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PERFORMANCE MEASURES ON VARIABLE COMPRESSION RATIO ENGINE FUELLED WITH COOKED PALM OIL BASED BIODIESEL BLENDS

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Abstract

Performance characteristics of an unmodified variable compression ratio single cylinder engine that has fuelled by cooked palm oil and its blends with diesel has established through the experimental study. Performance tests has been accomplished on the engine to acquire the relative measures of brake thermal efficiency, mechanical efficiency and brake specific fuel consumption under the fuel injection pressure of 180, 200 & 220 bar, compression ratio of
14:01, 17:01 and 20:01, 100% diesel fuel (B0), 90u% diesel fuel-10% cooked palm oil (B10) and 80% diesel fuel-20% cooked palm oil (B20) respectively. The output results from the experimental study have compared and the optimized testing parameters has represented. Results acquired from the experimental studies unveiled that the performance of the variable compression ratio single cylinder diesel engine has improved, when it has operated with diesel-cooked palm oil combination as fuel.

Keywords: Performance measures, VCR diesel engine, cooked palm oil, fuel injection pressure, compression ratio.

1. Introduction

Biodiesel made from the natural vegetable oil has be a sign of capable alternate fuel. The world meets the catastrophe of power demand, increasing fuel cost and exhaustion of fossil fuel resources [1]. In an every economic action, power source and energy has considered as an indispensable and essential contribution. Foundation of physically powerful support of power sources is the major requirements for the each countries cost-effective and societal enlargement [2]. Biodiesel is at present the majority extensively acknowledged substitute fuel for diesel engines owed to its technological, ecological and deliberate recompenses. Biodiesel have the several advantages like, improved reusability, lesser poisonous and enhanced lubrication properties when compared with the conventional fuels. Biofuel also able to forming the homogeneous mixture when added with the diesel fuel in several fractions [3]. Biofuel has considered as a highly securable power sources in upcoming for the replacement of the existing conventional fuels through the government guidelines for its lesser carbon content [4]. Biofuel, prepared from the different plants, seeds and animal plump are reusable, biodegradable, harmless and ecological measure up to with normal conventional fuels [5]. View on the biodiesel as an impending ecological substitute fuel and it can get better the profitable magnification of the nation in the type of service in provincial and pastoral areas [6]. Burning characteristics of the typical biodiesel is environmentally responsive fluid fuel like as the conventional fuels [7]. The inventor of diesel engine Rudolph Diesel used vegetable oil as a fuel approximately 100 years before [8]. Obtained biofuel from the various bioresources have enhanced the protection of power sources and the financial system liberty [9]. Groups of investigations have done on the biodiesel, it has established a considerable concentration, and it is a potential substitute fuel. Biodiesel and its mixtures with diesel have engaged as a fuel for diesel engine not including some alterations in the current engine [10]. Biofuel that has obtained from the bio-resources through the transesterification process reveals the comparable belongings to the conventional fuel source [11]. In modern years, numerous research activities have focused on the invention of biodiesel appreciably [12]. The biofuel received from the vegetables have considered as a quite capable fuel for diesel engine. Oil obtained from the palm tree seed has considered as an alternative fuel for diesel engine due to its closer physical and chemical behaviour of the diesel fuel [13]. Burning behaviour of the diesel engine operated with diesel fuel- waste palm oil methyl esters and canola oil blends have enhanced when compared to conventional diesel fuel [14].

A DI diesel engine operated with biofuel has revealed the enhanced brake specific fuel consumption and brake thermal efficiency [15]. An IDI-turbo diesel engine, which has operated with diesel -crude palm oil blends, exhibited the lower brake thermal efficiency and elevated brake specific fuel consumption for upper amalgamation portion [16]. Fuel consumption in diesel engine has reduced and the brake thermal efficiency has increased at the lower bio fuel blends [17]. Performance, emission and burning characteristics of an unmodified diesel engine, which have operated with diesel- palm oil methyl esters and its blends, have found affirmative [18]. Engine's thermal efficiency has faintly improved and the energy utilization for brake power has decreased significantly, when is has operated with

80% diesel fuel and 20% biofuel blends respectively [19]. Diesel engine's thermal efficiency has found lower for biodiesel and oil blends when compared to diesel fuel. Fuel consumptions for specific brake power for biodiesel and oil blends have exhibited the higher value than diesel fuel [20]. 11.4% higher brake specific fuel consumption for 20%palm oil-

80%diesel blend has obtained and the thermal efficiency is 5.1% lower than diesel fuel [21]. A 6% superior peak pressure has attained with crude palm oil-diesel blends [22]. Comparing crude palm oil combustion to diesel combustion, In the present experimental study, brake thermal efficiency, mechanical efficiency, brake fuel consumption of an unmodified direct injection diesel engine under various fuel injection pressures, different compression ratio- using diesel and blends of cooked oil from palm in diesel at the selected portions of 0, 10, and 20% in volume basis.

2. Experimental plans

2.1 Preparation of biodiesel

In this experimental study, biodiesel has engendered from cooked palm oil. Cooked palm oil used in this experimental study has gathered from different restaurants, hotels and hostels in Perundurai region of Tamilnadu, India. A transesterification reaction process has used to produce the biodiesel from the cooked palm oils. In this process, biodiesel has engendered by using the methanol to cooked palm oil ratio of 06:01 with the catalyst, potassium hydroxide of 1% of cooked palm oil by weight. In order to start the transesterification reaction, moisture-free cooked palm oil has added to the reaction tank after solving the potassium hydroxide catalyst in methanol at room temperature. The above mixture has completely stirred up to 3-hour duration at 60-65°C. After this separation process of glycerol from the cooked palm oil, warm distilled water has used to wash the glycerol-free cooked palm oil.

The entire washing process has continued and repeated for three times, to obtain the complete glycerol free-cooked palm oil blends. Afterwards, the well-washed palm oil blends have heated up to 100°C under the unchanged atmospheric conditions to eliminate the final traces of wetness and alcohol contents that has present in the cooked palm oil blends due to the transesterification process.

2.2 Biodiesel blending

Three test fuels have chosen for these experimental studies. The test fuels elected are (1)

100% regular diesel fuel (B0) acquired from a local fuel station at Perundurai, (2) 90% diesel fuel and 10% cooked palm oil (B10) and (3) 80% diesel fuel and 20% cooked palm oil (B20). Volume based blended proportions were used in this study. The test fuel of cooked palm oil blends have blended with diesel for 30 min using a mechanical homogenizer operated at 2000 rpm. It has ensured that the water molecules are completely absence in the blended fuels and there is no additional phase separation in that blended fuels.

2.3 Test engine setup

This experimental study was conceded by means of three fuel samples: diesel fuel (B0), the B10 (90% diesel and 10% cooked palm oil) blend, and the B20 (20% cooked palm oil and 80% diesel) blend. The test engine was a Kirloskar single-cylinder diesel engine. The test engine has not altered for diesel-cooked palm oil blends as fuel. The test engine arrangement has shown in figure.1 (A). A single cylinder diesel engine has been utilized in this experimental study. The complete specifications of the test engine are shown in table.1. In order to ensure the full exhaustion of the earlier diesel-cooked palm oil blends from the fuel line, the test engine has allowed running about more than thirty minutes. The test engine also allowed running at a full speed of 1600 rpm and full loaded conditions during the study. The test engine has coupled with an eddy current dynamometer with full load conditions. The different performance measures of the test engine has established by maintaining constant speed. Bio-fuel blend's injection pressure at fuel injector in the engine cylinder has varied from 180 to 220 bar. In the same way, the test engine has allowed to run at different compression ratio like, 14:01,

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17:01 and 20:01 respectively. The test engine has allowed to run for quite a few minutes to warm up it before test. Similarly, the test engine has allowed operating with diesel fuel before its shut down stage. The engine performance characteristics like brake thermal efficiency, mechanical efficiency and brake specific fuel consumptions have noted for all the blends of cooked palm oil and were compared with pure diesel fuel.

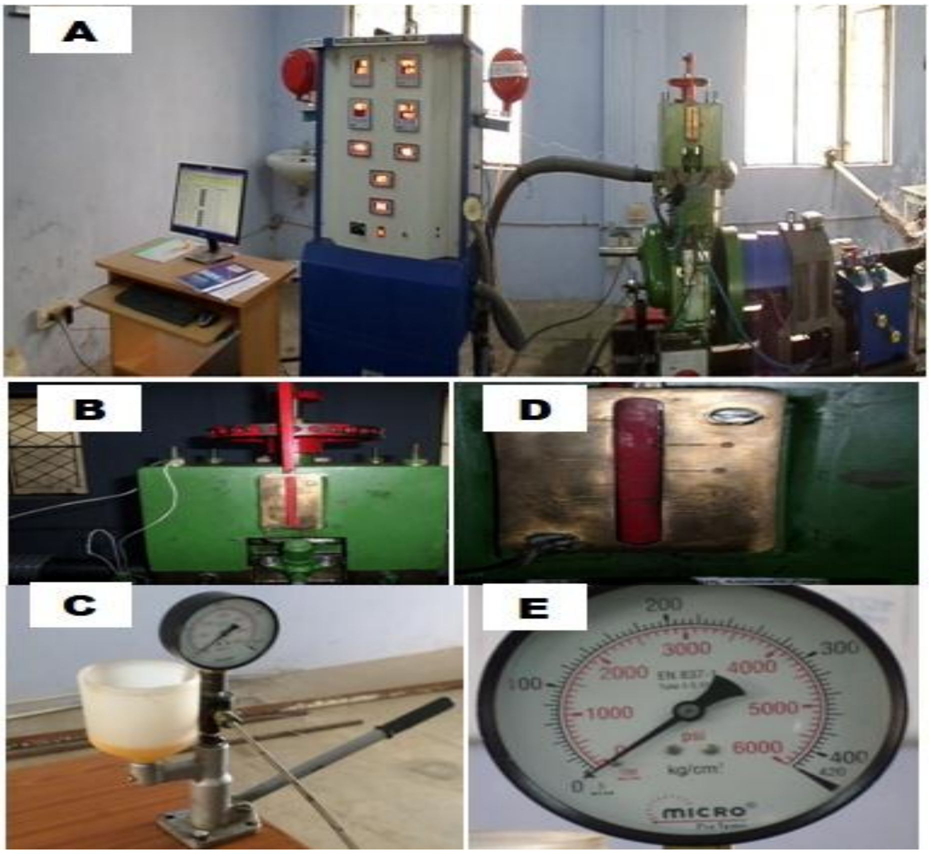

Figure 1. (A) Variable compression ratio engine with test rig (B) Compression ratio changing device (C) Fuel injection pressure variation kit (D) Compression ratio indicating device (E) Fuel injection pressure indicator

Table 1 Specification of test engine

Made	Kirloskar Stroke
Four stroke Rated power	3 – 5
HP	
Speed	1450 - 1600 rpm Compression ratio
05:01 to 20:01 (Variable) Bore diameter	80 mm
Ignition type	Compression ignition
Load device	Eddy current dynamometer Load
sensor	Strain gauge load cell Temperature sensor
Type K – thermocouples Type of engine starting	Manual crank
start	
Type of engine cooling	Water
Injector operating pressure	180 bar to 220 bar (Variable)

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3. Results and discussions

Experimental studies on an unmodified variable compression ratio diesel engine that has fuelled with diesel-cooked palm oil blends have effectively conceded results has acquired from that experimental studies. and the following

3.1 Brake thermal efficienc

Thermal input from the fuel to a heat engine that has measured as brake power, which has represented in terms of efficiency have illustrated in figure.2, 3 and figure.4. Minimum brake thermal efficiency of 12% has obtained at fuel injection pressure of 220 bar, compression ratio of 14:01 and 100% diesel-0% cooked palm oil blends. Maximum brake thermal efficiency of 24% has noticed at fuel injection pressure of 180 bar, compression ratio of

14:01 and 80% diesel-20% cooked palm oil blends correspondingly.

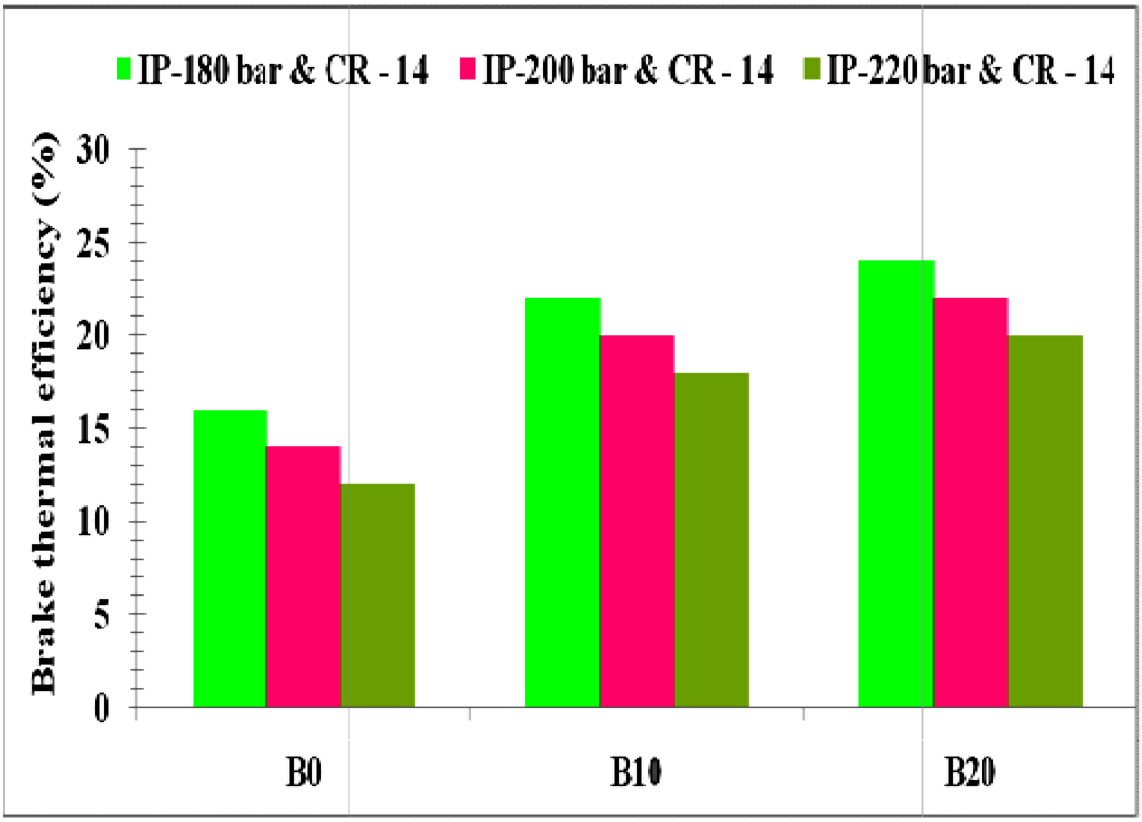

Figure 2. Variation on brake thermal efficiency under 180, 200 injection pressure for compression ratio 14:01

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and 220 bar fuel Brake thermal efficiency for the engine compression ratio 17:01 were found maximum of 25 % at fuel injection pressure of 180 bar and 80% diesel-20% cooked palm oil blends respectively. Thermal efficiency for brake power in the variable compression ratio engine for compression ratio 17:01 were found minimum in 220 bar fuel injection pressure and 100% diesel-0% cooked palm oil blends accordingly. Brake thermal efficiency of 28% maximum value in magnitude were attained by the variable compression ratio engine which has a compression ratio of 20:01 and fuel injection pressure of 180 bar for 80% diesel-20% cooked palm oil blends likewise.Minimum brake thermal efficiency of 14% has noted for 20:01 compression ratio at 220 bar fuel injection pressure in 100% diesel-0% cooked palm oil blends correspondingly.

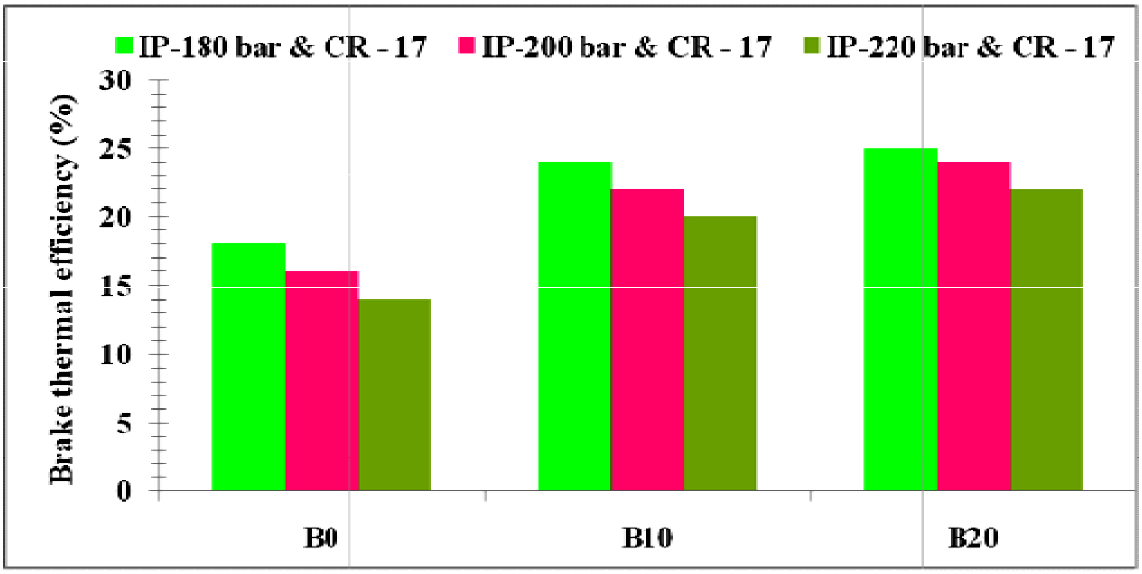

Figure 3. Variation on brake thermal efficiency under 180, 200 injection and 220 bar fuel pressure for compression ratio 17:01

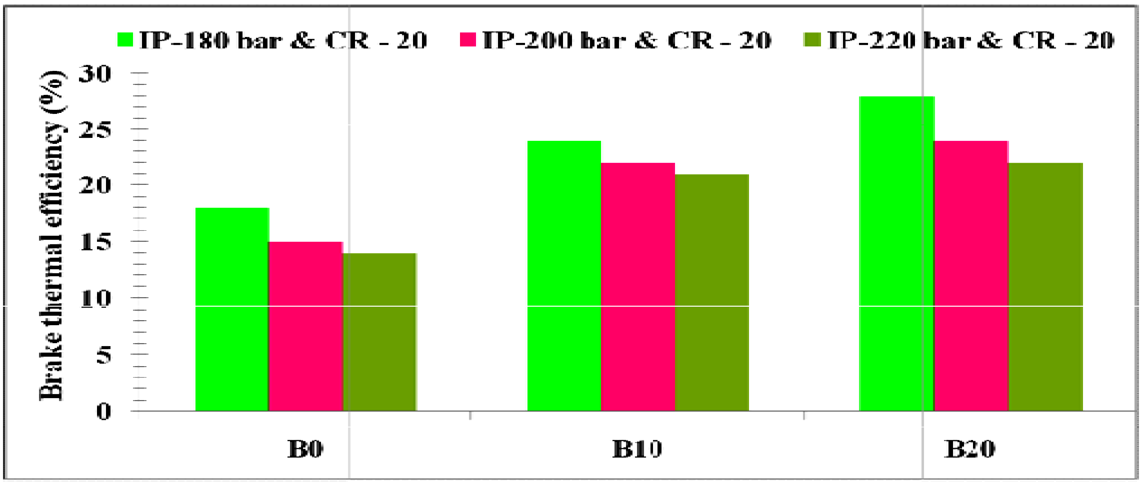

Figure 4. Variation on brake thermal efficiency under 180, 200 injection and 220 bar fuel **pressure for compression ratio 20:01**

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3.1 Mechanical efficiency

Performance parameter that gives the effectiveness of an engine in terms of amount of input energy conversion into output energy, which has called as mechanical efficiency of the engine. Effect of different fuel injection pressure, compression ratio and diesel-cooked palm oil blends on mechanical efficiency of the engine has interpreted in the form of graphical representation in figure.5, 6 and figure.7 respectively.

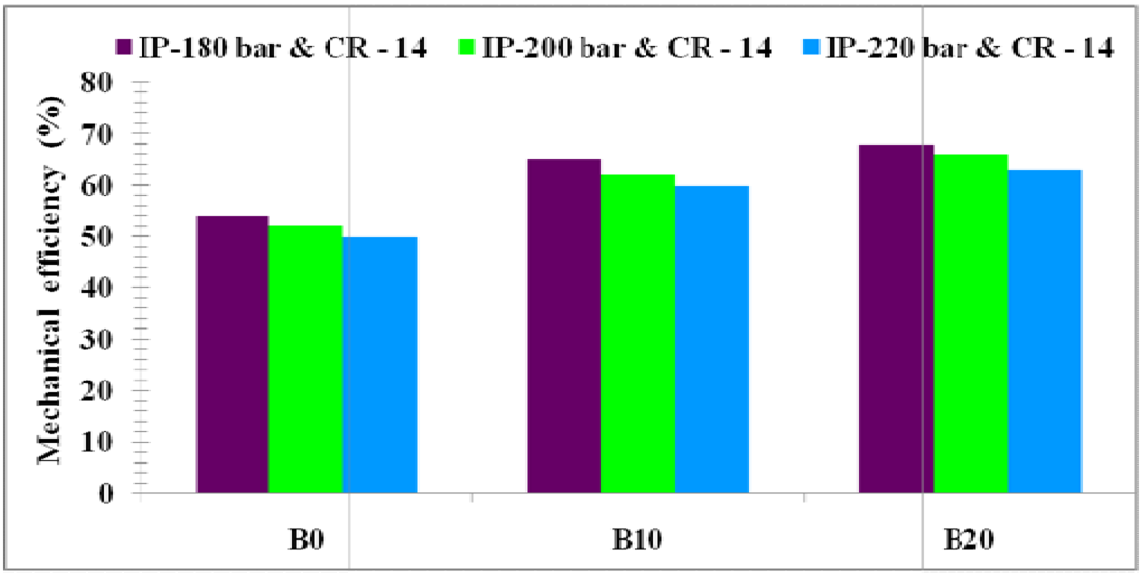

Figure 5. Variation on mechanical efficiency under 180, 200 and 220 bar fuel injection pressure for compression ratio 14:01

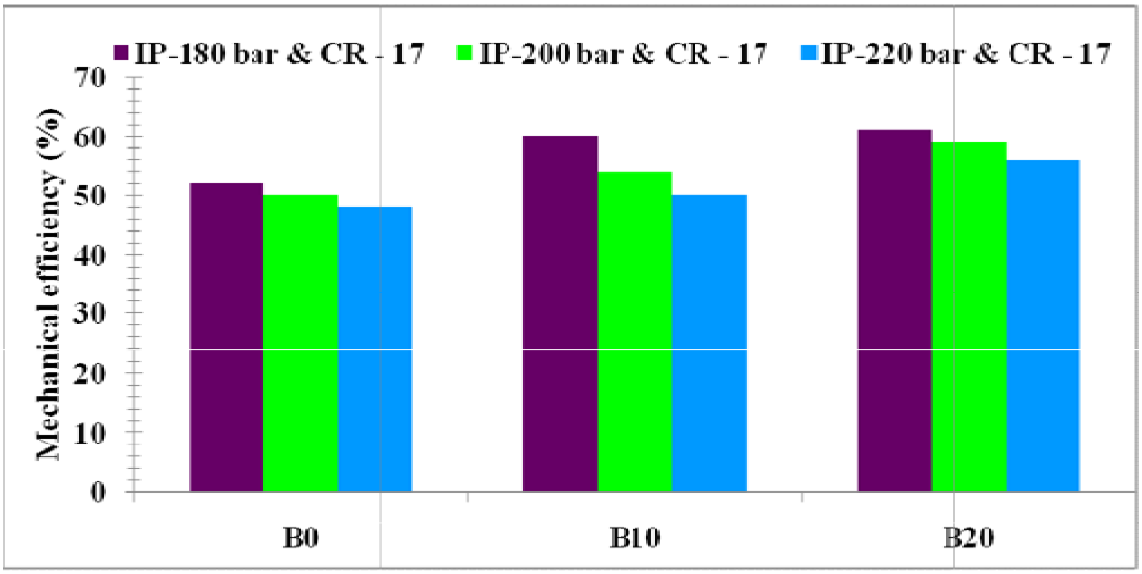

Figure 6. Variation on mechanical efficiency under 180, 200 and 220 bar fuel injection pressure for compression ratio 17:01

Mechanical efficiency of 68% that has perceived at 180 bar fuel injection pressure, 14:01 compression ratio and 80% diesel-20% cooked palm oil blends accordingly. Conversely, the minimum mechanical energy of 50% has noticed in an unmodified variable compression ratio diesel engine with 14:01 compression ratio, 220 bar fuel injection pressure and 100% diesel-

0% cooked palm oil blends correspondingly. VCR diesel engine operating at 17:01 compression ratio, 180 bar fuel injection pressure and 80% diesel - 20% cooked palm oil blends are evidence for maximum mechanical efficiency of 61% correspondingly. Minimum mechanical efficiency of 48% has observed at 220-bar fuel injection pressure,
17:01 compression ratio and 100% diesel - 20% cooked palm oil blends respectively.
Mechanical efficiency of the engine, which has operated at higher compression ratio i.e.
20:01, has found maximum of 64% at 180 bar fuel injection pressure and 80% diesel - 20% cooked palm oil blends considerably. Minimum mechanical efficiency of 49% for the same compression ratio in the engine has observed at 220-bar fuel injection pressure and 100% diesel-0% cooked palm oil blends noticeably.

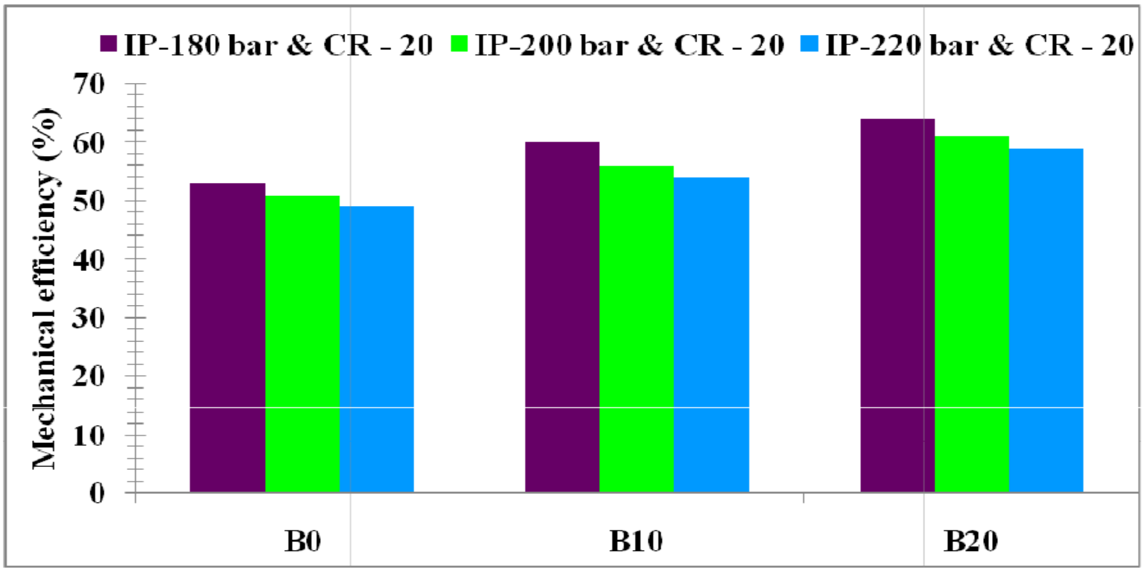

Figure 7. Variation on mechanical efficiency under 180, 200 and 220 bar fuel injection pressure for compression ratio 20:01

3.3 Brake specific fuel consumption

Rotational power or shaft power produced by the an automobile engine due to the burning of fuel, which has measured in terms of specific value called as brake specific fuel consumption. Effect of compression ratio, fuel injection pressure and bio-diesel blends on brake specific
fuel consumption in an unmodified variable compression ratio diesel engine has exemplified

in figure.8, 9 and figure.10 respectively. Brake specific fuel consumption has instigate

maximum in a magnitude of 0.425 kg/kW-h at fuel injection pressure of 180 bar under a operating compression ratio of 14:01 and the 100% diesel-0% cooked palm oil blends specific perceptibly. Engine's brake fuel consumption for compression ratio 14:01 has

examined minimum in magnitude of 0.320 kg/kW-h at 220 bar fuel injection pressure under the bio-fuel blends of 80% diesel - 20% cooked palm oil blends conspicuously.

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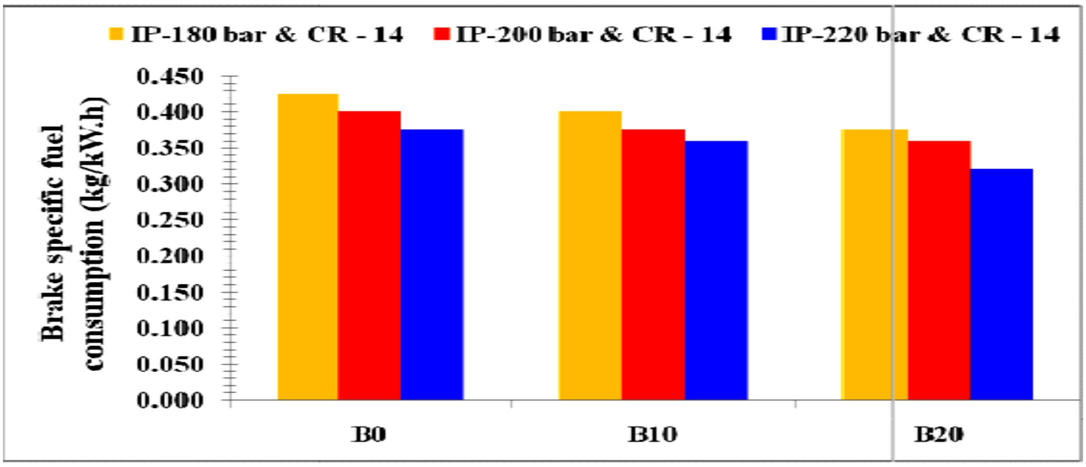

Figure 8. Variation of brake fuel consumption of the engine under 180, 200 and 220 bar fuel injection pressure for compression ratio 14:01

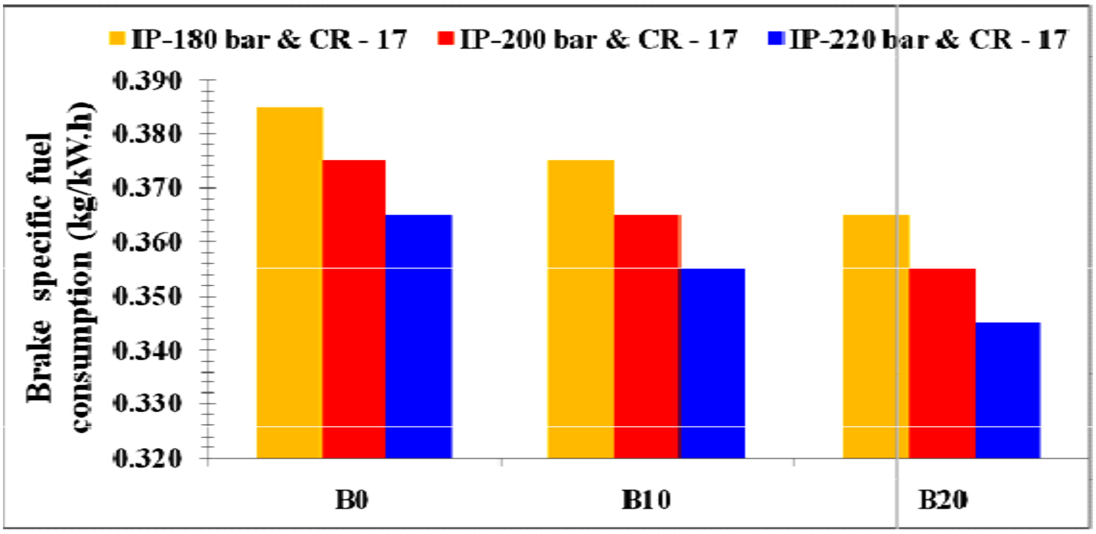

Figure 9. Variation of brake fuel consumption of the engine under 180, 200 and 220 bar fuel injection pressure for compression ratio 17:01

Maximum brake specific fuel consumption of 0.385 kg/kW-h for compression ratio 17:01 had attained at 180 bar fuel injection pressure and 100% diesel-0% cooked palm oil blends observably. Brake specific fuel consumption of 0.345 kg/kW-h has noticed as lower value in magnitude for compression ratio 17:01 at 220 bar fuel injection pressure and 100% diesel-0% cooked palm oil evidently. Specific fuel consumption for brake power has maximum at 180 bar fuel injection pressure for compression ratio of 20:01 with a magnitude of 0.425 kg/kW-h in 100% diesel-0% cooked palm oil distinctly. Brake specific fuel consumption of 0.325 kg/kW-h has perceived in an unmodified variable compression ratio diesel engine for 20:01 compression ratio at 220 bar fuel injection pressure in 80% diesel - 20% cooked palm oil blends obviously.

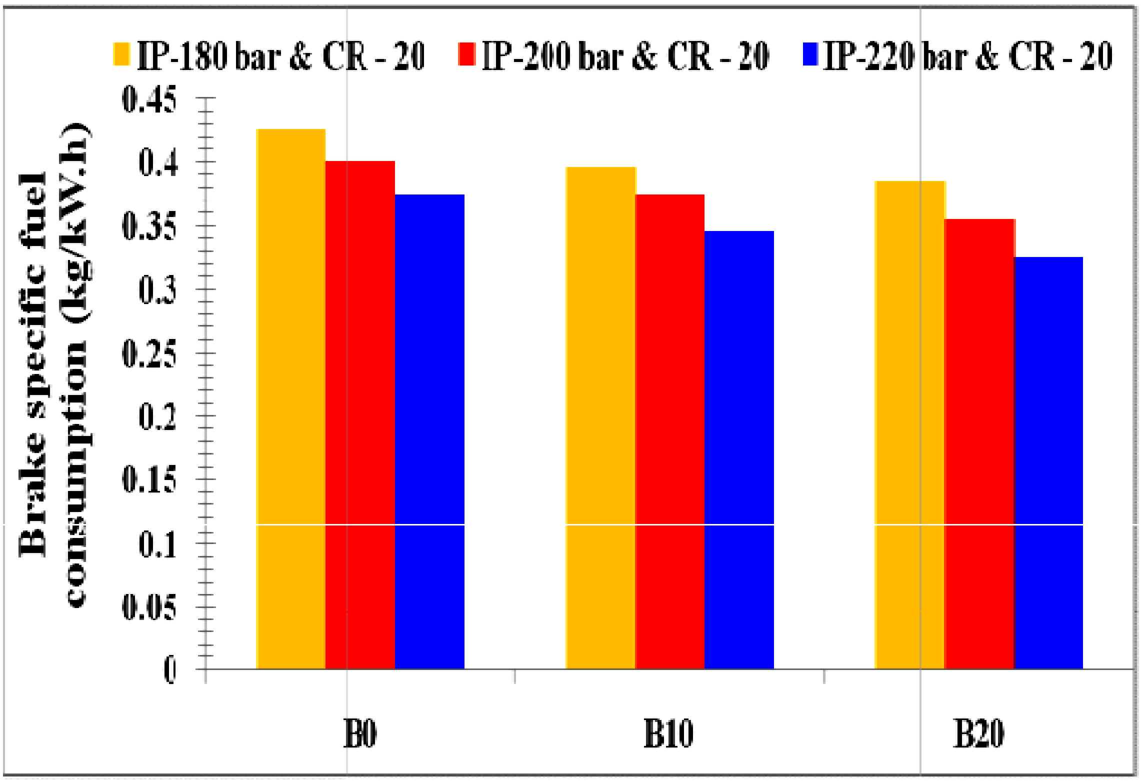

Figure 10. Variation of brake fuel consumption of the engine under 180, 200 and 220 bar fuel injection pressure for compression ratio 20:01

4. Conclusions

Performance characteristics of an unmodified variable compression ratio diesel engine has established as follows by using the cooked palm oil-based biofuel and cooked palm oil has identified as the admirable biofuel than other biofuel resources. Brake specific fuel consumption by the test engine is appreciably reduced (0.320 kg/kW-h) at 180 bar injection pressure and 14:01 compression ratio with B20 blends as compared to diesel, whereas the brake specific fuel consumption has considerably increases (0.425 kg/kW-h) when the test engine operated with pure diesel blends at 180 bar injection pressure and 14:01 compression ratio. Brake thermal efficiency of the test engine is significantly increases with respect to the increasing cooked palm oil blends with diesel. Cooked palm oil blends B20 have revealed the maximum brake thermal efficiency of 28% at 180 bar fuel injection pressure and 20:01 compression ratio. Unlikely 12% of brake thermal efficiency in magnitude has obtained in pure diesel fuel at 220 bar fuel injection pressure and 14:01 compression ratio. Maximum mechanical efficiency observed from the experimental studies have found maximum in cooked palm oil blends B20 and the mechanical efficiency of the engine is appreciably increases with respect to the higher amount of cooked palm oil blends with diesel. Cooked palm oil blends B20 have exposed the maximum mechanical efficiency of 68% at 180 bar fuel injection pressure and 14:01 compression ratio. Implausibly 48% of minimum mechanical efficiency in magnitude has attained in pure diesel fuel at 220 bar fuel injection pressure and 17:01 compression ratio. In culmination, cooked palm oil is an impending feedstock for biodiesel making process.

Blends obtained from the cooked palm oil would be the replacement of replace diesel fuel in an unmodified engine to diminish the universal power demands.

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