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Analysis of Performance and Emission Characteristics of Thermal Barrier Coated DI Diesel Engine Fueled with Waste Plastic Pyrolysis Oil with Exhaust Gas Recirculation - A Review Study.

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***Abstract* - Internal combustion engines are main power source for automobiles. The transportation sector in India consumes 65% of the petroleum products, which leads to depletion of fossil fuel Resources, Hence There is a need to search an alternative fuel to fossil fuel. Waste plastic pyrolysis oil is suitable for diesel engines. However there are certain problems(performance and emissions) encountered with the use of waste plastic oil as alternative fuel to diesel fuel. Hence in this work two measures will be considered for commercial viability of waste plastic oil. They are "Thermal barrier coating to piston crown part" and "Exhaust gas recirculation". The aim of this work is to review of Impact of Thermal Barrier coating on the performance and Emissions of a single cylinder diesel engine fueled with waste plastic pyrolysis oil with Exhaust Gas recirculation.**

Key words: Diesel Engine, waste plastic pyrolysis oil, Thermal Barrier coating, Performance, Emissions, EGR,LHR.

1. INTRODUCTION

The transportation sector in india consumes most of the petroleum products, this leads depletion of fossil fuels. The continuous rise in prices of fuel and increasing threat to environment due to exhaust emissions like Carbon monoxide (CO), Carbon dioide(CO_2) and oxides of nitrogen(NO_x). The problem of global warming and the threat of supply fuel oil instabilities have adversely impacted the developing countries,[1].

The increasing use of plastics products, especially carry-bags and films and its littering and open burning emitting gaseous emissions has posed serious environmental problems. The synthetic and conventional (petro-based) plastics being non-biodegradable remains in the dump-yard/landfills for several years. For management of plastics waste (PW), source segregation is necessary to ensure that collected PW is used for beneficial purposes like road construction, co-processing, conversion of plastics waste into liquid fuel, etc. To quantify the plastics waste generation, a study was undertaken through Central Institute of Plastics Engineering and Technology (CIPET), Ahmedabad for "Assessment and Quantification of Plastics Waste Generation in 60 Cities" during 2010-12. The study has revealed that the total plastics waste generation is 3501 tons/day,[2].

By the use of pyrolysis process waste plastic can be converted into waste plastic oil, which is having a compatible properties with the diesel fuel, Hence we can use in diesel engines without modification to the engines. However certain problems (Performance and emissions) encountered with the use of waste plastic oil as alternative to diesel. Hence in this work two measures are taken, Those are (i) Thermal Barrier Coating on Piston Crown, (ii) Exhaust Gas recirculation.

The concept of thermal barrier coating for diesel engines began in 1980s. The petroleum crisis and the subsequent increase in the cost of fuels, the improvement of fuels and the improvement of fuel economy of the I.C Engines has become a high priority to the researchers. Numerous investigations have modelled and analysed the effects of in-cylinder thermal insulation. Reducing heat rejection in reciprocating engines is a possible way of reducing fuel consumption. This may be possible by eliminating a part of the cooling system and incorporating high-temperature insulting materials in the combustion chamber to withstand the higher combustion gas temperature. The advent of high temperature, high performance ceramics has tempted engine researchers to strive for higher operating temperatures with subsequent

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higher engine thermal efficiency by reducing fuel consumption. Engine with thermal barrier coating for various engine parts in combustion chamber is called Lowheat rejection engines(LHR)[3].

Exhaust gas recirculation(EGR) is a method to reducing the NO_x emission from the compression ignition engines and is widely use to meet emission standards. EGR is an effective technique, where part of exhaust exhaust gas is recirculated to intake charge, which reduces the availability oxygen and adiabatic flame temperature which in turn reduces the NO_xemissions. But EGR application results higher specific fuel consumption, and also higher HC and CO emissions,[4].

2 MATERIALS AND METHODS

2.1 Pyrolysis of Waste Plastic

Pyrolysis is a process of thermochemical decomposition of organic and synthetic materials to produce fuels at elevated temperatures without the presence of oxygen. The operating temperature is varying depending on type of plastic(LDPE,HDPE,etc.) , the range is of around 360^0-500^0C,[5].

Pyrolytic reactor unit is used to produce biodiesel from waste plastic. The reactor consists of pyrolytic chamber, a catalyst bed, a condenser, and a flare system. To supply heat into the reactor, an electrical heater covering the outside surface of the pyrolytic chamber was used. A flare system was applied to burn the non-condensable gases produced from the pyrolysis reaction. Zeolites used as catalyst, [5].

The main products of pyrolysis are oil, Hydrocarbon Gas and Carbon black.When waste plastic is used as raw material for pyrolysis plants, generally following is the input-output ratio,[6].

Table 1 Plastic Pyrolysis : Input-Output ratios

Input Material	Input Quantity	Output Quantity
Waste mixed Plastic scrap	1000 kgs	-650 to 900 lit. Of Pyrolysis oil -50to100 kg of Hydrocarbon Gas -50 to 70 kg of carbon black

Table 2 : Comparisons of Properties of WPPO,diesel

Sr.No.	Properties	WPPO	Diesel
1	Density	0.7930	0.84 to 0.88
2	Ash Content(%)	<0.01%(wt)	0.045
3	CalorificValue (kj/Kg)	41,858	42,000
4	Kinematic viscosity cSt@40^0C	2.149	5
5	Cetane Number	51	55
6	Flash Point(^{O}C)	40	50
7	Fire Point(^{O}C)	45	56
8	Carbon residue(%)	0.01%(wt)	0.20
9	Sulphur content(%)	<0.002	<0.035
10	Acidity(mg KOH/gm)	0.16	0.20
11	Pour Point, ^{O}C	-4	3-15

2.2 Materials used for thermal Barrier coating

2.2.1 Zirconia Ceramics

Zirconium dioxide(ZrO_2) has a monoclinic crystallographic structure at ambient temperatures. Pure zirconium dioxide is unstable, because it has a phase transition from tetragonal to monoclinic upon decreasing temperature at 1170^0 C. It will form solid solutions with aliovalent oxides including CaO, MgO , and Y_2O_3 and rare earth oxides.

Y_2O_3 is a stabilizing agent of zirconium dioxide. Addition of 9% mole fraction of yttria(Y_2O_3) or more to ZrO_2will result in fully stabilized zirconia(FSZ), and 6% mole fraction of yttria(Y_2O_3) to ZrO_2 will result partially stabilized zirconia(PSZ). Out of above two mostly PSZ is preferred because it has a advantage of minimizing stress concentration at the crack, and results in high strength and toughness,[7].

2.2.2. Mullite ($3Al_2O_3$-$2SiO_2$)

Mullite is an important ceramic material because of its low density, high thermal stability, stability in severe chemical environments, low thermal conductivity and favourable strength and creep behaviour. Compared with yittria stabilized zirconia, mullite has much lower thermal expansion coefficient and higher thermal conductivity, and is much more oxygen resistant than YSZ. The low thermal expansion coefficient of mullite is an advantage relative to YSZ in high thermal gradients and under thermal shock conditions. However the large mismatch in thermal expansion coefficient with metallic substrate leads to poor adhesion. The other disadvantage of mullite is crystallization at 1023-1273 K,[8].

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2.3 Coating Methods

a).Physical Vapour Decomposition(PVD),
b). Chemical Vapour Decomposition,
c).Ion coaing,d).Splash Coating,
e).ElectronBeamEvaporationCoating
f).Flame Spray(FS),
g).Plasma Spray(PS),
h).Sol-gel(SG),
i).Detonation Gun(DG),
j).Reactive ion coating,
k).Hot izostatical press coating(HIP).[3]

3. WASTE PLASTIC OIL IN DIESEL ENGINE.

3.1. Paper 1[6]

In this paper Mr.Rajesh Guntur et al. investigated that the performance and emissions of a single cylinder diesel engine fueled with diesel, WPPO50,WPPO70 fuels.

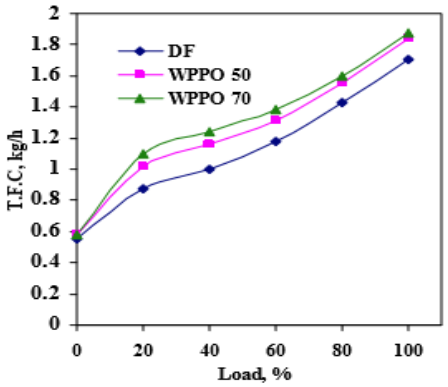

Fig 1. load vs T.F.C

As the amount waste pyrolysis plastic oil increases fuel consumption is increasing, this is due to lower net calorific value of the waste pyrolysis plastic oil.

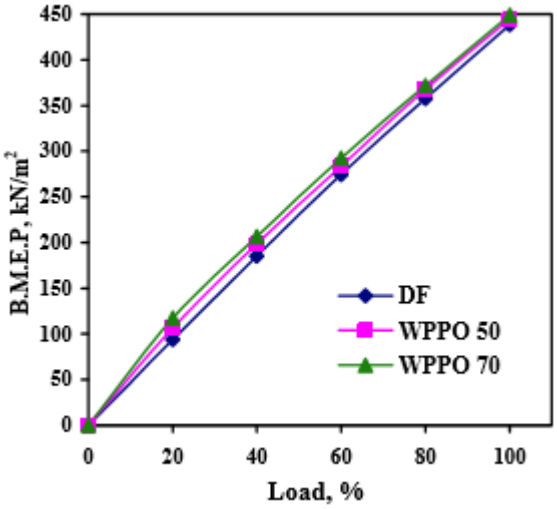

Fig2 Load vs B.M.E.P

Brake mean effective pressure of diesel is less than the other fuel blends, this is due to change in high heating value which increases heat release rate of fuel and consequently increasing BMEP

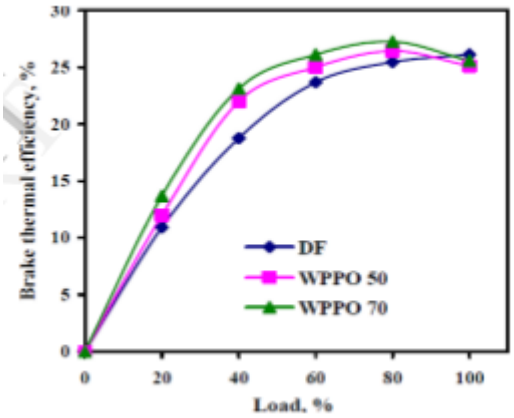

Fig 3 load vs BFC

Brake thermal efficiency of WPPO-DF blends is higher than the diesel fuel upto 80% load. Beyond efficiency of Diesel fuel is increasing.

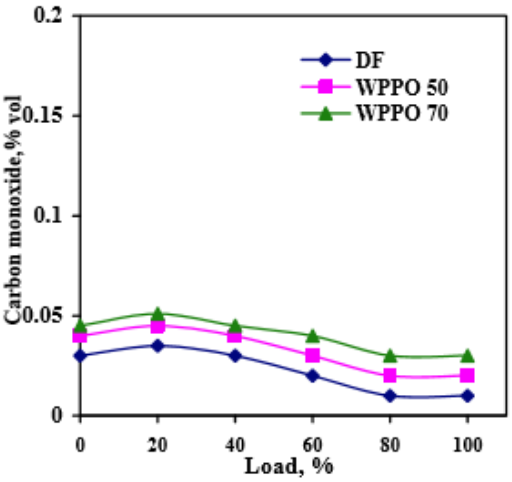

Fig 4 Load vs CO

The formation of carbon monoxide due to incomplete combustion. It depends mainly air fuel ration relative to stochiometric proportions. CO emissions are higher incase of WPPO-DF blends, this is due to reduced in-cylinder temperatures.

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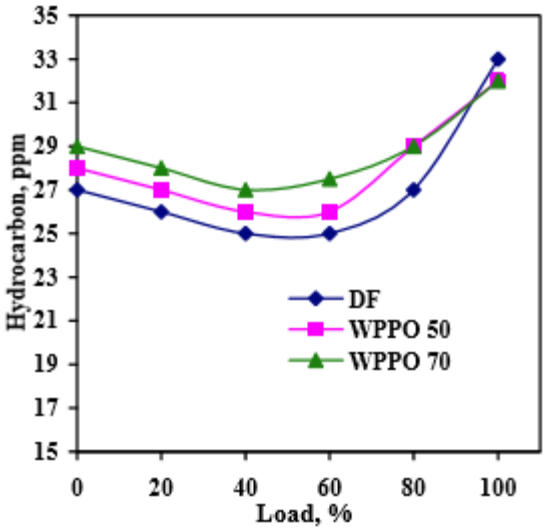

Fig5 load vs hydrocarbon

It can be noticed that the concentration of the hydrocarbon of WPPO-DF blends is marginally higher than diesel. The reason behind increased unburned hydrocarbon in waste plastic oil may be due to higher fumigation rate and non-availability of oxygen relative to diesel. At ligher loads due to charge homogeneity and higher oxygen availability, The unburned hydrocarbon level is less in case of waste plastic oil, where as at higher load ranges due to higher quantity of fuel admission, unburned hydrocarbon increases.

3.2.Paper 2[8]

In this paper M.Mani et al. Investigated the performance and emissions on single cylinder diesel engine.

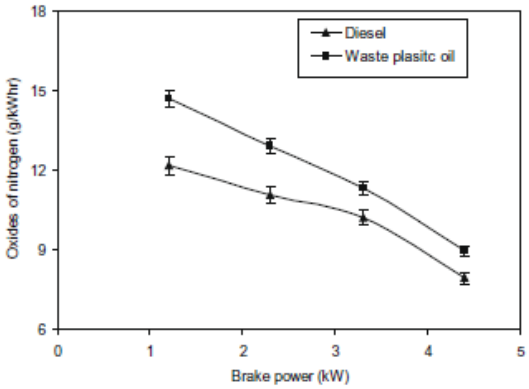

Fig.6.Brake power vs oxides of nitrogen

In the above fig. The oxides of nitrogen for waste plastic oil higher compared to diesel, the reason behind is higher heat release rate and high combustion temperature

4.THERMAL BARRIER COATED DIESEL ENGINE

4.1 Paper 3 [9]

In this paper Mohd Abdul Haleem Abir et al. Investigatedthe performance and emissions characteristics of diesel engine coated with thermal barrier coating. Fuel used in this paper is diesel, animal thallow methyl ester.

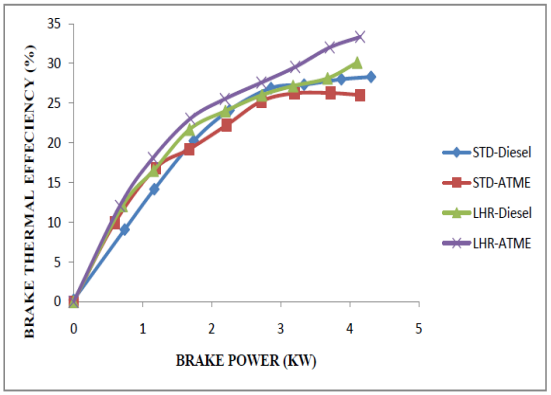

Fig.7.Brake power vs Brake thermal efficiency

In the fig 7 the brake thermal efficiency of LHR engine higher than the STD(baseline) engine.

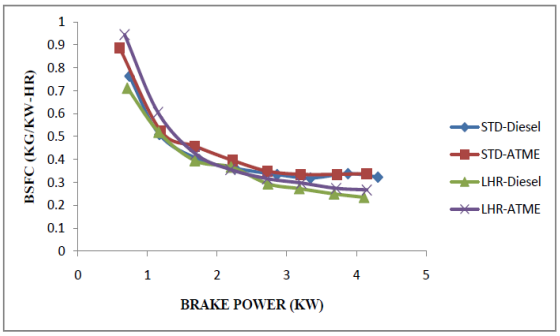

Fig.8. Brake Power vs BSFC

In the fiig 8 , It is inferred that coated engine powered with diesel has the lowest fuelconsumption. This is due to higher temperature of combustion chamber walls which atomize fuel issuing from the injector completely and reduce quenching distance yielding lower fuel consumption.

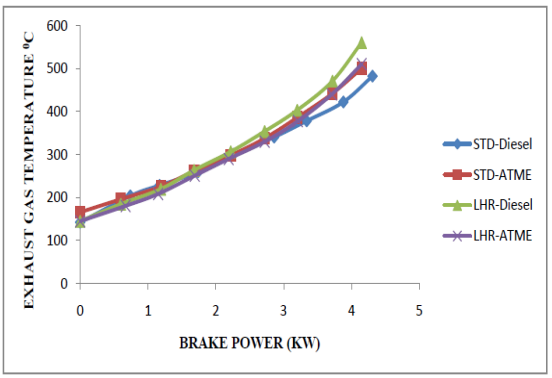

Fig.9.Brake Power vs Exhaust Gas temperature

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In the fig 9 ,the exhaust Gas temperature is increasing due to insulation of LHR engine,some heat transfer reduce from cooling is recovered as exhaust energy**.**

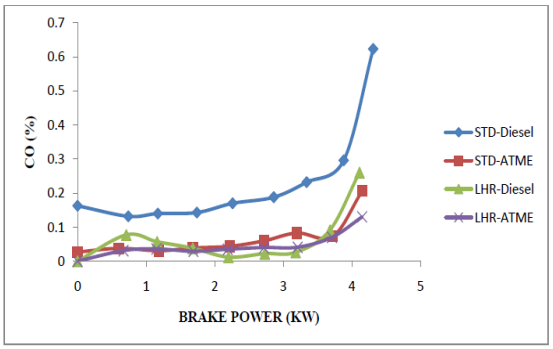

Fig.10. Brake power vs CO emissions

In the Fig 10,the CO emission of LHR engine is low compared to Baseling engine, This is due complete combustion in insulated environment of LHR engine.

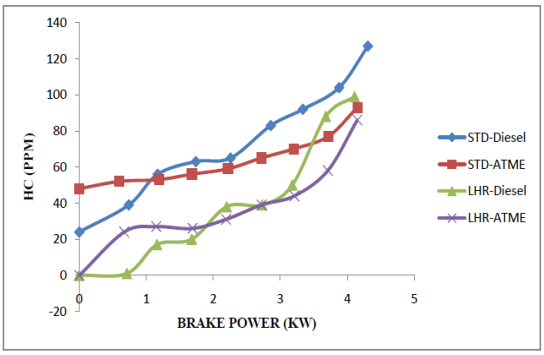

Fig.10.Brake Power vs HC emission

In the fig.10., the HC emissions are decreased for LHR engines. HC emissions are indirectly related to combustion inefficiency, in the LHR engines proper combustion will takes place**.**

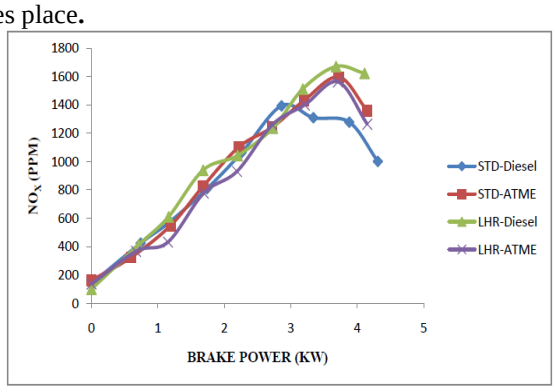

Fig 11.Brake power vs NOx emissions

In the fig.11, the NO_x emissions are higher for LHR engine compared to STD engine. The high combustion temperature and inherent availability of oxygen from fuel and intake charge creates favourable conditions to formation of nitrous oxides.

5 ENGINE WITH EGR& PLASTIC OIL

5.1 Paper 4 [10]

In this paper M.Mani et al. Investigated the performance and emissions of diesel engine with EGR fueled with plastic oil.

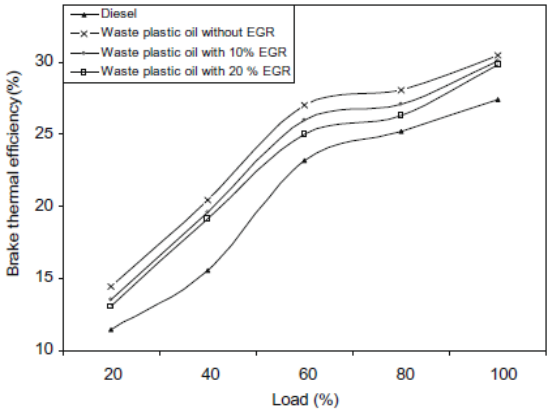

Fig .11. load vs Brake thermal efficieny

In the fig 11, it shows that brake thermal efficiency is decreased with increasing mass flowrate of EGR , this is due to as the quantity of EGR mixes with intake chrge make deficiency in oxygen concentration and also reduces the combustion temperature resulting in reduction in brake thermal efficiency.

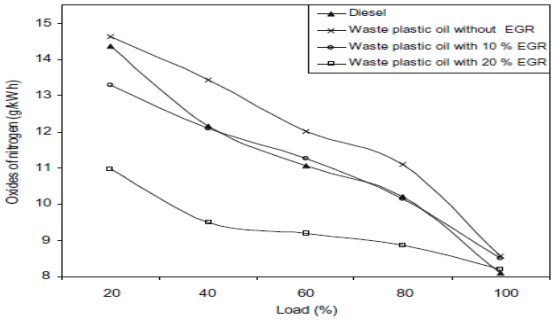

Fig.12. load vs NO_x emissions

In the fig 12 , the emission of NO_x emissions are decreased by the increasing of mass flow rate of EGR.

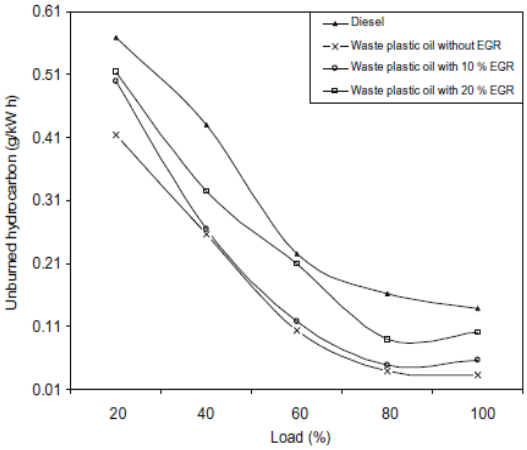

Fig 13.load vs HC emissions

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In the fig 13. The HC emissions are increases with EGR rate, The increase in unburned hydrocarbon with increase in EGR rate is due to thereduction of oxygen in the inlet charge by the EGR into the cylinder.The lack of oxygen is responsible for reduced oxidation rate,which leads to incomplete combustion, hence higher unburned hydrocarbon emissions.

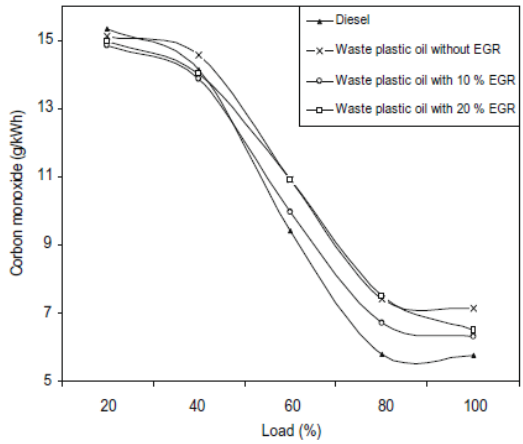

Fig 14. Load vs CO

In the fig 14, CO emissions are increasing with EGR rate, this is due to oxygen deficiency. As some amount of oxygen is replaced by exhaust gases, this leads to incomplete combustion, which results increase in CO emissions**.**

6 CONCLUSIONS

Following are the major conclusions from the above review papers.

- Engine fueled with Waste plastic pyrolysis oil results higher efficiency, higer fuel consumption and higher HC,CO, and NOx emissions.
- LHR (thermal barrier coated) engine results increase in thermal efficiency, decrease in fuel consumption and decrease in HC and CO emissions but higher NOx formation.
- Engine with EGR results mainly decrease in NOx emissions but slightly increase in HC,CO emissions and slightly decrease in efficiency.
- By combining above three methods we can use waste plastic pyrolysis oil as alternative fuel for diesel engines**.**

7. REFERENCES

[1] Nitesh Dagar[1] , Ibrahim H. Shah[2], "Experimental Investigation on Two Cylinder Diesel Engine Using Biodiesel and Diesel as Fuel with EGR Technique", International Journal of Science and Research, ISSN: 2319-7064, volume 2 Issue 7,July-2013

[2] PlasticWaste-Report-2015 by CPCB

[3] K.Thiruselvam, "Thermal Barrier Coatings in Internal Combustion Engine", Journal of Chemical and Pharmaceutical Sciences, ISSN:0974-2115, JCHPS Special Issue7:2015

[4] PoluVidya Sagar[1], Lokesh Agarwal[2], M.V.L.Sravan Kumar[3], K.Nanthagopal[4], T.Elango[5], "Effect of EGR on Emissions from a single cylinder Diesel engine using Jatropha Biodiesel Blends, IEEE publisher,ISBN-978-1-4673-6149-1, Pages-562-565

[5] Ahmad Tawfiequrrahaman Yuliansyah[1], Agus Prasetya[2], Muhammad A.A.Ramadhan[3], Rizki Laksono[4], "Pyrolysis of Plastic waste to produce pyrolytic oil as an alternative fuel",international journal of technology, chemical engineering, vol6, No7,2015

[6] Mr.Rajesh Guntur[1], Dr.M.L.S.Deva kumar[2], Dr.K.Vijayakumar Reddy[3], "Experimental Evaluation of a diesel engine with blends of diesel-plastic pyrolysis oil", international journal of Engineering science & Technology: June2011, Vol.3 Issue 6, p5033

[7] S.H.Chan[1], K.A.Khor[2], "The effect of thermal Barrier Coated piston crown on engine characteristics", Journal of Materials Engineering and Performance , February 2000, Volume 9, Issue 1, pp 103-109

[8] M.Mani[1], C.Subash[2], G.Nagarajan[3], "Performance , emission and combustion characteristics of a Diesel Engine using waste plastic oil", Applied Thermal Engineering 29(2009) 2738-2744

[9] Mohd Abdul Haleem Abir[1], Dr.A.Aruna Kumari[2], Dr.K.Vijaya Kumar Reddy[3], " Analysis of performance and emission characteristics of thermal barrier coated DI diesel engine Fueled with animal tallow methyl ester", International Journal of Innovative Research in Science, Engineering and Technology, Vol.2, Issue 12, December 2013

[10] M.Mani[1] , G.Nagaraja[2], S.Sampath[3], " An experimental investigation on a DI diesel engine using waste plastic oil with exhaust gas recirculation", Elsevier, Fuel 89(2010) 1826-1832