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

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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, Engine performance, Combustion analysis, Emission analysis.*

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

II. LITERATURE REVIEW

The present work concerns by transesterification of genus Jatropha curcas 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. [3]. 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. [4]. 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% [5]. It was discovered that the tried biodiesels give for all intents and purposes indistinguishable vigorous execution as oil fuel, while the exegetic introduction parameters by and large seek after related pattern through comparable energetic ones [6]. Sturdiness of the solution is an additional subject which is able to be examining in an exceedingly exploration. Yet, coupling of exhaust device once a particulate entice appear to be the foremost capable answer to keep away from preventive from dirt build-up [7]. Crucial downgrades in fumes of carbon monoxide (CO), natural compound (HC) and smoke square measure identified with biodiesel, while the transmission of oxides of nitrogen (NOx) and carbonic corrosive gas (CO2) increment. The diminishing in pressure quantitative connection will expand the discharges of CO, HC and smoke; anyway 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 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 exergetic 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, and marshaled oils at low burden; anyway 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 exergetic 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].

III. METHODOLOGY

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

A. 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.

B. 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.

C. 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.

D. 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.

E. 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.

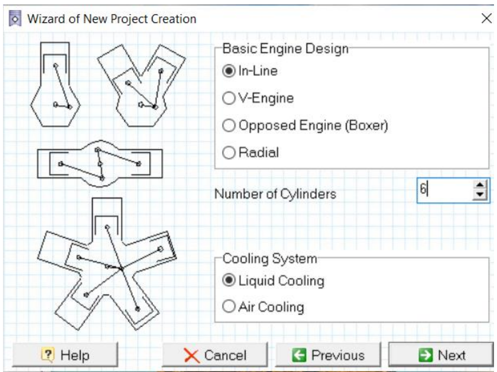

Figure 1: Input sub-Window of new project Creation-Engine Selection.

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.

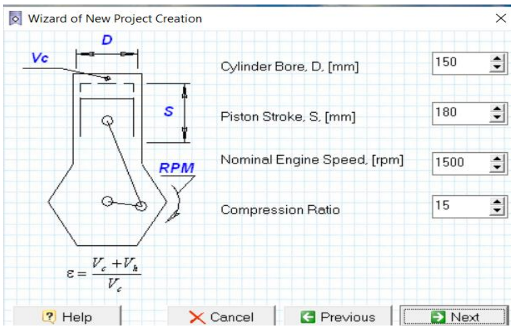

Figure 2: Input sub-window of new engine Creation-Engine Dimensions.

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.

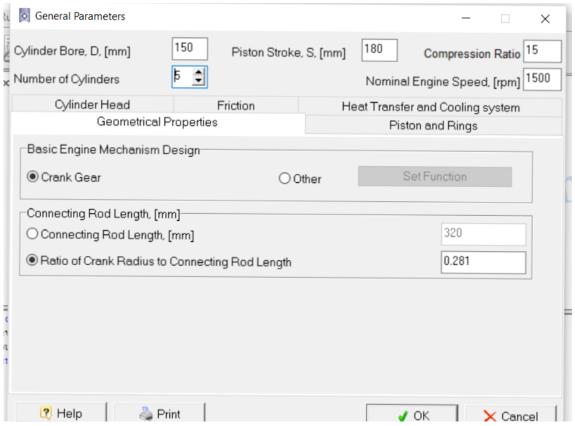

Figure 3: Input sub-window of general parameters.

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.

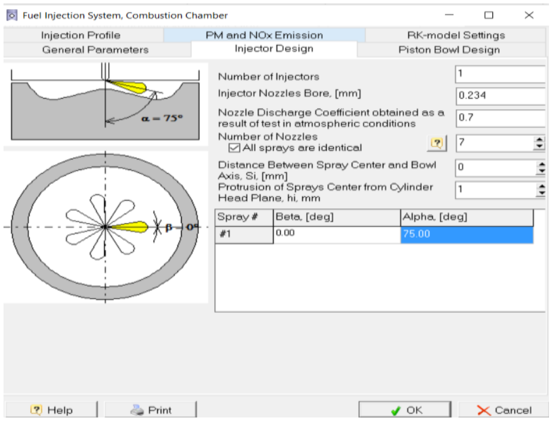

Figure 4: Input sub-window of fuel injection system, combustion chamber

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.

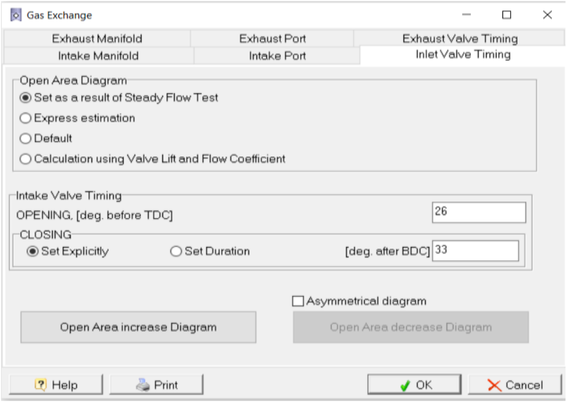

Figure 5: Input sub-window of gas exchange

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.

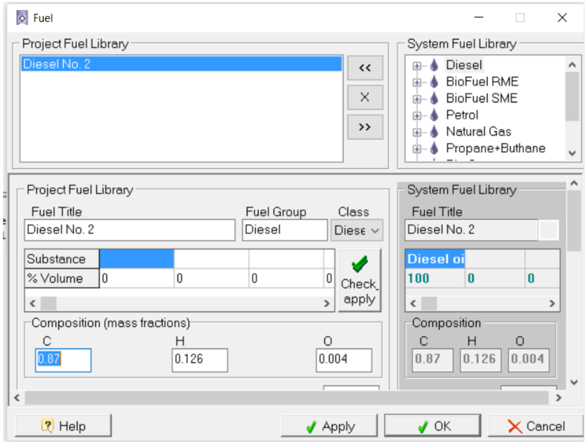

Figure 6: Input sub-window of fuel library

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

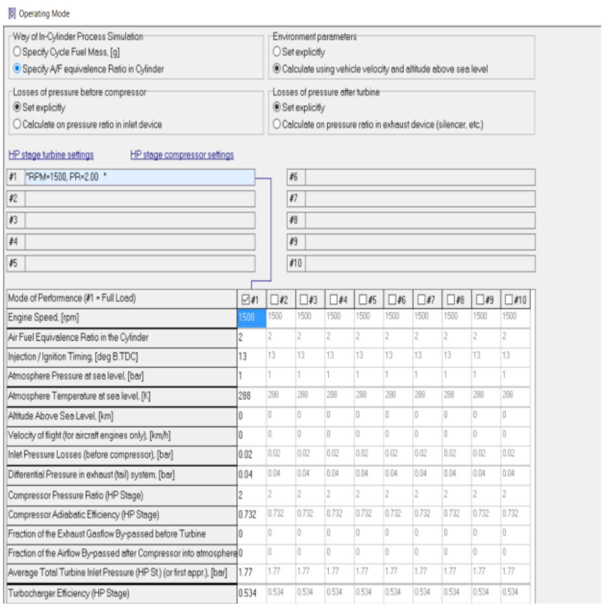

Figure 7: Input sub-window of operating mode

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.

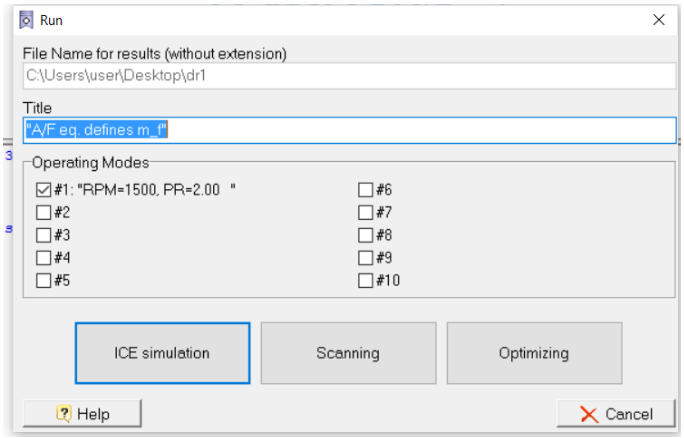

Figure 8: Input sub-window of ICE Simulation.

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

IV. RESULTS & DISCUSSION

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

3.1. Combustion Analysis

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.

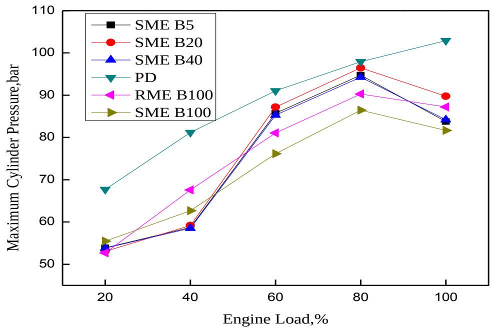

Figure 9: Variations in Maximum Cylinder pressure with engine load at 1500 rpm.

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 conditions the values of maximum cylinder temperature are (1945.8, 1913.9, 1903.9,1973.6,1850.6, 2220) 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.

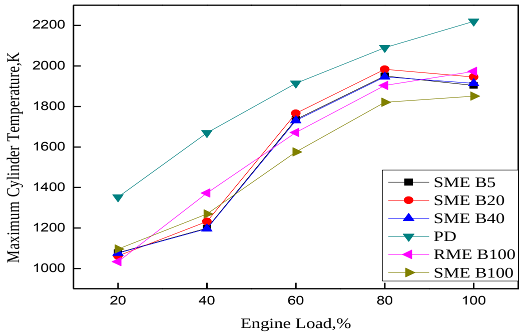

Figure 10: Variations in Maximum Cylinder temperature with engine load at 1500 rpm.

Ignition Delay

In the Figure 11, variations in ignition delay period 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 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.

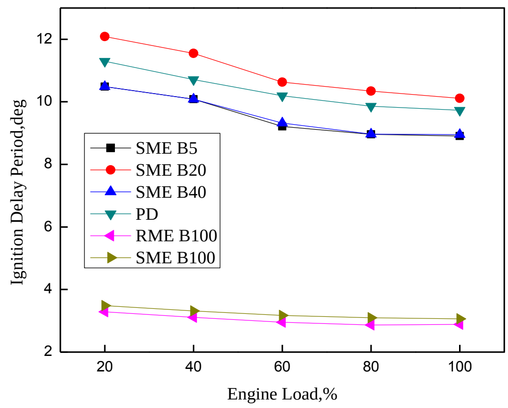

Figure 11: Variations in Ignition delay period with engine load at 1500 rpm

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 B40,RME B100,SME B100 and Pure Diesel .

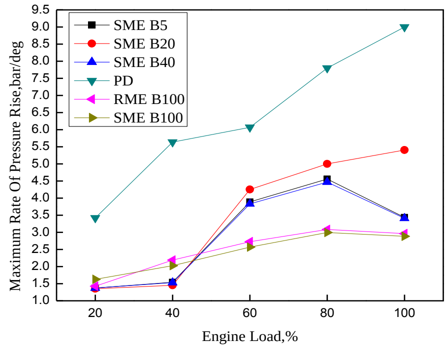

Figure 12: Variations in Maximum Rate of pressure rise with engine load at 1500 rpm

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 B20,RME B100, SME B100 and Pure Diesel respectively.

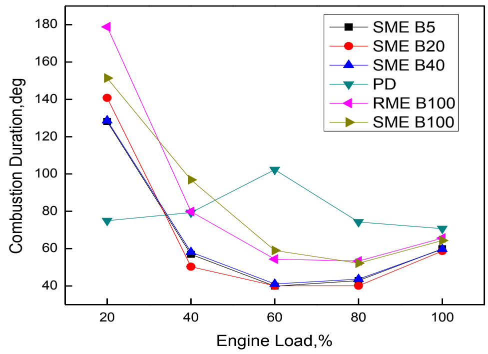

Figure 13: Variations in Combustion duration with engine load at 1500 rpm

3.2. Performance Analysis

Specific 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 conditions 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 B20,RME B100, SME B100 and Pure Diesel respectively.

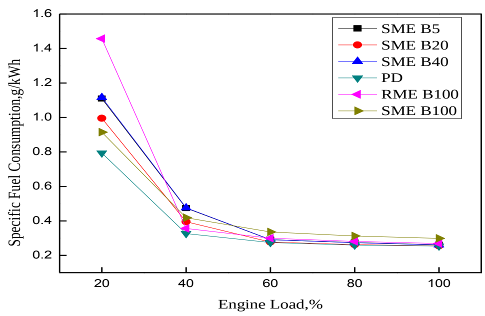

Figure 14: Variations in Specific fuel combustion with engine load at 1500 rpm

Brake Thermal Efficiency

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 B40,RME B100, SME B100 and Pure Diesel respectively.

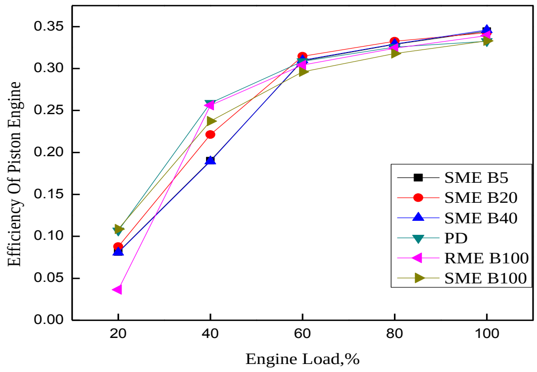

Figure 15: Variations in Efficiency of Piston Engine with Engine Load at 1500 rpm.

Indicated Efficiency

In the figure 16, variations in indicated efficiency on 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 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 B5,RME B100, SME B100 Pure Diesel respectively.

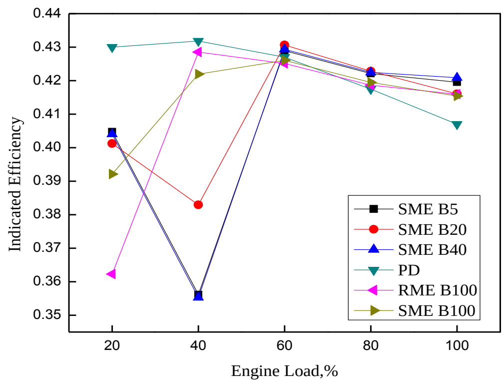

Figure 16: Variations in Indicated efficiency with engine load at 1500rpm

Mechanical Efficiency

In the Figure 17 variations in mechanical efficiency with increment in engine load is presented using bio-fuel (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 B20,RME B100,SME B100 and Pure Diesel respectively.

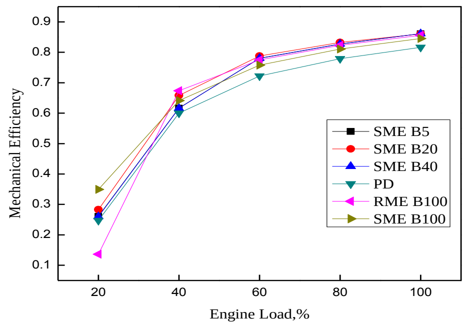

Figure 17: Variations in Mechanical efficiency with engine load at 1500 rpm

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 are (0.90963, 0.91832, 0.91837,0.91865,0.92010, 0.9012) of SME B20, SME B40, SME B5,RME B100,SME B100 and Pure Diesel respectively.

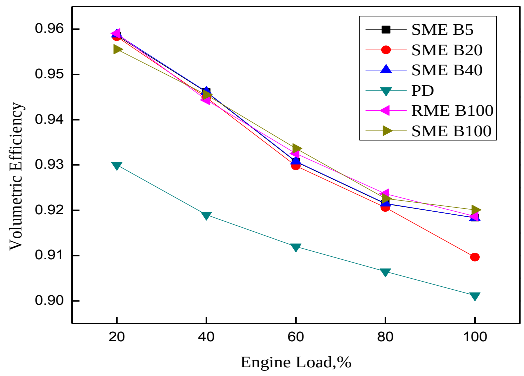

Figure 18: Variations in Volumetric efficiency with engine load at 1500 rpm

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.

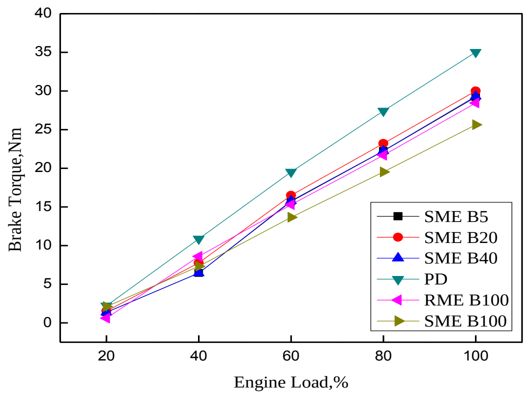

Figure 19: Variations in Brake torque with engine load at 1500 rpm

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 B20,RME B100,SME B100 and Pure Diesel respectively. Highest temperature obtained is 707.4 of PD.

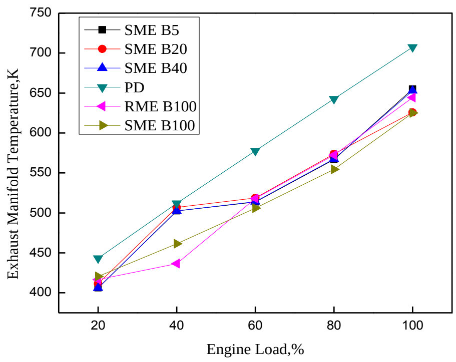

Figure 20: Variations in Exhaust manifold temperature with engine load at 1500 rpm

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 conditions the values of indicated mean effective pressure are (8.2729, 8.1077, 8.0816,7.9236,7.2658 9.75) of SME B20, SME B40, SME B5 , RME B100, SME B100 and Pure Diesel respectively.

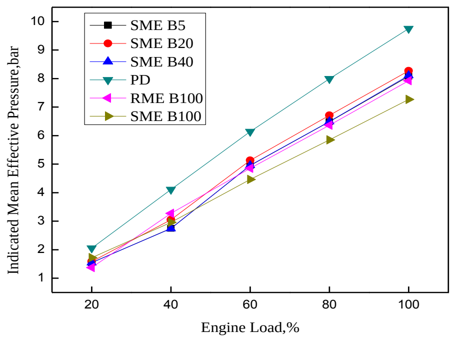

Figure 21: Variations in Indicated mean effective pressure with engine load at 1500 rpm

3.3. Emission Analysis

Bosch Smoke Number

Figure 5.14, 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 an 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.

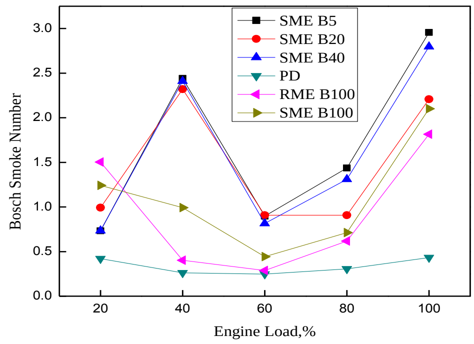

Figure 21: Variations in Bosch smoke number with engine load at 1500 rpm

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.

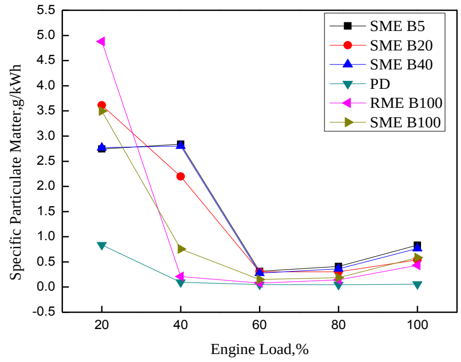

Figure 22: Variations in Specific particulate matter with engine load at 1500 rpm

Specific Carbon dioxide Emission

In the Figure 23, 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.

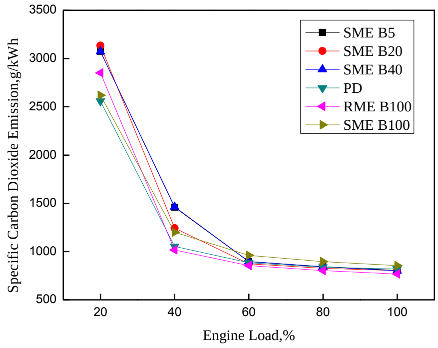

Figure 23: Variations in Specific carbon dioxide emission with engine load at 1500 rpm

Fraction of Wet NO_x Exhaust Gas

The NOx emanation is reliant on heat of engine chamber. In Figure 24, 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 NOx 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.

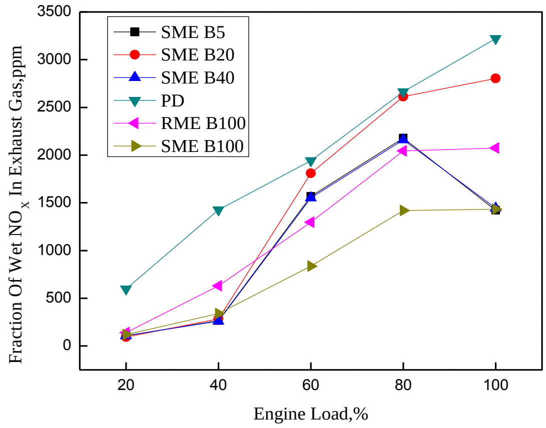

Figure 24: Variations in Fraction of wet NOx in exhaust gas with engine load at 1500 rpm

V. 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.
- Also in emission characteristics the specific CO_2 emission, specific particulate matter decrease with raise in engine load, but NOx 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 understudy 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 have 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 A

Table 1: Engine parameters adopted in this work.

Number of cylinders	1
Type of cooling	Liquid cooling
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 values
Injection pressure	800….1000 bar
Connecting rod length	235
Number of nozzles	3
Inlet value timing (opening, closing)(deg)	4.5^o,35.5^o
Exhaust value timing (opening, closing)(deg)	35.5^o,4.5^o

Table 3.2: Properties of the fuels [3] used in the process

Properties	**Pure Diesel**	**SME**	**RME**
Density (kg/m^3)	830	885	874
Viscosity at 40^0 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 (^{0}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
Sulfur Content (%)	0	0.5	0.15

Table 3.3: Comparisons of various parameters from numerical and experimental [3] studies

Parameters	Numerical (17.5)	Rajak (17.5)	Present Study
Maximum cylinder pressure, bar	85.1	. 86.76	88.56
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, degrees	38.01	36.66	37.59
Specific Fuel Consumption, kg/kW	0.33	0.36	0.38