Production of Bioethanol from Different Feedstocks and Performance, Emission Characteristics of Single Cylinder CI Engine

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Abstract - ***The need of bioethanol is being increased nowadays, hence the production of bioethanol must be increased using cheaper and eco-friendly raw materials. Based on these criteria, fruit rinds wastes, vegetable and Samanea saman (Rain tree) pods wastes are considered as cheaper and eco-friendly. In the present study selected fruit wastes, vegetable waste and Rain tree pods wastes were used as raw materials to produce bioethanol by using Saccharomyces cerevisiae (yeast) and the results were compared. The results obtained from this work shows that the higher rate of ethanol production through fermentation of Rain tree pods waste, which gives good percentage of ethanol as compared to fruits rinds and vegetable wastes, and the operating conditions (pH 5.5, temperature 30±2 ^{0}C, speed 100 rpm, fermentation period 7 days). The results of this study suggests that wastes from Rain tree pods that contain rich fermentable sugar can be converted into useful products like bioethanol that can serve as an alternative energy source. Also an attempt has been made to find out the suitability of extracted bioethanol as a fuel in CI engine. Experimental work on Performance and emission characteristics of ethanol blended diesel fuel was conducted on single cylinder four stroke CI engines at operating pressure 210 bar with rated speed of 1500 rpm. The different blends of Rain tree pods waste fuel with diesel was also conducted.***

Key Words: *Municipal solid wet organic wastes, Saccharomyces cerevisiae, Fermentation, Bioethanol, Diesel engine.*

1. INTRODUCTION

1.1 Municipal solid wet organic wastes

India being an agro based economy generates nearly 350 million tonnes of waste from the vegetables, fruits and other organic materials. Organic matter including fruit rinds is a major part of wastes generated daily by households, agricultural sector and food processing industries. Fruits are used on a small and large scale for household consumption and by food processing industries like pulp and jam manufacturers. In urban areas, a considerable portion of solid waste includes fruit waste generated by fruit juice vendors and restaurants. These industries and establishments usually discard the inedible parts of the fruits which include the 'rind' or 'peel'. In most cases, these waste materials are dumped in landfills which lead unhygienic conditions. However, utilization of these waste materials in production of bio-fuels would be of great environmental and economic benefit as it could reduce the burden on conventional sources of energy and also get rid of the wastes.

India, with rich agricultural resources, accounts for 50 million tonnes of vegetable waste, which is about 30 % of its total production. Hence, utilization of these wastes generated at different levels of delivery starting from the agricultural farm, post-harvest handling, storage, processing, and from distribution to consumption would be economically highly beneficial. Such wastes can either be used directly as an untreated material for microbial growth or be used by appropriate treatment with enzymes for biofuel production.

2. MATERIAL AND METHODS

2.1 Microorganism and Culture media

The pure culture of *Saccharomyces cerevisiae* was obtained from MTCC (Microbial Type Culture Collection Centre, Chandigarh) and cultured on Sabouraud Dextrose Agar (SDA).the cultures were stored at 4^{0}C and sub-cultured every 30 days.

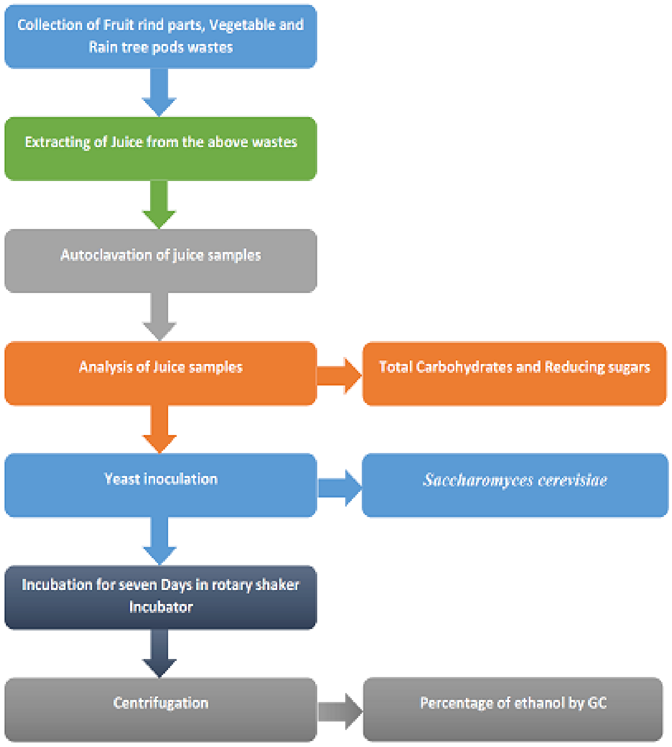

Fig -1: Process flow diagram

2.2 Fermentation unit

The tests mentioned as above were conducted as per the specified procedures and had a satisfactory results and we found that the specimen called *Samanea saman* (Rain tree) had a good yield compared to other specimens which had a yield of 2.54%. By analyzing the results we have decided to take the pods of *Samanea saman* (Rain tree) as a raw material to produce bioethanol.

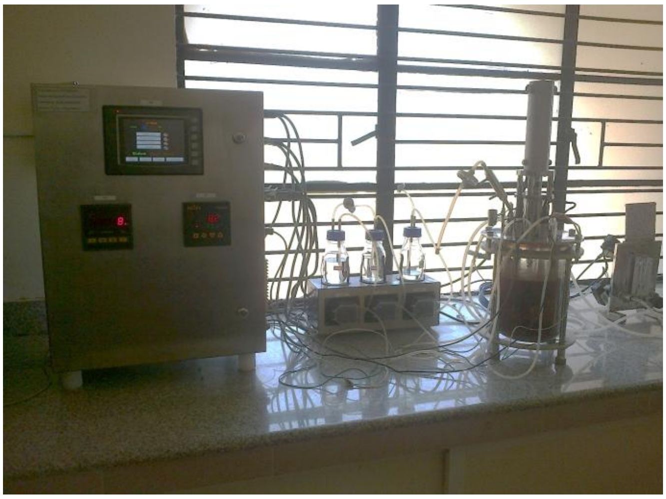

Fig -2: Stirrer type Fermenter unit

Figure-2 shows that the Stirrer type Fermenter unit. After fermentation process, the bioethanol produced was determined by Gas Chromatography test.

2.3 Fuel properties

The properties of Rain tree pods waste fuel and its blends with diesel as shown in table-1.

Table -1: Properties of fuels

Sl. No	Properties	Diesel	5% Bioethanol 95% Diesel	7.5% Bioethanol 92.5% Diesel	10% Bioethanol 90% Diesel	12.5% Bioethanol 87.5% Diesel	15% Bioethanol 85% Diesel	100% Bioethanol
1	Flash point ^0C	53	50	47	45	42	38	13
2	Fire point ^0C	58	53	50	48	45	41	15
3	Density kg/m^3	848.5 1	848.35	848.23	848.15	848.07	847.90	845.55
4	Kinematic Viscosity mm^2/sec	3.15	2.89	2.80	2.72	2.61	2.59	1.36
5	Calorific value in MJ/kg	42.48	42.08	41.73	41.53	41.19	40.31	19.17

2.4 Experimental test set up

The system consists of single cylinder, four stoke Diesel engine associated with electrical loading as shown Fig-3.

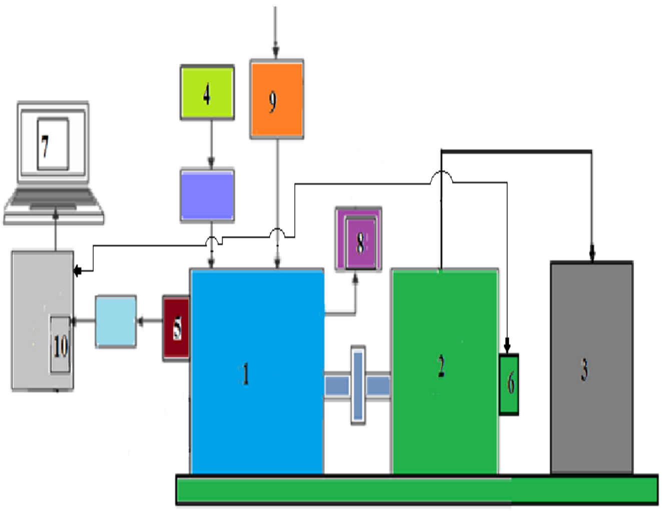

Fig -3: Line diagram of single cylinder, four stroke Diesel engine

1. Diesel engine.
2. Generator.
3. Electrical load.
4. Fuel tank.
5. Pressure pickup.
6. Shaft encoder.
7. Computer.
8. Exhaust gas analyzer.
9. Exhaust temperature measurement meter.
10. Data Acquisition System.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 02 Issue: 08 | Nov-2015 www.irjet.net p-ISSN: 2395-0072

Table -2: Engine Specification

Company	Kirloskar
Engine type	4 Stroke Single Cylinder
Power	5.2 kW
Bore	87.5 mm
Stroke	110 mm
Cooling	Water Cooled
Speed	1500 rpm
Compression Ratio	17.5:1
Fuel injection	Mechanical Injection with injection timing 23^0 BTDC, 210 bar injection pressure.

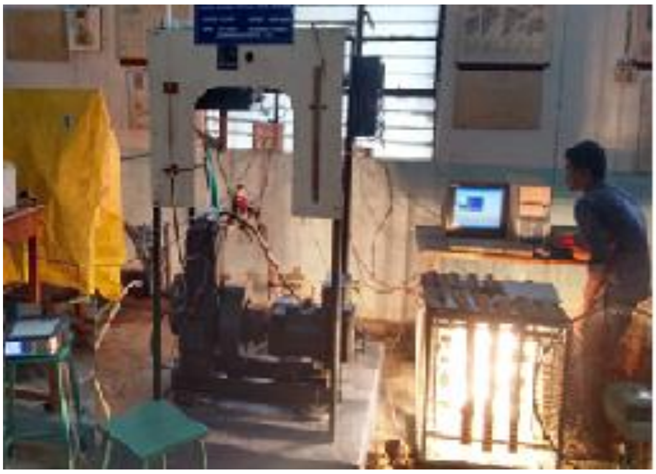

Fig -4: Computerized, four stroke single cylinder CI engine with Electrical loading

Figure-3 Shows a line diagram of four stroke single cylinder Diesel engine and Figure-4, Shows actual image of Diesel engine with Electrical loading. Engine Specification shown in Table-2. Experimental work on Performance and emission characteristics of ethanol blended diesel fuel was conducted on single cylinder four stroke CI engines at operating pressure 210 bar with rated speed of 1500 rpm. The different blends of Rain tree pods waste fuel with diesel was also conducted.

3. RESULTS AND DISCUSSIONS

The results obtained by performing experiments under pure diesel mode and ethanol blended diesel fuel mode and results are shown in figures**.**

3.1 Brake Specific Fuel Consumption

Engine operating condition: Pressure at 210 bar, speed 1500rpm and injection timing 23^0 bTDC

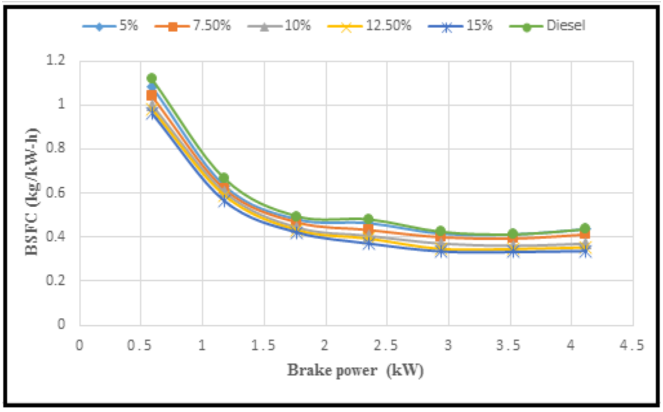

Fig -5: Variation of BSFC with Brake power for various percentage of ethanol fuel

Figure-5.shows that Variation of BSFC with BP for various Ethanol fuel blends are 5%, 7.5%, 10%, 12.5%, and 15% of ethanol. As the BP increasing the BSFC decreases in ethanol fuel blends as well as in diesel. As the percentages of the ethanol increases in diesel, the BSFC are decreases as compared to diesel fuel due to calorific value. Thus the values show that 15% of ethanol blend has lower BSFC compared to all other blends for different loads.

3.2 Brake thermal Efficiency

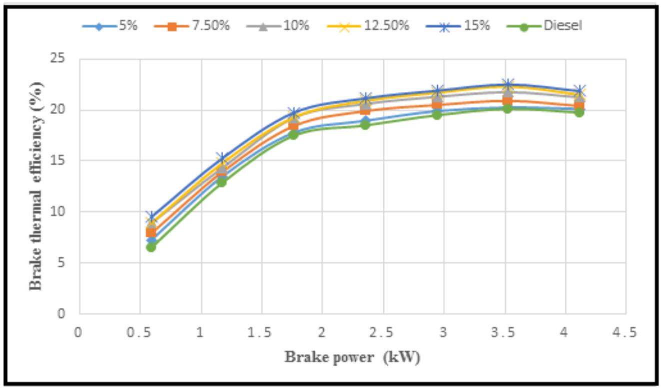

Fig -6: Variation of BTE with Brake power for various percentage of ethanol fuel

Variation of BTE with BP for various Ethanol fuel blends are 5%, 7.5%, 10%, 12.5%, and 15% of ethanol. As the BP increasing the BTE increases in ethanol fuel blends as well as in diesel. As the percentages of the ethanol increases in diesel, the BTE are increases as compared to diesel fuel due to lower CV value and high latent heat of vaporization. The values show that 15% of ethanol blend has higher BTE compared to all other blends for different loads.

3.3 Exhaust Gas temperature

Variation of Exhaust gas temperature with BP for various Ethanol fuel blends are 5%, 7.5%, 10%, 12.5%, and 15% of ethanol as shown in Figure-7.

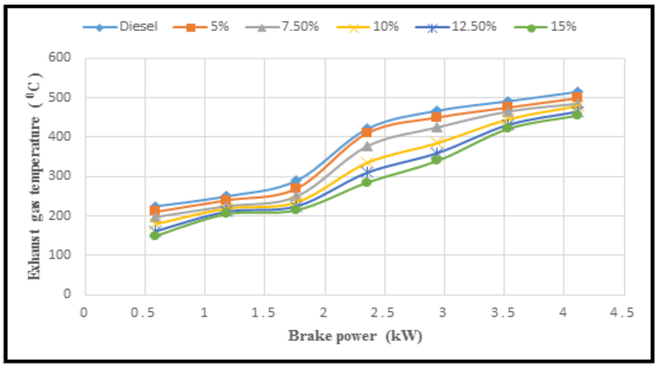

Fig -7: Variation of Exhaust Gas Temperature with Brake power for various percentage of ethanol fuel

As the percentage of ethanol blend increases the exhaust gas temperature decreases are compared diesel due to its lower CV of ethanol blends and ethanol blends having oxygenated fuel and its gives the cooling effect to the engine and reduces the EGT.The values show that 15% of ethanol blend has lower EGT compared to all other blends for different loads.

3.4 Peak pressure rise

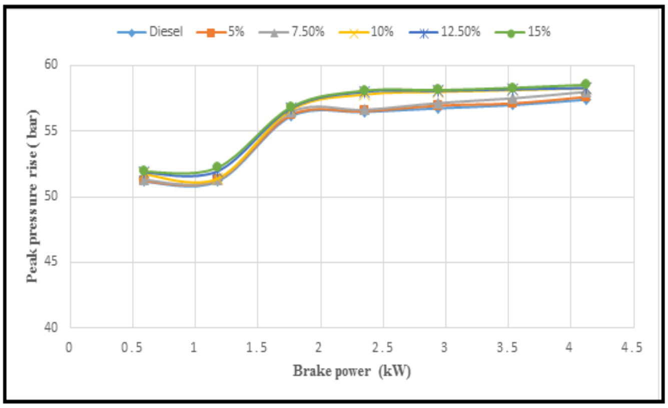

Fig -8: Variation of Peak pressure rise with Brake power for various percentage of ethanol fuel

Variation of Peak pressure rise with Brake power for various percentage of ethanol fuel as shown in Figure -8. As the BP increases the peak pressure rises is higher in ethanol blends and lower pressure rises in diesel for entire load range. The 15% ethanol blend is higher peak pressure rises as compared to other blends as well as diesel due to the fact that the ethanol have more oxygen content.

3.5 Indicated Mean Effective Pressure

Variation of IMEP with BP for various ethanol blends as shown in Figure-9. The Indicated mean effective pressure is increases as well as increasing ethanol blends and IMEP is lower for diesel fuel. The maximum IMEP was achieved about 15% of ethanol blend, because the ethanol having more oxygen content and higher latent heat of vaporization compared to diesel fuel.

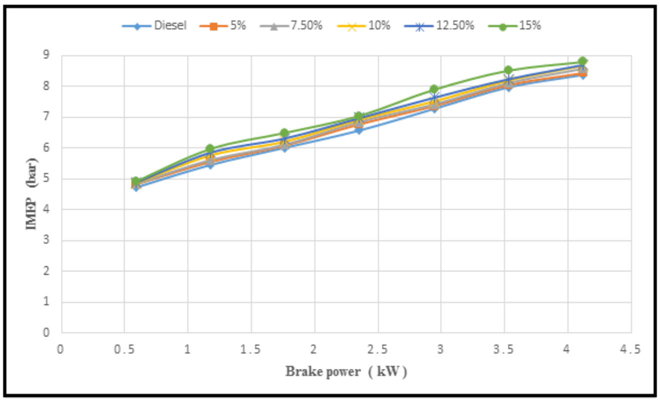

Fig -9: Variation of IMEP with Brake power for various percentage of ethanol fuel

3.6 Carbon Monoxide

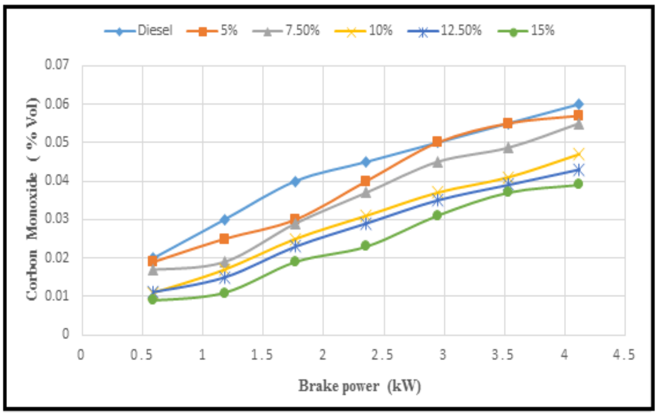

Fig -10: Variation of Carbon Monoxide with Brake power for various percentage of ethanol fuel

Figure-10: shows that variation of CO with BP for various ethanol blends. It is indicates the CO emissions are decreases as increasing ethanol blends as compared to diesel fuel, due to fact that the ethanol have oxygenated fuel, so that ethanol blends having more oxygen content compared to diesel fuel and gives the complete combustion and hence reduces CO emissions. The values show that 15% of ethanol blend has lower CO compared to all other blends for different loads.

3.7 Carbon Dioxide

Variation of CO_2 with BP for various ethanol blends. As the percentage of ethanol blends increases the CO_2 emissions are decreases with BP as well as diesel fuel as shown in Figure-11. Because the ethanol having more oxygen content compared to diesel fuel, so that ethanol blends having more oxygen content and gives the complete combustion and hence reduces CO_2 emissions. Thus the values show that 15% of ethanol blend has lower CO_2 compared to all other blends for different loads.

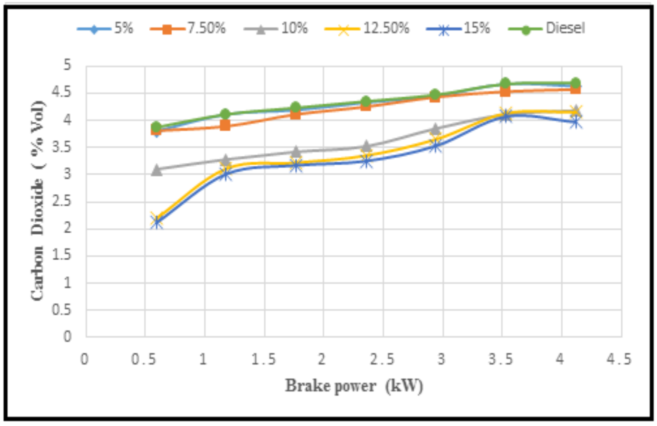

Fig -11: Variation of Carbon Dioxide with Brake power for various percentage of ethanol fuel

3.8 Hydrocarbon

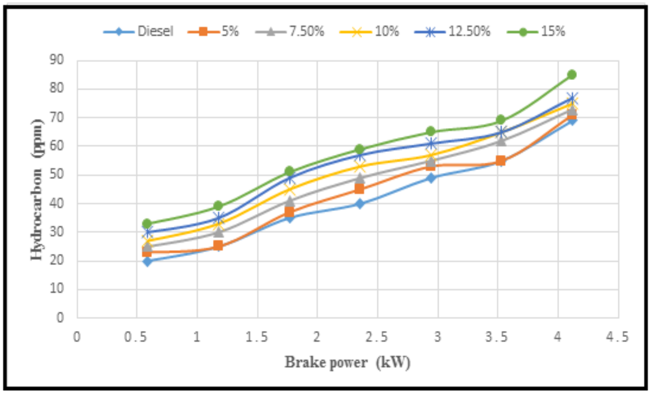

Fig -12: Variation of Hydrocarbon with Brake power for various percentage of ethanol fuel

Variation of HC with BP for various ethanol blends. The HC emissions increased with the increasing percentage of ethanol blends as compared to diesel fuel as shown in Figure-12. Because it's having high latent heat of vaporization and lower cetane number, higher percentages of ethanol blends reduces the gas temperature and promotes the rapid combustion and thus the values show that 15% of ethanol blend has higher HC compared to all other blends for different loads.

4. CONCLUSIONS

From the results obtained, the fallowing conclusion are made.

1. In this present study, selected fruit and vegetable wastes such as Pineapple rind parts, Watermelon rind parts and jack fruit rind parts, Decaying vegetable wastes Tomato, Carrot and Cabbage were considered as raw materials for the production of Bioethanol and the conversion of waste into fuel, which forms an attractive solution towards both waste management and Biofuels generation.

2. The Rain tree pods were considered as potential municipal waste. After incubation the Rain tree pods wastes shows higher yield about 2.54% of ethanol content as compared to fruits and vegetable wastes. After Fermentation process Rain tree pods wastes shows higher yield about 5.7% of ethanol content.

3. The extracted Bioethanol from Rain tree pods wastes and analysis of fuel properties, the performance and emission characteristics of single cylinder CI engine were carried out.

4. The brake specific fuel consumption ethanol blended diesel decreased because ethanol having lower calorific value and lower cetane number as compared to diesel. At 0.58kW BP the BSFC decreased about 13%, similarly at 4.11kW BP the BSFE decreased about 22%.

5. The brake thermal efficiency of ethanol blended diesel is higher and as the percentage of ethanol increases, the efficiency also increases because ethanol having more oxygen content and high latent heat of vaporization as compared to diesel and hence promotes the better combustion. At 0.58kW BP the BTE increased about 31%, similarly at 4.11kW BP the BTE increased about 9%.

6. The ethanol blended diesel fuels are reduced the CO emissions, due fact that the ethanol have oxygenated fuel as compared to diesel and gives the complete combustion. At 0.58kW BP the CO decreased about 55%, similarly at 4.11kW BP the CO decreased about 35%.

7. The ethanol blended diesel fuels are decreases the CO_2 emissions, because the ethanol having more oxygen content compared to diesel fuel, so that ethanol gives the complete combustion and hence reduces CO_2 emissions. At 0.58kW BP the CO_2 decreased about 45%, similarly at 4.11kW BP the CO_2 decreased about 15%.

8. The ethanol blended diesel fuels are increases the HC emissions, because it's having high latent heat of vaporization and lower cetane number, higher percentages of ethanol blends promotes the rapid combustion. At 0.58kW BP the HC increased about 39%, similarly at 4.11kW BP the HC increased about 18%.

ACKNOWLEDGEMENT

The authors are thankful to the management of Bapuji Institute of Engineering and Technology, Davanagere for their consistent encouragement and support to carry out this project work. We also thankful to AICTE, New Delhi for supporting through RPS funding (NO-8-145/RIFD/RPS/Policy/2013-14) to Dept. Biotechnology.

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