OPTIMIZATION OF INJECTION PRESSURE AND COMPRESSION RATIO OF VCR CI ENGINE FUELED WITH WASTE PLASTIC OIL BLENDED WITH DIESEL

DR. SRINIVAS KOMMANA, P. GOPINADH CHOWDARY & A. H. R. MADHURI

¹Mechanical Engineering, VRSEC, Vijayawada, Andhra Pradesh, India

ABSTRACT

Running down of fossil fuel reserves increased the need of alternative fuels which can be capable to meet the energy demand of today's world. Plastic is indispensable material, non-biodegradable and has wide range of application in the industrial field. In this perspective, as an alternative, waste plastic oil draws the attention of the researchers and it is renewable fuel because of huge availability of waste plastic. The properties of the waste plastic oil extracted from pyrolysis are compared with petroleum products and found that it has similar properties to that of neat diesel fuel. In this work, conversion of waste plastic to alternate fuel, blending with petro diesel (WP010, WP020) had done, and analyzed their performance, combustion and, emission parameters on a single cylinder VCR CI Engine at different compression ratios (14:1, 16.5:1, 19:1) and at different injection pressures (200, 220, 240 bar), and came out with optimum results at 19:1 CR and 240 bar Injection pressure.

KEYWORDS: Waste Plastic Oil, Pyrolysis, Biodiesel Blends, VCR Engine, Combustion Characteristics & Emissions

Received: May 25, 2020; **Accepted:** Jun 15, 2020; **Published:** Jul 08, 2020; **Paper Id.:** IJMPERDJUN2020243

1. INTRODUCTION

From past to present, oil prices continue to increase due to drop in supply. Particularly, insufficient fossil fuel reserves India needs to import petroleum products to meet energy demand in the country. To overcome this situation, energy generating from waste is one of the new approach to produce alternative fuels for internal combustion engines, reduce pollution and helps for waste disposal in large proportions. "Plastic" includes materials consist of elements like carbon, hydrogen, oxygen, nitrogen, chlorine and sulfur. They are obtained from sources like natural gas, oil, coal, minerals and plants. They have high molecular weight. Plastics are mainly classified into two categories (1) thermoplastics (2) thermosetting polymers. Thermoplastics can recycle more than once and can be made into new plastic products. Examples are polyethylene, polystyrene and polyvinyl chloride. Thermosets can recycle only one because these are not suitable for repeated heat treatments. Examples are phenol formaldehyde and urea formaldehyde.

Gaurav, Madhukar M et al. [1] Conducted experiment using waste plastic (low density polyethylene). Fuel oil obtained when waste plastic subjected to pyrolysis that has similar physical properties compared to neat diesel fuel and also petroleum products such as petrol, kerosene, diesel, and lubricant oil etc. were obtained when waste plastic was subjected to depolymerisation, pyrolysis, thermal cracking and distillation. **L.B.Bhuyar and A.S. Shahare [2], Moinuddin Sarker, Mohammad Mamunor Rashid et al.[7]** conducted survey and observed that waste plastic is increasing day by day from social activities due to poor waste management system and in collected waste only 10% is recycling, 25% is incinerated, and left 65% is just dumping in the landfills which causes serious environmental problems and underground water gets polluting. **Lilies Widojoko and P. Eliza Purnamasari et al.**

[3] plastic bottle wastes used as ingredient in the Asphaltic concrete mixture along with cement in certain proportion and observed that Marshall stability increased by 19%, obtained best bitumen content compared to without adding plastic waste. Similar investigation has done by **Miss Apurva J Chavan** [4] plastic waste without any impurities coated over the aggregate mix and this mix added to the hot bitumen. Final mixture is used for road construction and observed that strength as well as life of the construction has increased. Under waste plastic management **M. Puncchar, B. Ruj et al.** [5] using plasma pyrolysis technology, high calorific plastic waste is converted into synthesis gas (syngas) under high temperature in absence of oxygen. **Mochamad Syamsiroa and HarwinSaptoadi et al.** [6] investigated using three different types of municipal plastic waste, fuel oil is produced by successive pyrolysis and catalytic reforming processes. Results showed that feedstock types shows great impact on product yields, quantity of liquid and solid products. HDPE waste produced the highest liquid fraction. It is concluded that by using established technologies waste plastics can be convert into a renewable source for production of alternative fuels to meet the country's energy demand.

2. MATERIALS AND METHODS

A. Pyrolysis (Thermal Cracking)

Pyrolysis is a method of conversion of one substance into another through heating/ heating with help of the catalyst in absence of air/oxygen. It breakdowns chemical compounds into small molecules. Materials like vegetable oils, animal fats, natural fatty acids and methyl esters of fatty acids can be used for pyrolysis. The liquid fuel obtained from this process has similar physical and chemical properties to that of neat diesel fuel.

Pyrolysis Setup

Figure 1: Pyrolysis Process.

B. Biodiesel Production

One of the processes of converting raw oil into biodiesel is called Transesterification. In this process, crude Plastic oil is taken as basic material to produce useful liquid fuel. The ingredients used in this process are: a) waste plastic oil -1000 ml b) Methanol-200 ml c) KOH 6.5 g. 1000 ml of crude waste plastic oil is taken into a glass beaker heated up to 100°C to separate impurities from the waste plastic oil and after heating, the oil is cooled to 60°C which is standard temperature for the process.

Figure 2.1: Transesterification Process of Biodiesel.

Then in another beaker, 200ml of methanol is taken and 6.5 g of KOH is added to this methanol and this mixture of methanol and KOH is poured into raw oil which is at 60°C. Then a lid is placed on the container which contains raw oil at 60°C and dissolved KOH in methanol and is stirred with a magnetic stirrer at 55°C-60°C for 150 minutes. Then heater is switched off and allowed to cool. the mixture is poured into a funnel and the mixture is left stable for 24 h to settle. After 24 hrs the mixture is separated into two different layers in the funnel. Top layer is pure liquid fuel and bottom layer is glycerin. Glycerin is Drained off and left over liquid fuel after water washed with more than 50% of water. After vigorous shaking this mixture allowed to settle for 18-20 hrs. Refined Bio diesel found as top layer and crude as bottom layer. Refined Bio diesel produced is collected and heated up to 45°C-55°C.

Figure 2.2: Transesterification Process of Biodiesel.

C. Biodiesel blends Preparation

Blends WP010 (10% biodiesel, 90% pure diesel), WP020 (20% biodiesel, 80% pure diesel) were. The various properties like density, viscosity, and calorific value, flash and fire point of two blends were determined by using ASTM methods. The mixed blends appearances presented that viscosity of the mixed blends increases with biodiesel proportions. The biodiesel and diesel description is given below in table 2.1. biodiesel has high viscosity and low calorific value compared to neat diesel. The density of the mixed blends (i.e. WP010, WP020) showed a commonly in relation to an increase in blends proportion. It was described that lower calorific value of biodiesels is due to more oxygen content than compare to diesel. Blends have more viscosity due to their complicated chemical structure and higher molecular weight.

Figure 3: Different Blends.

Table 3.1: Properties of Fuels

Fuel	Viscosity (Cst)	Calorific Value (Kcal/Kg)	Density (Kg/mm ³)	Flash & Fire point(°C)
Diesel	3.25	46,500	0.840	74&78
Waste plastic oil	4.839	44,340	0.883	63&68

D. Experimental Setup

Experiments were carried out on a single cylinder, naturally aspirated VCR diesel engine with a constant speed of 1500

RPM, 3.5 KW rated power, variable compression ratios. The engine was coupled with an eddy current dynamometer (50kg) to load the engine. Specifications of the engine are listed in “table 2.2”.

Figure 4: Experimental Setup.

Table 2.2: Test Engine Specifications

Parameter	Specifications
Model	Kirloskar VCR engine
Type	4Stroke, Single cylinder
Cooling System	Water Cooled
Bore diameter	80 mm
Stroke	56 mm
Compression Ratio	12:1 to 20:1
Rated Speed	1500 rpm
Rated Power	3.7 kW

3. RESULTS AND DISCUSSIONS

Experiments were conducted using biodiesel blends (i.e. WP010, WP020) on VCR CI engine under different engine load conditions, at different compression ratios (14:1,16.5:1,19:1) and different injection pressures (200, 220, 240 bar) with constant speed. Obtained results are systematically presented and compared with neat diesel fuel.

A. Effect of Injection Pressure 200 Bar & Compression Ratio 16.5:1 on Performances

Figure 5: Load Versus Mechanical Efficiency At 16.5:1 CR.

Figure 6: Load Versus Brake Thermal Efficiency At 16.5: 1 CR.

Figure 7: Load Versus Brake Specific Fuel Consumption At 16.5: 1 CR.

Figure 8: Load Versus Exhaust Gas Temperature At 16.5: 1 CR.

B. Effect of Injection Pressure 200 Bar & Compression Ratio

Figure 9: Variation of Mechanical Efficiency with Load.

Figure 10: Variation of Brake Thermal Efficiency with Load.

Figure 11: Variation of Brake Specific Fuel Consumption with Load.

Figure 12: Variation of Exhaust Gas Temp with Load.

C: Varying Injecting Pressure, Compression Ratio 19:1

Figure 13: Variation of mechanical Efficiency with Load.

Figure 14: Variation of Brake Thermal Efficiency with Load.

Figure 15: Variation of Brake Specific Fuel Consumption with Load.

Figure 16: Variation of Exhaust Gas Temperature with Load.

D: Emission Analysis: all Fuels, at CR16.5, INJ PR 200

Figure17: Variation of Carbon Monoxide with Load.

Figure 18: Variation of Carbon Dioxide with Load.

Figure19: Variation of Hydrocarbons with Load.

E: Varying cr at Injection Pressure 200 for WPO20+d80

Figure 20: Variation of Carbon Monoxide with Load.

Figure 21: Variation of Carbon Dioxide with Load.

Figure 22: Variation of Hydrocarbons with Load.

Figure 23: Variation of Nitrogen Oxides with Load.

F: WPO80+D20, CR 19, Varying INJ PR

Figure 24: Variation of Carbon Monoxide with Load.

Figure 25: Variation of Carbon Dioxide with Load.

Figure 26: Variation of Hydrocarbons with Load.

Figure 27: Variation of Nitrogen Oxides with Load.

G: Load VS Smoke Opacity

Figure: 29: Load vs Smoke Opacity.**H: P-θ Diagram** **Figure 30: Pressure- Crank Angle Diagram.**

Above pressure and crank angle diagram shows that for WPO 20+ D80 blend with compression ratio 19:1 and 220 bar injection pressure, the cylinder pressure increases with increase in compression ratio.

4. CONCLUSIONS

Experiment was conducted using two blends of biodiesel (WPO10, WPO20) and observed that WPO20 + D80 blend which can run the engine giving the maximum mechanical and brake thermal efficiency at CR19:1 and INJ PR 240 and thus by showing the least specific fuel consumption for this blending percentage. The exhaust gas temperature also reached to high elevated temperatures due to increase in rate of combustion when compared to other fuels blends. From emission analysis we can observe that the values of CO, CO₂, NO_x and Smoke produced by the blend WPO20+D80 are nearer to that of diesel without much affecting the environment.

REFERENCES

1. Guoxin Hu, Haojie Fan and Yaqin Liu. *Experimental studies on pyrolysis of Datong coal with solid heat carrier in a fixed bed. Fuel Processing Technology.* 2001;69: 221–228.
2. Mani M., Nagarajan G. and Sampath S., *Characterisation and effect of using waste plastic oil and diesel fuel blends in compression ignition engine, Energy*, **36**, 212-219 (2011)
3. Rajesh Guntur and Deva Kumar M.L.S., *Experimental evaluation of a diesel engine with blends of diesel-plastic Pyrolysis oil, International Journal of Engineering Science and Technology*, 3(6), (2011)
4. A. A. Sagung Dewi Afiati, Apip Amrullah, Akhmad Syarief, Rudi Siswanto *Characteristics of Synthetic Fuel from Plastic Waste by Gasification Method international journal of scientific & technology research volume 3, issue 3, march 2014*
5. <http://biomassmagazine.com/articles/2067/power-and-fuel-from-plastic-wastes>
6. Kanth, TN Ravi, Sudhakara Reddy Kalavapalli, and B. Phani Kumar. "Performance Evaluation of Vcr Ci Engine Using Cd Intake Manifold with Internal Grooving." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 8. 1, Feb 2018, 319- 326

7. G.V.N. Kumar, G.G. Srinivas, AnilKumar. Ch, "Experimental Investigations on Diesel Engine Fueled with Tyre Pyrolysis Oil and Diesel Blends" *International Journal of Emerging trends in Engineering and Development* Issue 2, vol.7 (November 2012) ISSN 2249-6149.
8. Prajakta Sontakke fuels from plastic wastes *International Journal of Technical Research and Applications* e-ISSN: 2320-8163
9. https://m3challenge.siam.org/pdf/Team_1356.pdf
10. <http://www.all-recycling-facts.com/recycling-plastic.html>
11. Soni, Tanmay, and Abhishek Gaikwad. "Waste pyrolysis tire oil as alternative fuel for diesel engines." *Int. J. Mech. Prod. Eng. Res. Dev.* 7.6 (2017): 271-278.
12. Central Pollution Control Board (CPCB), New Delhi, www.CPCB.Delhi.NIC.in
13. <http://www.env.gov.bc.ca/epd/bcairquality/reports/ecmswi.html>
14. <http://www.greencitizen.com/what-is-the-problem-with-plastic/>
15. [http://www.ghanaweb.com/ghanahomepage/newsarchive/article\(accesson12June, 2006\)](http://www.ghanaweb.com/ghanahomepage/newsarchive/article(accesson12June, 2006))
16. Awasthi, Prabhat Kumar, and Abhishek Gaikwad. "Comparison of Power Output's of Different Blends of Pyrolysis Plastic Oil & Diesel With Pure Diesel on Single Cylinder 4-S (Vcr) Diesel Engine." *International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)* 7. 6, Dec 2017, 255-262
17. <http://www.zerowaste.sa.gov.au/upload/resource-centre/publications/waste-toenergy/Case%20Study%203%20Cynar%20Plastics%20to%20Fuel%20FINAL.pdf>
18. <http://www.polymerplace.com/articles/World%20Plastics%20Review.pdf>
19. <http://www.mhenergy.com/Petrochemicals/Resources/News%20Features/Polymers/market.html?S=printer>
20. Keerthi Kumar N, B Yogesh, Shankar Nag G L, Effect of fuel injection pressure, timing and compression ratio on performance and emission characteristics of fish-oil operated diesel engine, *International Journal Of Research In Engineering And Technology*, 5 (4) 2016.
21. Kumar, Pravin, and A. Rehman. "Performance and Emission Characteristics of Dual Injection in Compression Ignition (CI) Engine." *International Journal of Automobile Engineering Research and Development (IJAEERD)* 4.6 (2014): 13-26.
22. Wail M. Adailah, Khaled S.Alqadah, Performance Of Diesel Engine Fuelled By A Biodiesel Extracted From A Waste Cooking Oil, *Energy Procedia* 18 (2012), pp-1317-1334.
23. Sukumar Puan, N Vedaraman, Boppana V.B.Ram, G.Sankaranarayanan, K.Jeychandran, Mahua oil (madhuca indica seed oil) methyl ester as biodiesel-preparation and emission characteristics, *Biomass And Bioenergy* 28 (2005), pp-87-93.
24. Investigation of Various Properties of Biodiesel Prepared from Waste Cooking Coconut and Palm Oil and Comparison with the Petroleum Diesel V Rakesh1, B C Anilkumar 2, Robins Aikkara3 *International Journal of Emerging Engineering Research and Technology* Volume. 2, Issue 7, October 2014, PP 36-42 ISSN 2349-4395 (Print) & ISSN 2349-4409

AUTHORS PROFILE

Dr. Kommana Srinivas M.tech,Ph.D, Senior.Assistant Professor, Department of Mechanical Engineering, V.R.Siddhartha Engineering College, Vijayawada, AP,India, @25 yrs Experience Areas of Research Interest:

- Bio Fuels and their performance & emissions in IC Engines.
- Renewable energy resources and their utilization.
- Gas turbine and combined cycle power plants.
- Publications(intnl) 16 International conf: 5,Nat.conf 2