

Performance Combustion and Emission Analysis of Diesel Engine Using Different Bio Fuels Diesel-RK

Chitteti Venkatesh Reddy^{1*}, D. Praveen Kumar Reddy², M. Srinadh³, Badu Dharmateja⁴

^{1,2,3,4}Student, Department of Mechanical Engineering, Audisankara College of Engineering and Technology, Gudur, India

Abstract: Alternative of the conventional fossil fuel has been an important concern in current energy scenario due to its capable performance characteristics in internal combustion engines. Numerous analysis is conducted for estimating performance, combustion and emission characteristics of an internal combustion engine which offers near values to the regular diesel fuel engines. In this work, comparative analysis is evaluated with two biodiesels as SME (B5, B20, B40 and B100), RME and Pure Diesel, using Diesel RK - single cylinder, naturally aspirated, liquid cooled, direct injection diesel engine with altered engine load (20%, 40%, 60%, 80% and 100%) at stable compression ratio (CR17.5). The study performed to evaluate the performance, combustion and emission analysis of two different bio-fuels with pure diesel. The outcomes characteristics (performance, combustion and emission) from this analysis are nearer to the pure diesel. Bio-fuels are capable as alternative fuels for IC engine.

Keywords: pure diesel, diesel engine, efficiency combustion analysis.

1. Introduction

Demand for the industrial fuel in Asia's 3rd major financial system is projected in the direction of raise between 5 and 8 percent this year, Since the rise of crude oil prices which are a huge distress which affect country's financial system and expansion (pollution also remainders a main dispute) one of the major are emanation from the automotive. Due to the increasing rates of crude oil, the researchers have compelled to find an alternative solution. One of the foremost necessary parts in present world is energy. In 2012, overall energy utilization was 1.5891014 kWh [1]. Raising trade in of rock lubricate by the ordinarily temperamental costs influences the socio-money related structure of states. Additionally, overall global warming is due to consuming of fuel might be a noteworthy risk to the environment. For example, circumstance, requests the usage of sustainable power sources [2]. Biodiesel is a determination for fuel. It's innocuous, recyclable, highlights a small emanation summary and its utilization decreases the harmful ecological effects of abuse petroleum products. Hence, performance, combustion & emission characters of diesel engine by means of different bio-diesels (SME B5, SME B20, SME B40, RME B100 AND SME B100) and pure diesel. Performance,

combustion, and emission characteristics variations are estimated and graphically reported at different engine loads in this work.

2. Literature Review

The present work concerns by transesterification of genus *Jatropha lubricate* which supplies >83% of methyl radical organic compound and >17% of glycerine exploitation molar quantitative relation 6:1 (methyl alcohol to oil) plus 0.5wt % of sodium hydroxide at 650 C for ninety minutes and grant to settle long. The properties of biodiesel Depends on top of the character of the lubricate to be exercised for preparation of biodiesel depends method is scaled up to industrial levels then glorious business chance are offered by the biodiesel obtained from genus *Jatropha* oil alkyl organic compound. And it may well be a severe pace towards the making of an ecological transport fuel that's comparatively spotless on ignition and provide farmers through substantial gain. B20 is best mix among option biodiesel mixes. Extra the execution and burning character of B20 be amazingly close towards diesel though the radiation character of B20 is more advantageous than that of diesel in light of the fact that the spread of CO, HC and smoke is 27.27%, 23.8%, and 8.3% a lesser measure of B20 than diesel severally. In this way we watch out for all over that B20 is that the best mix of WP for proxy of diesel that can downsize diesel utilization via 20% It was discovered that the tried biodiesels give for all intents and purposes vigorous execution parameters by and large seek after indistinguishable as oil fuel, while the exegetic introduction related pattern through comparable energetic ones. Sturdiness of the solution is an additional subject which is able to be examining in an exceedingly.

The diminishing in pressure quantitative connection will expand the discharges of CO, HC and smoke; any way the radiation of Roman divinity and ozone depleting substance decay with lessen in pressure quantitative connection [8]. At full engine load, the NOx emanation was condensed by 15% for JME-GO mixes compare to clean *Jatropha* biodiesel. The outcome additionally illuminated that the combination of 50 mg/L had the maximum development within the character of emissions and engine performance [9]. Exergy disposal will

*Corresponding author: venkateshreddyvenkey0@gmail.com

increment with augmentation in biodiesel volume inside the mix and it totally was impressively more prominent for fuel application with B40 at various hundreds. Outcome conjointly demonstrates that the motor productivity is a littler sum just if there should be an occurrence of fuel application through biodiesel blends. This examination demonstrates the extent of improvement in motor applications through biodiesel fuel mixes remarkably with B40 and in this way the more noteworthy offer mixes [10]. It totally was conjointly discovered that the biodiesels are having altogether lower CO transmission than diesel. NOx outflows were slightest at superior burden in diesel pursued by devastate planning oils. Residue outflows were indistinguishable for diesel, squander arrangement oils, at low burden; any way at higher burden diesel has partner degree exponential addition in ash discharges [11]. For accessibility in brake control still as fumes gases of diesel were 5.66 and 32% more than that of B20. Destructed accessibility of B20 was 0.97% more than diesel. Therefore, according to as execution, emanation, vitality, and exergy half were concerned; B20 is found to as great option of diesel [12]. The energy investigation shows that concerning 37.23 and 37.79 is transformed to capability to accomplish exertion for diesel and SB20 severally. The competence was 34.8 and 35% for diesel and Simarouba respectively. [13]. Iso-butanol add-on is a plausibility to mix with current lower extent connection of methanol-fuel for SI motor activity as a substitute gas [14].

3. Methodology

The system to estimate the performance, combustion and emissions is adopted by the Diesel RK model for super charged engine. The components utilized are as follows

Engine: is a machine intended to alter one form of energy into mechanical energy engine burns fuel to create heat which is next employed towards work.

Calorimeter: It is used for measuring amount of heat involved in the process. It is utilized for estimating measure of warmth engaged with the procedure.

Rotameter: It is used for computing the volumetric flow rate of the fuel into system. It is used for evaluating the volumetric stream rate of the fuel into the structure.

Dynamometer: It's an instrument which is used for measuring the power output of an engine employed in a number of other roles. It's an instrument which is utilized for estimating the power yield of a motor. Indeed, past basic power and torque estimations, dynamometers can be utilized as a component of a proving ground for an assortment of motor advancement exercises.

Control panel: Control panel controls the programming's that to be performed in a systematic way. Control board controls the programming's that to be performed deliberately.

Table 1, presents the engine specification which is used in this analysis. Table 2, presented with physical – chemical properties of different fuels. Table 3, presented with comparisons of various parameters from numerical and experimental studies are displayed in the Appendix A.

The DIESEL-RK is proficient thermodynamic full-sequence motor reproduction programming. DIESEL-RK is centred

around cutting edge diesel burning re-enactment and on emanation development forecast as of all purpose multi cylinder motor idea examination positive outline of motor frameworks. The piece of DIESEL-RK include gas-exchange model, heat-exchange in engine essentials, turbo charging, EGR, friction, water condensation, etc.

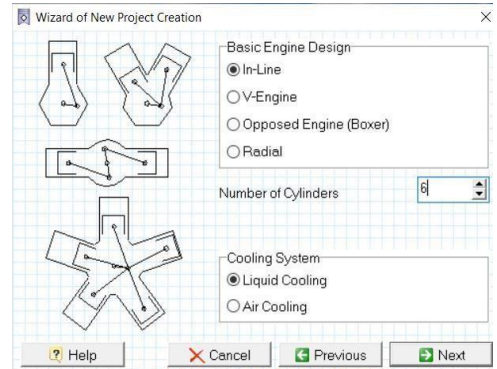


Fig. 1. Input sub-window of new project creation-engine selection

In the above Figure 1, variations in the values of number of cylinders, cooling system either liquid cooling or air cooling and basic engine design inline engine V-engine opposed engine (boxer radial) can be performed.

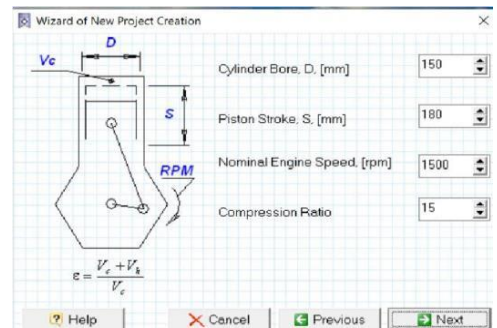


Fig. 2. Window involve of new engine creation-engine dimensions

In the above Figure 2, sub-window the values of cylinder bore (mm), piston stroke (mm), nominal engine speed (rpm), compression ratio can be varied.

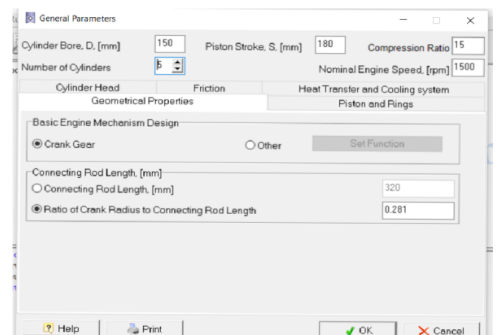


Fig. 3. Input sub-window of general parameters

In the above sub-window of the general parameters, we can vary the connecting rod length or the ratio of the crank radius to connecting rod length.

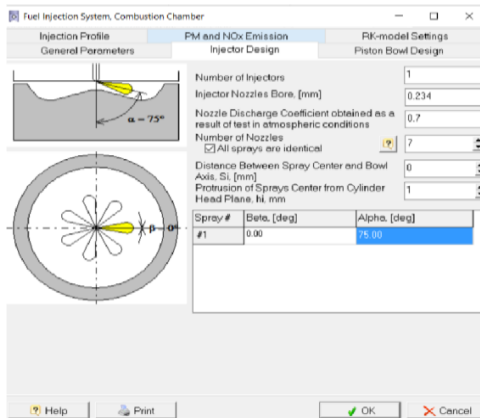


Fig. 4. Input sub-window of fuel injection system, combustion chamber

In the above sub-window injector design is presented in this the number of injectors, injector nozzle bore(mm), number of nozzles and the angle between the sprays, nozzle discharge coefficient obtained as a result of test in atmospheric conditions can be varied.

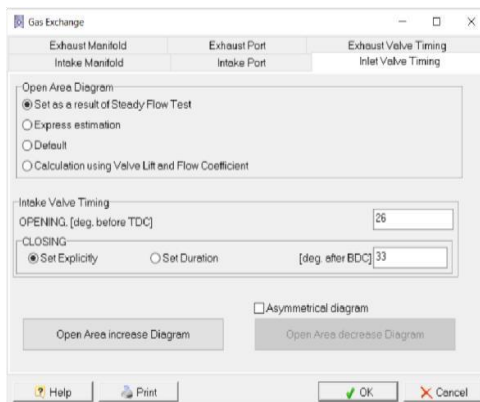


Fig. 5. Input sub-window of gas exchange

This is the figure 5, of the gas exchange, in this inlet value timing i.e. opening [DEG.BEFORE TDC], closing [DEG.AFTER BDC] can be varied.

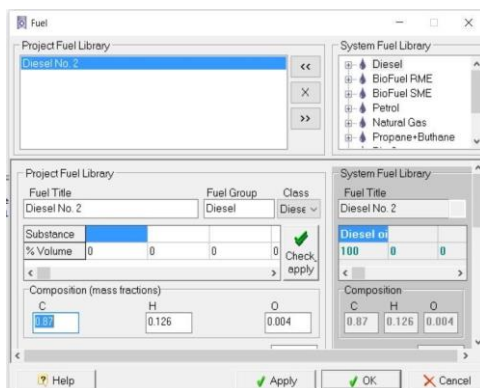


Fig. 6. Input sub-window of fuel library

In the above figure 6 fuel a library is presented, we can select various fuels that are used in the time of combustion.

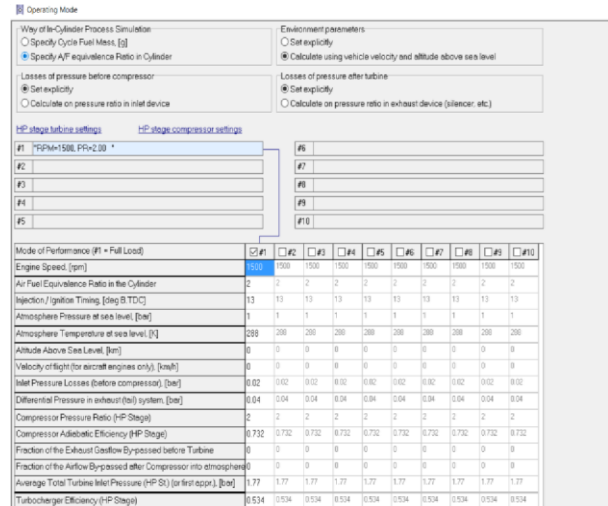


Fig. 7. Input sub-window of operating mode

In the above Figure 7, of operating mode is presented where we can select the way of in-cylinder process simulation either specify cycle fuel mass or specify A/F equivalence ratio in cylinder, environment parameters Losses of pressure before compressor, Losses of pressure after turbine can be varied.

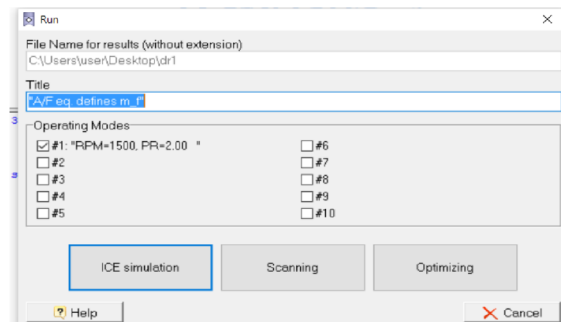


Fig. 8. Input sub-window of ICE Simulation

In the above Figure 8, of the ICE simulation, Scanning, Optimizing can be performed and results can be obtained.

4. Results and Discussion

The combustion analysis, performance analysis and the emission analysis are provided in the following sections.

A. Combustion Analysis

1) Maximum cylinder pressure

In the figure 9, variations in maximum cylinder pressure with the increment in engine load is presented using different bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and Pure Diesel. It can be evident that cylinder pressure increases continuously with increment in engine load using pure diesel. Whereas, in case of bio-fuels, there is increment in maximum cylinder pressure up to 80% engine load and then decreases with increment in engine load. Highest value obtained for maximum cylinder pressure is 102.9 bar for pure diesel.

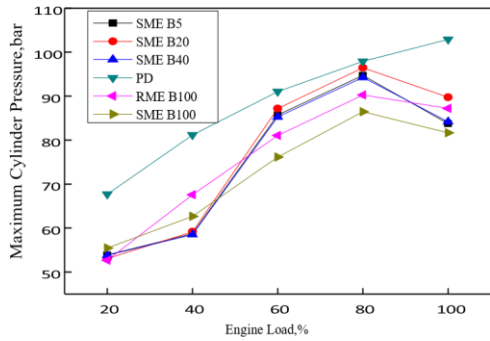


Fig. 9. Variations in maximum cylinder pressure with engine load at 1500 rpm

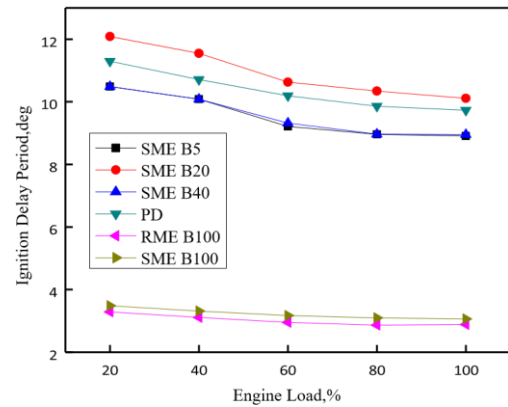


Fig. 11. Variations in ignition delay period with engine load at 1500 rpm

2) Maximum cylinder temperature

In the figure 10, variations in maximum cylinder temperature with increment in engine loads is presented using biodiesel fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and Pure Diesel. It can be evident that cylinder temperature rises continuously with increment in engine load using pure diesel. Whereas, in case of bio-fuels, there is a growth of maximum cylinder temperature up to 80% engine load and then decreases with increment in engine load. At maximum engine load of the values of maximum cylinder temperature are \ of SME B20, SME B40, SME B5 RME B100 SME B100 and Pure Diesel respectively. Highest value obtained for maximum cylinder temperature is 2220 K of pure diesel.

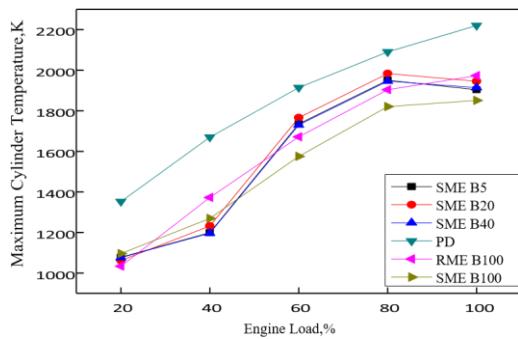


Fig. 10. Variations in maximum cylinder temperature with engine load at 1500 rpm

4) Maximum rate of pressure rise

In the figure 12, variations in maximum rate of pressure rise with increment in engine load are presented using biodiesels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be evident that the max. rate of pressure rise rises continuously with increment in engine load using pure diesel. where as in case of bio-fuels there is an increment in maximum rate of pressure rise up to 80% and then decreases with increment in engine load At full engine load conditions the significance of maximum Rate of pressure rise are (5.4042, 3.4358, 3.4087, 2.9633, 2.8853, 9) of SME B20, SME B5, SME B40RME B100SME B100 and Pure Diesel.

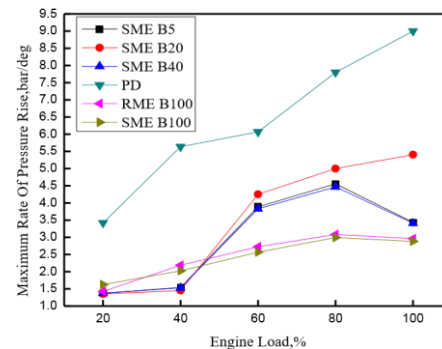


Fig. 12. Variations in maximum rate of pressure rise with engine load at 1500 rpm

3) Ignition delay

In the figure 11, variations in ignition delay period with increment in engine load is presented using biofuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be evident that the ignition delay period decreases continuously with increment in engine load for all the fuels used. At 20% of engine load the values of ignition delay period are (12.086, 10.487, 10.484, 3.2881, 3.4823, 11.3) of SME B20, SME B5, SME B40 RME B100, SME B100 and pure diesel correspondingly. At top load the values of ignition delay period are (10.111, 8.9538, 8.9045, 2.8870, 3.0612 9.73) of SME B20, SME B40, SME B5, RME B100 SME B100 and pure diesel respectively.

5) Combustion duration

In the figure 13, variations in combustion duration through increment in engine load is presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be evident that the ignition duration increases up to 60% of engine load and decrease with increment in engine load for pure diesel, where as in case of bio-fuels combustion duration of the fuel at engine load 20% to 40% takes a steep decrement and increases with engine load. At full load the values of combustion duration are (59.928, 59.728, 58.728, 65.624, 64.424, 70.7) of SME B40, SME B5, SME B20RME B100, SME B100 and Pure Diesel respectively.

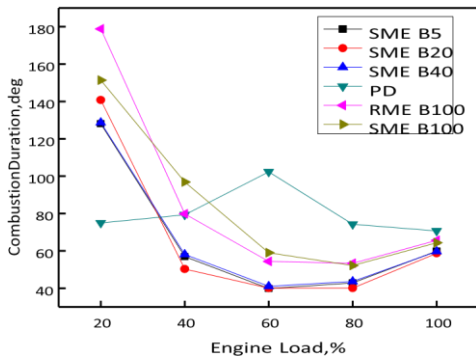


Fig. 13. Variations in combustion duration with engine load at 1500 rpm

B. Performance Analysis Specific

1) Fuel combustion

In the figure 14, variations in specific fuel combustion through increment of engine load are presented using bio-fuels (SME B5 SME B20 SME 40 RME B100 SME B100) and Pure Diesel. It can be evident that specific fuel consumption decreases continuously with increment in engine load for all the fuels used. At full engine load the standards of specific fuel consumption are (0.26092 0.26194 0.2557 0.269 0.29843 0.25441) of SME B40 SME B5 SME B20RME B100SME B100 and Pure Diesel respectively.

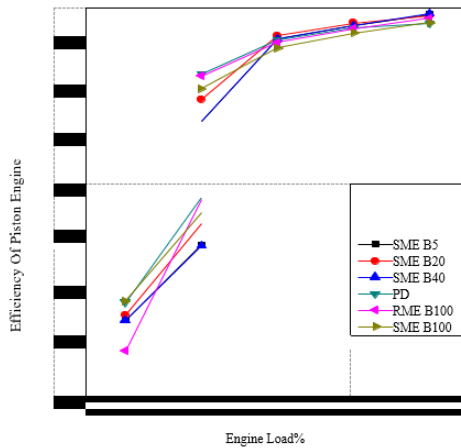


Fig. 14. Variations in Specific fuel combustion with engine load at 1500 rpm

2) Brake thermal efficiency

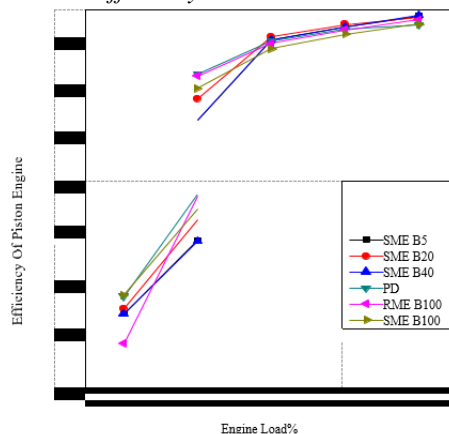


Fig. 15. Variations in efficiency of piston engine with engine load at 1500 rpm

In the figure 15, the variations in efficiency of piston with increment in engine load is presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and Pure Diesel, Efficiency of piston continuously increases with the increment in engine load. At full load conditions the values of efficiency of piston engine are (0.34454, 0.34273, 0.34589, 0.33924, 0.33305, 0.3325) of SME B5, SME B20, SME B40RME B100, SME B100 and Pure Diesel respectively.

3) Indicated efficiency

In the figure 16, variations in indicated efficiency on increment in engine load is presented using biofuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be evident that the indicated efficiency decreases continuously with increment in engine load for pure diesel, where as in case of bio-fuels there is a decrement of indicated efficiency up to 20% to 40% and increment up to 60% and decrease continuously with increment in engine load. At 100% engine load values of indicated efficiency are (0.42091, 0.41955, 0.41603,0.41593,0.41542, 0.407) of SME B40, SME B20, SME B5RME B100, SME B100 Pure Diesel respectively.

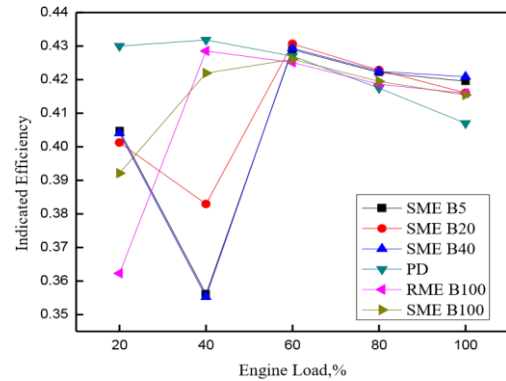


Fig. 16. Variations in indicated efficiency with engine load at 1500rpm

4) Mechanical efficiency

In the Figure 17 variations in mechanical efficiency with increment in engine load is presented using biofuel (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. Mechanical efficiency continuously rises with the increment in engine load for the fuels used. At 20% load least the value is (0.26022) of SME B40.At full load, values of mechanical efficiency are (0.86156, 0.86117, 0.86051,0.85601,0.84548, 0.816) of SME B40, SME B5, SME B20RME B100SME B100 and Pure Diesel respectively.

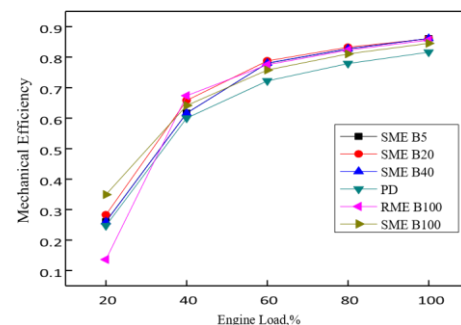


Fig. 17. Variations in mechanical efficiency with engine load at 1500 rpm

5) Volumetric efficiency

In the figure 18, variations in volumetric efficiency with increment in engine load are presented using bio-fuels (SME B5 SME B20 SME 40 RME B100 SME B100) and pure diesel. It can be evident that the volumetric efficiency reduces continuously with increment in engine load. At 100% load of the engine the estimation of volumetric efficiency (0.90963, 0.91832 0.9183, 0.91865, 0.92010, 0.9012) of SME B20, SME B40, SME B5RME B100SME B100 and Pure Diesel respectively.

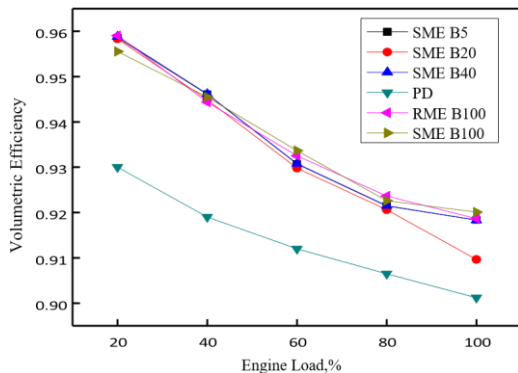


Fig. 18. Variations in volumetric efficiency with engine load at 1500 rpm

6) Brake torque

In the Figure 19, variations in brake torque with increment in engine load are presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and Pure Diesel. It can be evident that the brake torque rises with increment in engine load for all the fuels used. At full engine load the values of the brake torque are (29.99, 29.318, 29.203,28.437,25.633, 35.023) of SME B20, SME B40, SME B5, RME B100, SME B100 and Pure Diesel respectively. The highest value obtained at full load is 35.023 of Pure Diesel.

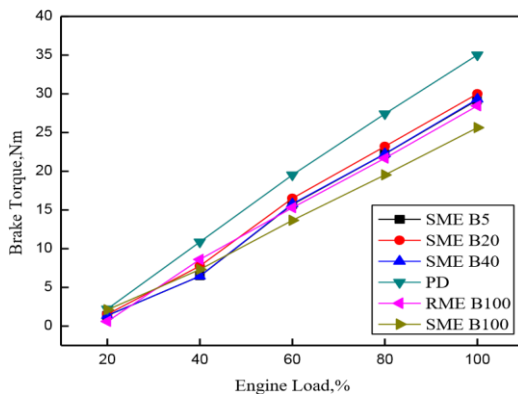


Fig. 19. Variations in brake torque with engine load at 1500 rpm

7) Exhaust manifold temperature

The exhaust gas temperature is the heat gained at the ending of the extension stroke. In the figure 20, variations in exhaust manifold temperature with increment in engine load is presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and Pure Diesel. It can be observed that exhaust manifold temperature rises continuously with increment in engine load for every fuel. At complete engine

load conditions values of the exhaust manifold temperatures are (655.09, 653.03, 625.09, 644.29, 625.01, 707.4) of SME B5, SME B40, SME B20RME B100SME B100 and Pure Diesel respectively. Highest temperature obtained is 707.4 of PD.

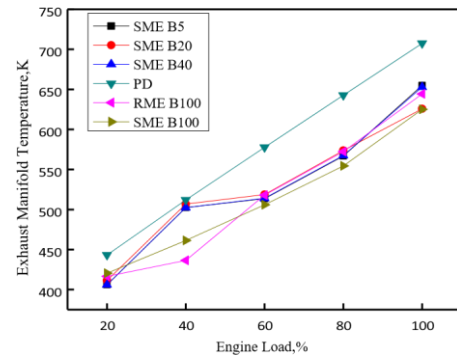


Fig. 20. Variations in exhaust manifold temperature with engine load at 1500 rpm

8) Indicated mean effective pressure

In the figure 21, variations in indicated mean effective pressure with increment in the engine load is presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and Pure Diesel. It can be observed that the indicated mean effective pressure increases continuously with the increment in engine load for all the fuels. At full engine load the values of indicated mean effective pressure are (8.2729, 8.1077 8.08167 9236,7.2658 9.75) of SME B20, SME B40, SME B5 RME B100, SME B100 and Pure Diesel respectively.

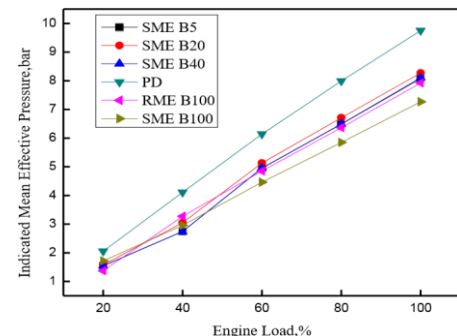


Fig. 21. Variations in indicated mean effective pressure with engine load at 1500 rpm

C. Emission Analysis

1) Bosch smoke number

Figure 22, variations in BOSCH SMOKE NUMBER with increment in engine load is presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. The Bosch smoke number decreases up to 60% engine load and increases continuously with increment in engine load using pure diesel. Where as in case of bio-fuels a Bosch smoke number increases and then decreases with increment in engine load, at full load there is a high increase in the smoke number of bio-fuels.at full load the values of the Bosch smoke number are (2.9571, 2.7971, 2.2083, 1.8143, 2.1013, 0.43263) of SME B5, SME B40, SME B20, RME B100, SME B100 and Pure Diesel respectively.

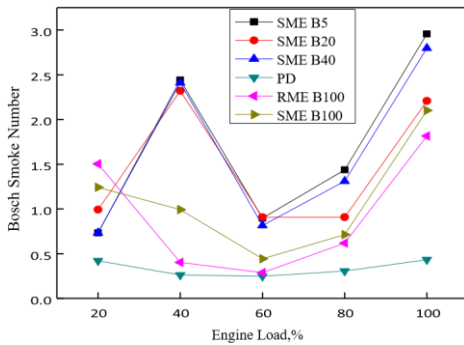


Fig. 22. Variations in Bosch smoke number

2) Specific particulate matter

The main issue of specific particulate emanation is due to inappropriate burning of the gas within the ignition compartment and exercise of intense lubrication. In the Figure 22, variations in specific particulate matter with increment in engine load are presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be observed that the specific particulate matter decreases continuously with increment in engine load for all the fuels. Values of specific particulate matter at full load are (0.83338, 0.76739, 0.54066, 0.43237, 0.58559, 0.05723) of SME B5, SME B40, SME B20, RME B100, SME B100 and Pure Diesel respectively.

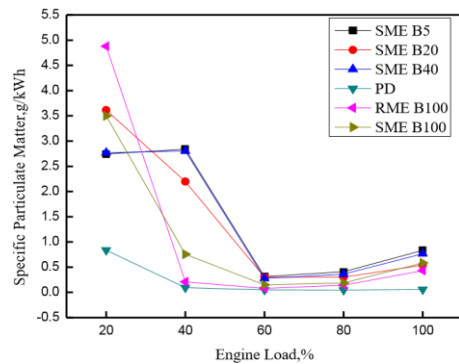


Fig. 23. Variations in specific particulate matter with engine load at 1500 rpm

3) Specific carbon dioxide emission

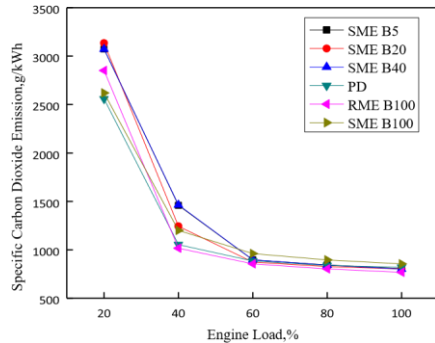


Fig. 24. Variations in specific carbon dioxide emission with engine load at 1500 rpm

In the figure 24, variations in specific carbon dioxide emanation with increment in engine load are presented using

bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be evident that the specific carbon dioxide emanation decreases continuously with increment in engine load for every fuel at full load circumstances values of the specific carbon dioxide emission are (804.93, 802.63, 801.79, 767.14, 854.5, 819.77) of SME B5, SME B20, SME B40, RME B100, SME B100 and Pure Diesel respectively.

4) Fraction of wet NO_x exhaust gas

The NO_x emanation is reliant on heat of engine chamber. In figure 25, variations in portion of wet NO_x exhaust gas with increment in engine load is presented using bio-fuels (SME B5, SME B20, SME 40, RME B100, SME B100) and pure diesel. It can be observed fraction of wet NO_x exhaust gas increases continuously with increment in engine load for pure diesel, where as in case of bio-fuels there is increment up to 80% of engine load and decreases continuously with percentage raise in device load. At full engine load conditions values of wet NO_x in exhaust gas are (2804.1, 1445.8, 1420.8, 2075.4, 1433.8, 3221.3) of SME B20, SME B40, SME B5, RME B100, SME B100 and PD respectively.

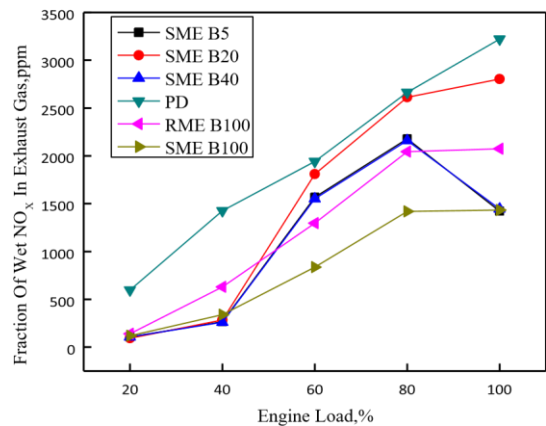


Fig. 25. Variations in fraction of wet NO_x in exhaust gas with engine load at 1500 rpm

5. Conclusion

The study was carried out for pure diesel (PD), Soybean methyl ester (SME B5, B20 and B40) and RME. As synopsis of the present examination are as per the following:

- Bio diesels SME B5, SME B40 have lesser ignition delay compared to pure diesel but bio diesel SME B20 have higher ignition stoppage than to pure diesel within combustion characteristics.
- In performance characteristics, the specific fuel utilization reduces in favour of every fuel through raise in load of the motor. As the brake thermal competence improved for every fuel, the volumetric efficiency reduces through raise in load. The significance of indicated and mechanical efficiency for every tested bio-fuels was near Pure Diesel.

The emission characteristics the specific CO₂ emission specific particulate matter decrease with raise in engine load but NO_x formation enhances with engine load.

The results have shown the eventuality of the bio-fuels for utilize as substitute fuels. The convenience of heating values of

the fuels under study have predicted an option of the biodiesels in actual instance since they represent comparable uniqueness on combustion, performance and emission, with pure diesel. The study has accomplished the option of using computational tool Diesel-RK as a capable tool in envisaging plus evaluating combustion, performance and emission characteristics of an IC engine with a smaller amount period along with precise outcomes.

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Appendix

Table A1
Engine parameters adopted in this work

Number of cylinders	1	Present Study	
Type of cooling	Liquid cooling	88.56	
Cylinder bore D, (mm)	80 mm		
Piston stroke S(mm)	110 mm		
Nominal engine speed (rpm)	1500		
Compression ratio	17.5		
Number of valves	2 valves		
Injection pressure	800....1000 bar		
Connecting rod length	235 3		
Number of nozzles	4.5°,35.5° 35.5°,4.5°		
Inlet valve timing (opening closing)	RAJAK (17.5)		
Exhaust valve timing (opening, closing)	.86.76		
Parameters Maximum cylinder pressure, bar	Numerical (17.5)		
	85.1		
Break thermal efficiency%	31.75	31.2	33.25
Maximum Rate of Pressure rise,	4.92	5.32	6.41

Ignition Delay, degrees	9.1	9.76	9.73
Exhaust Gas Temperature, K	278.5	295.32	287.4
Combustion Duration degree	38.01	36.66	37.59
Specific Fuel Consumption, kg/kW	0.33	0.36	0.38

Table A2
Properties of the fuels [3] used in the process

Properties	Pure Diesel	SME	RME
Density (kg/m ³)	830	885	874
Viscosity at 40 ^o C	3.2	5.2	7.9
Cetane Number	48	51.3	54.4
Low Heating Value of Fuel (MJ/kg)	42.5	36.22	39.45
Flash Point (^o C)	56	-	244
Fire Point	63	-	-
Oxygen (%)	0.4	10.81	10.9
Carbon Content (%)	87	77.31	77
Hydrogen Content (%)	12.6	11.8	12.1
Sulphur Content (%)	0	0.5	0.15