Endurance Study Of A Single Cylinder Diesel Engine Using Jatropha Biodiesel

Ravi Kumar, Ajay Kumar Sharma, Devendra Singh

Abstract: The search for alternative fuels has been inevitable in view of the rapid depletion of fossil fuels. When we look at the huge demand of diesel in transport, captive power and agriculture, biodiesel is considered a diesel substitute. Power is recognized as one of economic and industrial growth's most important factors. There is a high demand for an alternative and better source of power with the increased use and depletion of fossil fuels. In this paper we show the effects, performance and emission characteristics of single cylinder diesel engine with biodiesel blend B20J (20% jatropha biodiesel+80% diesel). The test were performed C10(modal no) single cylinder, four stroke , vertical, water cooled high compression ignition diesel engine at the same engine speed under Indian standard : 10000 (Part V111)-1980. Its show the engine can be safely operated with jatropha fuel. It gives the good result without change in engine power, Performance and lubricating oil properties

Index Terms: fossil fuels, biofuels, biodiesel, renewable, transesterification, Significance of biodiesel.

1 INTRODUCTION

Many researchers have reported which reducing harmful exhaust emissions and comparable engine performance to diesel have been achieved by the utilization of vegetable oil ester as diesel engine fuel (1–7). Soybean or rapeseed was most esterifies oils tried on diesel engines. Such oils in the Indian sense are basically edible oils as a replacement for diesel fuel by biodiesels can lead to an auto-sufficiency concept in the production of vegetable petroleum that India hasn't yet achieved. With an abundance of non-edible oils found in India, the use of esters of these non-edible oils as a replacement for diesel is not much attempted. Karanja is one of the forests with a production capacity of 135,000 million metric tones[8] and forest-built tree-borne non-edible oil. Energy is the main driver of economic growth and plays a key role in the sustainable development of today's economy and society. The long-term production of energy from easily available, safe and affordable sources makes a considerable difference to our future economic growth. Global economic growth has seen the world's energy demand rise rapidly. The consumption of energy in certain developing countries is expected to increase by 84% in 2035. India faces a terrible challenge to meet its energy requirements to supply adequately-preferred energy at competitive prices in different forms in a sustainable way [9]. Due to the inadequacy of conventional fossil fuels, increased prices or increased emissions during combustion, biomass sources were found to be more efficient in recent days. The reserves of oil-based fuel in several parts of the world are concentrated. Any investment in biofuels greatly boosts economic development. The production process of biofuels is projected to substantially reduce greenhouse gas emissions compared to fossil fuels [5].

2 HISTORY OF BIODIESEL

The diesel engine was invented by a major Germany inventor, Dr. Rudolph Diesel, in 1893[1].

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Rudolph Diesel first began using vegetable oil, and published the paper titled "The ideas or designs of a logical heat engine." He built the first diesel engine to operate on peanut oil at the 1900 World Exhibition in Paris[2]. The main emphasis of biodiesel production was on oilseed crops. Until the 1920s, diesel-powered vegetable oils were used as an energy source. Earnings, affordability, high sulfur, low aromatics, biodegradability and renewability all contribute to more diesel fuel for vegetable oils [3]. The use of crops for production of biodiesel is now limited by higher demand market prices.

3 SIGNIFICANCE OF BIODIESEL

This is biodiesel, therefore it is similar to petrodiesel, meaning biologically derived petrol. Biodiesel is used to replace traditional diesel oil as safe alternative fuel. It is a clean burning coal, strongly lubricated. Functions such as ethanol, green biodiesel also decreases air pollution significantly It is biologically degradable or safe. Different approaches to the production of biodiesel can be used. Biodiesel is a fatty acid single alkyl ester, contained in vegetable and animal fat both in food and in non-edible foodstuffs [11,12].

3.1. Transesterification: catalytic process

The Transesterification process emerged when Glycerol preparation was illustrated in Rochieder's methanolysis of beaver oil at the beginning of 1846. Many parts of the world have since begun to study ethanolysis[6]. Vegetable oils are highly viscous and their viscosity must be reduced for use in diesel engines. You can do this using a wide range of processes including transesterification, pyrolysis, micro-emulsification or petrol diesel blending[7, 8].It is the most used method for transesterification. In the presence of a catalyst, this reaction is caused by oil extracted including any appropriate alcohol from the seeds. Alkyl esters and glycerol are formed products. The formed alkyl esters are called biodiesel.

$$Tryglycirides \xrightarrow{Catalyst} Diglycerides + \text{R'COOR}$$
$$Diglycirides \xrightarrow{Catalyst} Monoglycerides + \text{R''COOR}$$
$$Monoglycirides \xrightarrow{Catalyst} Diglycerides + \text{R'''COOR}$$

Generally, bases, acids or immobilized enzymes may be the catalysts used on the transesterification process [9, 10]. In biodiesel production, the retrospective reaction is not or does not take place, because formed glycerol is immoderate in a product that leads to a 2-phase system (1,2)). Transesterification is not a reversible reaction. After the reaction is performed, glycerol is removed from alkyl esters. Low solvents of glycerol in esters can be separated rapidly and can be achieved through the settlement and centrifugation processes[6].Water is used to improve the glycerol separation in the reaction mixture after the transesterification process. After separation of glycerol, the alkylester enter a neutralization phase, remove excess alcohol or washes the water. Acids to biodiesel produced and any soap formed during a split reaction phase are added to neutralize residual catalysts. The soaps produced are acid-based or water-soluble and fatty acidic. The water washing cycle eliminates soluble salts but biodiesel remains free of fatty acids. The pre-wash neutralization step eliminates the need for water and decreases emulsion capacity for the wash water applied to biodiesel [4]. The system of transesterification varies depending on the water content of fats and oils, reaction temperature, catalyst, reaction time and fatty acid content [5]

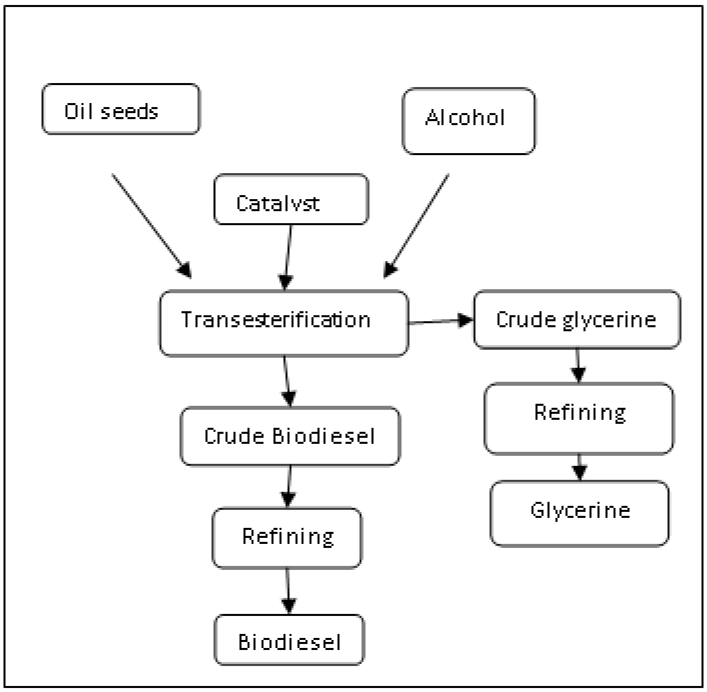

***Figure 1:** Production of Biodiesel*

4. LITERATURE STUDY

YogendraRathoreet. al. (2019) The latest survey focuses on crude oil, which is in the category of edible and non-edible vegetable oil (jatropha and coco oil fuel). We have a strong view that C.I can be regarded as possible alternative fuels. Engines and choose to look for their quality as a future fuel. The viscosity of these two types of oil or diesel fuel is the most important distinction. Combined with pure diesel, the oils above are mixed. Each oil was mixed separately with pure diesel in a variable percentage (20%-50%). Tests of pure diesel fuel were performed in a calculated compression ratio of 18 against various combinations of either Jatropha-biodiesel or Cocos-biodiesel (B20-B50). The output limit for different combinations of fuel is the increase in fuel consumption and the efficiency of the thermal break at different loads [13]. NichaonnChumuanget. al. (2019) A 5-level Central Design Response Surface (RSM) methodology was used for investigating the effects of the experimental facet on the per cent fatty acid methyl ester (FAME) percentages. This study aims to improve the catalytic transesterisation cycle of heterogeneous calcium methoxides ($Ca(OCH_3)_2$), supplemented with tetrahydrofuran (THF, THF), to produce biodiesel from waste cooking oil. For the prediction of FAME convert, a quadratic model with such a variance analysis obtained the RSM is suggested or shows that the model explains 99.43 percent of the observed variance. Depending on these requirements, the properties of processed biodiesel comply with the norm. THF as a cosolvent effectively reduced concentration of catalyst, methanol-to-oil molar or response time compared with the development of bio-diesel without cosolvent. The finding for $Ca(OCH_3)_2$ as an economical or sustainable biodiesel co-solvent for THF is promising [14]. Rajalingamet. al. (2019)The purpose of the paper is to examine clearly the production methods for biodiesel. The alternative fuel should be found to offset future demand for fuel as well as to reduce pollution. The energy recovery of vegetable oils/animal fats can be accomplished with a high energy density but their product can not be transformed into biodiesel for better atomization. In general, the processing of biodiesel from vegetable oil or animal fat is using four methods. Some factors such as cost, property, production methodology, necessary equipment, etc. are to be considered in the production of biodiesel,A better fuel quality or efficiency will be achieved with transesterification phase, and no complicated special equipment is required. As a by-product of a process, glycerol is obtained. It can be used to reduce overall production costs for certain other necessary applications[15]. AlemayehuGashawet. al. (2019)The study will explore transesterification processes for biodiesel production as well as the factors affecting biodiesel production. As an alternative fuel for diesel engines, decreasing oil reserves, as well as impact of exhaust gasses from oil-powered engines, are becoming increasingly important. In recent days, waste cooking oil was used as a feedstock to minimize the cost of biofuels. The cooking oils used are primary options to reduce biodiesel costs, such as adapting continuous transesterificationprocesses or retrieving the high-grade glycerol from biodiesel byproducts (glycerol)[16]. Niraj Kumar et. al. (2015) Testing tested the fundamental premise on the scientific reliability of the B40 engine (40 percent jatropha biodiesel + 60 percent diesel) in approximately 512 hours of long-term endurance testing. Several phenomena have been based on motor activity, such as lubricating oil dilution, oxidative stability or deposition formation. Experimental results showed that B40 is a successful motor for altered motors.Using experimental results, It can be concluded that a better way to use a higher biodiesel blend can be by adjusting engine parameters (B40). The optimized motor is efficient and has superior durability based on test results without major difficulties [17]. AtulDharet. al. (2014) The effect of Karanja 20% biodiesel blend (KOME20) on engines wearing and durability with mineral diesel was checked in the 250 hour long stamina test on the directed injection compressor ignorance (DICI). Visual examination of motor components for the deposition of higher carbon deposits proposed for the bottom, head and injector of the biodiesel motorFor the biodiesel-powered engine comparatively less wear was found on cylinders, piston rings, liners and connector rods. For biodiesel-powered motors, wear of large end rods, core bearings or pins has been found to be higher. The cylindrical surface texture was an appropriate following endurance test of both mineral diesel as well as biodiesel blend of Karanja [18]. KeshiniBeetulet. al. (2014)This study examined lipid content and biodiesel potential for different microalgae produced in Mauritian marine water. The measurements were gravimetrically quantified and analyzed with spectroscopy 1H & 13C NMR. An attempt was made to synthesize biodiesel through an alkaline reaction as well as a biodiesel presence was found using Fourier Transform Infrared Spectroscopy. The infrared analysis brought in peaks of carbonyl or ether characteristics. 1738cm-1 or 1200cm-1 indicating biodiesel presence. In this study, preliminary data showed the capacity for the production of biodiesel in various microalgae found in Mauritian waters [19]. Prem Kumar et. al. (2014)The biodiesel is regarded as a replacement for diesel, which has been investigated for the demand for transport fuel, captive power generation or agriculture industries. The performance of the diesel engine under loading conditions showed that B10 or diesel fuel has almost equal maximum power output at the full load level. Biodiesel with a light reduction in SO2 and HC emissions or increased NOX emission when biodiesel or its mixtures are used have been observed in combustion characteristics for less inflammable time or lower peak heat release rates. The study includes biodiesel as well as its blends with diesel combustion, performance or emission characteristics. Biopower, torque and Brake Specific Fuel Control (BSFC), thermal efficiency (BTE) and exhaust emissions for the output of the diesel engines and its blends with Petro-diesel are checked [20]. Sangeetaet. al. (2014)This article explores the prospects and opportunities in various applications for the use of alternative fuels. The properties, as well as the performance of such fuels as fuel, are thoroughly discussed. Vegetable oils are very good for use as alternatives to fossil fuels. The use of biodiesel in a traditional diesel engine is due to a considerable reduction in non-burnt hydrocarbons, carbon monoxide, carbon or nitrogen oxides. Compared to conventional fuels, different alternative fuels, as well as use of mixed fuels, significantly reduces their consumption [21]. Mohamed Chakeret. al. (2013)Research or study on biodiesel production from bioresources will be investigated or discussed. The main goal is to present the newest research, observation or development on the production of biodiesel in scientific and industrial communities for different biological sources or waste. Research and development (R&D) are not recent in biofuels in general and in biodiesel in particular. In recent decades, the use of petroleum fossil fuels has gained momentum due to growing economic and environmental concerns [22]. CenkSayinet. al. (2013) the effect of injection pressure on injection, combustion or output of single-cylinder, four-stroke, direct, aspirated diesel and diesel combustion has been examined in an experimental study. At 4 specific injection pressure (18, 20, 22 and 24MPa) constant checking and various loads have been conducted at constant motor speed. It has been shown that the fuel can have various motor charges or pressure by means of different injection, combustion or performance characteristics. Research into combustion injection properties showed that COME is contributory to faster injection times rather than Diesel [23]. Daming Huang et. al. (2013) Studied biodiesel history and developments of recent years, including various types of biodiesel, biodiesel industry characteristics, processing, and economies. Biodiesel's use in the automotive industry, biodiesel production issues and biodiesel policy are also discussed [24].

6 EXPERIMENTAL SECTION

Two diesel engines were used for the tests; one engine has use diesel and other using B20J fuel. Type of engine [vertical, water-cooled, high compression ignition diesel engine, single-cylinder, four stroke]. Specification of engine: bore-120mm, stroke-115mm, cubic capacity-0.9392 litre compression ratio-16.5:1, speed-1600rpm, weight of engine-165kg, governor type-centrifugal governor fuel injection release pressure-210kg/sg.cm. The engine was joint to an hydraulic dynamometer for power measurement. Other standard instruments were used to measure temperature; water temperature etc. engines were running for 512h with fuel to calibrate the effect of long term engine affair on engine wear, both physical dimension and lubricating oil analysis. Two similar new diesel engines dissociated and measure to a dimension of all parts and then start long term endurance test on 20% biodiesel blends and petroleum diesel. In this test, each engine was operated for 32 cycles at rated speed as per IS: 10000, 1980, SAE 30/40 was used for both tests. Samples of Lubricating oil were collected after every 150h from engines and analyzed to obtain wear results [25].

Test cycle for long term endurance test.

Table 1: *Engine running time at various loads. According to IS: 10000-1980(part viii)*

Percentage Load (%)	Engine running time (hours)
100	4
50	4
110	1
No load	0.5
100	3
50	3.5

Figure 1: *Arrangement of Experimental setup.*

Figure 2: *Arrangement of Experimental setup.*

Table 2: *Fuel properties of jatrophacurcas biodiesel (B20J) and diesel [4]*

Sr. No.	Properties	Biodiesel(B20J)	Diesel
1	Cloud point, °C	4	1
2	Pour point, °C	2	-6
3	Flash point, °C	136	69
4	Kinematic viscosity$^{40°C}$, cSt	4.07	3.35
5	Relative density$^{15°C}$	0.891	.8544
6	Carbon residue, %wt	0.18	0.015
7	Ash content, %wt	0.004	< 0.01
8	Copper strip corrosion$^{100°C}$, 3 h	No 1	No 1
9	Moisture, %wt	0.005	Nil
10	Cetane no.	57.6	49 (Cetane index)

7 RESULTS AND DISCUSSION

7.1. Physical measurement of piston diameter for B20J and diesel operated engine

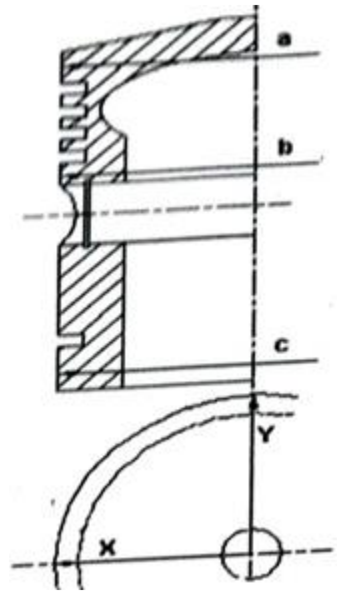

Figure 3*: physical measurement of piston.*

Table 3*: dimensions of piston*

	DV		BT		AT		WEAR	
	DX	DY	DX	DY	DX	DY	DX	DY
A	101.427	101.427	101.465	101.467	101.457	101.46	0.008	0.007
	101.481	101.481						
B	101.360	101.770	101.400	101.796	101.393	101.788	0.007	0.008
	101.420	101.810						
C	101.590	101.894	101.605	101.904	101.597	101.896	0.008	0.008
	101.650	101.960						

BT: Before test AT: After test DV: Deviation

Table 4: *Surface conditions of piston*

		BT	AT
surface condition	piston crown	normal	wet carbon deposited
	top land	normal	wet carbon deposited
	skirt	normal	normal

BT: Before test AT: After test

6.2. Physical measurement of Valves diameter for B20J and diesel operated engine

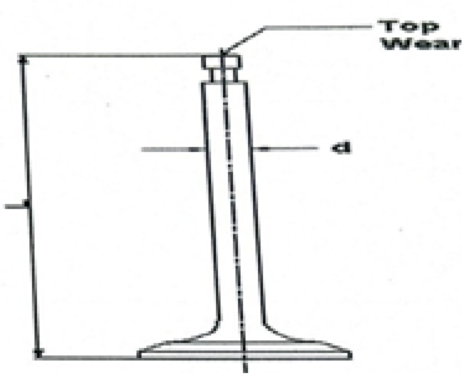

Figure 4: *Engine poppet valve*

Table 5: *Dimensions poppet valve*

	STEM DIA(d)				LENGTH (l)			
	DV	BT	AT	WEAR	DV	BT	AT	WEAR
INLET	7.860 7.875	7.871	7.864	0.007	107.7 108.1	107.9	107.9	0
EXHAUST	7.860 7.875	7.870	7.863	0.007	107.7 108.1	107.9	107.9	0

BT: Before test AT: After test DV: Deviation

Table 6: *Surface conditions of valve*

		DV	BT	AT
surface condition (pitting, cracks, scratches, etc)	Inlet	_	Normal	Normal
	Exhaust	_	Normal	slightly pitted

7.3. Physical measurement of Cylinder liner diameter for B20J and diesel operated engine

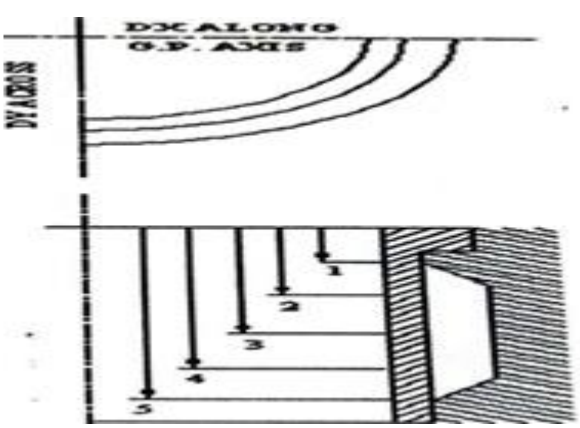

Figure 5: *physical measurement cylinderliner*

Table 7: *Dimensions cylinderliner*

	DV		BT		AT		WEAR	
	DX	DY	DX	DY	DX	DY	DX	DY
1	102 102.025	102 102.025	102.015	102.016	102.054	102.055	0.039	0.039
2	102 102.025	102 102.025	102.015	102.016	102.054	102.055	0.039	0.039
3	102 102.025	102 102.025	102.015	102.016	102.054	102.055	0.039	0.039
4	102 102.025	102 102.025	102.016	102.015	102.055	102.055	0.039	0.04
5	102 102.025	102 102.025	102.016	102.015	102.055	102.055	0.039	0.04

BT: Before test AT: After test DV: Deviation

Table 8: *Surface conditions of Cylinder liner*

SURFACE CONDITION	DV	BT	AT
(BURNT/PITTED/ERODED /SCOURED/LACQURED)	–	NORMAL	NORMAL

BT: Before test AT: After test

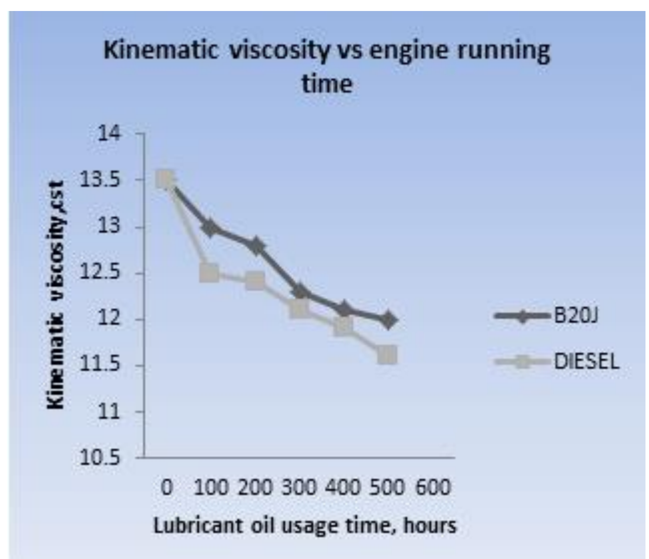

Figure 6: *Kinematic viscosity with respect to time*

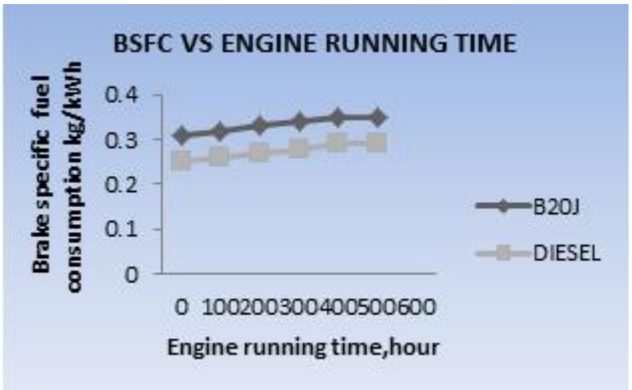

***Figure 7**: Brake specific fuel consumption with engine running time*

7 CONCLUSION

The production of biofuels such as bio-diesel is rapidly growing and fossil fuels are non-regenerative forms of energy resources and they become exhausted each day. Biofuels such as biodiesel are energy resources that are sustainable, eco-friendly and not harmful. Biodiesel has similar properties to petroleum diesel but biodiesel emits much lower CO2, sulfur and particulates than gasoline. The process can be produced using acid or base catalyst or enzymes as a catalyst by a simple transesterification process. The B20J engine and diesel engine were successfully conducted under the same conditions for the long term endurance test. Cylinder, piston, connecting rod and injector carbon deposit analysis for engine operations. Surface roughness testing application for surface ruggedness. Mechanical comparator is also use for surface roughness. The tested engine was performed successfully without any breakdown in engine with B20J. Break specific fuel consumption for B20J is more comparison with diesel. Jatrophacurcus has lower calorific valve, higher cetane number, and density than those of petro-diesel. Hydrocarbon emission (HC), carbon monoxide (co) has less of B20J. Thus blend of B20J in diesel has no adverse effect on the engine body part and lubricating oil

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