Journal of Engineering and Sustainable Development
www.jeasd.org
Vol. 21, No.04, July 2017
ISSN 2520-0917

THE EFFECT OF METHANOL BLENDED WITH GASOLINE ON THE PERFORMANCE AND VIBRATION OF SPARK IGNITION ENGINE

Dr. Fouad Alwan Saleh[1],* Dr. Fadhel Abbass Abdulah[2], Hajir Haitham Labeeb[3]

1) Assist Prof., Mechanical Engineering Department, Al-Mustansiriyah University, Baghdad, Iraq.
2) Assist Prof., Mechanical Engineering Department, Al-Mustansiriyah University, Baghdad, Iraq.
3) Mechanical Engineering Department, Al-Mustansiriyah University, Baghdad, Iraq

Abstract: This study is an experimental investigation of the effects of methanol addition to gasoline on the performance (brake power, brake specific fuel consumption), and emissions (carbon monoxide CO, hydrocarbons HC) of a spark ignition engine, engine vibration was also measured (Acceleration) .The tests were carried out at constant throttle variable speed condition operating with standard and advanced spark timing (10˚ and 11˚ BTDC respectively) over the range of speed from 1500 to 2250 rpm and compression ratios CR=8 and 9 using various blends of methanol/gasoline 0% (M0), 5% (M5), 10% (M10), 15% (M15) and 20% (M20) methanol by volume .The experimental results showed that for standard spark timing, maximum power was obtained at M10 CR9 by increase of (18.29%) from M0. While for advanced spark timing, maximum power was obtained at M20 CR9 by an increase (18.27%) from M0. Advancing spark timing resulted in power increase by (13.4%) from standard spark timing. Optimum compression ratio for gasoline fuel was 8 while for methanol-gasoline blends was 9 .Emissions of CO and HC were decreased significantly by using methanol as fuel additive and increasing methanol content in the fuel. M0 exhibited the lowest and most stable acceleration level at higher engine speed at CR8 (2000-2250 rpm). While for CR9, M5 generally showed the lowest acceleration values for lower and higher engine speeds. M15 fuel blend, showed maximum acceleration level compared to other fuel blends.

Keywords: *methanol, performance, vibration, acceleration.*

تأثير خلط الميثانول مع وقود البنزين على أداء واهتزازات محرك الاشتعال بالشرارة

الخلاصة: الدراسة الحالية هي دراسة عملية لتأثير اضافة (كحول الميثانول الى وقود البنزين) على اداء المحرك (القدرة المكبحية، صرف الوقود)، والانبعاثات (احادي اوكسيد الكربون، دقائق الهيدروكربون) لمحرك الاشتعال بالشرارة وتم كذلك قياس الاهتزازات (التعجيل). تم اجراء التجارب العملية على محرك احادي الاسطوانة، رباعي الاشواط متغير نسبة الانضغاط موديل. ان الهدف الاساسي هو اختبار المحرك بنسب انضغاط متغيرة وتقديم توقيت الشرارة لإيجاد الاداء الامثل للمحرك بعد استخدام وقود جديد يتكون من الميثانول والبنزين.

تم اجراء الاختبارات لمدى سرعة من 1500-2250 دورة/دقيقة بنسب انضغاط 8 و 9 باستخدام عدة خلطات وقود من الميثانول و البنزين (5%، 10%، 15% و 20%). عند توقيت الشرارة القياسي تم الحصول على اعلى قدرة عند M10 CR9 بزيادة (18.29%) بينما عند تقديم توقيت الشرارة تم الحصول على اعلى قدرة عند M20 CR9 بزيادة (18.27%) عن .M0 ان تقديم توقيت الشرارة قد ادى الى زيادة قدرة المحرك بنسبة (13.4%) عن توقيت الشرارة القياسي. ان نسبة الانضغاط المثلى للبنزين هي 8 بينما خليط الميثانول- البنزين هي 9 .ان انبعاثات CO وHC قد انخفضت بصورة كبيرة بإضافة الميثانول الى البنزين وزيادة نسبته. ان M0 اظهر ادنى مستوى اهتزازات واكثر استقرار عند السرع العالية عند CR8. بينما عند CR9 فإنه بصورة عامة M5 اظهر ادنى مستوى اهتزازات عند سرع المحرك العالية والواطئة. اما M15 فقد اظهر اعلى نسبة اهتزازات مقارنة بخلطات الوقود الاخرى.

---

*Corresponding Author fadhel975@yahoo.com

1. Introduction

Even though fossil fuels are the primary energy source for most of the combustion engines, there have been concerns about the future availability and environmental impact of such fuels. For a long-term sustainability, the application of renewable fuels in traditional combustion devices needs to be investigated to replace fossil fuels. In engines, renewable fuels such as Methanol, Ethanol have been demonstrated as the promising replacements of the nonrenewable petroleum fuels. Due to their good characteristics, Methanol and Ethanol have been used to replace gasoline fuel in SI engines[1]. In practice, to achieve the optimum emission level and performance, renewable fuels are blended with petroleum fuels at different ratios in engine applications [2]. The role of existing internal combustion engines needs to be reviewed now in the context of these two major crises in present (future availability and environmental impact of fossil fuels). In view of the versatility of internal combustion engines, they will continue to dominate the existing transportation sector [3]. Over the past decade, alternative fuels have been studied for the possibility of lower emission, economy, better fuel availability and lower dependence on crude oil generated fuels. Before any alternative fuels could be used as an alternative to petrol or diesel, it has to full fill some criteria [4].Oxygenated fuels contain oxygen-bearing compounds (alcohol). Ethanol, Methanol, is oxygenated fuels. Since these compounds add oxygen to the air/fuel mixture, they artificially lean the air/fuel mixture, resulting in more complete combustion and lower hydrocarbons [5].

Alcohol is an alternative transportation fuel since it has properties, which would allow its use in existing engines with minor hardware modifications. Alcohols have higher octane number than gasoline. A fuel with a higher octane number can endure higher compression ratios before engine starts knocking, thus giving engine an ability to deliver more power efficiently and economically [6]. Alcohol burns cleaner than regular gasoline and produce lesser carbon monoxide, HC and oxides of nitrogen. Alcohol has higher heat of vaporization; therefore, it reduces the peak temperature inside the combustion chamber leading to lower NOx emissions and increased engine power. [7]

Methanol has many fuel properties that make it cleaner burning in gasoline engines. Besides containing oxygen for cleaner fuel combustion, the methanol also has a high blending octane for smoother burning, a lower boiling temperature for better fuel vaporization in cold engine operation, the highest hydrogen to carbon ratio for lower carbon intensity fuel, and no sulphur contamination which can poison the vehicle’s catalytic converter. [8]

In this work, an investigation will be done to study the effect of blending methanol on both engine vibration and performance by taking the effect of advancing the spark timing and varying the compression ratio together, using new fuel consisting of gasoline and methanol instead of only gasoline fuel.

2. Experimental Work

The objective of the experimental work is to study the effect of variable compression ratio and spark timing for methanol blending with gasoline on the optimum performance, emissions and vibration of single cylinder, 4 stroke SI engine. This will be done by a series of experimental tests with varying of the engine parameters to find the optimum and useful data.

The variables that could be changed were (compression ratio, spark timing, fuel composition) for the range of engine velocity 1500-2250 with 250 rpm increment. Figure (1) gives a general view of the experimental test rig.

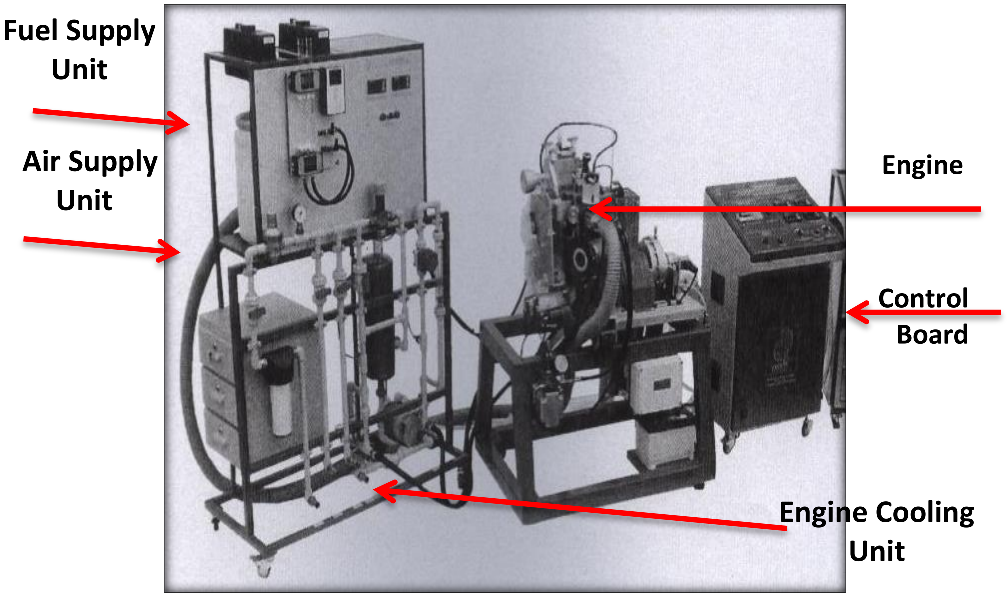

Figure (1) General View the Experimental Test Rig

All Experiments were performed on a “VARICOMP” internal combustion engine model (GR0306/000/037A) manufactured by Prodit Company, Italy, the engine is designed to work either as SI or CI engine, it is equipped with dynamometric test unit (Hydraulic Type). The main specifications of the test engine are shown in table (1).

The first run, for all performance, emissions and vibration tests were carried out by using gasoline as a base fuel so that the effect of adding methanol could be understood clearly.

After the first experiment was completed with all runs, the second experiment is carried out by blending 5% methanol (by volume) into gasoline and so on until the 20% methanol blend, by increment 5% methanol for each blend respectively. The specifications of the methanol and gasoline used in the experiments are given in Tables (2)

Table (1) Engine Specifications.

Manufacturer:	PRODIT s.a.s. (Italy)
Origin:	Italy
Cycle strokes:	OTTO or DIESEL, 4 Strokes
Number of cylinders:	1 vertical
Diameter:	90 mm
Stroke:	85 mm
Swept volume:	541 cm^3
Compression ratio:	4 - 17.5
Standard spark timing:	10˚ BTDC
Maximum power output:	4kW at 2800 rpm
Maximum torque:	28 N.m at 1600 rpm
Method of Starting:	Self-Starting
Cooling:	Water cooled
Dynamometer:	Hydraulic type
Fuel Tank:	Capacity 4 liters with glass fuel metering column (burette).

Table (2) Specifications of Leaded Gasoline.

Property	Value & Description
Appearance	Clear and Bright
Final Boiling Point ˚C (max)	210
Energy Content (kJ/kg)	48000
Color	Yellow
Octane no. (Research) (min)	85
Sulfur content (ppm) (max)	100
Lead Content (g pb/l) (max)	0.15
Reid Vapor Pressure (kg/cm^2) @ 37.8 ˚C	0.45-0.62 (Summer) 0.5-0.84 (Winter)
Density (g/cm^3) @ 15 ˚C (min)	0.710
Oxygen Content % wt (max)	1.3

Table (3) Specifications of Methanol

Property	Value & Description
Chemical Structure	CH_3OH
Physical State	Liquid
Energy Content (kJ/kg)	22700
Octane No.	112
Auto Ignition Temperature	470 °C

Regarding the vibration measurement and in order to determine the effect of adding methanol, varying the compression ratio and spark timing on engine vibration, surface vibrations on the engine block were detected using a hand held vibration monitoring instrument (From: Lutron, Inc., Model: VB8220 with computer interface), it was used to measure surface vibrations at various locations on the engine. This vibration meter’s sensor was attached to the engine using magnet. Vibration signals from engine were recorded on the head of the cylinder placed vertically (Vertical Direction), acceleration was measured in the vertical direction since it is related to the gas pressure inside the cylinder. During experiments multiple points were measured and the point which showed the maximum value was chosen. The mounting location is shown in figure (2).

The main objective from vibration measurements is to investigate the trend of vibration levels when the fuel type is varied and also the varying of compression ratio and spark timing

Engine emissions were measured using exhaust gas analyser (from TEXA S.p.A.), which is a complete unit for carrying out exhaust gas analysis on all types of Petrol, diesel and methanol fueled engines. It consists of GAS BOX Autopower (analysis chamber) and MULTI PEGASO (workstation).

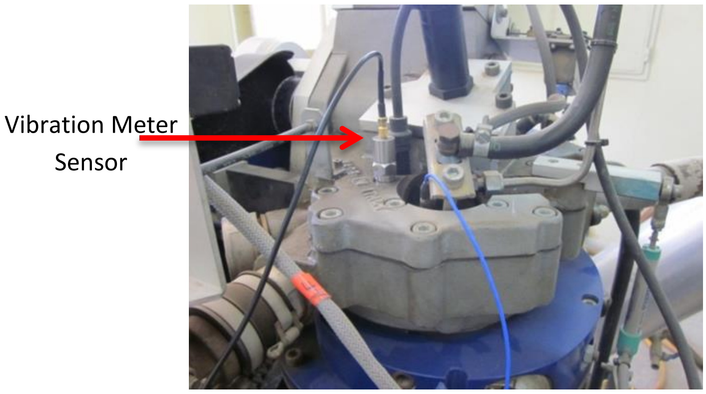

Figure (2) Mounting Location of the Vibration Meter Sensor.

Figure (3) TEXA Exhaust Gas Analyzer

3. Results and Discussion

3.1. Brake Power

Figures (4), (5) represent the effect of compression ratio on the engine brake power at standard spark timing for M0, M5, M10, M15 and M20 respectively. It is shown that increasing the compression ratio increases the engine power when methanol used as fuel due to its better combustion characteristics since there is oxygen atom in its chemical formula. Also engine brake power is increased by increasing the compression ratio because the use of methanol permits the increasing of compression ratio without knocking. Maximum power was obtained at M10 and CR9. From figures it is noticed that power is maximum at 2000 rpm and then started to decrease due to the reduced volumetric efficiency and increased friction forces.

Figures (6), (7) show that by advancing the spark timing, engine power increases and maximum power was at M20 and CR9. Advancing the spark timing permits the increasing of peak pressure inside the cylinder and result in increased power. For standard spark timing maximum power was obtained at M10 CR9 by increase (18.29%) from M0. While at advanced spark timing maximum power was obtained at M20 CR9 by an increase (18.27%) from M0. Advancing the spark timing resulted in power increase by (13.4%) from standard spark timing.

3.2. Brake Specific Fuel Consumption

Figures (8), (9) show the effect of increasing CR for M0, M5, M10, M15 and M20 respectively. It is shown that the BSFC is decreased when using methanol as fuel additive, and reduced by increasing the compression ratio.

The effect of increasing CR at advanced spark timing for M0,M5, M10, M15 and M20 is shown in figures (10), (11) respectively. It is shown that BSFC is decreased when using methanol as fuel additive and advancing the spark timing, as it is function of brake power.

3.3. CO Emissions

Figures (12), (13) represent the CO emissions for the gasoline and fuel blends for CR 8 and 9 at standard spark timing. CO is resulted from incomplete combustion process. CO percentage is decreased by increasing the compression ratio means more fresh air will be present by increasing the compression ratio.

For M5, M10, M15 and M20, it is noticed that CO percentage is decreased by increasing the methanol percentage since there will be more oxygen content in the charge and this will enable the charge from completely burn and thus all CO is oxidized to CO_2. Lowest CO emissions was found at CR8 (0.2%) and at CR9 (0%) at 2250 rpm.

Figures (14) , (15) represent the CO emissions for the gasoline and fuel blends at advanced spark timing, CO percentage was decreased slightly by advancing the spark timing due to improvement in combustion process. Lowest CO emissions was found at CR8 (0.07%) and at CR9 (0%) at 2250 rpm.

3.4. HC Emissions

Figures (16), (17) represent the HC emissions for the gasoline and fuel blends at standard spark timing. HC is resulted from improper combustion process of the fuel, HC emissions are increased by increasing the compression ratio, due to rich mixture and this will make more unburned hydrocarbons.

For M5, M10, M15 and M20, is clear that HC emission is decreased by increasing the methanol percentage since there will be complete combustion and due to oxygen presence and thus the HC emissions will be less because of complete combustion. Lowest HC emissions was found at CR8 (77ppm) and at CR9 (82ppm) at 2250 rpm .

Figure (18), (19) represent the HC emissions for the gasoline and blended fuel at advanced spark timing. HC is reduced by advancing the spark timing, due to the reason that a chance for more proper combustion is available and in this case will be no unburned hydrocarbon from the fuel. Lowest HC emissions was found at CR8 (67ppm) and at CR9 (72ppm) at 2250 rpm.

3.5. Vibration Tests

Vibration data were acquired for all fuel blends used in this study, by varying the compression ratio and spark timing and engine speed in addition to varying the fuel blends.

Figures (20), (21), demonstrate the time domain signal for fuel blends at 2000 rpm and CR 8 and 9. It is clear that M5 showed the minimum acceleration value (5 m/s^2) at CR9 and the other fuel blends were almost constant especially for M0, M15 and M20.

The peaks in time domain signal means the changes in gas pressure inside the cylinder. The combustion at varied compression ratios is found to be not following the same rule and acceleration values is changing with respect to engine speed.

For advanced spark timing results figures (22) to (23), it was generally noticed that the signal had many fluctuations not stable as in the standard spark timing this is due to the fluctuations in gas pressure inside the cylinder. All blends exhibited same trend in minimum acceleration at each corresponding speed as in the standard spark timing values but with lower acceleration values generally.

In general, it is obvious from all figures that using different percentages of methanol as fuel additive to gasoline affect the engine vibration. M0 exhibited the lowest acceleration values at higher engine speeds at CR8. While for CR9, M5 generally showed the lowest acceleration values for higher and lower engine speeds. M15 blend, showed the maximum acceleration values.

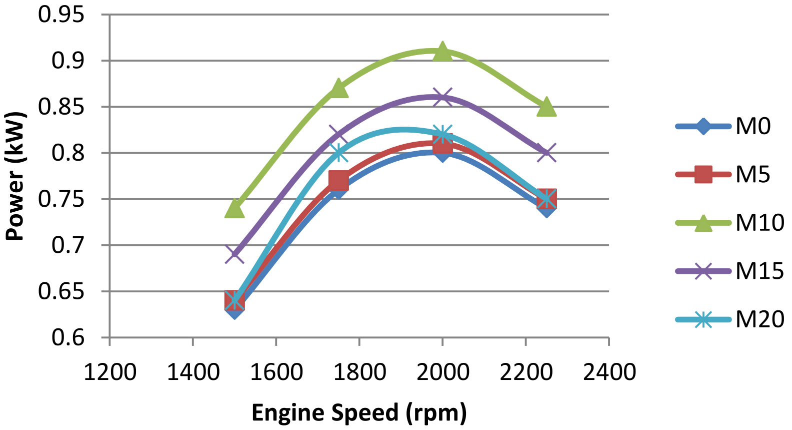

Figure (4) Engine power versus engine speed for CR8 – standard spark timing

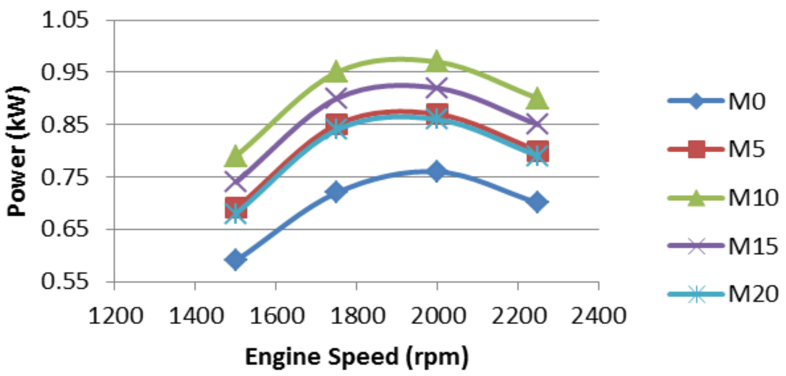

Figure (5) Engine power versus engine speed for CR9 – standard spark timing

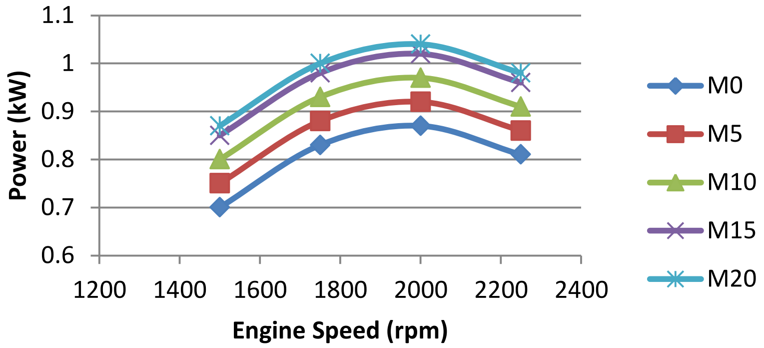

Figure (6) Engine power versus engine speed for CR8 – advanced spark timing

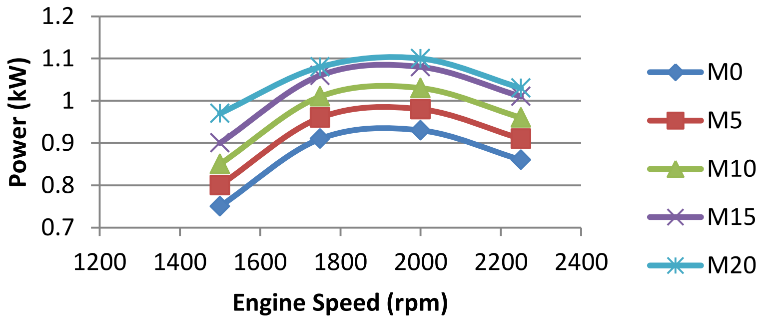

Figure (7) Engine power versus engine speed for CR9 – advanced spark timing

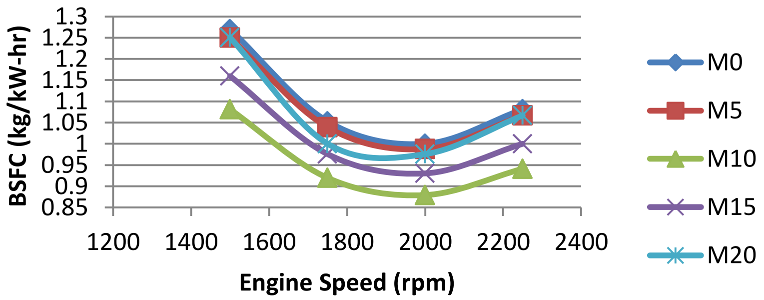

Figure (8) BSFC versus engine speed for CR8 – standard spark timing

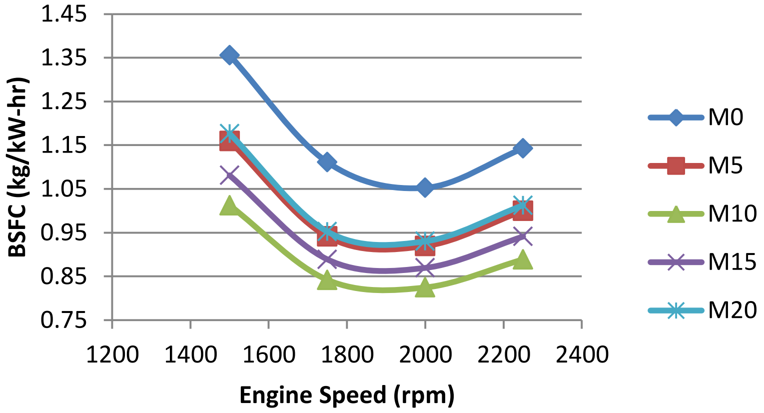

Figure (9) BSFC versus engine speed for CR9 – standard spark timing

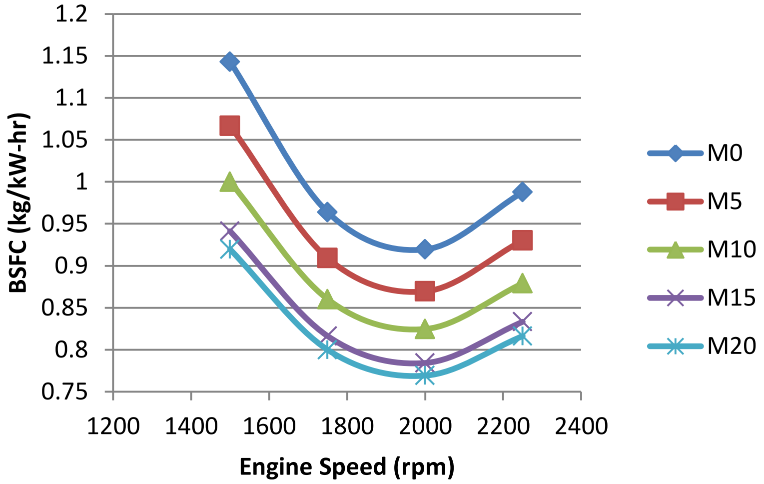

Figure (10) BSFC versus engine speed for CR8 – advanced spark timing

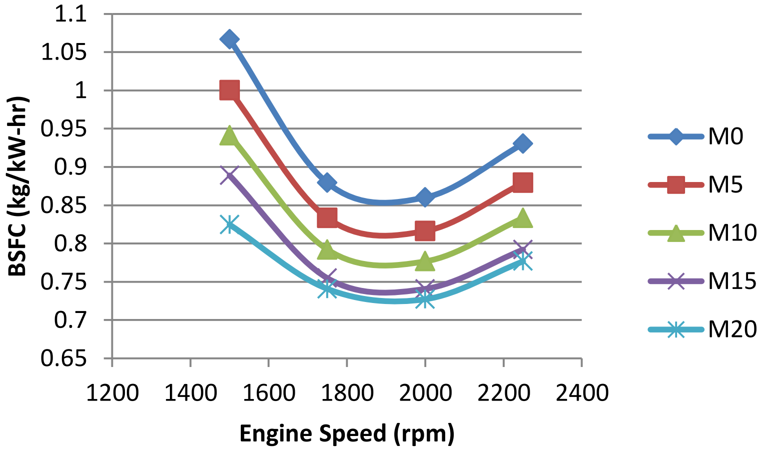

Figure (11) BSFC versus engine speed for CR9 – advanced spark timing

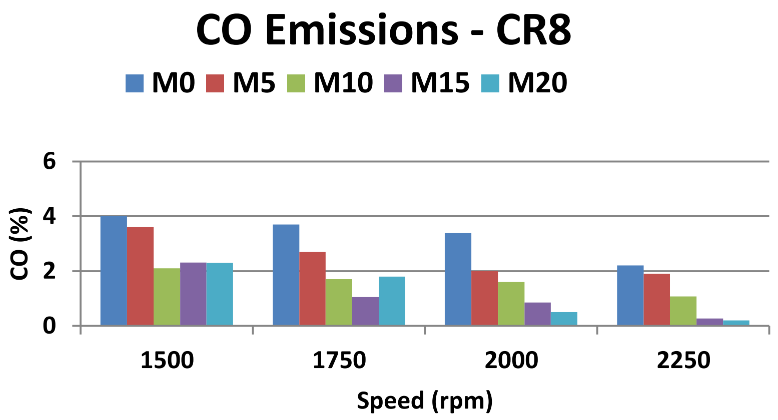

Figure (12) CO emissions for fuel blends at CR8 – spark timing 10 ˚ BTDC

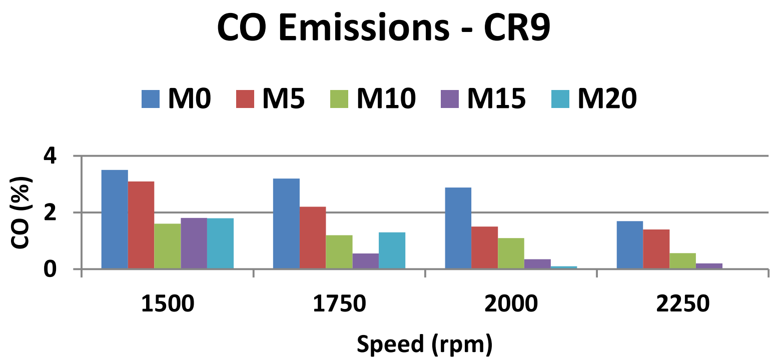

Figure (13) CO emissions for fuel blends at CR9 – spark timing 10 ˚ BTDC

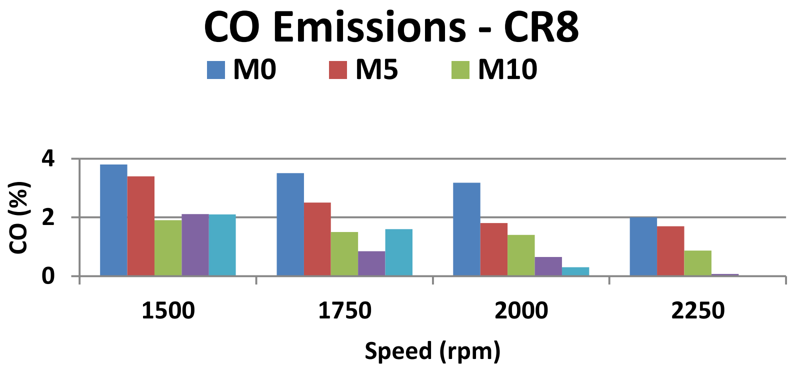

Figure (14) CO emissions for fuel blends at CR8 – spark timing 11 ˚ BTDC

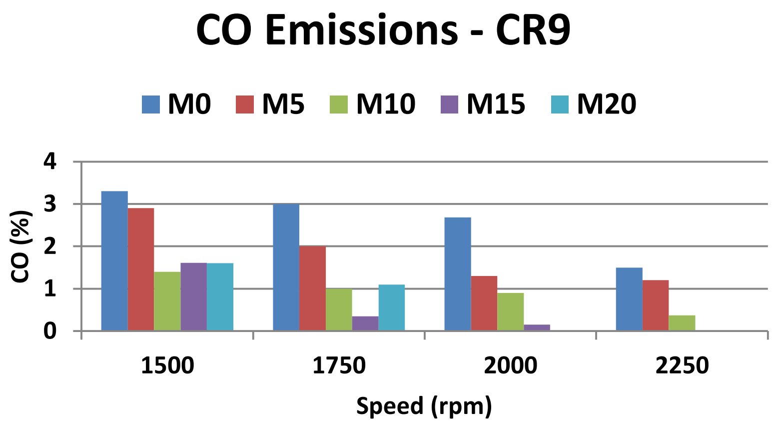

Figure (15) CO emissions for fuel blends at CR9 – spark timing 11 ˚ BTDC

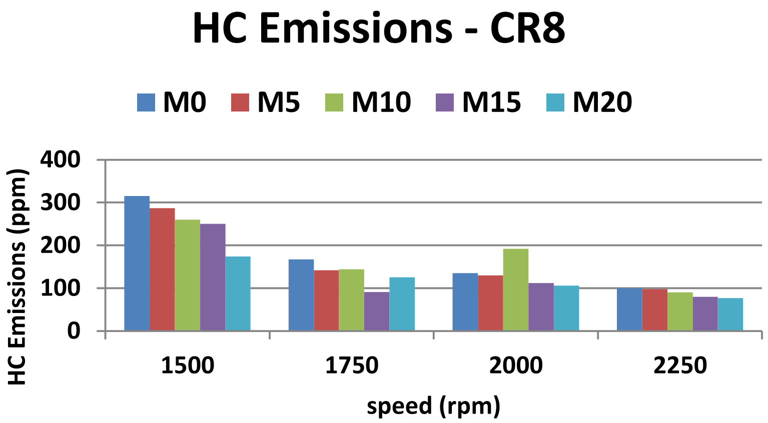

Figure (16) HC emissions for fuel blends at CR8 – spark timing 10 ˚ BTDC

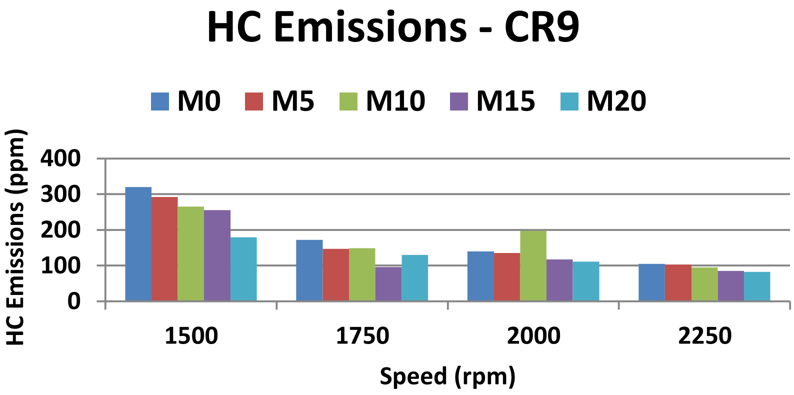

Figure (17) HC emissions for fuel blends at CR9 – spark timing 10 ˚ BTDC

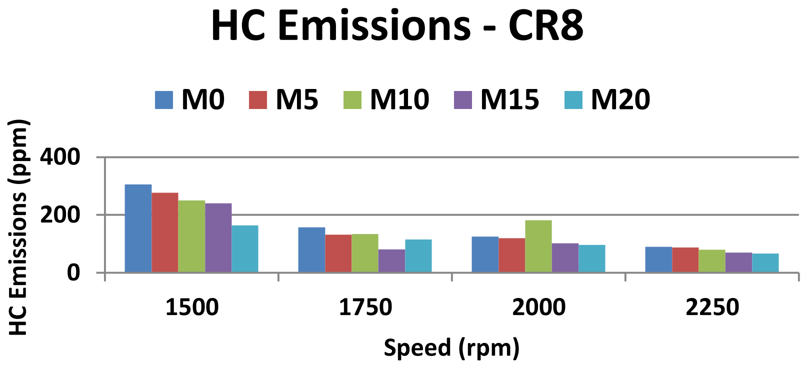

Figure (18) HC emissions for fuel blends at CR8 – spark timing 11 ˚BTDC

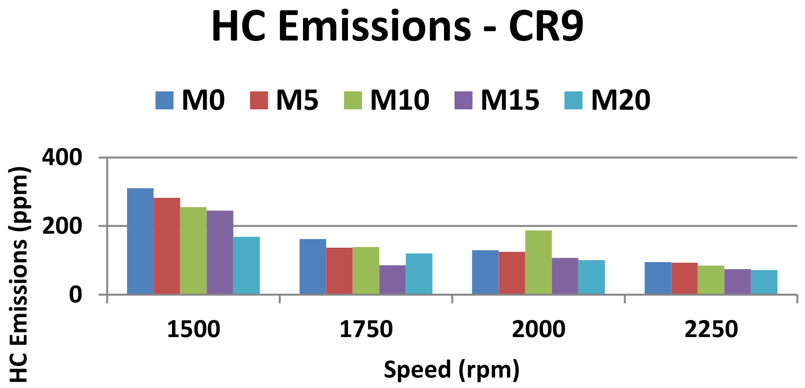

Figure (19) HC emissions for fuel blends at CR9 – spark timing 11 ˚ BTDC

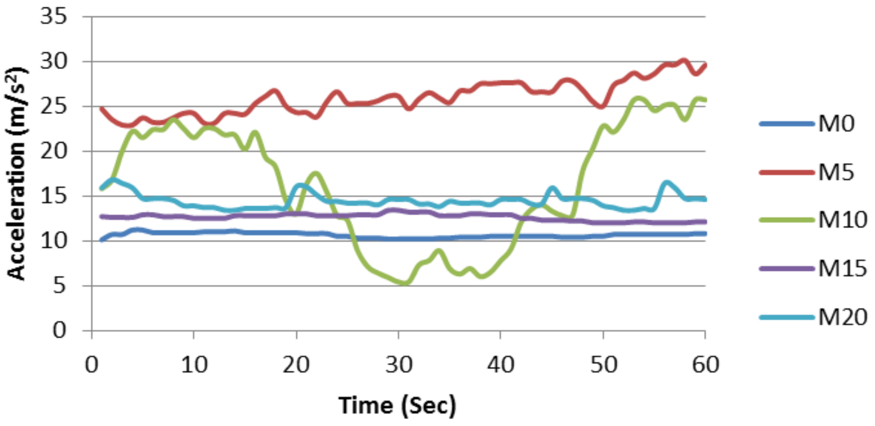

Figure (20) Acceleration values at CR8 – Standard Spark Timing 10˚BTDC– 2000 rpm

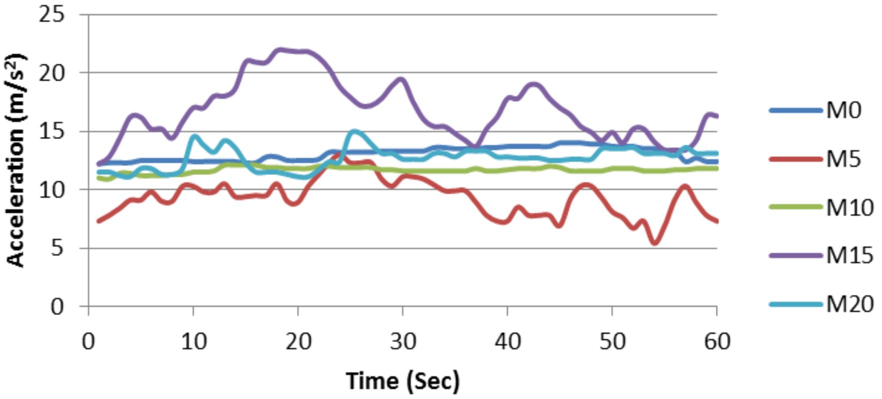

Figure (21) Acceleration values at CR9 – Standard Spark Timing 10˚BTDC– 2000 rpm

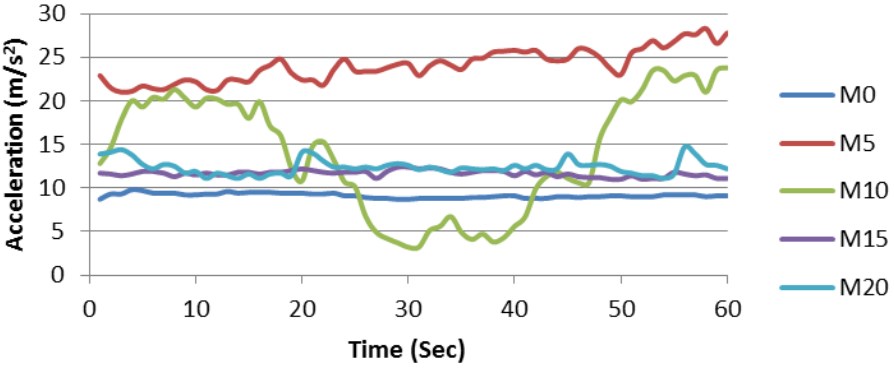

Figure (22) Acceleration values at CR 8 – Advanced Spark Timing 11 ˚ BTDC – 2000 rpm.

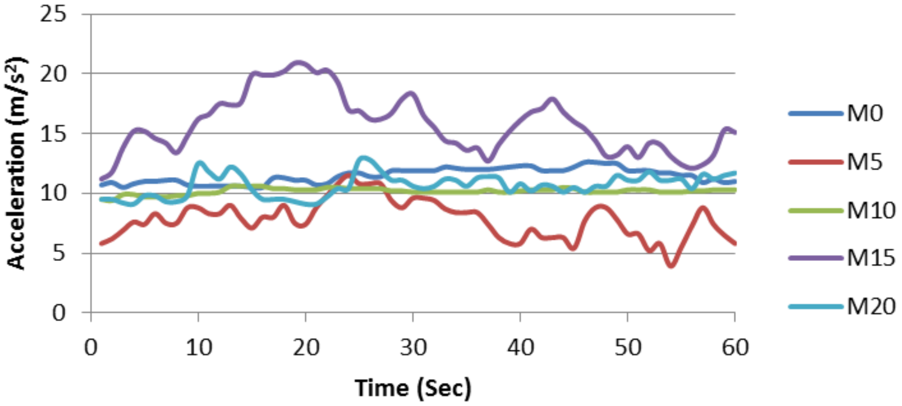

Figure (23) Acceleration values at CR9 – Advanced Spark Timing 11˚BTDC–2000 rpm

4. Conclusions

1. Adding methanol to gasoline fuel at standard spark timing (10˚ BTDC) , increase the power, the maximum power obtained at M10CR9 by an increase of (18.29%) from M0.
2. Advancing the spark timing (11˚ BTDC) increased engine power for all M5, M10, M15 and M20. Max power was obtained at M20CR9 by an increase of (18.27%) from M0.

3. Increasing compression ratio for gasoline fuel from 8 to 9 didn't increase the power, the knock characteristics increased by increasing compression ratio for pure gasoline.
4. Increasing compression ratio for methanol blends from 8 to 9 increased the power.
5. Adding methanol reduces CO and HC emissions efficiently for all cases.
6. For gasoline, increasing the compression ratio didn't increase power, because of knocking. While for methanol, increasing the compression ratio increases the engine power for all fuel blends. Increasing the compression ratio and advancing the spark timing, decreased the vibration.
7. Vibration signal didn't follow a specific rule, but for engine working at advanced spark timing many fluctuations.

6. References

1. Mehdi et al., (2008) *"Effect of ignition timing, equivalence ratio and compression ratio on the performance and emission characteristic of variable compression ratio SI engine using ethanol unleaded gasoline blends"*, IJE Transactions B: Applications Vol. 21, No. 1, April.
2. Zhang, Lei, (2011) "Multicomponent drop vaporization modeling of petroleum and biofuel mixtures", Ph.D thesis, Iowa state university,.
3. www.obitet.gazi.edu.tr.
4. Bairwa, Rajnish, (2011) "Experimental analysis of gasoline and CNG in a SI engine for performance and emissions", Master thesis, University of Delhi, Delhi college of engineering,.
5. www.stjoesauto.com
6. Charalampos, (2003)"Behavior of a Small Four-Stroke Engine Using as Fuel Methanol-Gasoline Mixtures" SAE, September, Paper No. 2003-32-0024.
7. Agarwal, Avinash Kumar, (2007) "Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines", Progress in Energy and Combustion Science 33,.
8. www.methanol.org on (2013)..*"Methanol use in Gasoline Bulletin, blending, storage and handling of Gasoline containing Methanol"*, Methanol institute, retrieved from