# Experimental Investigation the RON 95 and RON 97 on the Performance and Emissions

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**Abstract**

Nowadays, gasoline engine has most extensive as transportation and passenger for the economical demand. Gasoline fuels combust as clean, economical and abundant can improve the lean operating limits and decrease emission limits. The objective of study is to evaluate the gasoline engine on performance and emission using fuels RON 95 and RON97. An experimental study was carried out on 1800cc 4 cylinders, port injection and coupled with 100 kW Eddy Current dynamometer. The engine was tested at 1000-3000 RPM and 30% engine load. The results showed increase BMEP and cylinder pressure when using RON 97. While the $CO_2$ and HC was decrease when increase RPM and instead for NOx.

**Keywords*:*** Spark Ignition Engine, RON 95, RON 97, Performance, Emission

## Introduction.

Many routes have been and are being investigated with respect to reducing fuel consumption, most of the case of Otto engines target the reduction of throttling losses inherent in the cycle. Nowadays, vehicle producer were looking to hybridization concept, but gasoline engine still cannot eliminate. The homogeneous charge compression ignition engine, variable valve timing control, exhaust gas recirculation (EGR) and dilute combustion (including lean operation and with EGR) all provide benefits in automobile area. The fuels also reveal the basic engine performance to combust mix air and fuel and as thermodynamic reaction.

The gasoline engine, spark timing is a key parameter that affects the combustion and exhaust emissions. Ignition of the fuel mixture must take place sufficiently early in order to extract the maximum power from the power stroke. If the spark occurs a slight too advance, the piston will be slowed down in its upward movement. On the other hand, if it occurs too late then the piston will already be moving downwards, so both cases the work done on the piston will be reduced. Binjuwair & Alkudsi reveal, if the spark occurs much too advance, the mixture in various zones of the engine chamber might be ignited as result of the ignition pressure wave, causing detonation (Binjuwair & Alkudsi, 2016). The additions of fuel also need to balance air fuel ratio cause increases temperature during combustion.

The octane number of gasoline is one of the most important parameter that determines the fuel quality. The effect of octane number on detonation has been investigated by several researchers since the octane number of a gasoline is a measure of its resistance to detonation. J. E. Anderson et al. shown the fuel with higher octane ratings will also be increasingly important for advanced engines now being introduced that provide greater efficiency through downsizing and/or turbocharging, and that operate more often at high load where the most efficient operating conditions are limited by knock (Anderson et al., 2012).

(Sayin, 2012) describe the gasoline (RON 95) is the most important fuel for the SI internal combustion engine. It consists of numerous compounds that can be broadly classified into the hydrocarbon groups of paraffin, aromatics, and olefins. In other hand, gasoline were increasing fuel efficiency, changing its attributes and progressing features are the major research areas in the automotive industry.

The RON and MON are determined by Cooperative Fuel Research engine according to the ASTM procedures D-2699 and D-2700 respectively. An alternative method to determined RON and MON was realized by associating distillation curves (ASTM D86) with multivariate calibration (PLS – Partial Least Squares). Both the RON and MON scales are based on two paraffinic hydrocarbons which define the two ends of the scale; iso-octane is assigned the value of 100 and n-heptane the value of zero in both the scales. Primary reference fuels (PRF) are the blends of these two components which define the intermediate points in the RON or MON scale. Thus theoretically, RON95 and RON97 are blend of 95% and 97% iso-octane with 5% and 3% of n-heptane by volume respectively. In both RON and MON scales they are PRF 95 and PRF 97 (Mohamad & How, 2014).

N. Türköz et al. describes the biofuel like ethanol, butane, methanol has been and is being used as an additive to increase octane number and decrease exhaust emissions (Türköz, Erkuş, İhsan Karamangil, Sürmen, & Arslanoğlu, 2014). Similarly, most of the developed countries use staples such as corn, sugar beet, soybean, rapeseed, and wheat in order to obtain energy (Koçar & Civaş, 2013; Komninos & Rakopoulos, 2012; Raslavičius, Keršys, Starevičius, Sapragonas, & Bazaras, 2014; Scovronick & Wilkinson, 2014; Wu et al., 2011). Now the new engine design obstacle for gasoline engine is the price of fuel and emission legal from emitted combustion.

Most of researcher was study in gasoline engine performance and emission but not clear when engine run under variable timing ignition control. In this study, gasoline Ron 95 and Ron 97 was tested with spark ignition engine 4 cylinder, port injection and using programmable ECU. The adjustment timing was control spark timing between 7° to 12° BTDC at 1000-4000 RPM and 30% load. All the experiment was conduct under stoichiometry condition.

## Experimental set up and procedures.

*Experiment Setup*

The experiments were applied a 1800cc, 4-cylinder Mitsubishi 4G93 single overhead cam (SOHC) engine with compression ratio (CR) is 9.5:1. Engine specifications are listed in Table 1 for detail. The setup of the engine experimental schematic diagram was shown in Figure 1. An Eddy Current dynamometer were coupled with propeller shaft for grip the power created by the engine that has the capability of applying brake load. The Dynalac control unit was measured value of brake torque, revolving speed of engine and level of throttle position sensor (TPS).

Gasoline consumption was measured using a volume scaled recording by model AIC-1204 HR 2000. The measurement of fuel flow was showed by trip per second to properly engine running with 35 Psi pressure from the main fuel pump. Every tested the calibration meter fuel consumption to be done in order to obtain absolute accuracy.

The Kistler product 6118bfd16 model was mounted for piston number one to measure the engine cylinder pressure. This pressure transducer located with spark plug and which processed by a Dewetron 1624 model combustion analyzer. This instrument very sensitive to the movement pressure and has smallest piezoelectric. The cylinder pressure sensor is also suitable for pressure measurements at high engine speeds and for knock investigations.

The Kistler Crank Angle Encoder Type 2613B consists of an angle encoder, a signal conditioner and a line terminator. The time and crank angle resolved with cylinder pressure data with 1000 Hz sampling rate were processed by Dewetron 1624 software Kistler Crank Angle Encoder Type. It generates 3 transistor–transistor logic (TTL) rectangular-pulse signals: A crank angle signal with adjustable resolution (0-360$^{O}$ CA) which can be used for the engine management system or the engine speed at the test bench. The Top

Dead Center (TDC) detected need to calibrate while Crank Angle Encoder adjustments find a great new location.

**Table 1:** The 4G93 SOHC engine specification.

| Type | In-line SOHC 16 V MPI |
|---|---|
| Number of cylinders | 4 |
| Combustion of Chambers | Pentroof Type |
| Total displacement | 1834 cc |
| Cylinder bore (mm) | 81 |
| Piston stroke (mm) | 89 |
| Compression ratio | 9.5:1 |
| Maximum output | 88Kw(120Ps;118bhp) |
| Maximum torque | 159Nm (117 ft lbt) |

*Procedures*

The engine was tested at 1000-4000 RPM with 30% load. The selection of its RPM because engine running normal driving cycle for small gasoline engine. During the test, all data are taken after temperature the engine oil has reached between 80°-85$^0$C. The environment temperature of the laboratory was considered at 30$^O$C during the test stable operation then humidity is around 60%.

When an engine testing, spark timing was placed at 7 degrees at top dead center (TDC). This action has taken by using the timing light tool to confirm the well degree of ignition timing is right. An experimental data was taken on interval 500 time engine cycles and average by Deweca software.

The thermocouple used to measure temperature for this experiment. The thermocouple K-type (Range -20 ℃ to 158 ℃) are applied to reading the data. The Pico data logger instrument implements for it. The temperature were measure at the intake manifold, exhaust manifold, water in and water out from the engine and dynamometer cooling.

Characteristics of fuel with high vaporization latent heat, high octane number, high oxygenated content and high laminar flame speed are listed. Some physical and thermal properties of gasoline used are shown in Table 2. These properties were taken from standard sources. Detailed gasoline additives were not obtained from the manufacturer as it is considered confidential.

The fuel stoichiometry of RON95 and RON97 were predicted for 14.7 as an air fuel ratio (AFR). This value applied cause engine used factory original parts. It's also respect to the residual gas normal condition for this experiment.

**Table 2:** Properties of fuel for RON 95 and RON97.

| Descriptions | RON | |
|---|---|---|
| Research octane number | 97 | 95 |
| Lower heating value (kJ/kg) | 43,961 | 43,304 |
| Final boiling point ($^0$C) | 210 | 209 |
| Density @ 15 $^0$C (kg/L) | 0.764 | 0.75 |
| Reid vapors pressure (kPa) | 60.03 | 60.03 |

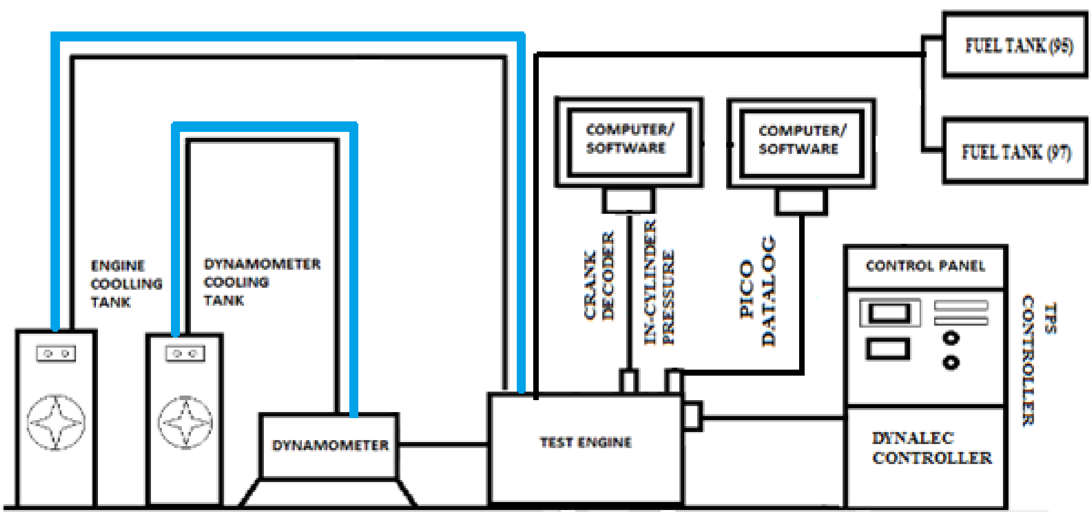


**Figure 1:** Schematic diagram gasoline engine setup using RON95 and RON97.

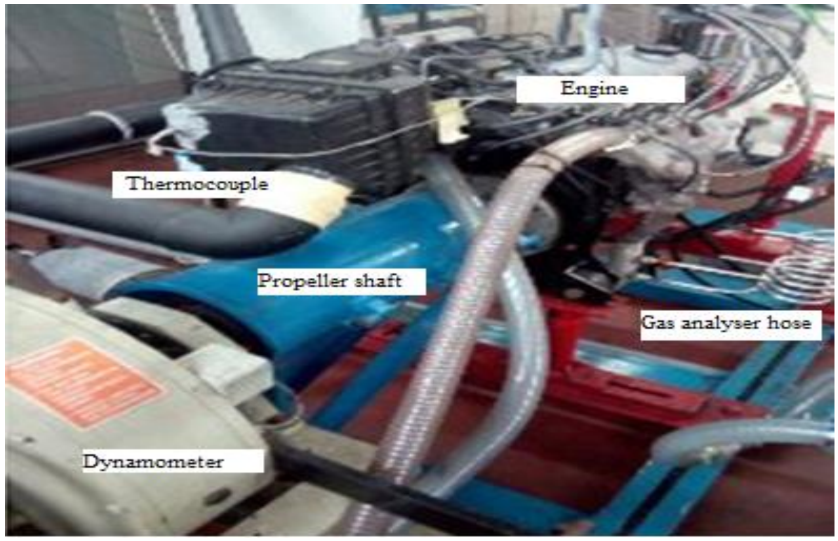


**Figure 2:** The gasoline engine 1.8L and dynamometer.

## Result and discussion

### *Cylinder Pressure*

Cylinder pressures were measured using different fuels and different engine speeds at 1000-3000 RPM. The motoring pressure is around 9 bar (135 Psi). Cylinder pressure for motored case was calculated using Eq. (1) and the apparent heat release method is used as a point of reference in the comparison process. Cylinder pressure increases with the increase of engine speed up due open of degree throttle. Figure 3 shows the cylinder pressure when engine using RON 95 and RON 97. At 1000 RPM, the turbocharger not produces the boost but still ready. For the 1000 RPM, RON 95 yield 500 Psi and RON 97 is 480 Psi cylinder pressure. The cylinder pressure at 2000 RPM, RON 95 slight decrease compared with RON 97 is 530 Psi and 600 Psi respectively. For engine speed 3000 RPM, RON 97 showing highest pressure at 690 Psi compare with RON 95 is only 650 Psi.  The turbocharger engine show 2000-3000 RPM decrease the combustion occur then when engine rise the boost, the combustion was retard to 10-12° ignition timing. During the test, slight knocking occur when engine increase the load at 3000 RPM. This resulted support the hypothesis by Türköz et al.  that knock occurs when pockets of unburned fuel–air mixture, termed end gases, spontaneously ignite before they are consumed by the flame and resulted in rapid pressure rises in the cylinder (Türköz, Erkuş, Karamangil, Sürmen, & Arslanoğlu, 2014). The pressure at crank angle also delayed when engine running under boost at 2000-3000 RPM.

This is a method for tuning turbocharger engine when create the boost to avoid the knocking rise.

$$Pmotoring = Pff\{(Pcal + vc)/Vol\}^{k-1+1} \qquad \text{Eq. 1}$$

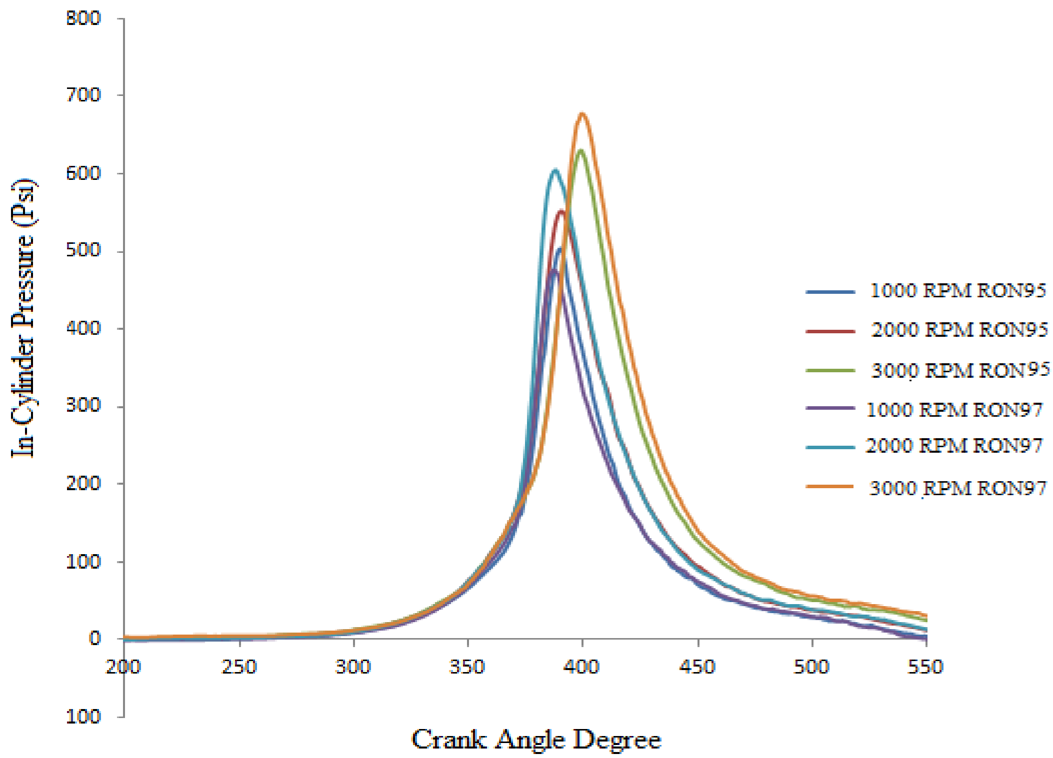


**Figure 3:** Cylinder pressure Vs Crank angle degree.

*Effects on Brake Mean Effective Pressure (BMEP)*

Brake mean effective pressure (BMEP) is main engine performance characteristics. Mean effective pressure is defined as a hypothetical (or) average pressure which is assumed to be acting on the piston calculation. Most of the researches reported that BMEP increased when increase the octane number engine in spark ignition and compression ignition engine. T. I. Mohamad and H. G. How describe in their study is under the same engine specification and operations, RON95 resulted in an average of 4.4% higher brake torque, brake power and BMEP compared to that of RON97 and the differences were significantly revealed at higher engine speed and loads (Mohamad & How, 2014). Figure 4 was shown the BMEP for 1000-3000RPM. The BMEP every engine speed is increase 4 bar to 7 bar.

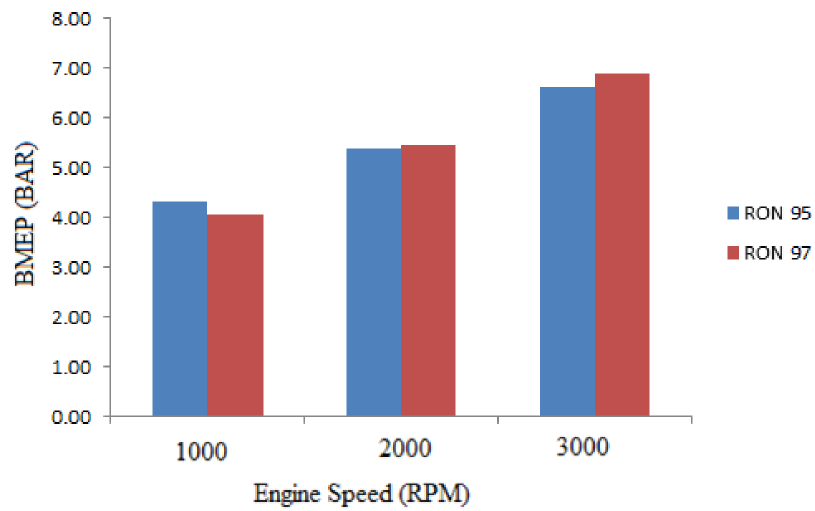


**Figure 4:** Graph BMEP at 1000, 2000 and 3000 RPM.

*Effect on Brake Specific Fuel Consumption (BSFC)*

Figure 5 indicates the variations of the BSFC for RON 95 and RON 97 under various engine speeds at 30% engine load. As shown in this figure, the BSFC slight increased when engine using RON 95 for 1000 RPM compared RON 97. The reason is well known: the difference value properties of fuel, which means the graph show. The effect of fuel density showed contribution to increase the fuel consumption. Similar result found by Mohammad and How describe that the RON97 have 97% of its content as iso-octane, but remaining percentage includes many anti-knocking substances, not limiting to n-heptane (Mohamad & How, 2014). With 97% iso-octane, calorific value is generally higher thus the engine requires less fuel mass per unit power produced, resulting in lower BSFC. On the other hand, because RON95 possesses lower calorific value but produces higher power on average. The specific fuel consumption also increases at 2000-3000 RPM for RON 95 with values of 0.00055 and 0.0007 (kg/kW-s), respectively.

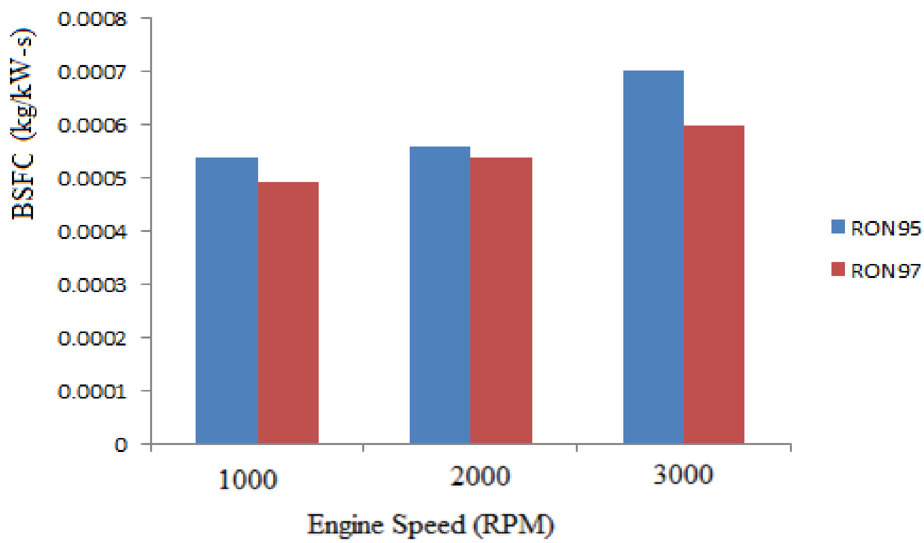


**Figure 5:** Graph BSFC at 1000, 2000 and 3000 RPM.

*Effects on Emission*

To focus the further development of gasoline engines on lower fuel consumption and emissions, new technologies for worldwide are required. The formation rate of NOx is directly dependent to cylinder temperature and the amount of NOx generated also sensitive to the location within the cylinder; i.e. highest concentration usually found around the spark plug vicinity, at which temperature and pressure are highest. Figure 6 showed the emission produces by RON 95 and RON 97 for NOx and HC both of fuels. At 1000-3000 RPM, the NOx increase from 480-750 ppm for RON 95 and 400-780 for RON 97. While the HC show slight decrease at 270-200 ppm for RON 95 and 250-220 ppm for RON 97. Using the oxygenate fuel contribution reducing the HC. The clarified value also main reason the HC was reduce. The trend also was shown when temperature increase, the NOx will increase and the HC will reduce.

Figure 7 was shown the graph emission of $CO_2$ and CO. The emission reduces for $CO_2$ from 11.5 to 9% for RON 97 and 10-6.5% for RON 95. The CO also reduces from 4-3% for RON 97, 3-2.8% for RON 95. Characterize of fuel contribution reducing the CO and CO2 like density, octane number and lower heating value is main reason decreasing this value.

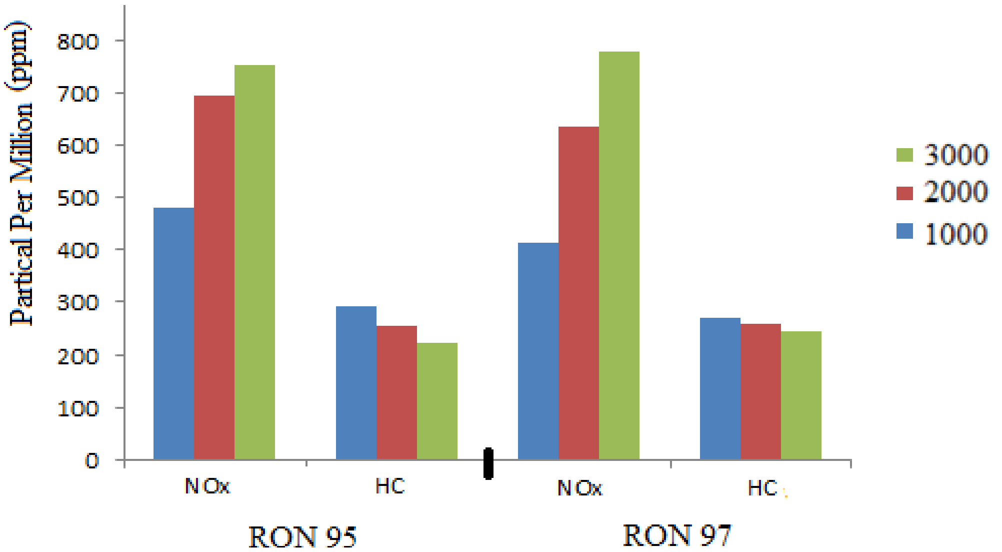


**Figure 6:** Graph NOx and HC at 1000, 2000 and 3000 RPM.

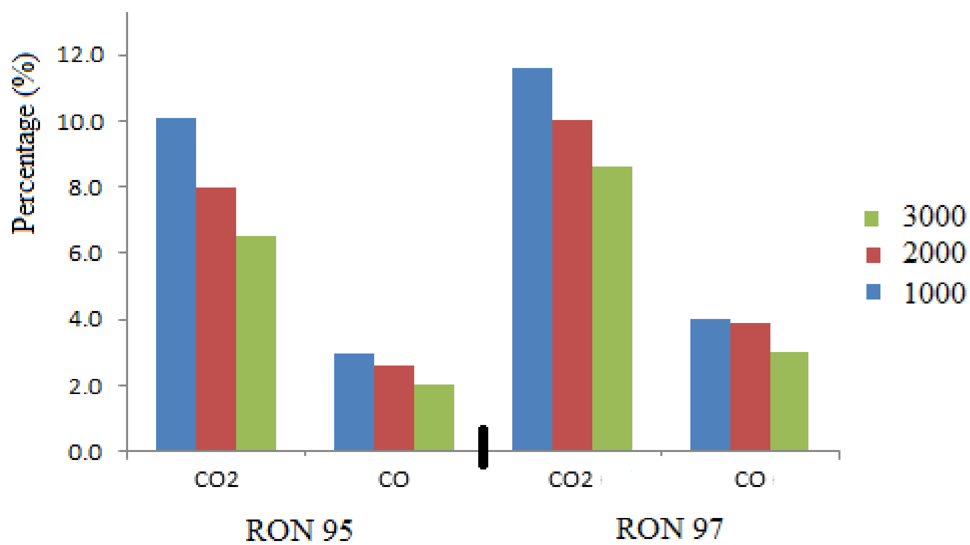


**Figure 7:** Graph CO2 and CO at 1000,2000 and 3000 RPM.

## Conclusion

The effect of using a higher-octane gasoline than the engine requirement on fuel economy and exhaust emissions was studied. The 95-RON and 97-RON were tested using the 1.8L spark ignition engine. Then the engine was tested at constant 30% load and 1000-3000 RPM showed that RON 95 produced.

We briefly summarize the results as follows:

1. In observed the study, torque and power out-put with respect to the cylinder pressure value for RON 95 and RON 97 was increase the BMEP from 4 Bar to 7 Bar.
2. The BSFC was increase 5-10% when applied RON 95 compared RON 97 at all engine speed.
3. Effect on NOx for RON 95 is 5% highest than RON 97 for 1000-2000 RPM. When engine speed 3000 RPM NOx for RON 95 is 5% lowest from RON 97.
4. The HC also is highest 2% for RON 95 compared RON 97 every engine speed.
5. The CO2 and CO emissions, RON 95 was shown 10% lowest compared RON 97 every engine speed.

## Reference

Anderson, J. E., DiCicco, D. M., Ginder, J. M., Kramer, U., Leone, T. G., Raney-Pablo, H. E., & Wallington, T. J. (2012). High octane number ethanol–gasoline blends: Quantifying the potential benefits in the United States. *Fuel*, *97*, 585–594. http://doi.org/10.1016/j.fuel.2012.03.017

Binjuwair, S., & Alkudsi, A. (2016). The effects of varying spark timing on the performance and emission characteristics of a gasoline engine: A study on Saudi Arabian RON91 and RON95. *Fuel*, *180*, 558–564. http://doi.org/10.1016/j.fuel.2016.04.071

Koçar, G., & Civaş, N. (2013). An overview of biofuels from energy crops: Current status and future prospects. *Renewable and Sustainable Energy Reviews*, *28*, 900–916. http://doi.org/10.1016/j.rser.2013.08.022

Komninos, N. P., & Rakopoulos, C. D. (2012). Modeling HCCI combustion of biofuels: A review. *Renewable and Sustainable Energy Reviews*, *16*(3), 1588–1610. http://doi.org/10.1016/j.rser.2011.11.026

Mohamad, T. I., & How, H. G. (2014). Part-load performance and emissions of a spark ignition engine fueled with RON95 and RON97 gasoline: Technical viewpoint on Malaysia's fuel price debate. *Energy Conversion and*

*Management*, *88*, 928–935. http://doi.org/10.1016/j.enconman.2014.09.008

Raslavičius, L., Keršys, A., Starevičius, M., Sapragonas, J., & Bazaras, Ž. (2014). Biofuels, sustainability and the transport sector in Lithuania. *Renewable and Sustainable Energy Reviews*, *32*, 328–346. http://doi.org/10.1016/j.rser.2014.01.019

Sayin, C. (2012). The impact of varying spark timing at different octane numbers on the performance and emission characteristics in a gasoline engine. *Fuel*, *97*, 856–861. http://doi.org/10.1016/j.fuel.2012.03.013

Scovronick, N., & Wilkinson, P. (2014). Health impacts of liquid biofuel production and use: A review. *Global Environmental Change*, *24*, 155–164. http://doi.org/10.1016/j.gloenvcha.2013.09.011

Türköz, N., Erkuş, B., İhsan Karamangil, M., Sürmen, A., & Arslanoğlu, N. (2014). Experimental investigation of the effect of E85 on engine performance and emissions under various ignition timings. *Fuel*, *115*, 826–832. http://doi.org/10.1016/j.fuel.2013.03.009

Türköz, N., Erkuş, B., Karamangil, M. I., Sürmen, A., & Arslanoğlu, N. (2014). Experimental investigation of the effect of E85 on engine performance and emissions under various ignition timings. *Fuel*, *115*, 826–832. http://doi.org/10.1016/j.fuel.2013.03.009

Wu, X., Daniel, R., Tian, G., Xu, H., Huang, Z., & Richardson, D. (2011). Dual-injection: The flexible, bi-fuel concept for spark-ignition engines fuelled with various gasoline and biofuel blends. *Applied Energy*, *88*(7), 2305–2314. http://doi.org/10.1016/j.apenergy.2011.01.025