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Engine Performance Analysis by using Dual Fuel

[1]Dr. Nan Aye Myint and [2]Dr. Mon Mon Aye

[1]Associate Professor, [2]Lecturer
Department of Mechanical Engineering
[1]Technological University (Toungoo), Myanmar,
[2]University of Technology (Yadanapon Cyber City), Myanmar
Email: [1]cherrypan082@gmail.com; monmonaye.mech@gmail.com

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Abstract: In recent years, considerable efforts mode to develop and introduce alternative renewable fuel, to replace conventional petroleum base fuels. The main objective of the current work is to investigate the engine performance and pollutant emission of a commercial Spark-Ignition (SI) engine fuel with ethanol-methanol-gasoline blends. The test results obtained with the use of low content rates of ethanol-methanol (15%, 20%) in gasoline were compared to pure gasoline test results. Combustion and emission characteristics of ethanol, methanol and gasoline and their blends were evaluated. Results showed that when the engine is running with ethanol-methanol-gasoline blends, the concentrations of CO and UHC (Unburned Hydrocarbons) emissions were significantly decreased, compared to the pure gasoline. Methanol-gasoline blends presented the lowest emission of CO and UHC among all test fuels. Furthermore, effects of blended fuels on engine performance were investigated and results showed that methanol (20%)-gasoline (95 Ron) blends present the highest efficiency and torque: ethanol (20%)-gasoline (95 Ron) blends provides the highest fuel mass flow rate and brake specific fuel consumption.

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1. Introduction

The reserves of petroleum-based fuels are directly correlated with the increasing demands of humankind for energy production. With growing world populations, industries, vehicles, and equipment, energy demand leads to the search for a substitute for petroleum fuels which can cater to the need of people today. Considering the current global economic crisis, the curiosity in alternative fuels is extremely high. Alternative fuels used as substitute petroleum-based fuels must be produced from renewable sources, and should be devised to use this fuel without bringing any modifications in the geometry of the engine. Alcohols have provided an answer to this problem. Ethanol and methanol are thought to be the most fitting fuel for spark ignition engines [1]. One of the goals of researchers is the development of high efficiency and clean fuels. Some of the most important fuels are natural gas, biogas, vegetable oil, esters alcohols derived from vegetable oils and hydrogen. Alcohol fuels such as methanol and ethanol have emerged as alternative fuels for spark ignition engines because they are flak and have physical and combustion properties analogous to gasoline.

Major research work on the evaluation of the performance parameters of the engines, operated on alternative fuel, has given us a food for thought to either replace petroleum by alternative fuel or use them in varying percentage ratios with gasoline. This review paper aims to study the spark ignition engine with various blends of gasoline-ethanol, gasoline-methanol, gasoline with other alcohol derivatives, and subsequent alternative fuels, by considering various aspects such as air-fuel ratio, operating cylinder pressure, ignition timing and compression ratio related to the performance parameters only [2].

2. Introduction to Four-Stroke SI Engine

A four-stroke cycle engine is an internal combustion engine that utilizes four distinct piston strokes (intake, compression, power, and exhaust) to complete one operation cycle. A four-stroke (also four-cycle) engine is an internal combustion (IC) engine in which the piston completes four-separate stroke while turning the crankshaft. It states that there would be one power stroke for every four stroke. Such engines use a spark plug which is used for the ignition of the combustible fuel used in engine [3].

A stroke refers to the full travel of the piston along the cylinder in either direction. The piston makes two complete passes in the cylinder to complete one operation cycle. An operation cycle requires two revolutions (720°) of the crankshaft. The four-stroke cycle engine is the most common type of small engine. A four-stroke cycle engine completes five strokes in one operation cycle, including intake, compression, and ignition, power, and exhaust strokes shown in Figure 1.

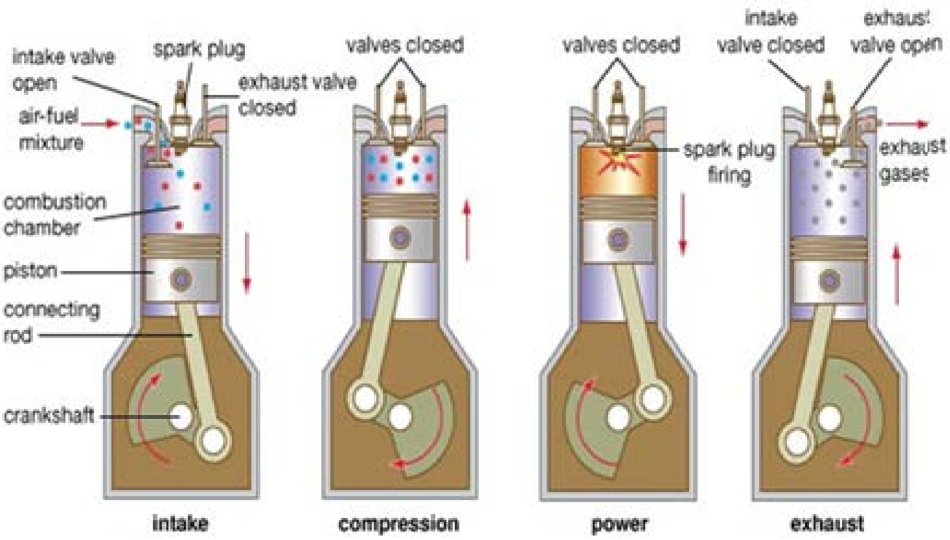

Figure 1. Working Principle of Four-Stroke Spark Ignition Engine [5]

3. Characteristics of Fuel

Petrol, also known as gasoline, is the most commonly used transport fuel. It is a highly volatile hydrocarbon derived from crude oil. In its natural state gasoline is a liquid with a strong solvent smell. Typically it is used to fuel internal combustion engines for cars, motorbikes, trucks, boats and other transport vehicles. Highly refined gasoline can be used as aviation fuel, referred to as aviation gasoline (avgas) [6]. Petrol varieties are distinguished by their octane rating. Premium fuels usually have an octane rating between 94, 95 or 96. The top quality fuel for road vehicles are often referred to as “Ultimate” and generally have an octane rating of 98. These fuels often contain additives such as lubricants which reduce engine wear and increase engine efficiency.

3.1 Blending Petrol with Ethanol

Ethanol blending is the practice of blending petrol with ethanol. Many countries, have adopted ethanol blending in petrol in order to reduce vehicle exhaust emissions and also to reduce the import burden on account of crude petroleum from which petrol is produced. It is estimated that a 5% blending can result in replacement of around 1.8 million Barrels of crude oil.

The renewable ethanol content, which is a byproduct of the sugar industry, is expected to result in a net reduction in the emission of carbon dioxide, carbon monoxide (CO) and hydrocarbons (HC). Ethanol itself burns cleaner and burns more completely than petrol it is blended into [6].

3.2 Blending Petrol with Methanol

Methanol-Petrol blends M5, M10, and M15 containing 5%, 10%, and 15% of methanol by volume, respectively, were used to investigate the effects of different methanol/gasoline ratios on engine power, thermal efficiency, and emissions, especially the exhaust emission. Experimental results show that the engine power/torque ratio under the wide open throttle condition mainly depends on the amount of heat delivered to the engine.

The addition of methanol significantly improves the brake thermal efficiency, while the methanol/gasoline ratio has a slight effect on it. Measurement indicates that the addition of methanol in petrol results in an increase of the unburnt CH_3OH emission [7].

3.4 Engine Performance Parameters

For comparing the performance of the engines, it needs to know the power and efficiency of the engine. Performance is used term which has to do with the power and efficiency obtainable when an engine is operated at various speed, inlet pressure and temperature, fuel air ratio, spark advance, compression ratio, etc.

To study engine performance, both the power and the torque characteristic are considered. The calorific value of petrol fuel and blended fuels are as shown in Table 1.

Table 1. Heating Value of Petrol Fuel, Ethanol, Methanol and Blended Fuels

No.	Type of Fuel	Heating Value (MJ/Kg)	No.	Type of Fuel	Heating Value (MJ/Kg)
1	Petrol (Ron-92)	44.31	7	92 (85%) +M (15%)	37.4723
2	Petrol (Ron-95)	47.48	8	92 (80%) +M (20%)	29.9435
3	Ethanol	26.8	9	95 (85%) + E (15%)	34.446
4	Methanol	19.7	10	95 (80%) + E (20%)	35.8328
5	92 (85%) + E (15%)	29.1927	11	95 (85%) +M (15%)	32.6047
6	92 (80%) + E (20%)	32.7264	12	95 (80%) +M (20%)	37.7121

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4. Results and Discussions

Figure 2 shows torque changes according to the rpm. This graph is the comparison of 92 Ron, 92 with Ethanol (15%) and (20%), 92 Ron with Methanol (15%) and (20%).

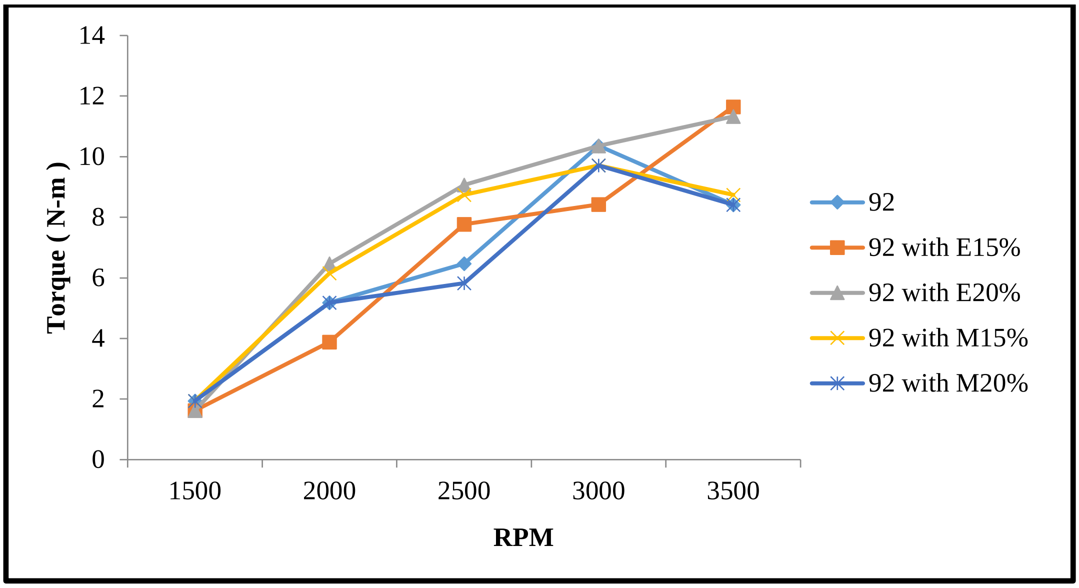

Figure 2. Compare with 92 Ron, 92 with Ethanol (15%) and (20%), 92 Ron with Methanol (15%) and (20%)

From the chart, 92 Ron with E15 has the highest torque at 3500 rpm. 92 Ron with E15, E20 and M15% are the lowest torque at 1500 rpm.

Figure 3 shows mass flow rate changes according to the rpm. From the chart, 92 Ron with M20 has the maximum mass flow rate of 0.57 kg/s at 3500 rpm. At this speed, pure 92 Ron has the lowest mass flow rate compared with others.

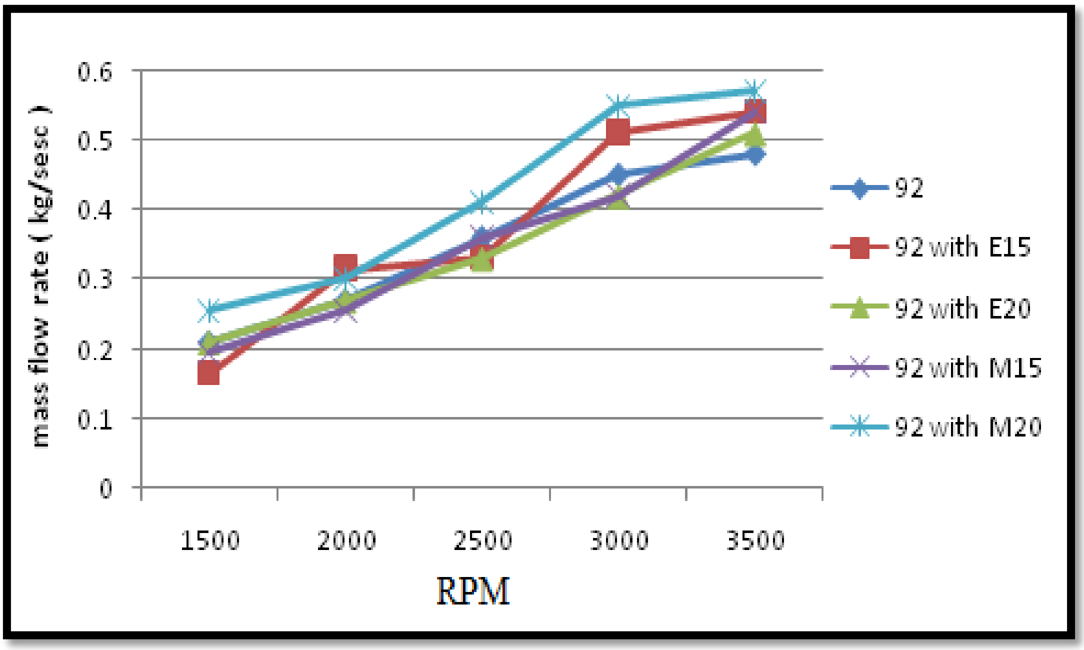

Figure 3. Compare with 92 Ron, 92 with Ethanol (15%) and (20%), 92 Ron with Methanol (15%) and (20%)

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Figure 4 shows break horse power changes according to the rpm. From the chart, 92 Ron with E15% and E 20% is the highest break horse power at 3500 rpm. Pure 92 Ron, M15 and M20 are the lowest bhp at this speed.

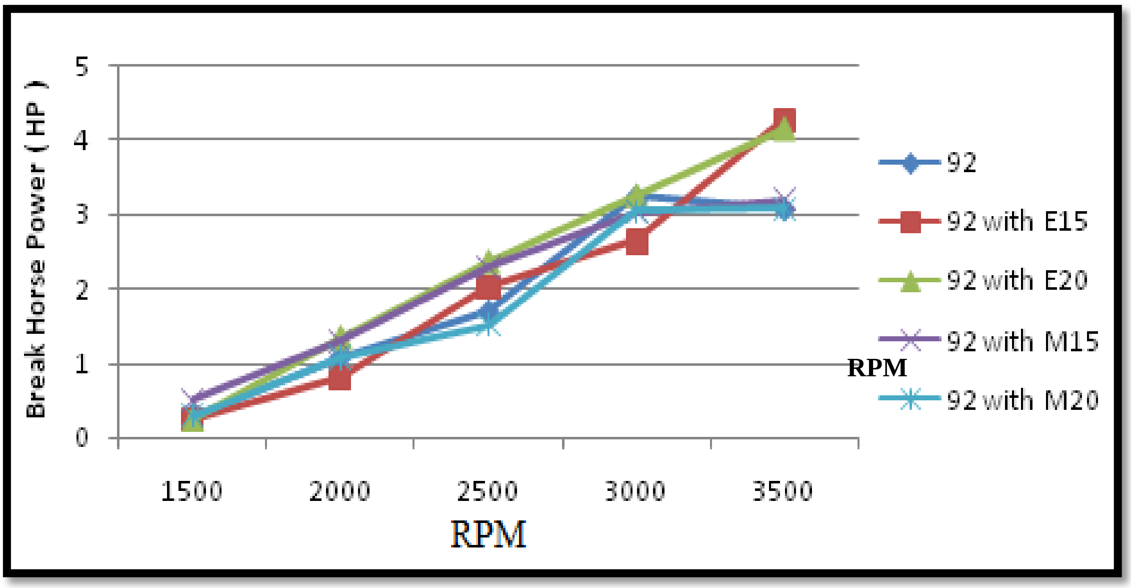

Figure 4. Compare with 92 Ron, 92 with Ethanol (15%) and (20%),92 Ron with Methanol (15%) and (20%)

Figure 5 shows b.s.f.c changes according to the rpm. From the chart, 92 Ron with Ethanol 20% is the highest break specific fuel consumption at 1500rpm. 92 Ron with E15 and E20 are lowest break specific fuel consumption at 3500 rpm.

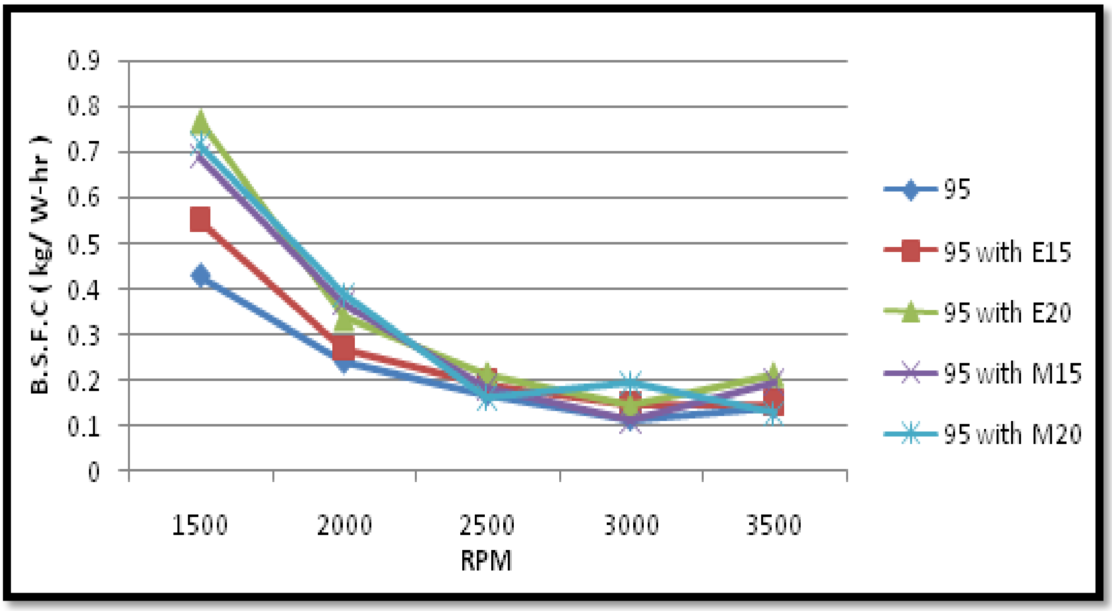

Figure 5. Compare with 92 Ron, 92 with Ethanol (15%) and (20%),92 Ron with Methanol (15%) and (20%)

Figure 6 shows efficiency changes according to the rpm. From the chart, 92 Ron with ethanol 20% is the highest break thermal efficiency at 3500 rpm. Pure 92 Ron and 92 Ron with methanol 20% are the lowest break thermal efficiency at 3500 rpm.

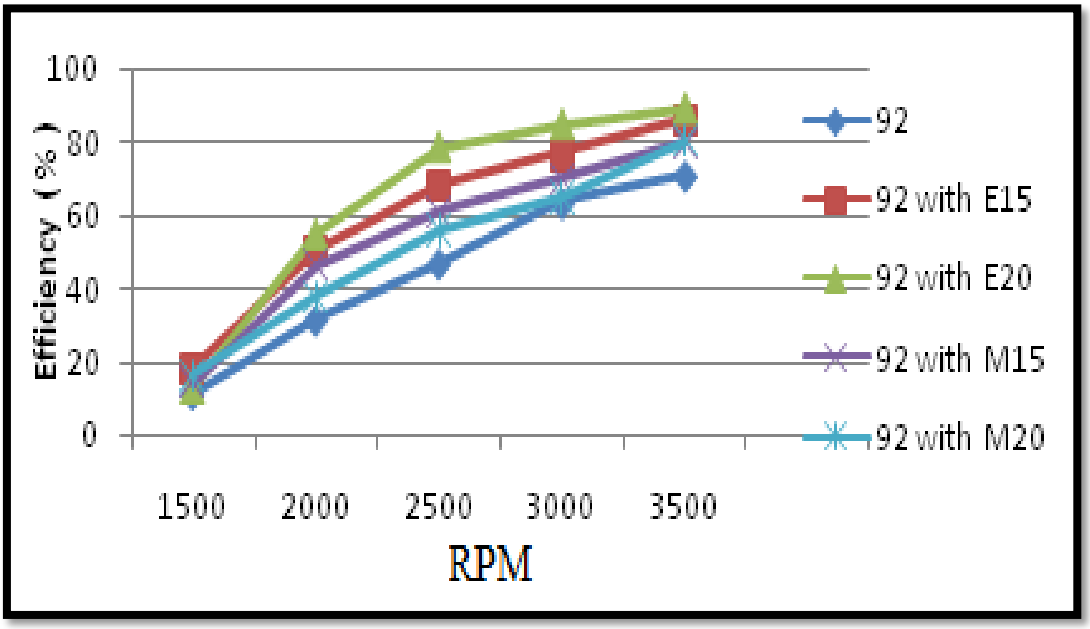

Figure 6. Compare with 92 Ron, 92 with Ethanol (15%) and (20%),92 Ron with Methanol (15%) and (20%)

Figure 7 shows torque changes according to the rpm In this graph, petrol (95 Ron) with ethanol 20% (E20) blended fuel gives the best torque performance among them. Secondly, petrol (95 Ron) with ethanol 15% (E15) gives better torque performance than pure petrol and petrol with methanol.

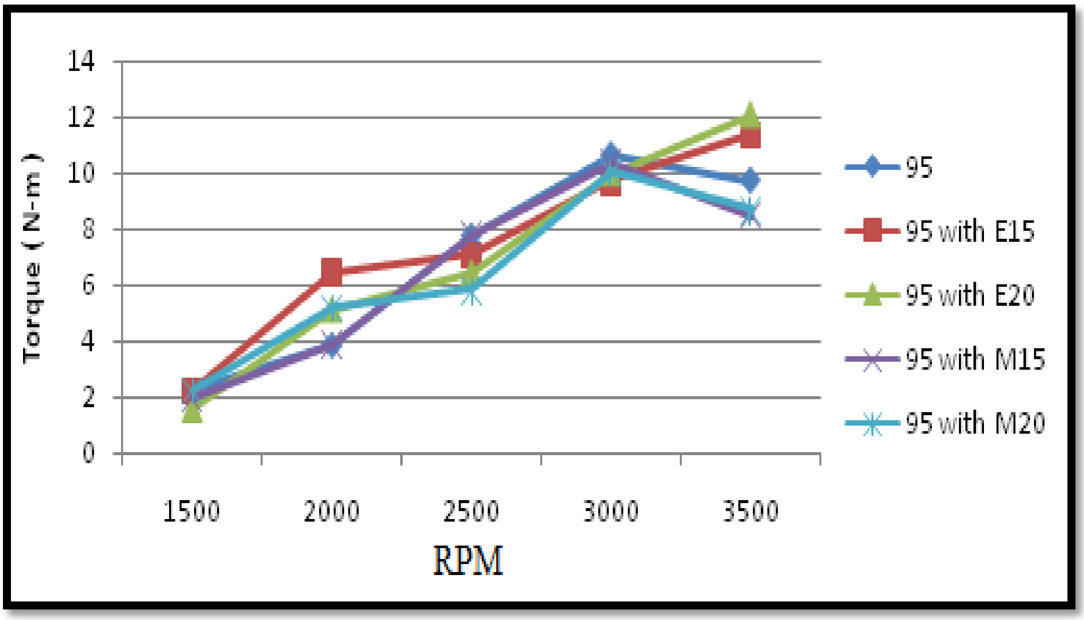

Figure 7. Compare with 95 Ron, 95 with Ethanol (15%) and (20%),95 Ron with Methanol (15%) and (20%)

Figure 8 shows mass flow rate changes according to the rpm. According to this graph, mass flow rate of the petrol (95 Ron) with ethanol 20% (E20) is higher than the pure petrol (95 Ron) and petrol with methanol. Petrol (95 Ron) with methanol 15% (M15) has lower mass flow rate.

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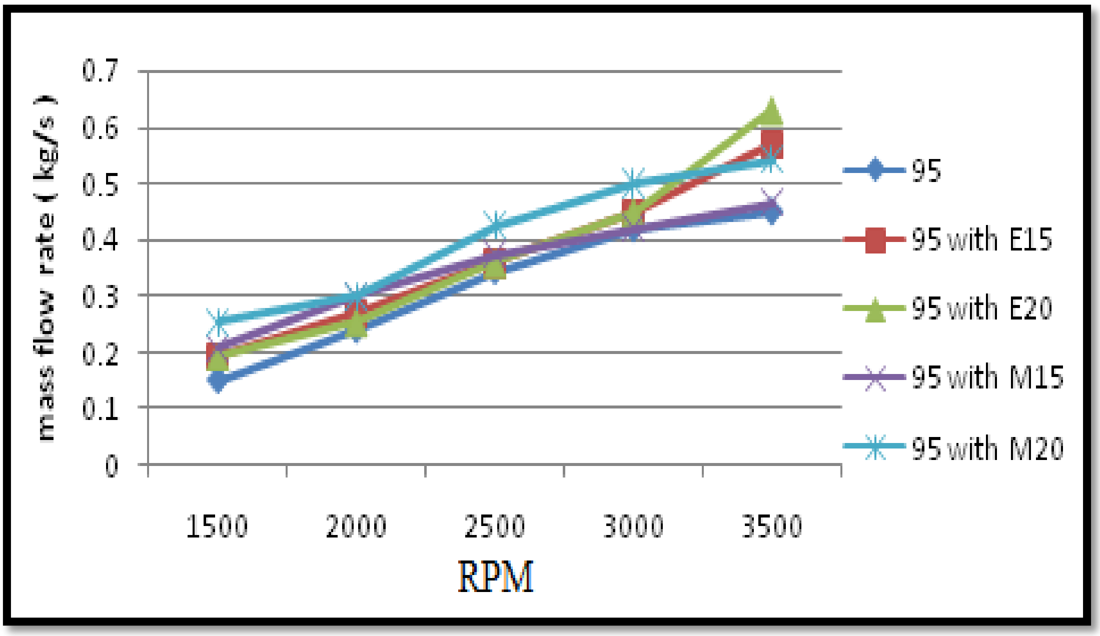

Figure 8. Compare with 95 Ron, 95 with Ethanol (15%) and (20%), 95 Ron with Methanol (15%) and (20%)

Figure 9 shows torque changes according to the rpm. In this graph, break horse power of the petrol (95 Ron) with ethanol 15% (E15) is significantly higher than the pure petrol and other blended fuel.

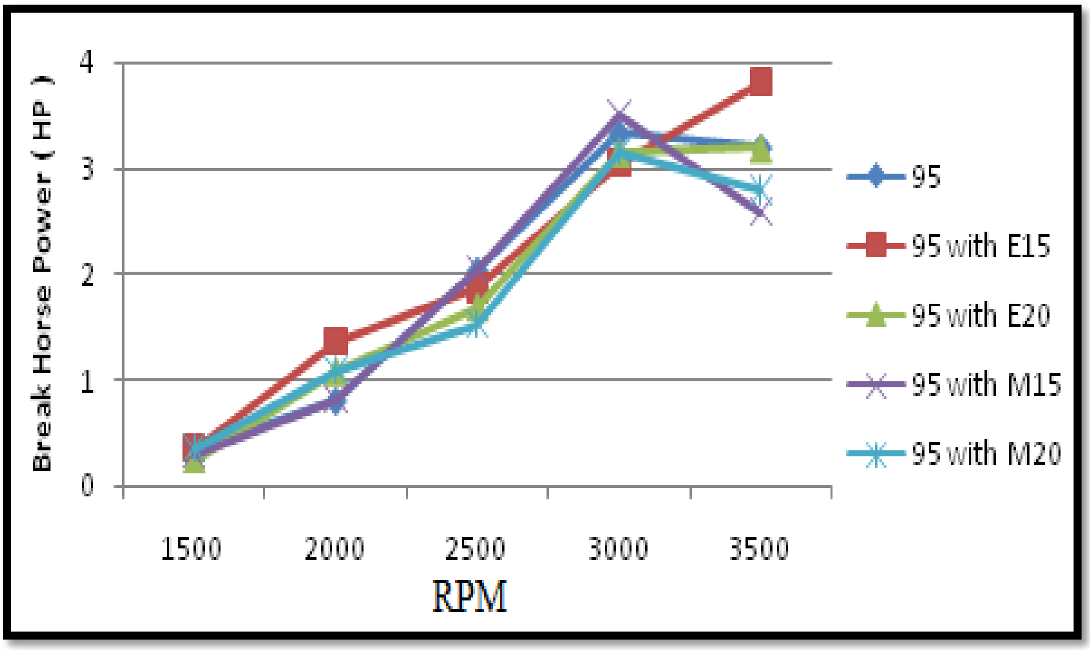

Figure 9. Compare with 95 Ron, 95 with Ethanol (15%) and (20%), 95 Ron with Methanol (15%) and (20%)

Figure 10 shows b.s.f.c changes according to the rpm. In this graph, we get the higher break specific fuel consumption at the petrol (95 Ron) with ethanol 20% (E20). Lower break specific fuel consumption appears at petrol (95 Ron) with methanol 20% (M20).

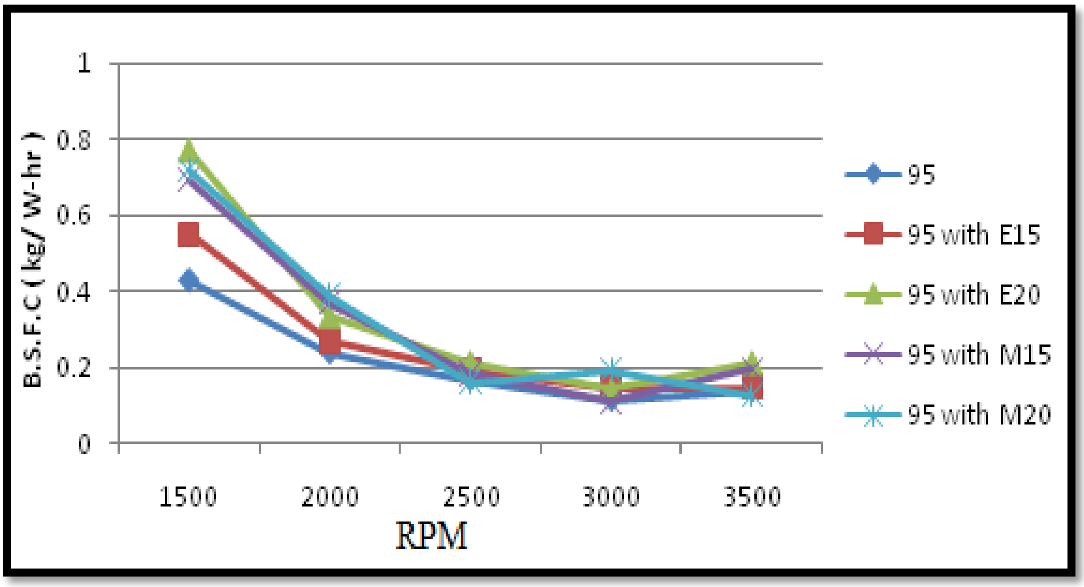

Figure 10. Compare with 95 Ron, 95 with Ethanol (15%) and (20%), 95 Ron with Methanol (15%) and (20%)

Figure 11 shows torque changes according to the rpm. This graph shows that the petrol (95 Ron) with ethanol 15% (E15) has higher efficiency among them. On the other hand, the petrol (95 Ron) with methanol 20% (M20) has low efficiency.

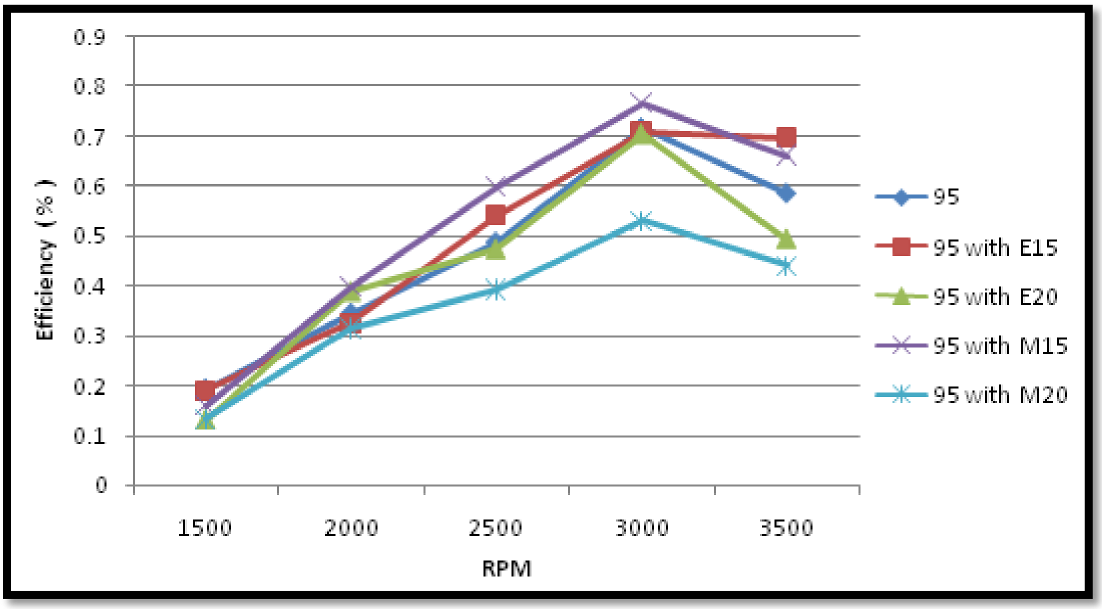

Figure 11. Compare with 95 Ron, 95 with Ethanol (15%) and (20%), 95 Ron with Methanol (15%) and (20%)

5. Conclusion

From the experiment, the torque output and fuel consumption of the engine slightly increase. CO (carbon monoxide) and HC (Hydro chlorofluorocarbon) emissions decrease dramatically as a result of the learning effect caused by the ethanol addition and CO_2 emission increases because of the improved combustion. From the results, it can be concluded that ethanol blends are quite successful in replacing pure gasoline in spark ignition engine. Results clearly show that there is an increase in specific fuel consumption because of low calorific value of ethanol that gasoline and also increase in the mechanical efficiency. So from the curves it is seen that 20% ethanol blended gasoline is the best choice for use in the existing spark ignition engines without any modification to increase efficiency. A little consideration has to be taken on material used as maximum pressure inside cylinder is increased by blending. A balance has to be made between specific fuel consumption and efficiency to take care of users using blend as more fuel will be consumed due to blending of ethanol with gasoline.

6. Recommendations

During the test, the blended fuel did not show any phase separation and the engine perform well without any modification. But it was observed that petrol-ethanol and petrol-methanol blends produced more vibration due to which certain part of experimental set up were damaged and then replaced. So, next researcher should consider the effect of vibration analysis. It is also recommend that the reduction of exhaust emission and the performance of petrol or diesel blend with the different percentage of alcohol type fuels should be analysed.

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