PERFORMANCE EVALUATION OF PYROLYTIC OIL IN CI ENGINE WITH DIESEL BLEND

[1]V.Sri kumar, [2]T.Dattatreya, [3]P.Chandra vyas, [4]Y.Leela Vinodh, [5]P.Deva Krupakar

[1]Associate Professor, [2-5]U.G Student
Department of Mechanical Engineering
KKR & KSR Institute of Technology and Sciences, Guntur, Andhra Pradesh, India.

ABSTRACT: Utilization of waste effectively and efficiently is one the major concern in today's world.We can extract oil from waste plastics through the process of pyrolysis. Pyrolysis oil is economic and efficient so that it can also be blended with diesel. Analysis is done with variable compression research engine and the result acquired are brake thermal efficiency of diesel is 25.84% and that of W30 blend mixture is 28.68%. The specific fuel consumption also got decreased with respect to diesel. The emission levels like CO, CO2, NOx, CH also low when compared with diesel.

IndexTerms– Pyrolytic Oil, VCR Engine, Brake thermal efficiency, waste plastics, specific fuel consumption, and emission levels.

1. INTRODUCTION

Utilization of wasteeffectivelyandefficientlyisone the major concernin today‟s world.Therefore, it is the duty of present generation to use fossil fuels judiciously so that something is left for the generations to comeThe depleting natural resources (like fossil fuels) add further to this concern. If we continue to use and exploit fossil fuels at the existing rate, then after another150 years or so they would be no longer available for our use. Therefore, it is the duty of present generation to use fossilfuels judiciously so that something is left for the generations tocome. A semi batch type pyrolysis reactor was used to carry out pyrolysis. The pyrolysis was carried out at 350°C. The vapors of the waste plastic and polythene generated during pyrolysis were condensed using condensing unit into oil. The pyrolytic oil obtained was filtered using multiple pass filter paper. The following test fuels were developed: blends (10%, 20% and 30% by volume) of this oil with diesel were prepared and they were compared with 100%diesel.

2. LITERATURE SURVEY:

Sumitbhat et al. [1] worked on Production of Oil from Waste Plastics and Polythene using Pyrolysis and its Utilization in Compression Ignition (C.I.) Engine. Finally The results clearly indicated that indicated thermal efficiency and Brake thermal efficiency obtained with 20% blend was more in comparison with 100% diesel. Achyut K. Panda et al. [2] worked on Thermolysis of waste plastics to liquid fuel a suitable method for plastic waste Management and manufacture of value added products. Finally they concluded that with different blends (5%, 10%, 15% and 20%) of pyrolytic oil with diesel have shown that the various performance parameters like indicated thermal efficiency, brake thermal efficiency, torque etc. are more or less at par with diesel fuel. KareddulaVijaya et al. [3] worked on Performance and Emission Studies of a SI Engine using Distilled Plastic Pyrolysis Oil-Petrol Blends. Finally From the experiments it is observed that 50% Distilled Plastic Pyrolysis Oil (50%DPPO) exhibits the substantial enhancement in brake power, brake thermal efficiency and reduction in brake specific fuel consumption running at full load conditions among different blends and pure petrol. ArchanaSaxena et al. [4] concluded that Conversion of Waste Plastic to Fuel: Pyrolysis **-** An Efficient Method. They did the experiment at highTemperature (>370◦C) in the absence of oxygen. Finally they concluded that by the process of Pyrolysis, plastics can be converted into fuel and in most scenarios three major products are obtained at the end of the process. These products are namely**-** Pyrolysis Oil, Carbon Black and a Gaseous mixture.Dr. Achyut Kumar Panda et al. [5] worked on Waste plastic to fuel a sustainable method for waste reduction and energy Generation. They had concluded that NOx, CO, HC and smoke emissions are found higher than diesel. Brake thermal efficiency **(**almost same or marginally higher than diesel up to 80% load and somewhat lower at full load**)** Exhaust gas temperature **(**Exhaust gas temperature is found marginally Higher with blend than diesel operation**)** Brake specific fuel consumption **(**Brake specific fuel consumption is marginally less than diesel.Ankit Verma1 , Aditya Raghuvansi2 , M.A Quraishi3,4 , Jeewan V. Tirkey2* , Chandrabhan Verma[6] This paper also presents the effect of waste plastic pyrolysis oil in a diesel engine at various compression ratios with different load and blending with pure diesel (pure diesel, 10%, 20%, 30%, 40%) at constant engine revolution. Aishwarya and Sidhu [6] studied the process of pyrolysis by using microwave oven. This system generates microwaves in continuous cycles. The setup is gravity feed and nitrogen is used to prevent oxygen to enter in the process. Muhammad et al. [7] studied the process of pyrolysis in preparing fuel from the plastics waste generated from electric and electronics equipment. This type of waste consist of acrylonitrile butadiene styrene, polypropylene, polystyrene, polyethylene, polycarbonate, etc. Zhang et al. [8] studied the conversion of LDPE into the jet fuel (C8-C16). The catalytic microwave degradation was carried out at 375°C with catalyst to feed mass ratio of 0.1 or 0.2 to produce different proportions of aliphatic and cyclic hydrocarbons. It is found that in catalytic microwave degradation of LDPE carbon yields were found 66.18% and 56.32% respectively. For obtaining optimal conditions for the production of fuels different parameters were changed in hydrogenation process. seo et al. [9] studied catalytic degradation of hdpe using a batch reactor at a temperature of 450°c. as shown in table 1, the pyrolysis performed with the catalyst zeolite zsm-5 had higher yield of the gaseous fraction and smaller yield of liquid fraction when compared with thermal cracking explained by the properties of the catalyst. most zeolites, including zsm-5, showed excellent catalytic efficiency in cracking, isomerization and aromatization due to its strong acidic property and its micro porous crystalline structure. the zsm-5 zeolite has a three-dimensional pore channel structure with pore size of 5.4 × 5.6 å which allows an increased cracking of larger molecules, beyond the high si /al ratio which leads to an increase in thermal stability and acidity.

3. Materials & Methods

3.1 VARIABLE COMPRESSION RESEARCH ENGINE:

Variable Compression Ratio (VCR) is a system which is used to adjust the compression ratios of the internal combustion engine. In simple terms, it changes the combustion chamber size of the cylinder according to various different operating conditions such as speed, load, acceleration and torque. Car emissions and fuel economy are two challenges for the automotive sector in which VCR engine is a very decent technology approaching low fuel consumption and pollutant emission reduction. The car manufacturers have to look forward for more thermally efficient and less polluting engine. In present world the automotive sector spends over millions of dollars for approaching low emission as well as low fuel consumption cars. Various different ways are been discovered such as hybrid cars, fuel cell cars, solar cars and many more as future development. VCR engine would practically prove to be boon for automotive sector (Evolution Perspectives).

The Fixed Compression Ratio (FCR) engine has a fixed compression ratio without any kind of change in the size of the combustion chamber in cylinder. The FCR engines have high emissions due to the fact that when it comes to high speed or load, FCR use more fuel which produces more emissions but VCR engine provides increase in the fuel efficiency under varying loads and speed. Most of the cars used recently are Spark plug (SI) or diesel Ignition engines. The different ways the SI engine can increase its efficiency is by higher compression ratio, reducing throttle losses, low friction, variable timing valve and down-sizing. The concept of VCR engine significantly contributes its benefits to thermo-dynamic efficiency. The concept of the VCR is that it continuously operates at different compression ratio as per the need of the performance. The change in the combustion chamber volume continuously takes place with the varying in the compression ratio. Compression ratio adjustment does not allow "knocking", and allows extreme torque and specific power with great driving conditions.At part loads the VCR engine functions under high compression ratio (up to 16:1 or 17:1) which provides better fuel efficiency compared to FCRengine.By retaining in best combination between Ignition advance and compression ratio, VCR engine reduces emission pollutant even under extreme superchargingpressure.VCR engine tends to keep the thermodynamic temperature of the engine low compared to FCR by working under preferable compression ratio range and avoid engine heating.

Fig : Pyrolysis Reactor Setup

4.6 ENGINE SPECIFICATIONS:

1. Made : Kirloskar
2. Bore diameter : 87.5mm
3. Stroke : 110mm
4. Rated speed : 1500 rpm
5. Compression ratio : 17.5:1
6. Fuel : diesel
7. Density of diesel : 0.827 gm/ml
8. Break drum diameter : 0.3 m
9. Rope diameter : 0.015 m
10. Calorific value of diesel : 45,350 Kj/kg

The experimental test rig consists of a variable compression ratio compression ignition engine, eddy current dynamometer as loading system, fuel supply system for both Diesel oil supply and biodiesel supply, water cooling system, lubrication system and various sensors and instruments integrated with computerized data acquisition system for online measurement of load, air and fuel flow rate, instantaneous cylinder pressure, injection pressure, position of crank angle, exhaust emissions and smoke opacity. There is the photographic image of the experimental setup used in the laboratory to conduct the present study and it represents the schematic representation of the experimental test setup. Table 4.6 gives the technical specifications of different components used in the test rig. The setup enables the evaluation of thermal performance and emission constituents of the VCR engine. The thermal performance parameters include brake power, brake mean effective pressure, brake thermal efficiency, volumetric efficiency, brake specific fuel consumption, exhaust gas temperature, heat equivalent of brake power and heat equivalent of exhaust gas. Commercially available lab view based Engine Performance Analysis software package ―Engine soft LV‖ is used for on line performance evaluation. The exhaust emissions of the engine are analyzed using an exhaust gas analyser. The constituents of the exhaust gas measured are CO (% and ppm), CO_2(%), O_2 (%), HC (ppm), NO_x(ppm)

Fig no 4.6(a) Experimental setup

5. EXPERIMENTAL OBSERVATIONS:

- **CALORIFIC VALUE OFFUEL:**

When fuels are burnt, heat is produced. The amount of heat produced by different types of fuels on burning is expressed in terms of calorific value. Calorific value of a fuel may be defined as the amount of heat produced on complete burning of 1 gm. of fuel. S.I. unit of calorific value of fuels is kilojoule per gram(KJ/g).

There are two types of calorific values

i. Higher Calorific Value(HCV):

When 1 kg of a fuel is burnt, the heat obtained by the complete combustion after the products of the combustion are cooled down to room temperature (usually 15degree Celsius) is called higher calorific value of thatfuel.

ii. Lower Calorific Value(LCV):

When 1 kg of a fuel is completely burned and the products of combustions are not cooled down or the heat carried away the products of combustion is not recovered and the steam produced in this process is not condensed then the heat obtained is known as the Lower Calorific Value.

- **VISCOSITY:**

Viscosity is a measure of a liquid's resistance to flow. High viscosity means the fuel is thick and does not flow easily. The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of "thickness": for example, syrup has a higher viscosity thanwater.

- **FLASH POINT AND FIREPOINT:**

The flash point of a volatile material is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Measuring a flash point requires an ignition source. At the flash point, the vapor may cease to burn when the source of ignition isremoved.

The fire point is the temperature at which the vapor continues to burn after being ignited. Diesel fuel flash points vary between 52 and 96 °C (126 and 205 °F). The fire point of a fuel is the lowest temperature at which the vapour of that fuel will continue to burn for at least 5 seconds after ignition by an open flame. At the flash point, a lower temperature, a substance will ignite briefly, but vapor might not be produced at a rate to sustain thefire.

- **POUR POINT AND CLOUDPOINT:**

The pour point of a liquid is the temperature below which the liquid loses its flow characteristics. In crude oil a high pour point is generally associated with a high paraffin content, typically found in crude deriving from a larger proportion of plantmaterial.

The cloud point refers to the temperature below which wax in diesel or biowax in biodiesels forms a cloudy appearance.

S.No	Properties	WPO	Diesel
1	Colour	Pale Black	Orange
2.	Specific gravity	0.8355	0.84-0.88
3.	Gross Calorific value(kJ/kg)	44.340	46.500
4.	Flash Point °C	44	60
5.	Fire point °C	51	60
6.	Pour point °C	<7	6

7.	Kinematic viscosity cSt @40 c	2.52	2.0
8.	Density(kg/m3)	981.3	839.8

- **EXPERIMENTAL OBSERVATIONS FOR DIESEL:**

Experiments were conducted on the specified diesel engine using diesel and note down the observations at zero load, speed and time taken for 10cc of fuel consumption were tabulated in form of tables. By varying loads steps 0, 4, 8, 12 were noted down.

S.no	Load (Kg)	SFC (kg/kWh)	BP (kW)	FP (kW)	IP (kW)	BTHE (%)	ITHE(%)
1	0	4.36	0.09	1.92	2.01	1.92	42.31
2	4	0.49	1.21	1.89	3.10	16.97	43.41
3	8	0.36	2.36	1.62	3.98	23.32	39.39
4	12	0.32	3.38	1.47	4.85	25.84	37.06

- **EXPERIMENTAL OBSERVATIONS FORW10:**

Experiments were conducted on the specified diesel engine using W10 and note down the observations at zero load, speed and time taken for 10cc of fuel consumption were tabulated in form of tables. By varying loads steps 0, 4, 8, 12 were noted down.

S.no	Load (Kg	SFC (kg/kWh)	BP (kW)	FP (kW)	IP (kW)	BTHE (%	ITHE(%)
1	0	3.35	0.12	1.29	1.41	2.55	30.37
2	4	0.50	1.18	1.36	2.54	16.98	36.43
3	8	0.34	2.34	1.05	3.39	25.21	36.47
4	12	0.32	3.46	0.69	4.16	27.11	32.51

- **EXPERIMENTAL OBSERVATIONS FORW20:**

Experiments were conducted on the specified diesel engine using W20 and note down the observations at zero load, speed and time taken for 10cc of fuel consumption were tabulated in form of tables. By varying loads steps 0, 4, 8, 12 were noted down.

S.no	Load (Kg)	SFC (kg/kWh)	BP (kW)	FP (kW)	IP (kW)	BTHE (%	ITHE(%)
1	0	5.83	0.06	1.53	1.59	1.49	39.76
2	4	0.42	1.17	1.39	2.56	20.49	44.71
3	8	0.35	2.30	1.15	3.45	25.06	37.60
4	12	0.30	3.43	0.92	4.35	28.48	36.16

- **EXPERIMENTAL OBSERVATIONS FORW30**

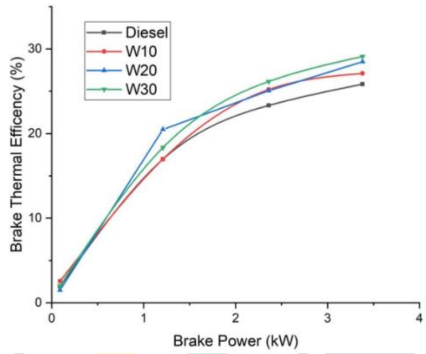
Experiments were conducted on the specified diesel engine using W30 and note down the observations at zero load, speed and time taken for 10cc of fuel consumption were tabulated in form of tables. By varying loads steps 0, 4, 8, 12 were noted down.

S.no	Load (Kg)	SFC (kg/kWh)	BP (kW)	FP (kW)	IP (kW)	BTHE (%	ITHE(%)
1	0	4.44	0.09	1.71	1.80	1.98	39.84
2	4	0.49	1.12	1.53	2.65	18.08	42.75
3	8	0.45	2.25	1.20	3.50	25.4	39.81
4	12	0.31	3.40	1.02	4.42	28.68	37.29

6.RESULTS AND ANALYSIS:

6.1 BRAKE THERMAL EFFICIENCY

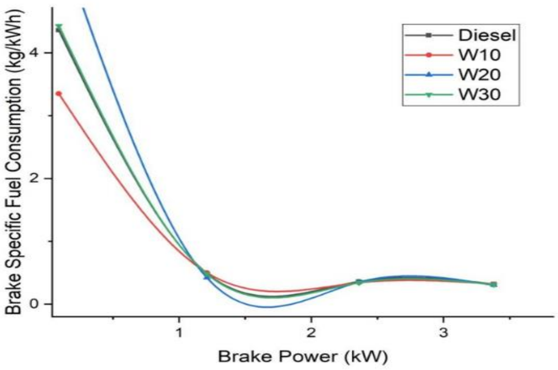
It can be defined as the ratio of brake power to the mass flow rate and calorific value of the fuel. It is one of the important performance parameter which indicates the percentage of energy present in the fuel that is converted into useful work. The variation of brake thermal efficiency at full load for diesel and WPO blends is shown in Figure 4.10.We can observe from the results that there is a marginal increase in brake thermal efficiency for all the blends. At higher loads, it was found that increasing with increase with blended ratio.



The brake thermal efficiency of WPO30 is 28.68% and of diesel is 25.84% so it is greater by 2.84%.Waste pyrolytic oil of blend 30% by volume has shown a greater efficiency than diesel at those particularloads.

6.2 SPECIFIC FUEL CONSUMPTION

Figure 5.1.3 shows that the variation of brake specific fuel consumption with load for the tested fuels. At higher speeds of the engine, the differences between BSFC values of fuel blends become smaller, due to the short combustion period in spite of the increased fuel amount. By excess oxygen and fast burning ethanol molecules, combustion temperature

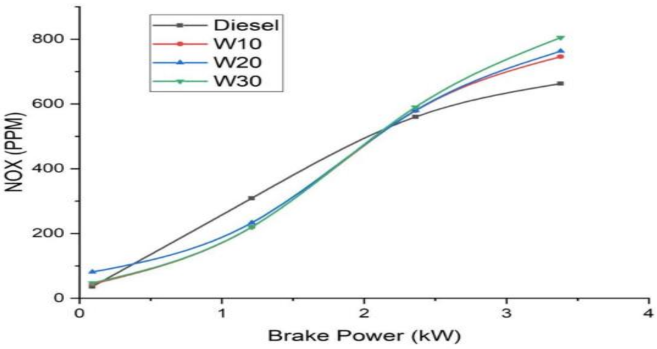


increases.

It can be observed that the specific fuel consumption of different blends is found to be slightly higher than the diesel at full load. It is also observed that specific fuel consumption of W10 blend is very close to specific fuel consumption of diesel at all loads. For blends W20, W30 the specific fuel consumption is found to be higher than the diesel because of poor combustion as load increases due to impurities and sulphur content

6.3 OXIDES OF NITROGEN

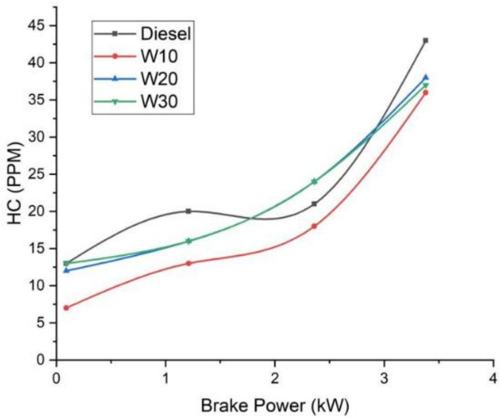
Nitric oxide (NO) and nitrogen dioxide (NO_2) are usually grouped together as NO_x emissions and nitric oxide is predominant in the oxides of nitrogen produced inside the engine cylinder



It can be observed that the NO_x emission for WPO operation is increasing with increase in load range compared to diesel operation, recording W30 produces higher NO_x emissions. At higher loads, the temperature inside the cylinder is high but the availability of oxygen forthe formation of $NO_x$is reduced as more oxygen is consumed for combustion of fuel. In Diesel engines more fuel is injected at higherloads.

6.4 HYDRO CARBONS(HC):

Hydrocarbon emissions are formed mainly due to the presence of gaseous hydrocarbons in the relatively stagnant low temperature boundary layer along the cylinder wall and in crevices. Hydrocarbons remain unburned in these areas because the flame does not wholly propagate into these areas. The term hydrocarbon means organic compounds in the gaseous state and solid hydrocarbons are the particulate matter.



The variation of hydrocarbon with load for tested fuels is seen in the figure. From the results, it can be observed that the concentration of hydrocarbon of WPO–diesel is marginally higher than diesel at moderate loads. It is observed that W10 has lowest HC when compared all other samples. At lower loads due to lean mixture, the difference in hydrocarbon between blends and diesel is low while at higher loads due to higher quantity of fuel admission leads to more hydro carbon Levels

6.5 CARBONMONOXIDE(CO)

Carbon monoxide emission is mainly due to the lack of oxygen, poor air entrainment, mixture preparation and incomplete combustion during the combustion process. Generally, CI engine operates with lean mixtures and hence the CO emission will be low. CO emission is toxic and must be controlled. It is an intermediate product in the combustion of a hydrocarbon fuel and its emission results from incomplete combustion. Emission of CO is therefore greatly dependent on the equivalence ratio. Rich mixture results in higher CO

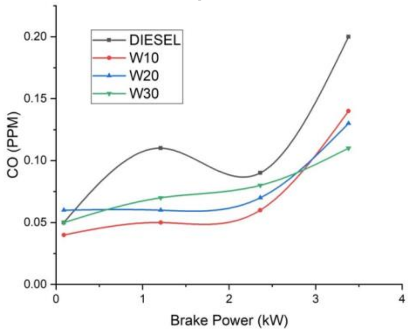
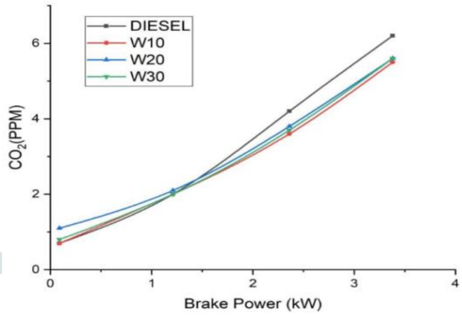


Figure shows the variation of carbon monoxide with load. The results show that CO emission of WPO-diesel blends is lower than diesel. With increase in load, the CO emission gradually reduces for WPO-diesel blends and the difference in values for CO emission from low load to full load reduces significantly. It is found that with increase in load the exhaust gas temperature increase considerably. This means that the in-cylinder temperature will be higher which results in better combustion and lower CO emission

6.6 CARBON DIOXIDE

Figure shows the variation of carbon dioxide emission with load for diesel and WPO- diesel blends operation. From the results, it can be observed that the amount of CO_2 produced while using WPO–diesel blends is lower than diesel at all loads. At lower loads, the longer ignition delay in the case of WPO-diesel blends leads to late burning of fuel and this results in higher CO_2. However, near full load, the difference in $CO_2$is found to be lesser in all the fuels.



7. CONCLUSION:

By this paper we gain some effective parameters those are

- The obtained calorific value of pyrolysis oil is 44340J/kg, flash point is 44°c, fire point is 51°c, density is 981.3kg/m3, kinematic viscosity is 2.53 m2/sec, pour point is4°c.

- The brake thermal efficiency of WPO30 is 28.68% and of diesel is 25.84% so it is greater by 2.84%.Waste pyrolytic oil of blend 30% by volume has shown a greater efficiency than diesel at those particular loads. Pyrolytic oil blending mixture can be further extended to certainlevel
- It is observed that the specific fuel consumption of different blends is found to be slightly higher than the diesel at full load. Specific fuel consumption of W10 blend is very close to specific fuel consumption of diesel at all loads. For blends W20, W30 the specific fuel consumption is found to be higher than thediesel.
- It is observed that W10 has lowest HC when compared all other samples. At lower loads due to lean mixture, the difference in hydrocarbon between blends and diesel is low while at higher loads due to higher quantity of fuel admission leads to more hydro carbonLevels
- With increase in load, the CO emission gradually reduces for WPO-diesel blends and the difference in values for CO emission from low load to full load reduces significantly.
- From the results, it is observed that the amount of CO_2 produced while using WPO–diesel blends is lower than diesel at all loads. However, near full load, the difference in CO_2 is found to be lesser in all thefuels.
- It can be observed that the NO_x emission for WPO operation is increasing with increase in load range compared to diesel operation, recording W30 produces higher NO_xemissions

8. REFERENCES:

[1]. Production of Oil from Waste Plastics and Polythene using Pyrolysis and its Utilization in Compression Ignition (C.I.) Engine by sumitbhat and rohitsinghlather, indian journal of science and technology, vol 9(48), Issue: December 2016
[2]. Thermolysis of waste plastics to liquid fuel a suitable method for plastic waste Management and manufacture of value added products - A world prospective by Achyut K. Panda, R.K. Singh, D.K.Mishra, Elsevier, vol (233-248), Issue: july 2009
[3]. Performance and Emission Studies of a SI Engine using Distilled Plastic Pyrolysis Oil- Petrol Blends by KareddulaVijaya Kumar, Ravi Kumar Puli, A. SwarnaKumari, P.Shailesh, MATEC web conference, vol 45, Issue: September 2016
[4]. Conversion of Waste Plastic to Fuel: Pyrolysis - An Efficient Method: A Review by Archana Saxena1, Hitesh Sharma, GirishRathi, Research Gate, Vol 31334950, Issue:Feb 2017
[5]. Waste plastic to fuel a sustainable method for waste reduction and energy Generation by Dr.Achyut KumarPanda, Sage journals, vol 674/KOL/2011, Issue june 24
[6]. Engine Fuel Production from Waste plastic Pyrolysis (WPO) and Performance Evaluation in a CI engine with Diesel Blend
[7]. J. Mater. Environ. Sci., 2018, Volume 9, Issue 6, Page 1712-1721