Emission Analysis of Mustard Oil Methyl Oil Methyl Ester at Varying Injection Timing

D. Yuvarajan1*, M. Venkata Ramanan2, D. Christopher Selvam3, M. Arulprakasajothi1 and N. Beem Kumar4

1Department of Mechanical Engineering, Vel Tech Dr. R R & Dr. S. R. University, Chennai - 600062, Tamil Nadu, India; dyuvarajan7@gmail.com
2Department of Mechanical Engineering, Anna University, Chennai - 600025, Tamil Nadu, India; venkat@annauniv.edu
3Department of Mechanical Engineering, Jeppiaar Institute of Technology, Chennai - 631604, Tamil Nadu, India; christadcr@gmail.com
4Department of Mechanical Engineering, Sathyabama University, Chennai - 600119, Tamil Nadu, India; beem4u@gmail.com

Abstract

Objectives: The intention of this work is to examine the emission characteristics of mustard oil methyl ester at various injection timings. Methods/Statistical Analysis: The work was done in vertical cylinder and air cooled diesel engine running at atmospheric conditions and at 1500 rpm. Findings: Result indicated that by advancing the fuel injection by 60 bTDC, NOX emission for Mustard oil methyl ester and diesel is increased by 11.61% and 16.12% respectively. In addition, HC emission elevates by 16.9% and 12.59% for MO and diesel. Furthermore, CO shoots up to by 6.94% and 10.42% for MO and diesel. Application/Improvements: This experimental study evidently indicates that by altering the fuel injection various emissions associated with CI engine increases for both the fuels stating that the fuels should be injected in appropriate timing (24°bTDC) to ensure uniform mixing, improved combustion and lesser emissions.

Keywords: Diesel Engine, Emissions, Injection Timing, Mustard Oil, Methyl Ester

1. Introduction

Fatty acid methyl ester generally referred as Biodiesel are promising alternative for diesel fuels. More researchers of late have been carried out to use vegetable oil as an alternative fuel because of its less emission and highly renewable comparing fossil fuel which depleting by time. Oil bearing crops of more than 350 in numbers which includes soybean, mustard, palm, sunflower, cottonseed, rapeseed, rice bran and peanut oil have been discovered and considered as potential alternative fuel for conventional fuel. Vegetable oil are renewable in nature and in exhaustible sources of energy closer to conventional fuel with merits of its liquidity, availability, renewable, lower sulphur, aromatic content and biodegradable. Vegetable oil is highly viscous with range of 10 to 18 times of diesel and it cannot be used directly into an engine. Vegetable oil has to be converted into methyl ester by number of ways which includes esterification, transesterification, dilution, micro emulsion, pyrolysis, thermal cracking, solvent extraction and blending with diesel, among which transesterification is an lucrative method to transform large molecular structure of bio oils to straight small chain molecules in simpler way. The other problem associated with long term run using vegetable oil in CI engine were injector coking, carbon deposits, oil ring sticking, gelling with lubrication oil. In recent experimental works the researchers found that combustion of biodiesel results lower smoke, PM, CO and HC emission comparing diesel fuel with increase in NOx and efficiency unaffected. In stating biodiesel as a promising alternative fuel for future. This experimental work paves the way to examine the various emission characteristics of mustard oil methyl ester injected at
three different angles (21°, 24° and 27° b TDC) in diesel engine. The work of similar nature in mustard oil methyl ester is least tried in the literature.

2. Materials and Reagents

This work involves raw mustard oil obtained from local supplier. KOH acts as catalysts and methanol acts as an alcohol.

2.1 Transesterification Process

Test fuel is prepared by straight transesterification process. Molar ratios of oil to alcohol were 5:1 and 0.5% wt/wt of mustard oil of catalysts was employed during the preparation.

2.2 Experimental Setup and Procedure

Test was conducted in diesel engine whose layout is shown in Figure 1. Specifications of engine and properties of fuels are given in Table 1 and 2. All the experiments were conducted through proper inspected and calibrated

![](image)

Figure 1. Schematic layout of the installation and experimental setup.

Table 1. Engine specifications

| Type               | Kirlosker |
|--------------------|-----------|
| Rated Power        | 4.4 kW    |
| Rated speed        | 1500 rpm  |
| Injection pressure | 220 bar   |
| Injection timing   | 24° b TDC  |
| Bore dia(D)        | 87.5 mm   |
| Stroke(L)          | 110 mm    |
| Compression ratio  | 17.5:1    |

Table 2. Fuel Type properties of diesel and mustard oil

| Properties                                | Diesel | Mustard oil |
|-------------------------------------------|--------|-------------|
| Density @15°C in gm/cc                    | 0.82   | 0.88        |
| Kinematic Viscosity @40°C (cst)           | 2.5    | 6.2         |
| Gross Calorific Value in KJ/kg            | 9724   | 8704        |
| Calculated Cetane Index (CCI)             | 47     | 52          |

3. Results and Discussions

Comparison of CO emission at various injection timing and loads is shown in Figure 2. With 6° b TDC advance in fuel injection CO was found to increase for mustard oil methyl ester and diesel respectively. By advancing the fuel injection more quantity of fuel is injected and makes the mixture richer. Hence the amount of oxygen required for partial oxidation reaction is less causing higher CO emissions. CO emissions increase piercingly as the mixture becomes richer due to the improper mixing of fuel with air causing poor fuel atomization and vaporization. CO emission is found lesser for MO than diesel in all the fuel injection due to superior carbon to hydrogen percentage. Figure 3 shows the variation of HC emission with loads. With 6° advancement in fuel injection, HC emission increases for mustard oil methyl ester and diesel respectively. As the fuel injection is advanced ignition delay is increased causing improper mixing and poor oxidation of HC. On the other hand, longer delay period originates over penetration of fuel spray and result in wetting of combustion chamber walls causing higher unburned or partially burned HC. It can also be seen that by retarding too much as in the case of 21° b TDC, the quantity of fuel injected is less which enhances over mixing of fuel with air and resulting slower oxidation reaction and produces partially oxidized and un burnt HC. HC emissions were found lesser in MO than diesel at all the fuel injection because of its higher oxygen content which enhances complete combustion and emits lesser HC emissions than diesel. Figure 4 shows the NOX emission by loads. NOX emission is higher in the case of advancing the injection, with advance in 6° b TDC of fuel injection 11.61% and 16.19% increase in NOX was found for mustard oil methyl ester and diesel. This is due to higher temperature of gas which causes non uniform temperature distribution and increase in local temperature near reaction zone. Since local temperature is a deciding factor of NOX formation rate, it increases as injection is advanced. The other reason is by retarding the
fuel injection more fuel gets burned late during expansion stroke there by reducing the local temperature near reaction zone and result in lesser NO\textsubscript{x} emissions. NO\textsubscript{x} emission is on higher side for MO than diesel for all fuel injection timing. The cause would be due to high oxygen availability in MO that enhances complete combustion of fuel and result in higher burn rate, gas temperature and NO\textsubscript{x} emission. Figure 5 shows the variation in smoke intensity at various loads. Smoke emission decreases by advancing the injection. By advance in 6\degree of fuel injection, smoke emission increases for mustard oil methyl ester and diesel respectively. In addition, by retarding the fuel injection, ignition delay period is shorten consequently amount of fuel injected is lesser causing delayed extinction of combustion process following decrease in residence time and causing high smoke intensity.

Figure 2. CO emission with loads.

Figure 3. HC emissions with loads.

Figure 4. NO\textsubscript{x} emissions with loads.

Figure 5. Variations of Smoke emissions with various loads.

4. Conclusions

Following conclusion were drawn from the experiment carried out on studying emission characteristics of mustard methyl ester methyl ester by altering the fuel injection timing on diesel engine.

- NO\textsubscript{x} emission is increased by 11.61\% and 16.19\% for MO and diesel.
- Unburned hydrocarbon is found to be higher by 12.96\% and 16.96\% for MO and diesel.
- CO emissions shoot up by 10.42\% and 6.94\% for MO and diesel.

This experimental study evidently indicates that by altering the fuel injection various emissions associated with CI engine increases for both the fuels (MO and diesel).
stating that the fuels should be injected in appropriate timing (24°bTDC) to ensure uniform mixing, improved combustion and lesser emissions.

5. References

1. Dulari Hansdah S, Murugan LM. Experimental studies on a DI diesel engine fueled with bioethanol-diesel emulsions. AEJ-Alexandria Engineering Journal. 2013 Sep; 52(3):267-76.
2. Chauhan HCL. A study on the performance and emission of a diesel engine fueled with Karanja biodiesel and its blends. Energy. 2013 Jul; 56:1-7.
3. Nabi MSA. Biodiesel from cotton seed oil and its effect on engine performance and exhaust emissions. Applied Thermal Engineering. 2009 Aug; 29(11-12): 2265-70.
4. Ozsezen AN, Canakci M. Determination of performance and combustion characteristics of a diesel engine fuelled with canola and waste palm oil methyl esters. Energy Conservation and Management. 2011 Jan; 52(1):108-16.
5. Labeckas G, Slavinskas S. The effect of rapeseed oil methyl ester on direct injection Diesel engine performance and exhaust emissions. Energy Conservation and Management. 2006 Aug; 47(13-14):1954-67.
6. Xue JL, Grift TE, Hansen AC. Effect of biodiesel on engine performances and emissions. Renewable Sustainable Energy Review. 2011 Feb; 15(2):1098-116.
7. Di Y, Cheung CS, Huang ZH. Experimental investigation on regulated and unregulated emissions of a diesel engine fueled with ultra-low sulfur diesel fuel blended with biodiesel from waste cooking oil. Science Total Environment. 2009 Jan; 407(2):835-46.
8. Chalatlon V, Roy MM, Dutta A, Kumar S. Jatropha oil production and an experimental investigation of its use as an alternative fuel in a DI diesel engine. Journal of Petrol Technology Alternate Fuels. 2011 May; 2(5):76-85.
9. Dorado MP, Ballesteros E, Arnal JM, Gomez J, Lopez FJ. Exhaust emissions form a diesel engine fueled with transesterified waste olive oil. Fuel. 2003 Jul; 82(11):1311-5.
10. Kalam MA, Husnawan M, Masjuki MH. Exhaust emission and combustion evaluation of coconut oil-powered indirect injection diesel engine. Renewable Energy. 2003 Dec; 28(15):2405–15.
11. Ulu Z, Kocak MS. The effect of biodiesel fuel obtained from waste frying oil on direct injection diesel engine performance and exhaust emissions. Renewable Energy. 2008 Aug; 33(8):1936-41.
12. Heywood JB. Internal combustion engine fundamentals. 1 ed. New York: McGraw Hill; 1988 Mar.
13. Yuvarajan D, Venkata Ramanan M. Experimental analysis on neat mustard oil methyl ester subjected to ultrasonication and microwave irradiation in four stroke single cylinder Diesel engine. Journal of Mechanical Science and Technology. 2016 Jan; 30(1):437-46.
14. Yuvarajan D, Venkata Ramanan M. Investigation on effect of magnetite nanofluid on performance and emission patterns of methyl esters of bio diesel. Journal of Environmental Engineering and Landscape Management. 2016 Jun; 24(2):90-6.
15. Venkata Ramanan M, Yuvarajan D. Performance study of preheated mustard oil methyl ester on naturally aspirated CI engine. Applied Mechanics and Materials. 2015 Aug; 787:761-5.
16. Venkata Ramanan M, Yuvarajan D. Emission analysis of preheated methyl ester on CI engine. Applied Mechanics and Materials. 2015 Nov; 812:21-5.
17. Navaneethakrishnan P, Vasudevan D. Experimental study on performance and exhaust emission characteristics of a C.I. engine fuelled with tri compound oxygenated diesel fuel blends. Indian Journal of Science and Technology. 2015 Jan; 8(1):96-102.
18. Selvam M, Vigneshwaran M, Irudhayaraj R, Palani S. Emission control diesel power plant for reducing oxides of nitrogen through selective catalytic reduction method using ammonia. Indian Journal of Science and Technology. 2016 Jan; 9(1):1-7.