ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

PERFOMANCE AND EMISSION TEST ON WASTE PLASTIC OIL BLENDED WITH DIESEL AS AN ALTERNATIVE FUEL

Gunasekaran.J, Mr.Prof.P.Prabakaran
Department of Mechanical Engineering, M.E Thermal Engineering
J.J College of Engineering and Technology, Trichy, India

Abstract—Nowadays the shortage of fossil fuels,.Evolutions of vehicles lead to the increase in the usage of fuels. Therefore demand and price of fuel is increasing day by day. This led to find an alternative fuels for internal combustion engines. If this alternative fuel is extracted from waste means its cost will be less and operative. Plastic is the major waste all over the world. It creates very serious environmental challenge because of their huge quantities and their disposals. In this study, these plastic wastes were subjected to pyrolysis process mainly consists of three units such as reactor, condenser and receiver. In this process plastic wastes were melted and cracked without oxygen at very high temperature range of 500 – 530^{0}C with 10% wt. of Aluminium oxide (Al2O3) neutral catalyst. The resulting waste plastic oil is received and this waste plastic oil is blended with diesel.

Performance and emission tests were carried out for 25%, 50%, 75%, and 100% waste plastic oil (WPO) diesel blends. Results indicated that the brake thermal efficiency, indicated thermal efficiency and specific fuel consumption is increase with the use of waste plastic oil diesel blends as compared to diesel alone.

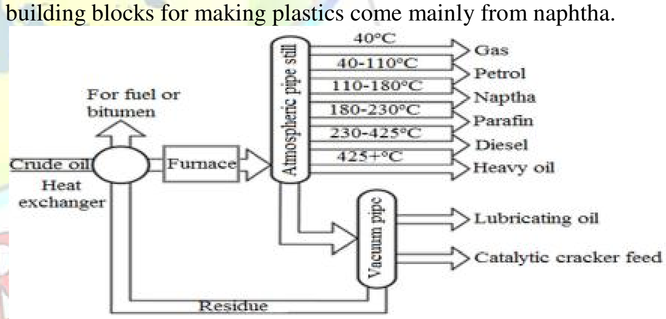
Key words: pyrolysis, catalyst, waste plastic oil, performance, emission

I. INTRODUCTION

Now a day, usage of fuel is increasing along with evolution of vehicles. Therefore the fuel demand and price is increasing rapidly. To overcome this issue alternate energy source is required. This alternate should be accessible and reasonable. If this alternate is extracted from waste means its cost will be less and operative.Plastics have been one of the materials with the fastest growth in this world because of their huge applications due to flexibility and relatively low cost. As a result of increase in the consumption of plastics, large amount of plastic wastes are generated from their production and transportation. The need for manage this waste from plastic becomes more important.This leads to pyrolysis, which is a way of making these wastes to become very useful to us by recycling them to produce fuel oil.

1. PLASTIC OIL PRODUCTION

Producing Most modern plastics are derived from natural materials such as oil, coal and natural gas with crude oil remaining are the most important raw material for their production. The starting point for the production process is the distillation, in petrochemical refineries, of the raw material into fractions. The heavy fractions give us lubrication oils and the heavy oils used for heating fuels. The lighter fractions give us gas, petrol, paraffin and naphtha. The chemical building blocks for making plastics come mainly from naphtha.



1.1 Naphtha cracking

The naphtha received from distillation is subjected to a cracking process in which complex organic chemical compounds are separated into smaller molecules, dependent on their molecular weight. These smaller molecules include monomers like ethylene, propylene, butane and other hydrocarbons.

1.2 Polymerization

Polymerization is the process by which individual units of similar or different molecules combine together by chemical reactions to form large or macromolecules in the form of long chain structures, having altogether different properties than those of starting molecules. Several hundreds and even thousands of monomers are combining together to form the macromolecules, polymers.

1.3 plastic recycling methods

1. Mechanical recycling
2. Thermal recycling
3. Chemical recycling

1.3.1 Mechanical recycling

Mechanical recycling is reprocessing of the used plastics to form new similar products. This is a type of primary and secondary recycling of plastic where the homogeneous waste plastics are converted into products with nearly same or less performance level than the original product. Mechanical recycling of household waste plastics is

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

particularly difficult when they are contaminated with biological residues or as is usually the case when they are a mixture of different kinds of plastics.

1.3.2 Thermal recycling

It is also known as incineration. Energy generation by incineration of plastic waste is in principle a viable use for recovered waste polymers since hydrocarbon polymers replace fossil fuels and thus reduce the CO2 burden on the environment. Incineration is the preferred energy recovery option of local authorities because there is financial gain by selling waste plastic as fuel. Co-Incineration of plastic wastes with other municipal solid wastes may be increasingly practiced, because the high calorific value of plastic can enhance the heating value of MSW and facilitate an efficient incineration, while their energy content can also be recovered.

1.3.3 Chemical recycling

Chemical recycling is also known as feedstock recycling or tertiary recycling. This process converts polymers into original monomers or other valuable chemicals. These products are useful for a variety of downstream industrial processes or as transportation fuels. There are three main approaches depolymerisation, partial oxidation and pyrolysis.Condensation polymers which include materials such as polyamides, polyesters, nylons and polyethylene terephthalate can be depolymerised via reversible synthesis reactions to initial diacids and dicols or diamines.The direct combustion of polymer waste, which has a good calorific value, may be detrimental to the environment because of the production of noxious substances such as light hydrocarbons, NO_x, sulphur oxides and dioxins. Partial oxidation could generate a mixture of hydrocarbon and synthesis gas, the quantity and quality being dependent on the type of polymer used.

PARAMETERS	VALUE
Density	1.2g/cm^3
Viscometer number	380ml/g
Melt flow rate	0.23g/10min
Specific gravity	0.95
Melting point	120^{o}C
Yield stress	26N/mm^2
Flexural stress	20N/mm^2
Stiffness in torsion	180N/mm^2
Hardness	41N/mm^2

2.Polyethylene Terephthalate:

Algae were ground with motor and pestle as much as possible. The In this present work Polyethylene Terephthalate (PET) plastic is used to obtain fuel range hydrocarbon by pyrolysis. Polyethylene Terephthalate (PET)) waste plastics have been considered for the experiments. Polyethylene Terephthalate (PET) is a thermoplastic material which is made from petroleum. This thermoplastic is available in a range of flexibilities depending on the production process.

2.1Catalyst: Aluminium oxide or alumina oxide neutral has been used as a catalyst this process to enhance the reaction.Aluminium oxide is a chemical compound of aluminium and oxygen with the chemical formula Al_2O_3.It is significant in its use to produce aluminium metal, as an abrasive owing to its hardness, and as a refractory material owing to its high melting point.Alumina has been used as a catalyst in a wide variety of industrial processes for many years. Even modest improvements in alumina catalysts can have a significant impact on efficiencies of production of a very wide variety of chemical compounds. There is continuing commercial need for new tailored alumina catalyst that can more efficient produce existing chemical compounds, or that lend themselves to the production of new compounds.

2.2Properties of aluminium oxide: Catalysts have some physical and thermal properties, which need to be considered when processing any Product. The following table contains the physical properties of aluminium oxide or alumina.

PROPERTY	VALUE
Atomic composition	>99%
Crystalline structure	Corundum
Grain size	1-5 microns
Density	3.95 g/cm^3
Water absorption	0%
Dilation co-efficient	8.4x10^{-6} /^{o}C
Specific heat	930 J/kg.k
Thermal conductivity	40 W/m.K
Thermal shock resistance	200^{o}C

3.1Experimentation setup:

The pyrolysis setup used in this experiment consists of the reactor, condenser, thermocouple and submersible pump. Reactor made of stainless steel tube (length- 320 mm, internal diameter- 150 mm and outer diameter- 158 mm) sealed at one end and an outlet tube at other end for obtaining the volatile gas products of the reaction.The SS tube is externally wounded by an electric coil for heating purpose. The coil is made up of ceramic material. The reactor is insulated by glass wool and sheet metal to avoid heat loss. Chromel - Alumel (K type) thermocouple is connected to the inner wall of the reactor to measure temperature. Liebig condenser is connected to the outlet tube. It is made up of borosilicate glass tube (Length -150cm, outer diameter -5cm, inner diameter -1.4cm). Submersible pump of 1650WP is connected to the condenser to circulate the water through the outer tube.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

3.2Experimental procedure:

Initially the plastic wastes are sliced manually. Then these sliced plastic wastes were washed and dried to remove dusts. 750g of dried plastic wastes (polyethylene Terephthalate) were fed into reactor with 75g (10% wt. of plastic) of Aluminium oxide (Al_2O_3) catalyst. Water is circulated through the condenser by using submersible pump.The coil is switched ON. The temperature is increased gradually inside the reactor. After 2hrs temperature is reached 500°C. Reactions were maintained in the temperature range of 500-530 °C. At this temperature range hot gas comes out from reactor and this hot gas is condensed by condenser. The waste plastic oil (WPO) is collected from condenser.

4 PERFORMANCES AND EMISSION TEST

Engine performance is an indication of the degree of success with which it does its assigned job *i.e.,* conversion of chemical energy contained in the fuel into useful work.In evaluation of engine performance certain basic parameters are chosen and effect of various operating conditions and modifications on these parameters are studied.

Specification of IC research engine:

S.No.	Parameters	Specifications
1	Engine type	Water cooled 4 stroke single cylinder diesel engine
2	Power	5.2 kW
3	Rated speed	1500 rpm
4	Cylinder bore	87.5 mm
5	Stroke length	110 mm
6	Compression ratio	17.5

Test rig diagram:

4.1Data collection

There are five test fuels were used during performance test includes 100 % diesel, 25%, 50%, 75% & 100% microalgae azolla blend with diesel. The following tables shows the obtained data's from performance tests for various diesel blends such as Brake power, Indicated power, brake mean effective pressure, indicated mean effective pressure, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, volumetric efficiency, specific fuel consumption, air flow, fuel flow and air fuel ratio.

4.2Types of Emission

1. Carbon monoxide (CO)
2. Hydrocarbons (HC)
3. Nitrogen oxide (NO_X)
4. Carbon dioxide (CO_2)
5. Oxygen (O_2)
6. Other gases (X)

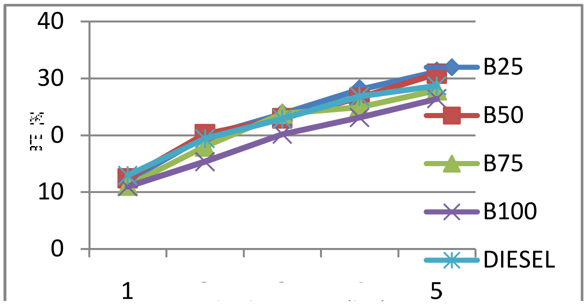
5.RESULT AND DICUSSION

The performance and emission was compared with pure diesel from the obtained performance and emission graphs. The basic performance and emission parameters were presented against brake power for all plastic oil diesel blends.

Brake thermal efficiency:

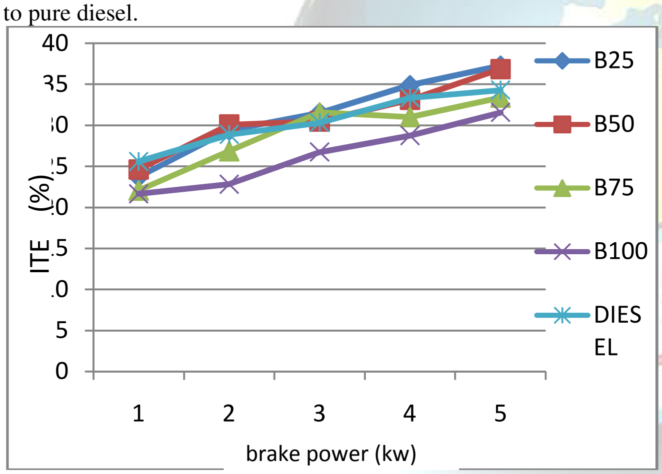
The variation of brake thermal efficiency with brake power is shown in Figure7.1. It can be observed from the figure that the thermal efficiency is 28.67% at 5.19kw brake power for diesel. However when the engine is fuelled with WPO-diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the thermal efficiency of 31.16%, 30.82%, 27.90%, and 26.40% respectively at 5.19kw brake power. It is also observed that brake thermal efficiency is higher for 25% and 50% WPO Diesel blends and it is slightly lower for 75 % and 100% WPO Diesel blend when compared to pure diesel.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016



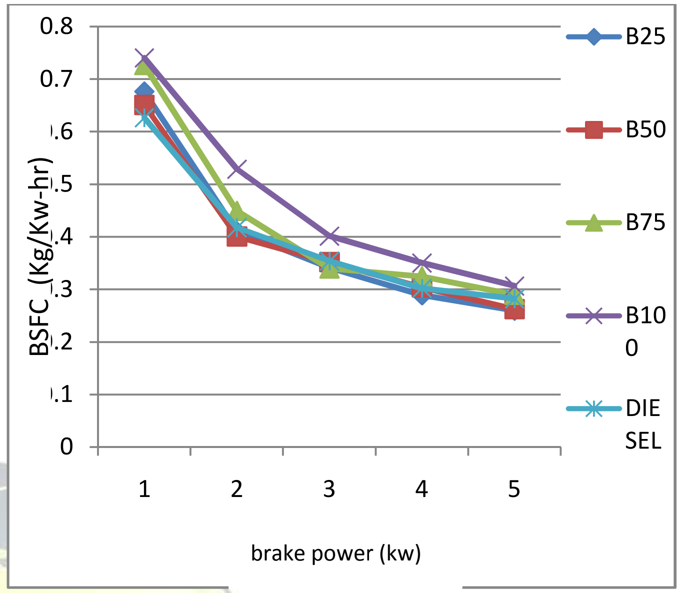
Indicated thermal efficiency

The variation of indicated thermal efficiency with load is shown in Figure 7.2. It can be observed from the figure that the indicated thermal efficiency is 34.30 % at 5.19kw brake power for diesel. When the engine is fueled with WPO diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the thermal efficiency of 37.27%, 36.86%, 33.37% and 31.57 % respectively at 5.19kw brake power. It is also observed that indicated thermal efficiency is also higher for 25% and 50% blends and it is slightly lower for 75% and 100% WPO Diesel blend when compared to pure diesel.



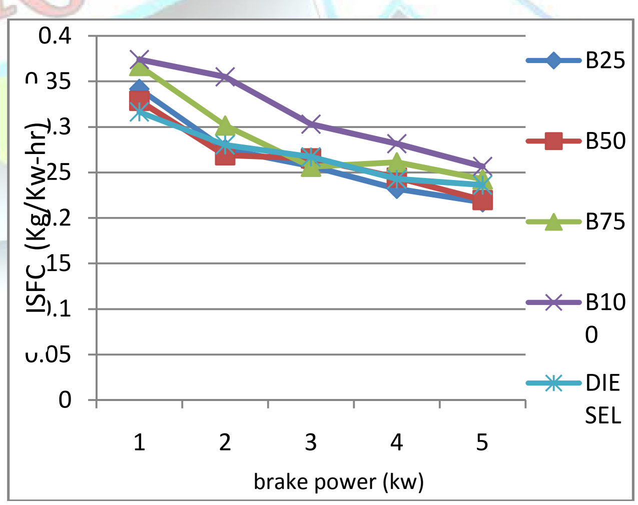
Brake specific fuel consumption:

The variation of brake specific fuel consumption with load is shown in Figure It can be observed from the figure that the brake specific fuel consumption is 0.282 kg/kWh at 5.19kw brake power for diesel. When the engine is fueled with WPO diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, its brake specific fuel consumption is 0.2597 kg/kWh, 0.2626 kg/kWh, 0.29 kg/kWh and 0.3066 kg/kWh respectively at 5.19kw break power. It is also noted that the brake specific fuel consumption is decreased for 25 % and 50% WPO Diesel blends and it is slightly increase for 75% and 100% WPO Diesel blend when compared to pure diesel.



Indicated specific fuel consumption

The variation of indicated specific fuel consumption with load is shown in FigureIt can be observed from the figure that the indicated specific fuel consumption is 0.236 kg/kWh at 5.19kw brake power for diesel. When the engine is fueled with WPO diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, its indicated specific fuel consumption is 0.2171 kg/kWh, 0.2195 kg/kWh, 0.2485 kg/kWh and 0.2563 kg/kWh respectively at 5.19kw break power. It is also noted that the indicated specific fuel consumption is decreased for 25 % and 50% WPO Diesel blends and it is slightly increase for 75% and 100% WPO Diesel blend when compared to pure diesel.

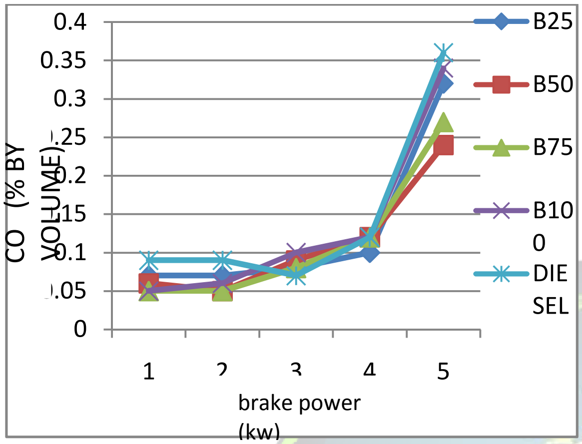


carbon monoxide (CO)

The variation of carbon monoxide (CO) with brake power is shown in Figure. It can be observed from the figure that carbon monoxide (CO) is 0.36% at 5.19kw brake power for diesel. However

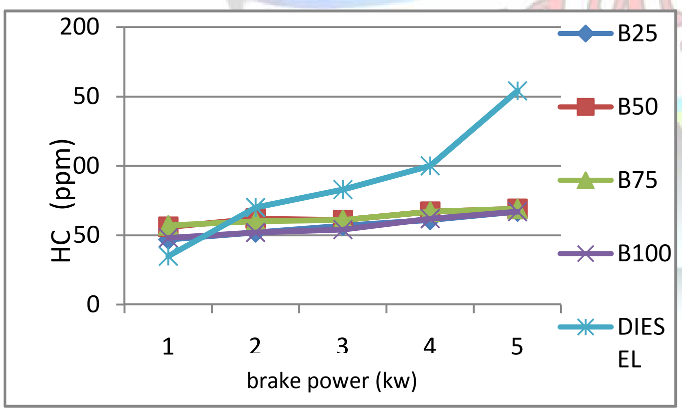
ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

when the engine is fuelled with WPO-diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the carbon monoxide (CO) of 0.32%, 0.24%, 0.27%, and 0.34% respectively at 5.19kw brake power. It is also observed that carbon monoxide (CO) is lower for 25% , 50%, 75% and 100% WPO Diesel blends when compared to pure diesel.



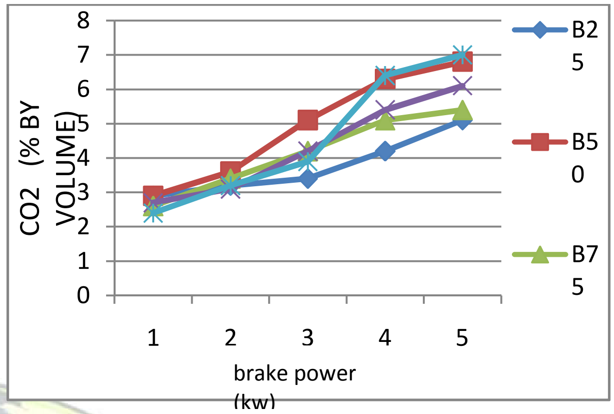
Hydrocarbons (HC)

The variation of hydrocarbons (HC) with brake power is shown in Figure. It can be observed from the figure that a hydrocarbon (HC) is 154ppm at 5.19kw brake power for diesel. However when the engine is fuelled with WPO-diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the hydrocarbons (HC) of 67ppm 69ppm, 69ppm , and 67ppm respectively at 5.19kw brake power. It is also observed that hydrocarbons (HC) is lower for 25% , 50%, 75% and 100% WPO Diesel blends when compared to pure diesel.



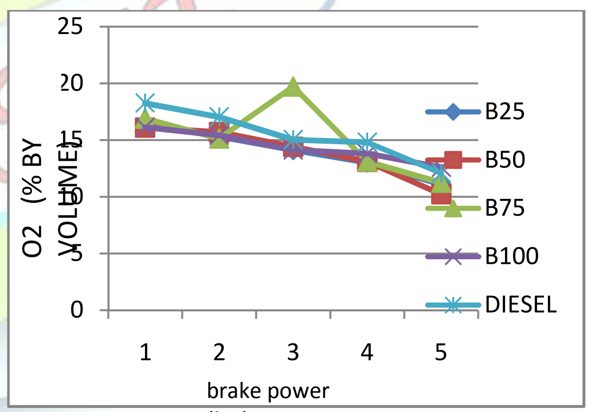
Carbon dioxide (CO_2)

The variation of Carbon dioxide (CO_2)with brake power is shown in Figure. It can be observed from the figure that Carbon dioxide (CO_2)is 7% at 5.19kw brake power for diesel. However when the engine is fuelled with WPO-diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the Carbon dioxide (CO_2)of 5.1%, 6.8%, 5.4% and 6.1% respectively at 5.19kw brake power. It is also observed that Carbon dioxide (CO_2) is lower for 25% , 50%, 75% and 100% WPO Diesel blends when compared to pure diesel.



Oxygen (O_2)

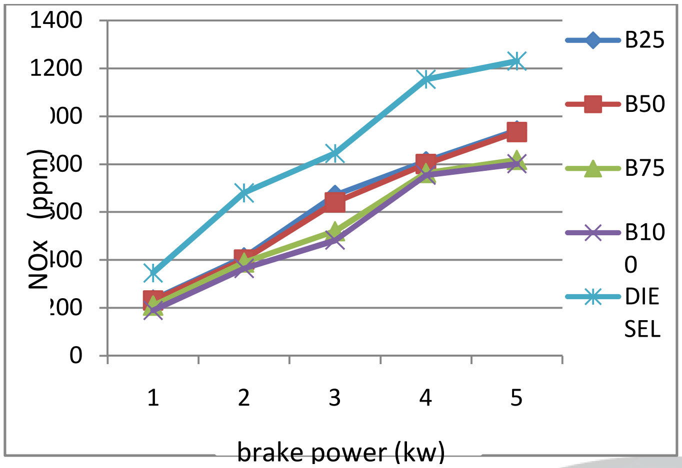
The variation of Oxygen (O_2)with brake power is shown in Figure. It can be observed from the figure that Oxygen (O_2)is 12.1% at 5.19kw brake power for diesel. However when the engine is fuelled with WPO-diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the Oxygen (O_2)of 11.1%, 10.24%, 11.24%, and 12.6 % respectively at 5.19kw brake power. It is also observed that Oxygen (O_2)is lower for 25%, 50% and 75% WPO Diesel blends and it is slightly higher for 100% WPO Diesel blend when compared to pure diesel.



Nitrogen oxide (NO_X)

The variation of Nitrogen oxide (NO_X)with brake power is shown in Figure7. It can be observed from the figure that Nitrogen oxide (NO_X)is 1230ppm at 5.19kw brake power for diesel. However when the engine is fuelled with WPO-diesel blends such as 25% WPO, 50% WPO, 75% WPO, and 100% WPO, it gives the Nitrogen oxide (NO_X)of 940ppm, 934ppm,818ppm and 801ppm respectively at 5.19kw brake power. It is also observed that Nitrogen oxide (NO_X) is lower for 25% , 50%, 75% and 100% WPO Diesel blends when compared to pure diesel.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016



CONCLUSION

In our work the pyrolysis of the high density polyethylene was investigated in batch reactor in the temperature range 500-530°C. To ensure the cracking reaction Aluminium oxide (Al_2O_3 –neutral) catalyst was used. The received oil is blend with diesel in different proportions 25 %, 50 %, 75% and 100%. The blends are subjected to performance and emission tests. From the test conducted with waste plastic oil blend with diesel and pure diesel on a diesel test rig engine, the conclusions are arrived:

- Engine was able to run with 50% waste plastic oil-diesel blend
- Engine fuelled with 50 % waste plastic oil-diesel blend exhibits higher brake thermal efficiency (30.815%) when compared to pure diesel (28.673%).
- Engine fuelled with 50 % waste plastic oil-diesel blend exhibits higher indicatedthermal efficiency (36.85%) when compared to pure diesel (34.30%).
- Brake specific fuel consumption 75% and 100% waste plastic oil-diesel blend exhibits higher indicated thermal efficiency (0.3066kg/ kw-hr) when compared to pure diesel (0.2822 kg/ kw-hr)
- Emission level is less compare to pure diesel. So, it's more suitable for alternate fuel in diesel engines.

REFERENCES

1. Achyut K. panda, Singh, R.K. and Mishra,D.K. (2010)'Thermolysis of waste plastics to liquid fuel A suitable method for plastic waste management and manufacture of value added products', Renewable and Sustainable energy reviews vol.14, pp.233-248.

2. Chart Chiemchaisri, BoonyaCharnnok and ChettiyappanVisvanathan (2010) 'Recovery of waste plastic wastes from dumpsite as refuse-derived fuel and its utilization in small gasification system', Biosource Technology 101 pp.1522-1527.

3. De la puente, G., Klocker, C. and Sedran, U (2002) 'Conversion of waste plastics into fuels Recycling polyethylene in FCC', Applied catalyst B: Environmental 36 pp.279-285.

4. Deshpande, D.P., Warfade V.V., Amaley, S.H. and Lokhande, D.D. (2012) 'Petro-Chemical Feed stock from plastic waste' Res.J.Recent Sci., vol.1 (3), pp.63-67.

5. Encinar, J.M. and Gonzalez, J.F. (2008) 'Pyrolysis of synthetic polymers and plastic wastes. Kinetic study', Fuel Processing Technology 89, pp.678-686.

6. Hung-Ta Lin, Mao-Suan Huang, Jin-Wen Luo, Li-Hsiang Lin, Chi-Ming Lee and Keng-Liang Ou (2010) 'Hydrocarbon fuels produced by catalytic pyrolysis of hospital plastic wastes in a fluidizing cracking process', Fuel Processing Technology 91, pp.1355-1363.

7. Kiran, N., Ekinci, E. and Snape, C.E. (2000) 'recycling of plastic wastes via pyrolysis', Resources, Conservation and Recycling 29, pp.273-283.

8. Kyong-Hwan Lee (2009) 'Thermal and catalytic degradation of pyrolytic oil from pyrolysis of municipal plastic wastes', J. Anal. Appl. Pyrolysis 85, pp.372-379.

9. Lopez, A., De macro, I., Caballero, B.M., Laresgoiti, M.F., Adrados, A. and Aranzabal, A. (2011) 'Catalytic pyrolysis of plastic wastes with different types of catalysts: ZSM-5 zeolite and red mud' Applied Catalyst B: Environmental 104, pp.211-219.

10. Mani, M., Subash, C. and Nagarajan, G. (2009) 'Performance, emission and combustion characteristics of a DI diesel engine using waste plastic oil', Applied Thermal Engineering 29, pp.2738-2744.

11. Miskolczi, N., Angyal, A., Bartha, L. and Valkai, I. (2009) 'Fuels by pyrolysis of waste plastics from agricultural and packaging sectors in a pilot scale reactor', Fuel Processing Technology 90, pp.1032-1040.

12. Mohammad Farhat Ali, Sakeel Ahmed and Muhammad Salman Qureshi (2011) 'Catalytic processing of coal and petroleum residues with waste plastics to produce transportation fuels', Fuel Processing Technology 92, pp.1109-1120.

13. Narayana, V.l.andMojeswararao, D. (2012) 'Experimental study on the performance of C.I. diesel engine using plastic pyrolysis oil blends with pure diesel', IJERT ISSN: 2278-0181, vol. 1 Issue 6.

14. Osueke, C.O. and Ofondu, I.O. (2011) 'Conversion of waste plastic to fuel by means of pyrolysis', Int. J. Advan. Engg.Sci. Technol. Vol. 4, pp.21-24.

15. Pinto, F., Costa, P., Gulyurtlu, I. and Cabrita, I. (1999) 'Pyrolysis of plastic waste. 1. Effect of plastic waste composition on product yield', Journal of analytical and applied pyrolysis 51, pp.39-55.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

16. Rajesh Guntur, Devakumar, M.L.S. and Vijaya Kumar Reddy, K. (2011) 'Experimental evaluation of diesel engine with blends of Diesel-Plastic pyrolysis oil', International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462 Vol. 3 No. 6.

17. Sudhir Kumar, J., Joshua Prasad, V.J., VenkataSubbaiah, K. and PrasadaRao, V.V. (2012) ' Experimental studies on a DI-CI Engine using blends of diesel fuel with plastic diesel derived from plastic waste at 250 bar injection pressure', International Journal of Current Engineering and Technology, ISSN : 2277-4106, Vol. 2, No. 1.

18. Tiwari D.C., Ejaz Ahmad and Kumar Singh K.K, (2009) 'Catalytic degradation of waste plastic into fuel range hydrocarbons', International Journal of Chemical Research, ISSN: 0975-3699, Vol 1, pp.31-36