	38.5 2

Table 3: performance of biodiesel (B50)

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



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

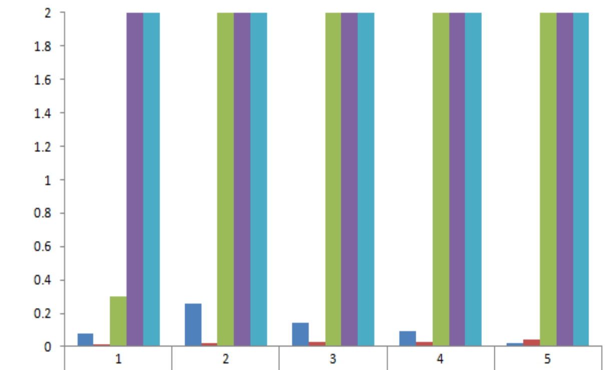


5.4 Emissions using biodiesel (B30) using catalytic convertor

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
FL	0.02	0.04	5.4	16	1060

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

5.2.1 Overall graphical representation of load versus emissions (B50)



	1	2	3	4	5
CO	0.08	0.26	0.14	0.09	0.02
HC	0.015	0.021	0.028	0.03	0.04
CO2	0.3	3.5	2.8	5	5.4
O2	20	18	18	17	16
NOX	24	120	248	930	1060

VI. 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) = 64.10
Indicated 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 B30 is 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

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

VII. 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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