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IJIEMR Transactions, online available on 23rd Dec 2019. Link :http://www.ijiemr.org/downloads.php?vol=Volume-08&issue=ISSUE-12

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Volume 08, Issue 12, Pages: 447-454.

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PERFORMANCE ANALYSIS OF SINGLE CYLINDER 4-STROKE DIESEL ENGINE USING BIO-DIESEL WITH ADDITIVE

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Abstract— In the present work feasibility of soap nut biodiesel as a potential alternative fuel for diesel engine. It is the high time to investigate experimentally for biodiesels (alternative fuel) performance on single cylinder four stroke diesel engine using different blends of conventional Diesel and biodiesels. In India there is a much scope for usage of biodiesels (% usage of biodiesel) potential biodiesel that are derived from non-edible vegetable oil to minimize the dependency on conventional diesel thereby saving foreign currency on crude oil import biodiesel blends in different percentages example rich soap nut and lean soap nut your work is confined to lean soap nut biodiesel blend, exhibited satisfactory engine performance and emissions or the entire load engine therefore b20 biodiesel marginally better than the conventional diesel then other blends

Keywords—biodiesel, Blend , additives, Soap nut oil

I. INTRODUCTION

The most efficient prime movers commonly available today are the diesel engines. They move a large portion of world's goods, power much of the world's equipment, drive agriculture and rural sector and generate electricity more economically than any other device in their size range. The magnitude of present fuel crisis is going to worsen in future because of significant increase in fuel consumption rate over the last few decades in transportation and rural agriculture sectors in our country, a better design of the engine, using alternate fuels or effective fuel formation can considerably improve the engine performance and reduce harmful exhaust emissions. This in turn will lead to better break thermal efficiencies and lower environmental pollution.

Diesel engines achieve their high performance and excellent fuel economy by compressing air at high pressures, then injecting a small amount of fuel into this highly compressed air. High particulate matter (PM) and oxides of nitrogen (NOx) emissions remains a challenge of technical issues for the diesel engine today. The new areas of technical issues for the diesel engine today. The new areas of technology including fuels post combustion emission control devices to assist in future emission standards. The use of fuel additives was a cost-effective method, it results in reduction of particles with sizes under 2.5 μm. A maximum drop of freezing point about was measured 15 °c with organic based manganese, and the optimum rate of dosage was determined as 54.2 μmol Mn/L, equivalent to 700 ppm. The trend on the fall of freezing point when subjected to metal additive dosage was subjected to metal additive dosage was significant. To improve the quality of diesel fuel, various metal additives are doped with diesel for reaching more complete fuel combustion and reducing the amount of exhaust gases. The principle of this

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additive action consists of a catalytic effect on the combustion of hydrocarbons. Use of transition (or) noble metals in the form of fuel additives lower the soot ignition temperature.

Ariharan V, Meena Devi V, Parameswaran N, Nagendra Prasad P1. he present study concluded that the kernel contains 30% of a fatty acid, approximately 85% of triglycerides and sterol. The oil extracted from the kernel is used as a bio-fuel. It can be directly blend with the fossil fuel at the maximum of 20%. Soap nut seed has a great potential source for an inhibitory agent for the bio-corrosion of mild steel and copper alloys. Fruit can be used for cleaning the teeth, polishing jewellery. The physicochemical property reveals that that the oil blend B20 could be a potential source for biodiesel.

P. Jyothi Phaneendraand T. Venkateswara Rao. In this study, biodiesel was prepared from soap nut seed oil through transesterification process and it was blended with mineral diesel in three concentration ratios of 5%, 10% and 15% (v/v). Later the performance and exhaust emissions of a CI engine were experimentally investigated when the engine was fuelled with biodiesel-diesel blends. The experimental data was compared with baseline mineral diesel. The important findings are as follows: BSFC for biodiesel blends is comparable to diesel fuel at different loads. BTE is optimum for biodiesel blends at S15. Allblends showed good ITE next to diesel. Diesel has shown highest mechanical efficiency compared to blends. S15 has shown better mechanical efficiency at second load. Diesel is the least contributor of CO and CO2 emissions when compared to biodiesel-diesel blends. Overall, the optimum is found to be regarding blend wise S15 is considered to be better in getting mechanical efficiency.

S. Padmanabhan, S. Rajasekar, S. Ganesan, S. Saravanan and M. Chandrasekaran. Alternative fuels should be available at easily and at low cost, should be atmosphere friendly and provide safe energy needs without compromising diesel engine's operational performance. In this work, bio fuel from soapnut blends has been attempted as an alternative fuel. The experiments were conducted without any modification on the engine. CI engine performance tests were conducted with three blend ratios of soapnut oil with diesel. Based on the engine performance and emission characteristic test of the soap nut oil an admirable substitute fuel which gives better performance and similar emission characteristics results compared with base pure diesel.

Kamal Kant Vashistha, Jitendra Jayant, Dr. A. C. Tiwari. The present work was undertaken to experimentally investigate, the feasibility of soapnut bio-diesel as a potential alternate fuel for diesel engine, as well as the engine performance of a single cylinder, four stroke water cooled diesel engine using petrodiesel and lean soapnut bio-diesel blends with petro-diesel as engine fuels. The investigation was performed for medium to high load range of 50% - 93.75%. The load range of 50% - 93.75% was chosen as it's the major operational load range of an engine.

MATERIALS AND METHODS

I.MATERIALS:

A. BIODIESEL:

Biodiesel is an alternative fuel prepared from renewable biological sources such as vegetable oils both (edible and non-edible oil) and animal fats. The biodiesel has some rewards as compared to petroleum diesel. The most important advantages of biodiesel are higher flash point, biodegradability, improved cetane number and reduced exhaust emissions. Practically the higher viscosity of vegetable oils (30-200 Centistokes) as associated to that to Diesel (5.8- 6.4 Centistokes) leads to unfavorable pumping, inefficient mixing of fuel with the air contributes to the incomplete combustion, high flash point result in increased inferior coking and carbon deposit formation. Due to these problems, vegetable oil wants to be modified to bring the combustion associated properties closer to those of Diesel oil. The fuel modification is majorly aimed at reducing the viscosity and increasing the volatility.

One of the major promising processes to transform from vegetable oil to methyl ester is the Transesterification in which alcohol reacts with triglycerides of free fatty acids (vegetable oil) in the presence of catalyst like NaOH/KOH. Jatropha vegetable oil is one of the leading non-edible sources existing in India. The vegetable oil used for biodiesel production might contain free fatty acids which will improve specification reaction as a side reaction during the transesterification process.All countries are at currently heavily dependent on petroleum fuels for agricultural machinery and transportation. The fact that a few nations together to prepared the bulk of petroleum has led to high price variation and uncertainties in supply for the engrossing nations. This in turn has led them to search for alternative fuels that they themselves can produce. Among the alternatives being treated are methanol, ethanol, vegetable oils and biogas.

Vegetable oils have some of features that make them attractive as substitute for Diesel. Vegetable oil has the characteristics compatible with the Compression Ignition engine systems. Vegetable oils are also mixing with diesel fuel in any proportion and can be used as extenders. India majorly depends on import of petroleum crude and almost two third of its requirement is met through imports. Moreover, the gases released by petrol, diesel driven vehicles have an opposing effect on the environment and human health.

The significant advantages of using the Biodiesel are its renewability, biodegradability, better quality exhaust gas emission, also it does not contribute to an increase in the level of carbon dioxide in the atmosphere. The major sources for biodiesel are both edible and non-edible oils can be reached from such as edible oils like Peanut oil, Palm oil, Sunflower oil, Seasame oil, Soyabeen oil etc., and the non-edible oils like Jatropha Curcas, PongamiaPinnata, Calophyllum inophyllum, Mahau, etc. Hence, it is assumed that non-edible oils can be one of the solutions to meet the world energy demand and decrease the dependency on the edible oils.

B.SOAPNUT OIL:

Sap Indus is a genus of about five to twelve species of shrubs and small trees in the Lychee family, Sapindaceae, native to warm temperate to tropical regions in both the Old World and New World. The genus includes both deciduous and evergreen species. Members of the genus are commonly known as **soapberries** or **soap nut** because the fruit pulp is used to make soap. The generic name is derived from the Latin words sapo, meaning "soap", and indicus, meaning "of India".

C. **ADDITIVES:**

Compounds added to diesel fuels to improve performance, such as cetane number improvers, metal deactivators,corrosion inhibitors,antioxidants,rustinhibitors,anddisper sants

Isopropyl alcohol(C_3H_8O):

Isopropyl alcohol (IUPAC name propan-2-ol; commonly called isopropanol) is a compound with the chemical formula C_3H_8O. It is a colourless, flammable chemical compound with a strong odor. As an isopropyl group linked to a hydroxyl group, it is the simplest example of a secondary alcohol, where the alcohol carbon atom is attached to two other carbon atoms. It is a structural isomer of 1-propanol. It is manufactured for a wide variety of industrial and household uses, and is a common ingredient in chemicals such as antiseptics, disinfectants and detergents.

II.METHODS

D.Blends

Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for using in the retail diesel fuel market place. Much of the world uses a system known as the "B" factor to state the amount of diesel in any fuel mix.

- 100% biodiesel is referred to as B100.
- 20% biodiesel, 80%diesel is labelled B20.

TRANSESTERIFICATION

Preparation of B20:

In this we use 480 ml of conventional diesel and 120 ml of Bio fuel. The Bio fuel used is Soap nut Oil it is extracted from the tree sap Indus manganates.20% Soapnut oil, 80% diesel is labelled Biodiesel B20.It is done by using a 1000ml jar, in that first we pore 480ml of conventional diesel (biodiesel), and then 120ml of biofuel (Soapnut oil).

Mixing of additive in b20:

600ml is considered as 100% therefore, 10% of additive means 60ml therefore the rest 540ml is considered as 100% therefore 20% of soapnut oil is 108ml and 80% conventional diesel is 432ml and all of them are mixed in 1000ml jar and stirred well for perfect mix up.

Performance tests:

The following are the tests we come across by this project, they are:

- Performance test with conventional diesel under 0-100 % load.
- Performance test with B20 under 0-100% load.

A. IC Engine performance parameters:

- Indicated thermal efficiency(η_{ith})
- Brake thermal efficiency(η_{bth})
- Mechanical efficiency(η_m)
- Volumetric efficiency(η_v)
- Relative efficiency or Efficiency ratio(η_{rel})
- Mean effective pressure(Pm)
- Mean piston speed(Sp)
- Specific power output(Ps)
- Specific fuel consumption(sfc)
- Inlet-valve mach index(Z)
- Fuel-air or air-fuel ratio(F/A or A/F)
- Calorific value of the fuel(C_V)

Torque (T): The product of the moment arm R and the measured force, F is termed as torque of the engine and is usually expressed in Nm.

$T = R \times F$ Nm

Indicated thermal efficiency (η_{ith}):

Indicated thermal efficiency is defined as ration of indicated power to fuel power

Brake thermal efficiency (η_{bth}):

Brake thermal efficiency is defined as ratio of brake power to fuel power

Mechanical efficiency (η_m): Mechanical efficiency is defined as the ratio of brake power to the indicated power

$$\eta_m = \frac{BP}{IP} \times 100$$

Volumetric efficiency (η_v) Volumetric efficiency is defined as the volume flow rate of air tom the intake system divided by the rate at which the volume is displaced by the system.

$$\eta_v = \frac{V_{air}}{(v_{disp} \times \frac{N}{2})} \times 100$$

Mean effective pressure (P_m):

Mean effective pressure is the average pressure inside the cylinders of an internal combustion engine based on the calculated or measured power output. It increases as manifold pressure increases.

$$P_{im} = \frac{60000 \times IP}{LAnK}$$

$$P_{bm} = \frac{60000 \times BP}{LAnK}$$

- IP = indicated power (KW)

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- P_{im} = indicated mean effective pressure (N/m^2)
- L = length of the stroke (m)
- A = area of the piston (m^2)
- N = speed in revolutions per minute (rpm)
- N = number of power strokes
- N/2 for 4-stroke and N for 2-stroke
- K = number of cylinders

Specific fuel consumption (SFC):

$$SFC = \frac{\text{Fuel consumption per unit}}{\text{power}}$$

RESULTS AND DISCUSSIONS:

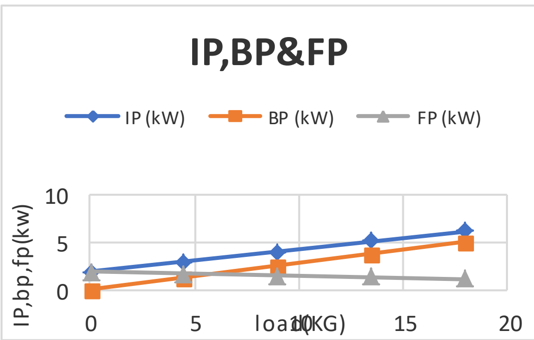
- Cylinder Bore 87.50(mm)
- Stroke Length 110.00(mm)
- Compression Ratio 17.50
- Swept volume 661.45 (cc)
- Area of piston (A) = 0.36 m^2
- Dynamometer Arm Length (mm): 185
- Calorific value (CV) = 42500 KJ/Kg
- Density (ρ) = 840 Kg/m^3

a) **Observation data for Conventional Diesel under 0-100 % load**

Load (Kg)	Speed (RPM)	Indicated Mean effective pressure (Pim) (bar)	Applied Force (N)	Air flow (mm WC)	Fuel flow (cc/min)
0.01	1571.00	2.15	0.09806	95.86	7.00
4.50	1504.00	3.62	44.1299	86.11	11.00
9.01	1488.00	4.92	88.3579	82.28	16.00
13.50	1474.00	6.33	132.3897	79.00	21.00
18.02	1463.00	7.63	176.7158	75.66	26.00

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.02	0.00	1.86	1.86	0.00	2.15	0.09	44.63	0.19
8.17	1.29	1.72	3.00	1.55	3.62	19.66	45.89	42.84
16.35	2.55	1.49	4.04	3.11	4.92	26.76	42.41	63.10
24.50	3.78	1.36	5.14	4.65	6.33	30.27	41.16	73.54
32.70	5.01	1.15	6.16	6.21	7.63	32.39	39.80	81.38

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
31.88	0.35	98.47	87.13	90.38	0.09	23.71	22.02	54.18
30.22	0.55	0.43	86.26	54.51	19.66	22.65	20.29	37.41
29.54	0.81	0.32	85.22	36.63	26.76	20.71	18.53	34.00
28.95	1.06	0.28	84.30	27.35	30.27	19.90	18.07	31.76
28.33	1.31	0.26	83.12	21.62	32.39	22.44	19.58	25.60



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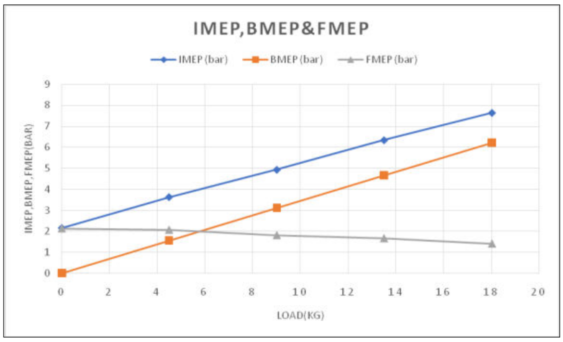
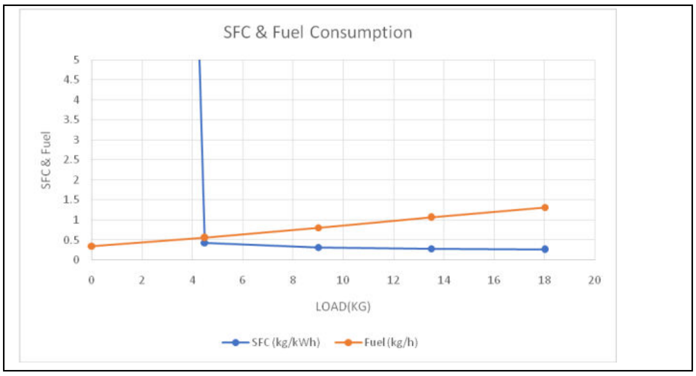
Break power, Indicated power& Friction power:



Indicated MEP, Break MEP & Friction MEP



SFC & FUEL CONSUMPTION:

b)**Observation data for B20 under 0-100% load**

- Cylinder Bore 87.50(mm)
- Stroke Length 110.00(mm)
- Compression Ratio 17.50
- Swept volume 661.45 (cc)
- Area of piston (A) = 0.36 m^3
- Dynamometer Arm Length (mm): 185
- Calorific value (CV) = 40431 KJ/Kg
- Density (ρ) = 864 Kg/m^3

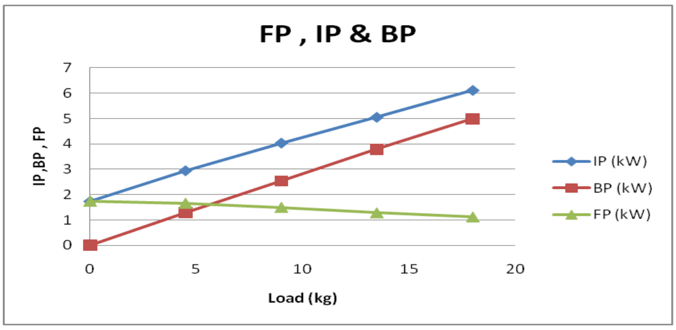
OBSERVATION TABLE FOR B20:

Speed (rpm)	Load (kg)	Comp Ratio	T1 (deg C)	T2 (deg C)	T3 (deg C)	T4 (deg C)	T5 (deg C)	T6 (deg C)
1538	0.01	17.50	42.87	43.83	42.87	41.12	117.81	99.03
1505	4.50	17.50	42.90	47.41	42.90	42.19	163.85	131.49
1484	9.01	17.50	42.89	49.78	42.89	43.24	213.12	167.13
1476	13.50	17.50	42.91	52.43	42.90	44.57	271.14	209.62
1460	18.02	17.50	42.89	55.84	42.90	46.40	349.71	266.92

Air (mmWC)	Fuel (cc/min)	Water Flow Engine (lph)	Water Flow Cal (lph)	Air (mmWC)	Fuel (cc/min)	Water Flow Engine (lph)	Water Flow Cal (lph)	Air (mmWC)
93.84	7.00	200	100	93.84	7.00	200	100	93.84
87.58	12.00	200	100	87.58	12.00	200	100	87.58
82.94	17.00	200	100	82.94	17.00	200	100	82.94
79.44	22.00	200	100	79.44	22.00	200	100	79.44
75.78	27.00	200	100	75.78	27.00	200	100	75.78

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.02	0.00	1.74	1.74	0.00	2.06	0.09	42.80	0.20
8.17	1.29	1.66	2.95	1.55	3.56	18.43	42.26	43.61
16.35	2.54	1.50	4.04	3.11	4.94	25.67	40.87	62.83
24.50	3.79	1.28	5.06	4.65	6.23	29.57	39.54	74.78
32.70	5.00	1.12	6.12	6.21	7.60	31.81	38.93	81.71

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. OF (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
31.55	0.36	103.46	88.05	86.94	0.09	5.48	21.73	72.71
30.48	0.62	0.48	86.93	48.99	18.43	15.07	18.61	47.89
29.66	0.88	0.35	85.80	33.66	25.67	16.25	17.55	40.53
29.03	1.14	0.30	84.42	25.45	29.57	17.34	17.57	35.52
28.35	1.40	0.28	83.35	20.25	31.81	19.21	18.66	30.32



Friction power, Break power, Indicated power:

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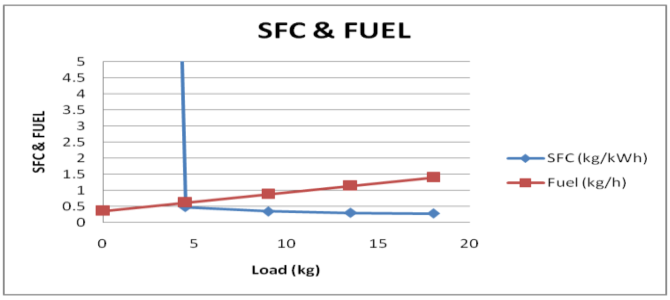
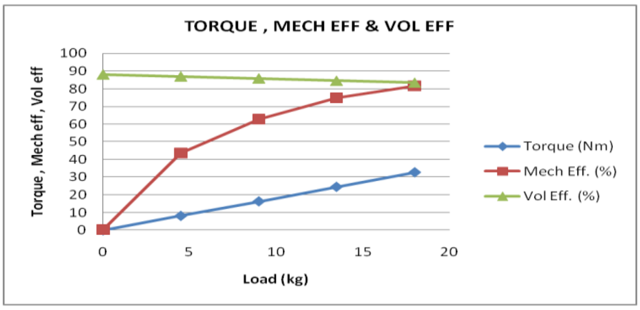
INDICATED THERMAL EFFICIENCY, BREAK THERMAL EFFICIENCY



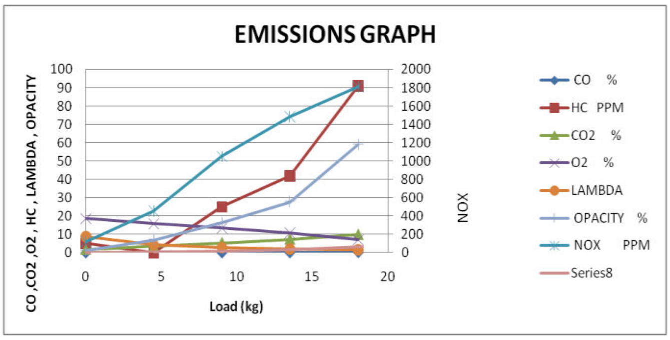
SFC & FUEL CONSUMPTION:



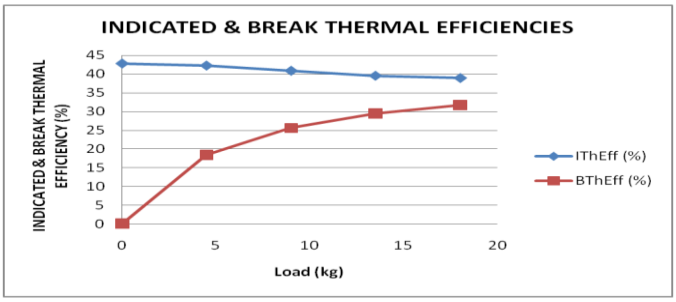
TORQUE, MECHANICAL EFFICIENCY, VOLUMETRIC EFFICIENCY

EXHAUST GAS EMISSION DATA

Load (Kg)	CO %	HC PPM	CO2 %	O2 %	NOX PPM	LAMBDA	OPACITY %
0.01	0.007	5	1.68	18.56	119	8.715	1.3
4.5	0.008	0	3.55	15.86	454	4.129	7
9.01	0.021	25	5.31	13.37	1051	2.753	16.4
13.5	0.039	42	7.32	10.69	1485	2.012	27.8
18.02	0.15	91	9.9	7.02	1815	1.476	59.1



EXHAUST GAS EMISSIONS GRAPH



CONCLUSION:

- The fuels with different compositions of diesels, soap nut oil and Diethyl Ether are blended by using mechanical stirrer.
- The performance tests like Indicated Power, Break Power, Specific Fuel Consumption, Total Fuel Consumption, Mechanical efficiency, Break Thermal Efficiency, Indicated Thermal Efficiency were conducted on single cylinder four stroke diesel engine. And analysis of exhaust emissions also conducted.

  The emissions B20+Iso propyl Alcohol results in lowering HC

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