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Investigations On Performance And Emission Characteristics Of CI Engine Fuelled With Juliflora seed Oil Biodiesel Blends

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Abstract

The present work investigates the performance of a diesel engine the use of Juliflora Oil biodiesel in phrases of brake specific fuel consumption and brake thermal efficiency as well as exhausts emissions. Juliflora Oil, a non-edible instantly vegetable oil became mixed with petroleum diesel in various proportions to evaluate the overall performance & emission characteristics of a single cylinder direct injection constant speed diesel engine. Blends of diesel oil and Juliflora Oil biodiesel with concentrations of 10 %(B10), 20 %(B20), and 30 %(B30) were used as fuels. Tests have been achieved for engine operations and engine overall performance parameters such as fuel consumption, brake thermal efficiency, and exhaust emissions (CO, HC and NOx) have been recorded. Among the blends B20 has proven a higher overall performance with respect to brake specific fuel consumption and brake thermal efficiency. All blends have proven better CO emission after about 75% load. The emissions of HC are relatively decrease at B20. However the NOx emissions have been better for all of the blends at all loads. The results screen that B20 has an overall higher performance as regards to each engine performance and emission characteristics.

Key words: Biodiesel, Juliflora Oil, Soxhlet apparatus, transesterification.

1.Introduction

1. The fossil fuels are depleting hastily and the prices are going up day by day. As aend resultalternative fuels have acquireda whole lotinterestbecause of its ability to update fossil fuels. Moreover, the environmental issuesconcerned with the exhaust gases emission with the aid of usingthe use of fossil fuels additionallyinspirethe use ofopportunity fuels together with biodiesel. In this context, there wasdevelopinghobby on alternative fuels like vegetable oils to provide a suitable diesel oil substitute for internal combustion engine. The veggies oils cannot be used immediately in diesel engines as alternativefuelbecause ofhigh viscosity of vegetable oils leads to problem in pumping and spray characteristics. The inefficient blending of vegetable oils with air contributes to incomplete combustion.Thus, although short-termtestsusing neat vegetable oils showed promising results, problemsappeared after the engine were operated for longer periods. Researchers have suggesteddifferentstrategies for decreasing the viscosity of the vegetable oils. The bestwayto use vegetable oils as fuel in diesel engines is to convert it into biodiesel. The differentstrategies are mixing with diesel fuel, micro-emulsification with methanol or ethanol, thermal cracking, and conversion into biodiesels through the transesterification process. Among these transesterification process is maximumwidely used. The benefits of biodiesels are that they are renewable, can be produced locally, cheap, higher lubricity, higher cetane number, minimal Sulfur content material and much less pollutant for environmentcompared to diesel fuel. On the other hand, their disadvantagesinclude the better viscosity and pour point, and lower calorific value and volatility. Moreover, their oxidation stability is lower, as solvents maycause corrosion in various engine components. In this experimental investigation, engine examshad beencarried outusingthreetypes of bio-diesel blends of oil to compare the performance and emission in a four-stroke single-cylinder direct-injection CI engine .

2. Production Of Juliflora Oil

Juliflora Oil is a tree Growing to a top of as much as 12 metres (39 ft), P. juliflora has a trunk diameter of as much as 1.2 metres (3.nine ft).[4] Its leaves are deciduous, geminate-pinnate, mild green, with 12 to twenty leaflets. Flowers seemquickly after leaf development. The plants are in five–10 cm lengthy green-yellow cylindrical spikes, which arise in clusters of two to fiveon the ends of branches. Pods are 20 to 30 cm lengthy and compriseamong 10 and 30 seeds according to pod. A mature plant can produce masses of heaps of seeds. Seeds stayfeasible for up to ten years. The tree reproduces completelyvia way of means ofmanner of seeds, now no longer vegetatively. Seeds are unfoldvia way of means offarm animals and different animals, which eat the seed pods and unfold the seeds of their droppings.[5]

Sincevegetableoilshavecetanenumbersclosetothatofdiesel fuel,they canbeusedinexistingcompressionignitionengineswithlittleorno modifications.Vegetableoiloffersmany benefits,includingsustainability,reductionof greenhousegasemissions,regionaldevelopment,andimprovementin agriculture.The chemicalcompositionofvegetableoilhelpsinreducing theemissionofunwanted components when theyareburned

Fig.1:Juliflora tree and seeds

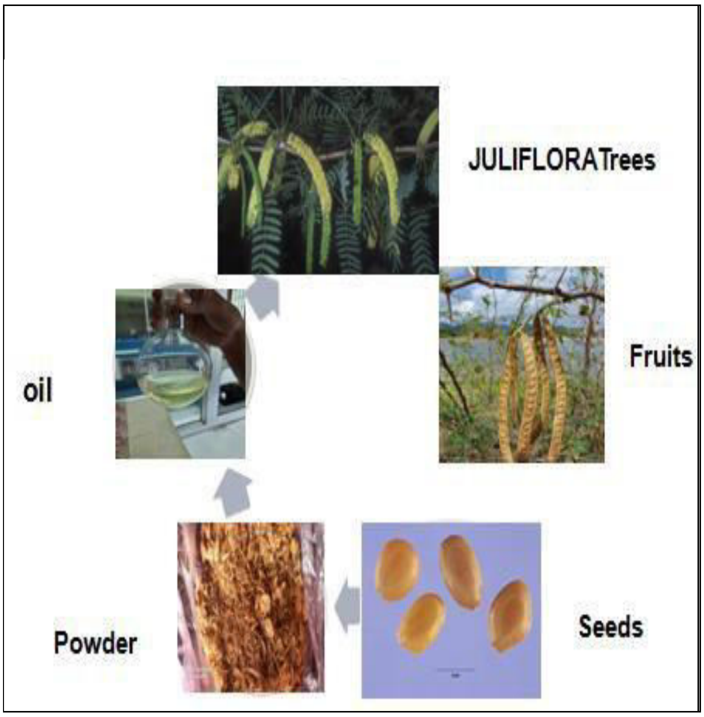

Fig.2:Juliflora oil production process

2.1 Soxhlet apparatus

A Soxhlet extractor is a piece of laboratory apparatus invented in 1879 by Franz von Soxhlet. It was originally designed for the extraction of a lipid from a solid material. Typically, Soxhlet extraction is used when the desired compound has a limited solubility in a solvent, and the impurity is insoluble in that solvent. It allows for unmonitored and unmanaged operation while efficiently recycling a small amount of solvent to dissolve a larger amount of material.A Soxhlet extractor has three main sections: a percolator (boiler and reflux) which circulates the solvent, a thimble (usually made of thick filter paper) which retains the solid to be extracted, and a siphon mechanism, which periodically empties the thimble

Fig:2.1Soxhlet apparatus

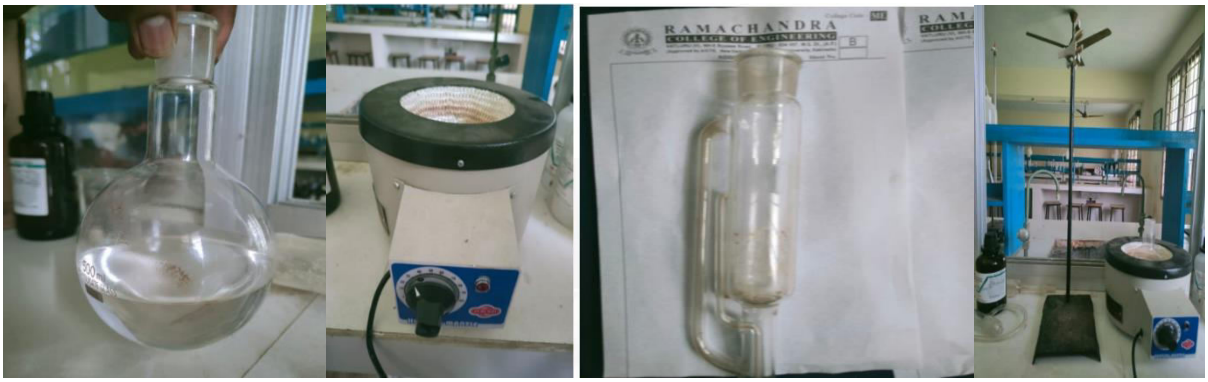

Fig:2.1.1 Soxhlet apparatus components

Fig 2.1.2 Preparation of Soxhlet process and produce juliflora raw oil

Fig 2.1.3 juliflora raw oil

3. ProductionProcessOfBiodiesel UsingJuliflora Oil

Vegetable oilfuelsgenerated an acceptable engine performanceandexhaust gasemissionlevelsforshort-termoperationonly,whereasthey causedcarbondeposit buildups and sticking of piston rings after extended operation. They also suggested practicalsolutionstoovercometheseproblems,suchasincreasingthefueltemperatureto200^{O}C,blending25%dieselfuelinthevegetableoil,blending20%ethanolinthefuel,orconvertingvegetableoilintomethylesters.Blendingof vegetableoilswithdieselfuel would solvethe problems of dieselengine operation with neat vegetableoils

Transesterification

Theprocessofconverting vegetableoilintobiodieselfueliscalled Transesterificationandisluckily lesscomplexthanitsounds.Chemically, Transesterificationmeanstakingatriglyceridemoleculeoracomplexfatty acid, neutralizingthefreefattyacids,removingtheglycerin,andcreatinganalcoholester.This isaccomplishedby mixingmethanolwithsodiumhydroxidetomakesodiummethoxide. Thisliquidisthenmixedintothevegetableoil.Afterthemixturehassettled,Glycerinis leftonthebottomandmethylesters,orbiodieselisleftontopandiswashedandfiltered. ThefinalproductBioDieselfuel,whenuseddirectlyinaDieselEnginewillburnupto75% cleaner then mineral oil Diesel fuel.Thetechnologyis matureand proven.

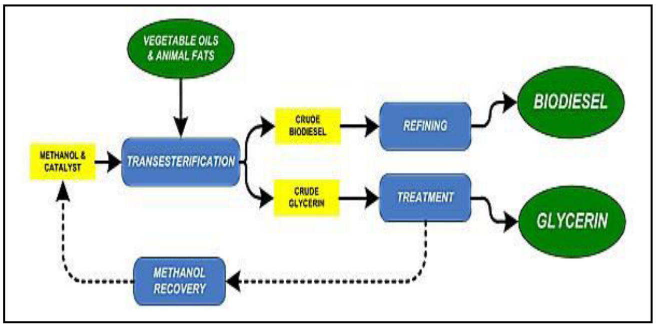

Fig 3.ProductionProcess ofBiodiesel using Juliflora Oil

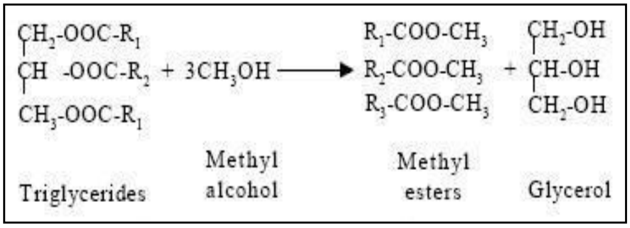

Fig 3.1 TransesterificationofTriglycerides

4.Blend Preparation

ThetransesterifiedJuliflora Oilisthenblendedwithpetroleumdieselindifferent ratios as follows

B10 -10%of Juliflora Oil and 90%of petroleum diesel.

B20 -20%of Juliflora Oil and 80%of petroleum diesel.

B30 -30%of Juliflora Oil and 70%of petroleum diesel.

Firstly theJuliflora Oil ismixedwithpetroleumdieselin3differentratiosin3 beakers.Thenthesebeakersareplacedinanelectricalwaterbathandisthenheatedat 40^0Cfor20minutes.Themixtureisheatedtoevaporatethewatervapourspresentinthe Juliflora Oil andtoremovetheSulphurcontentinitas theirpresencecausessootinthe piston cylinder during the combustion process. Thus the blended fuel samples were prepared by mixingJuliflora Oil methyl-esterwithpetroleumdiesel,at10-30%,with10% increment byvolume

Fig 3.1 Mixing ofJuliflora Oil-Diesel fuel blends

5.Blend Properties

The importantcauseof mixing the Juliflora Oil biodiesel with diesel is to lower the viscosity of the Juliflora Oil biodiesel and enhance volatility of biodiesel however its molecular structurestays unchanged. Properties of blends of Juliflora Oil biodiesel with diesel like B10, B20 and B30 are provenin thebelow table

Property	**Blends**				
Density *(Kg/m^3)*	811	833	824	834.3	870
Viscosityat 40^{o}C *(Cst)*	2.64	3.76	3.24	3.72	5.87
CalorificValue *(MJ/Kg)*	42.24	41.56	41	39.56	35.83

Flash Point (^{O}C)	55	61	58	65	162
Cloud Point(^{O}C)	9	10	11	12	13
"**B**"standsforBiodiesel&"**D**"stands forDiesel					

Table 5: Fuel properties ofblends ofJuliflora biodieselandneat diesel

5.1 Density

Density is definedas the ratio of the mass of the gas to the quantity of the gas. The variation of density of the blends is shown in below figure. Diesel has lowest density and naturalJuliflora Oil biodiesel has the best density. B20 has density towards diesel.

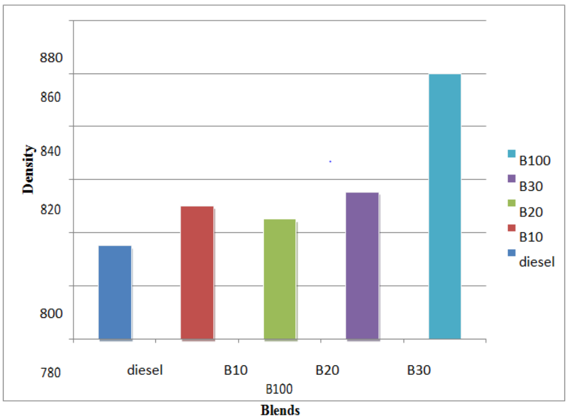

Fig5.1 Comparisonof density ofblendedfuelswith diesel

5.2 Calorific Value

The calorificvalueisthemeasurementofheatorenergy produced,andis measuredeitherasgrosscalorificvalueornetcalorificvalue.The differenceisdetermined by thelatentheatofcondensationofthewatervapourproducedduringthecombustion process.Grosscalorificvalue(GCV)assumesallvapourproducedduring thecombustion processisfully condensed.Netcalorificvalue(NCV)assumesthe waterleaveswiththe combustionproductswithoutfullybeingcondensed.Fuelsshouldbecomparedbasedon the net calorificvalue. Calorificvalue is low forB100.

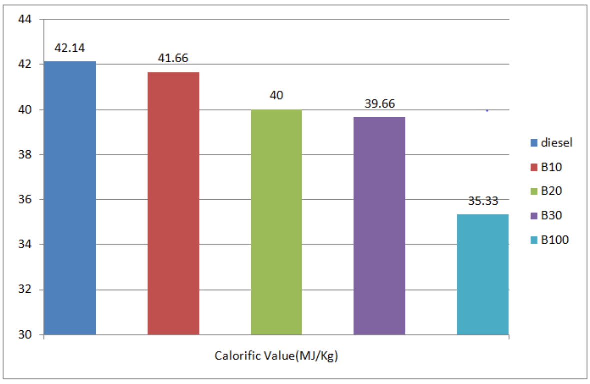

Fig 5.2 ComparisonofCalorific Valueofblended fuelswithdiesel

6.Experimental Procedure

- The enginewasstarted usingdiesel asfueland isallowed to runfor20 minutes so as to attain steadystatecondition.
- Nowthedigitalindicatorswereswitchedonforreadingthetemperatures(exhaust gases) sensed bythermocouples.
- Timetakenfor theconsumptionof10ccoffuelwasmeasuredwiththehelpofastop watch and burette.
- Readingsweretakenfromtheengineatnoload,25%,50%,75%,100%, loadsapplied on the engine with the help of electrical dynamometer.
- Allthe readingsthatare takenwhentheengine wasrun, usingdieselasfuelwere tabulatedandvariousperformancecharacteristicssuch asfuel consumption,brake thermal efficiency,etc. werecalculated.
- Nowthe aboveprocedurewillberepeated for blended fuels i.e.,B10, B20and B30.
- Smokedensityoftheexhaustgasescomingoutoftheenginewasmeasuredusing

AVL 437C smokemeter for allthe aboveexperiments.

- All theresults wereplotted and compared

7.Model calculations

Rated BrakePower (BP) : 5HP

Speed (N) : 1500 RPM

Bore (D) : 87.5 mm

Stroke(L) : 110 mm

1. <u>BRAKE POWER</u>(BP):

$$B.P(elec) = \frac{2x\pi xNxT}{60} \text{ KW}$$

$$B.P_{(eng)} = B.P_{(elec)} / \eta_{tran}$$

Where, η_{tran}=transmission efficiency=0.7

2. MASSOFFUELCONSUMED PERMINUTE(mf):

$$mf = \frac{PipetteReading\ xDensityofdieselx60}{1000}\ Kg/min$$

Where, Densityof diesel = 0.86gm/ml

3. TOTALFUELCONSUMPTION (TFC):

$$TFC = mfx60\ Kg/hr$$

4. SPECIFICFUELCONSUMPTION (SFC):

TFC

$$SFC = TFC /BP\ \ Kg/KW\text{-}hr$$

5. HEATINPUT (HI):

$$HI = \frac{TFC}{60x60}\ x\ C_V\ \ K$$

Where, C_V =Calorificvalue ofdiesel=40,000KJ/Kg(approx.)

8.Results and Discussions

Theexperimentswere conductedonasinglecylinder,fourstroke,constant speed,watercooled,directinjectionCI enginefor variousloadsand variousblendsof biodiesel.Analysisof performance parametersandemissioncharacteristicslikebrake specific fuel consumption, brake thermal efficiency, hydrocarbon, carbon monoxide, carbondioxide and nitrogen dioxideare evaluate

Load (kg)	**BP (kW)**	**Diesel**	**B10**	**B20**	**B30**
0.12	0.03	0.019	0.028	0.017	0.017
4.52	1.31	0.014	0.021	0.012	0.011
9.13	2.60	0.023	0.017	0.021	0.024
13.53	3.80	0.040	0.035	0.037	0.037
18.20	5.04	0.114	0.121	0.109	0.086

Table-8.1:Thefollowing tableshows the emissions ofCO in%fordiesel andOther blends:

Load (kg)	**BP (kW)**	**Diesel**	**B10**	**B20**	**B30**
0.12	0.03	7	7	5	4
	1.31	19	18	11	9
9.13	2.60	30	29	14	11
13.53	3.80	40	37	42	14
18.20	5.04	85	80	71	16

Table-8.2: Thefollowing tableshows the emissions ofHC inPPMforandotherblends

GRAPHPLOTTED FOR EMISSIONSOF HC INPPM:

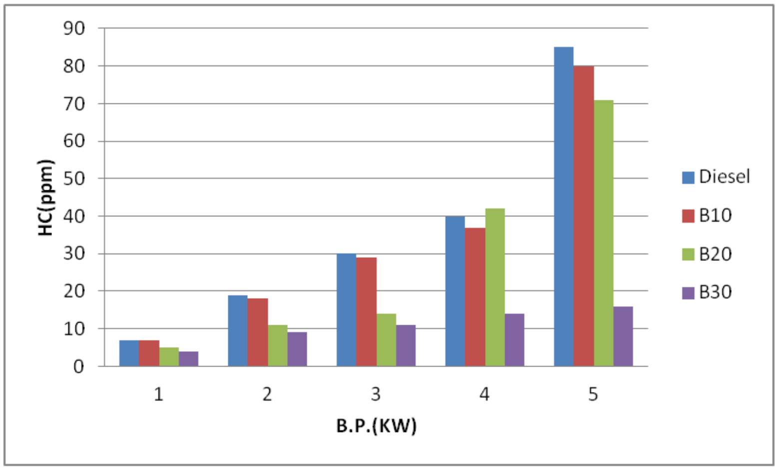

Fig 8.1Graph plotted forBrakePowerVs HC Emissions

Fig8.1shows the variation ofHCemissionswithload fordifferentdiesel–biodieselblends&neatdieselatcompressionratioof17.5:1andinjectionpressure of200 bar.TheHCemissionfor alltheblendsandneatdieselgoesonincreasesasloadincreases. B20showsthe lowerHCemissioncomparedtoneatdieselatallloads.Areasonforthe reductionof HCemissionswithbiodieselistheoxygencontentinthebiodieselmolecule, whichleadstomorecompleteandcleanercombustion.The HCemissionsare almostsame for allblends &neat diesel.

Load (kg)	**BP (kW)**	**Diesel**	**B10**	**B20**	**B30**
0.12	0.03	91	103	99	88
4.52	1.31	425	445	438	434
9.13	2.60	997	1016	982	973
13.53	3.80	1421	1446	1437	1434
18.20	5.04	1754	1783	1769	1758

Table-8.2:The following tableshows the emissions ofNOX inPPMfordiesel and Other Blends

GraphPlotted For EmissionsOfNox:

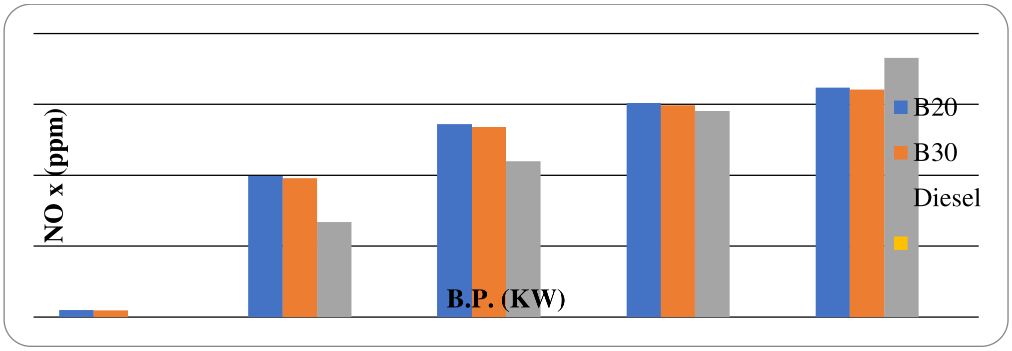

Fig 8.3Graph plotted forBrakePowerVs NOxEmissions

Fig8.3:showsthevariationofNO_X emissionswithloadfordifferentdiesel–biodieselblends&neatdieselatcompressionratioof17.5:1andinjectionpressure of200 bar. The NO_X emission for all the blends and neat diesel goes on increases as load increases.BiodieselshowsthehigherNO2emissioncomparedtodiesel atallloads.From thisbargraph,twoobservationsaremade.First,NO_X emissionsareadirectfunctionof engineloading.Thisisexpectedbecausewithincreasing load,thetemperatureprevailing insidethecombustionchamberincreasesandNO2formationisastrongly temperature dependant phenomenon.ThesecondobservationisthathigherNO_X isduetohighertemperatures prevailing inthecombustionchamber ofthebiodiesel-fuelledengine.Thisisalsoreflected bythe higher exhaust gas temperaturefrom thebiodiesel-fuelledengine

Brakepower (KW)	**B.Peng (KW)**	**T.F.C (Kg/h)**	**S.F.C (Kg/KW-h)**	**Hb th**
0.00	0.03	0.434	0	0
1.25	1.31	0.507	0.709	13.39
2.50	2.60	0.585	0.409	21.96
3.75	3.79	0.664	0.309	29.06
5.00	5.03	0.880	0.246	36.55

Table-8.4:Thefollowing tableshows the SFC, BrakeThermal Efficiency forDiesel

Brakepower (KW)	B.Peng(KW)	TFC (kg/h)	SFC (kg/kWh)	BThEff (%)
0.00	0.03	0.30	8.75	0.97
1.25	1.31	0.55	0.42	20.19
2.50	2.60	0.80	0.31	27.40
3.75	3.79	1.01	0.26	32.07
5.00	5.03	1.26	0.25	34.03

Table-8.5:Thefollowing tableshows the SFC, BrakeThermal Efficiency forB10

Brakepower (KW)	B.Peng(KW)	TFC(kg/h)	SFC (kg/kWh)	BThEff (%)
0.00	0.03	0.30	8.87	0.96
1.25	1.31	0.56	0.43	19.88
2.50	2.60	0.81	0.31	27.19
3.75	3.79	1.07	0.28	30.20
5.00	5.03	1.32	0.26	32.35

Table-8.6: Thefollowingtableshows the SFC, BrakeThermal Efficiency forB20

Brakepower (KW)	B.Peng(KW)	TFC (kg/h)	SFC (kg/kWh)	BThEff (%)
0.00	0.03	0.31	9.02	0.94
1.25	1.31	0.56	0.43	19.59

2.50	2.60	0.82	0.32	26.80
3.75	3.79	1.08	0.28	29.89
5.00	5.03	1.33	0.26	32.09

Table-8.7:Thefollowing tableshows the SFC, BrakeThermal Efficiency forB30

9.Conclusion

Thefollowing conclusions aredrawnfromthisinvestigations

The fuel properties results of all blends show that blends of up to20% straight Juliflora Oil have value of viscosity and density equivalent to specific range for diesel engine fuel, therefore it can be concludedthatupto20% blend can be used to run the stationary diesel engine at short term basis. Engine performance with biodiesel does not differ greatly from that of diesel fuel. The B20 shows good brake thermal efficiency in comparison with diesel. A little increasein fuel consumption is often encountered due to the lower calorific value of the biodiesel. MostofthemajorexhaustpollutantssuchasCO,CO2and HC are reduced with the use of neat biodiesel and the blend as compared to neat diesel. But NO2 emissions increase when fuelled with diesel–bio diesel fuel blends as compared to conventional diesel fuel. This is one of the major drawbacks of biodiesel. Among the blends,B20 shows the better performance and emission characteristics. In view of the petroleum fuel shortage, biodiesel can certainly be considered as a potential alternative fuel

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