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Review of Diesel Engine Emission under Waste Plastic Fuel

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Abstract:

Pyrolysis of waste plastics yields oil whose characteristics is comparable with the diesel fuel and could be replaced with fossil fuel with little bit modification. The production of plastic oil can also reduce the problem of plastic waste which is now big problem in India. The paper presents a general trend in emission characteristics of the plastic oil in diesel engine. The emission characteristics of the diesel engine under the plastic fuel and blend are showing acceptable condition and could be used in diesel engine in pure form.

Keywords: Pyrolysis, Plastic Fuel, Brake Power, Viscosity.

1. Introduction

There are 3500 tonnes of plastic waste every day in the country's 60 major cities including Delhi. This is a huge ammout of plastic waste to ruin our soil, water and air quality if rate of production will continue for long term. An organization of central government of India. Central Pollution Control Board(CPCB) has studied the negative effects of plastic waste. According to this study, the quality of land and water is being affected in the order of disposal of garbage near plastic waste dump site in Lucknow and disposal of waste[1]. Plastic garbage is also proven to be fatal for pets. The quality of ground water is also affected by expelling plastic waste at open spaces. For this, there is tremendous impetus for the disposal of plastic waste in India. Plastic recycling can be done in many ways, but this research paper describes pyrolysis of waste plastic in keeping the view of using plastic (Pyrolysis) oil in diesel engine to get mechanical power. Waste plastic is used as raw material for the pyrolysis process. Pyrolysis does not produce any harmful emission unlike incineration [2]. Plastic pyrolysis oil has been investigated as a fuel for the diesel engine and the properties of plastic pyrolysis oil is comparable to the diesel [3,4].

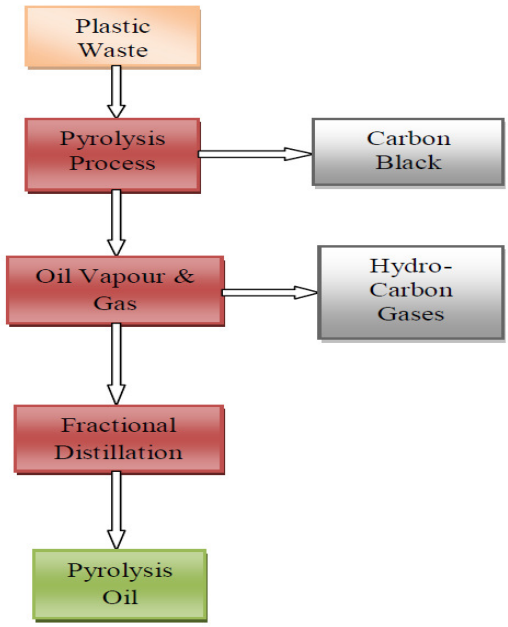

Fig. 1

2. Pyrolysis of Waste Plastic

Pyrolysis is a pre-stage chemical reaction of the both gasification and combustion process. Pyrolysis is a thermal conversion process in which chemical change caused by heat in absence of the air (oxygen). The raw material for the Pyrolysis process decides the characteristics of the pyrolysis oil. There are various Pyrolysis technologies are available in the market but the nature of the raw input help to choose proper technology. The plastic waste can be collected from the municipal solid waste plant sorting area or waste plastic traders.

In Plastic pyrolysis process, waste plastics are converted into fuels like Pyrolysis Oil, Carbon Black and Hydrocarbon Gas. Plastic pyrolysis process takes place in a reactor to maintain the absence of oxygen and the temperature more than 400 degree centigrade. The pyrolysis process of plastic Can be observed by the figure no. 1.

In the India, Plastic waste is approximately 9% of part[5] of total waste generated. The percentage of the plastic waste is also similar in almost in all metro cities of India. This huge amount of plastic waste can be converted into fuel oil by pyrolysis process.

As plastic is a polymeric material, the plastic pyrolysis process start the thermal de-polymerization process in the absence of oxygen. And this process results in conversion of plastic into fuel range hydrocarbons [6]. The Polyethylene (PE) and Polypropylene (PP) main component of the plastic in MSW are used to prevent the chlorine in the oil [7]. Temperature plays a very important role in product yielding in the pyrolysis process. The general specification of the oil which is prepared in the temperature range 400 degree to 500 degree at atmospheric pressure, are given in the table no.1.[8]

Table No. 1

Specifications of Waste Plastic Oil

Properties	Diesel	Waste plastic oil	ASTM standards
Density @ 15 °C (kg/m3)	832	837.5	ASTM D 1298
Kinematic viscosity @ 40 °C (cSt)	2.0	2.4	ASTM D 445
Carbon residue %	27	83.6	--
Cetane index	53	62	ASTM D 613
Fire point (°C)	57	46	--
Sulphur Content	0.046	0.032	ASTM D 4249
Gross calorific value (MJ/kg)	44.7	46.2	ASTM D 240

3. Engine Exhaust Analysis

a) Carbon Monoxide

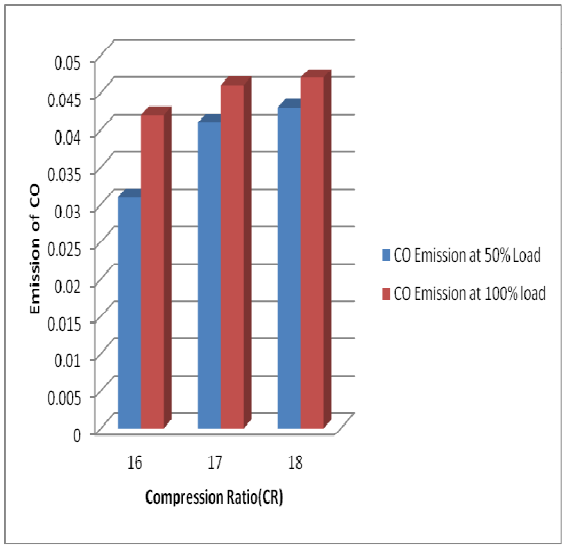

Fig. 2

After collecting the data from various researchers and analyzing, it has been observed that the variation of carbon monoxide emissions of the diesel Engine at various compression ratios is plotted in above Fig. no.2 to get a general concept to compare plastic fuel with diesel fuel. The CO emissions for the different compression ratios 16, 17 and 18 are 0.042%, 0.046% and 0.047% respectively at 100% load whereas for diesel[9] at the compression ratios 16, 17 and 18, it is 0.083%, 0.15%, and 0.14%. It is evident that the CO emissions decreases with the presence of di-methyl carbonate [10] in the plastic fuel and due to sufficient oxygen content in the Plastic Fuel[11]. So it is clearly evident that there is decreasing trend in the CO emissions of the plastic fuel at various compression ratios.

b) HC

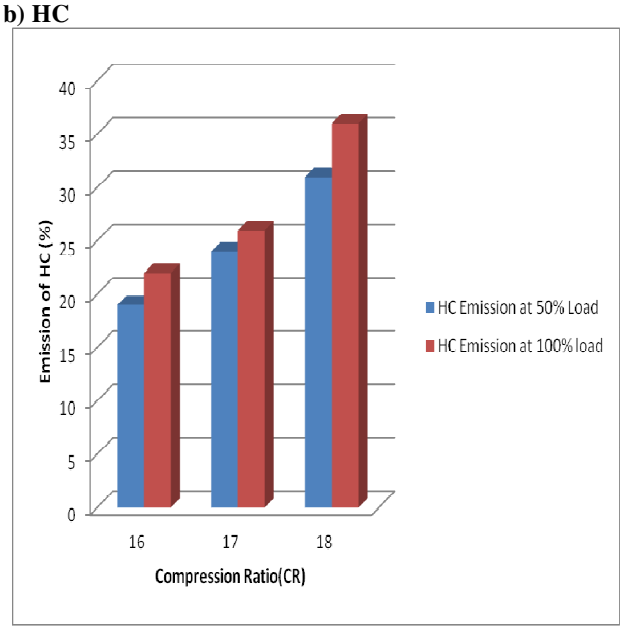

Fig.3

The emission of hydrocarbons of the engine on the various compression ratios is plotted in Fig. no. 3 and it is being compared at 100 % load and 50% load at diesel engine. The HC emissions on the compression ratios 16, 17 and 18 are 19%, 24% and 31% respectively at 50% load and 22, 26, 36 respectively at 100% load. Whereas for diesel at the compression ratios 16, 17 and 18, it is 38%, 43%, and 45% [12]. And from the bar graph it can be observed that HC emissions decrease with the presence of high amount of oxygen in the fuel [13]. And there is a decrement nature in the HC emissions of the plastic fuel at various compression ratios when it is compared with diesel.

c) NOx

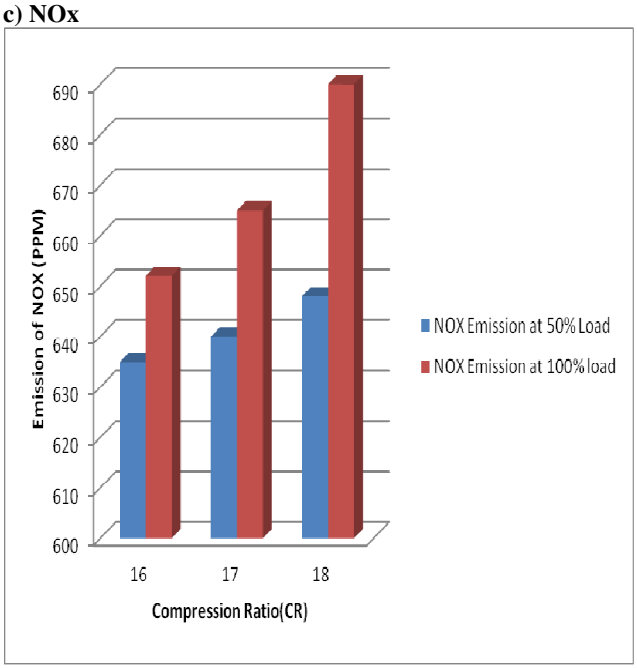

Fig. 4

The variation of NOx emission with plastic fuel on various compression ratios is shown in Fig. no.4 and being compared with the diesel. The NOx emissions for the plastic fuel with the compression ratios 16, 17 and 18 are 635 ppm, 640 ppm and 648 ppm respectively at 50% load and 652,665 and 690 respectively at 100% load[14]. From the above graph it can be absorbed that as compression ratios increases the emission of NOx is increases.

4. Conclusion

In this review paper the plastic oil characteristics has been taken from the various papers which is produced by dry plastic wastes by pyrolysis method. The plastic fuel could be used as an alternative fuel which is showing similar property like fossil fuel. The plastic pyrolysis oil's engine performance was found to be suitable and acceptable when it is compared with the performance of engine working on fossil fuel like diesel. The plastic fuel has significant influence on the emission on CO, HC and NOX . The CO is decreasing by increasing the plastic fuel percentage and CO2 goes up. The NOX and exhaust gas temperature increases significantly when compression ration and load is being increased. By observing the properties of plastic fuel with diesel, the plastic fuel could be used in the pure form by doing small modifications to the engines.The focus on fossil fuel cannot be a long term business of energy demands of India' growing sector s like rural India. The problem of energy demand and waste utilization could be addressed to a great extent by the adopting the modern practice of waste utilization as in case of plastic waste.

References

1. Annual Report 2015-16 on Implementation of Plastic Waste ... - CPCB
2. D. Rutz, and R. Janssen, "Biofuel Technology Hand-book," WIP Renewable Energies, 2007.
3. J. Scheirs and W. Kaminsky, "Feedstock Recycling and Pyrolysis of Waste Plastics: Converting Waste Plastics into Diesel and Other Fuels," John Wiley & Sons Ltd., Chichester, 2006. doi:10.1002/0470021543
4. M. Mani, G. Nagarajan and S. Sampath, "Characterisation and Effect of Using Waste Plastic Oil and Diesel Fuel Blends in Compression Ignition Engine," *Energy,* Vol. 36, 2011, pp. 212-219..
5. O. Arpa, R. Yumrutas and Z. Argunhan, "Experimental Investigation of the Effects of Diesel-like Fuel Obtained from Waste Lubrication Oil on Engine Performance and Exhaust Emission," *Fuel Process Technology*, Vol. 91, 2010, pp.1241-1249. doi:10.1016/j.fuproc.2010.04.004
6. M. Mani, C. Subash and G. Nagarajan, "Performance, Emission and Combustion Characteristics of a DI Diesel Engine Using Waste Plastic Oil," *Applied Thermal Engi-neering,* Vol. 29, 2009, pp. 2738-2744. doi:10.1016/j.applthermaleng.2009.01.007
7. S. Murugan, M. C. Ramaswamy and G. Narajan, "Per-formance, Emission and Combustion Studies of a DI Di-esel Engine Using Distilled Tyre Pyrolysis Oil-Diesel Blends," *Fuel Processing Technology*, Vol. 89, 2008, pp. 152-159. doi:10.1016/j.fuproc.2007.08.005
8. Prakash R, Singh RK, Murugan S. 2013 Experimental investigation on a diesel engine fueled with bio-oil derived from waste wood-biodiesel emulsions Energy convers management. 2013; 30:320–85.
9. Experimental study on combustion and performance characteristics in a DI CI engine fuelled with blends of waste plastic oil
10. Hariram Venkatesan *, Seralathan Sivamani, Kunal Bhutoria, Harsh H. Vora Frigo Stefano, Puccini Monica, VitoloSandra. Liquid fuel production waste tyre pyrolysis and it is utilization in a diesel engine fuel. 2014 ;116 : 399–408.
11. Demirbas, "Pyrolysis of Municipal Plastic Wastes for Recovery of Gasoline-Range Hydrocarbons," *Journal of Analytical and Applied Pyrolysis*, Vol. 72, 2004, pp. 97-102. doi:10.1016/j.jaap.2004.03.001
12. Sharmaa Brajandra k, Moserb Bryan R, Vermillionb Karl E, Dolly Kenneth M, Rajagopalana Nandakishore. Production, characterization and fuel properties of alternative diesel from pyrolysis of waste plastic grocery bags.Fuel Process Technology . 2014; 122:79–90.
13. R. W. J. Westerhout, M. P. Van Koningbruggen, A. G. J. Van Der Ham, J. A. M. Kuipers and W. P. M. Van Swaaij, "Techno-Economic Evaluation of High Temperature Py-rolysis Processesfor Mixed Plastic Waste," *Trans IChemE*, Vol. 76, Part A, March 1998, pp. 427-439.
14. E. A. Williams and P. T. Williams, "Analysis of Products Derived from the Fast Pyrolysis of Plastic Waste," *Jour-nal of Analytical and Applied Pyrolysis*, Vol. 40-41, 1997, pp. 347-363. doi:10.1016/S0165-2370(97)00048-X