Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi, **19** (1-2), 11-17, 2003

INVESTIGATION OF THE EFFECT ON ENGINE PERFORMANCE OF USING HIGHER OCTANE RATING GASOLINE THAN ENGINE REQUIREMENT

Cenk SAYIN, İbrahim KILIÇASLAN

Kocaeli Üniversity, Technical Education Faculty, İzmit, Turkey.

Abstract: The effect of using higher-octane gasoline than engine requirement on power and fuel economy is revealed. In this study, the engine required 91-RON gasoline was tested using 95-RON and 91-RON. Results show that.using octane ratings higher than required by the vehicle engine numbers don't increase engine performance.

Key words: Gasoline engine**,** octane number, gasoline fuel, engine performance.

MOTORUN İHTİYACINDAN YÜKSEK OKTANLI BENZİN KULLANIMININ MOTOR PERFORMANSINA ETKİSİNİN İNCENLEMESİ

Özet: Motorun ihtiyacından yüksek oktanlı benzin kullanımının güç ve yakıt tüketimine etkisi tartışılmaktadır. Bu çalışmada, 91 oktanlı benzine ihtiyaç duyan motor 91-RON ve 95-RON benzin kullanarak test edilmiştir. Sonuçlar, motorun ihtiyacından daha yüksek oktanlı benzin kullanımının performansı artırmadığını ortaya koymaktadır.

Anahtar kelimeler: Benzin motoru, oktan sayısı, benzin yakıtı, motor performansı

1. Introductıon

Refiners and automotive manufacturers are interested in the octane number requirement of engines or vehicles on the road. The octane number requirement of an engine or vehicles-engine combination is defined as the minimum fuel octane number that will resist knock throughout the engine's operating speed and load range. The octane number requirement of single engine or vehicle does not usually provide adequate information for that particular model; every model has a range of requirements due to production tolerances and variations in engine and vehicle condition [1].

Liquid hydrocarbons and rarely alcohols are used for in the internal combustion engine. Gasoline quality is indicated by octane rating. The engine design and compression ratio determine the octane it requires. However, this requirement changes with weather, driving conditions, and mechanical condition of the engine. For example combustion-chamber deposits reduce clearance volume. They also increase octane requirements and the possibility of detonation. Reduced cooling efficiency, fuel system or ignition troubles, and failure of emission controls may also change octane requirements. Octane requirement will be lower if the driver does not demand rapid acceleration and high-speed wide-open throttle [2)].

In practice, motorists have strong believes that higher octane rating, better engine performance and fuel economy. This leads to popular use of higher-octane gasoline than engines requirement and causes extra expense to produce high-octane fuel. Although campaign to use corrected gasoline grades has been launched through televisions, radios, and newspaper for period of time, the amount of high-octane gasoline sold still greater than expectation. It is expected that further information including test results of using higher-octane gasoline than engine requirement will clarify to motorists concerning their misconception and believes [3].

Various investigations clearly reported that octane number is effect on engine performance. In 1991 Coordinate Research Counsil (CRC) was studied the effect of gasoline octane quality on vehicles acceleration performance. There were 182 gasoline vehicles involved in the test. 78 vehicles were installed by knock sensor and 104 vehicles without knock sensor. Gasoline with 80-104 RON were included and each vehicle was tested with 4 gasoline grades, i,e. fuel with 4 RON less than engine required, fuel with the same RON as engine required, fuel with 4 and 8 RON greater than engine required. Testing method involved recording of the vehicle acceleration time from 0-48, 0-96, 0-112 and 64-96 km/h. Results show that acceleration performance of KS vehicles was improved with gasoline octane quality while acceleration performance of the vehicles without knock sensor was insignificant relation with gasoline octane rating [4].

In 1998 the effect of gasoline octane number on engine performance was studied in Thailand. Three different octane ratings of 91, 95 and 97-RON were investigated in three engine models that all required 95 RON. These engines were used in Toyota Corolla. The engine models were 5A-FE, 4A-FE, 7A-FE with engine displacements of 1.5, 1.6 and 1.8 l, respectively. Test runs were conducted at two throttle settings of 50 % WOT and 100 WOT and a range of engine speeds. Results show that at a given throttle position engine power insignificantly change with octane number for all engines [5].

2. Theoretical Analysis of Experimental Instrumentation

After each experimental run, raw data consisting of pressure drop reading in mm of water column from the manometer is recorded. From this raw data, mass flow rate, Reynolds numbers are calculated.

2.1.1 . Mass Flow Rate

Mass flow rate has been measured by means of an orifice plate. The operating principle of orifice plates is based on relation between the velocity and pressure of a flowing fluid. When a restriction, such as small diameter orifice plate, is inserted in a stream, fluid velocity must increase when passing through it. A proportional drop in pressure based on Bernoulli's equation accompanies the rise in velocity.

Mass flow rate through the PVC pipe is calculated by the following expressions given by ASME standards [6].

$$\dot{m} = C.\varepsilon.\frac{\pi.d^2}{4}.\left(\frac{2.\rho_a.\Delta P}{1-\Phi^4}\right) \quad (1)$$

where ε is the expansion factor, which can be assumed as the unity under our experimental conditions, d is the orifice plate diameter, Φ is the orifice plate diameter ratio, ρ_a is the density air, ΔP is the pressure drop across the orifice plate, and C is the charge coefficient expressed according to ASME standards [6] as;

$$C = 0,5959 + 0,0312\Phi^{2,1} + 0,1840\Phi^{8} + 0,039\Phi^{4}(1-\Phi^{4})^{-1} - 0,01584\Phi^{3} + 91,71\Phi^{2,5}\,\mathrm{Re}_p^{-3/2} \qquad (2)$$

The Reynolds number, Re_p in the PVC pipe is then calculated as:

$$\mathrm{Re}_p = \frac{4.\dot{m}}{\pi.\mu.D_p} \qquad (3)$$

where μ is the viscosity of air, D_p the PVC pipe diameter.

2.1.2 . Fuel Mass Flow Rate

Fuel mass flow rate has been measured by means of scaled container, which depends on time shown in the equation below.

$$\dot{m}f = \frac{\rho_f . V_f}{t} \qquad (4)$$

where ρ_f is the density of fuel, V_f is the volume of consumed fuel, t is fuel consumption period.

2.1.3 Specific Fuel Consumption Rate

Specific fuel consumption related to effective power and fuel mass rate as shown in the equation below:

$$bsfc = 3,6.10^{6}\,\frac{\dot{m}f}{Pe} \qquad (5)$$

where $\dot{m}f$ is fuel mass flow rate and Pe is effective power, which directly obtained from a digital dynamometer.

2.1.4 Experimental Uncertainties

The uncertainty associated with the mass flow rate was affected by all of the parameters in the experiments, such as pressure drop across the orifice plate, the calculations of all factors and coefficients and the thermal properties of the working fluid. The maximum value of the uncertainty in the mass flow rate was found as ± 1,03 % and ± 2,63 % for laminar and turbulent flows [6].

3. Experimental Facilities

Engine used in the test was a Fiat DKS 1,6 l. The engine originally requires gasoline fuel with 91-RON. Details of engine specification are shown in table 1.

Table 1. The technical specifications of the experimental engine.

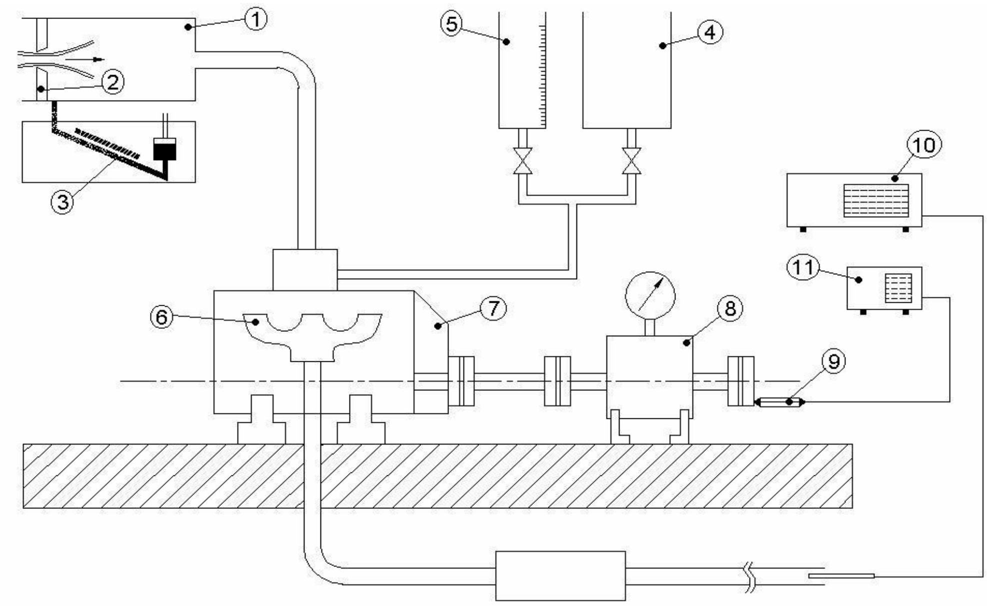
Engine type	131 A 1016
Cylinder number	4
Cylinder bore	84 mm
Stroke	71.5 mm
Total cylinder vol.	1600 cc
Compression ratio	8:1
Maximum torque	117,2 Nm/3400 rpm
Maximum power	58.88 kW
Value of valve adjustment	Cold (+20 ^{0}C): Intake:0, 30 Exhaust:0, 45

Fuel was commercial grades with 91 and 95-RON. Details of fuel compositions and properties in table 2.

Table 2. Properties of test fuel.

	91	95
Density at 15 ^{0}C, kg/lt	0,738	0,745
Reid vapour pressure, kPa	59,34	60,03
Boiling temperature, ^{0}C	198,9	209
Lower heating value, kJ/kg	43932	43304
Benzene, % volume	5	5

Pressure drop is determined by inclined manometer. Engine load is measured by a dynamometer. Fuel consumption is quantified by combined container method and air ratio is determined by orifice-meter. Cylinder pressure data were recorded using 6061 B piezoelectric pressure transducer. The experimental apparatus is shown in figure1.



1. Air tank, 2. Orifice, 3. Inclined manometer, 4. Fuel tank, 5. Measurement container, 6. Pressure transducers, 7. Test engine, 8. Dynamometer, 9. Exhaust gas analyser, 10. Tachometer sensor, 11. Tachometer

Figure 1. Experimental apparatus

4. Test Procedure

All test runs were conducted on the bench-test. In each test run, engine speed, torque, fuel consumption, throttle position were recorded. Moreover, for detail analysis of consumption process, cylinder pressure time, data for a resolution of one degree crank angle were recorded for 300 consecutive cycles. The combination of all performance tests included engine setting at throttle position of 50 % and 100 % WOT, engine speeds 1000-2400 rpm with 200 rpm intervals and engine torque of 20 %-90% of maximum value. For cylinder pressure data collection, the engine were set at 25 % and 35 % WOT and speeds of 1400-2400 rpm.

5. Results and Discussions

To compare output power of the engine when fuel with 91-RON and 95-RON gasoline, the engine was tested at 50 % and 100 % throttle opening and speeds were varied from 1000-2400 rpm. The results of output power were shown in figure 2-3. Power output of 91-RON at 50 % WOT and 100 % WOT are slightly greater than that of 95-RON for a range testing as shown in figure 1 and 2. At 50 % WOT, average power produced from 91-RON gasoline is 4.8 % greater than 95-RON while at 100 % WOT the benefit of power is about 4.2 %.

If it is used higher octane rating gasoline more than engine requirement, the ignition delay will be longer and the speed of the flame will be shorter. Therefore longer time is needed to reach maximum combustion pressure and this maximum pressure occur 10^0 (CA) after TDC. These cause the reduction of the maximum pressure and the engine utput power [7].

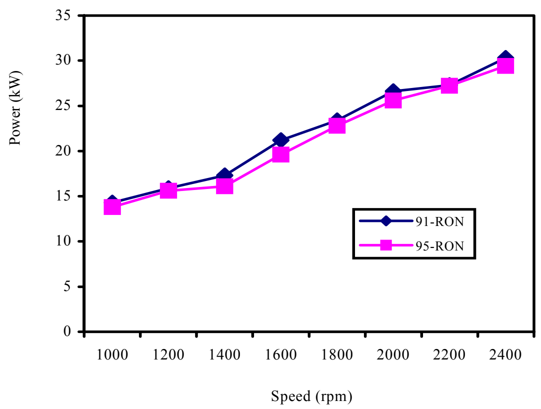


Figure 2.Engine power at various speeds (50 % WOT)

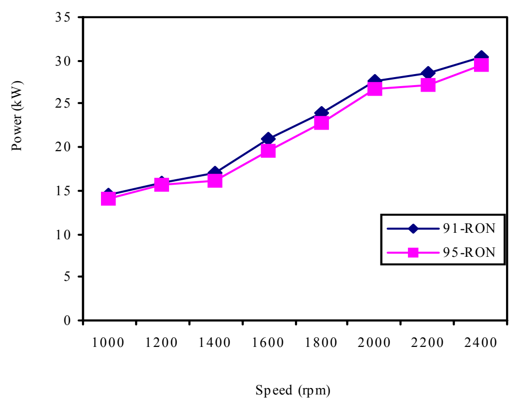


Figure 3. Engine power at various speeds (100 % WOT)

To compare bsfc when the engine was operated with 91 and 95-RON gasoline, the engine was tested at fixed speed and load for several test conditions. The test results at 1500 rpm are shown in figure 4. It can be seen that the trend of bsfc using 91-RON is slightly lower and average bsfc using 91-RON is 5.6 % better than that of 95-RON.

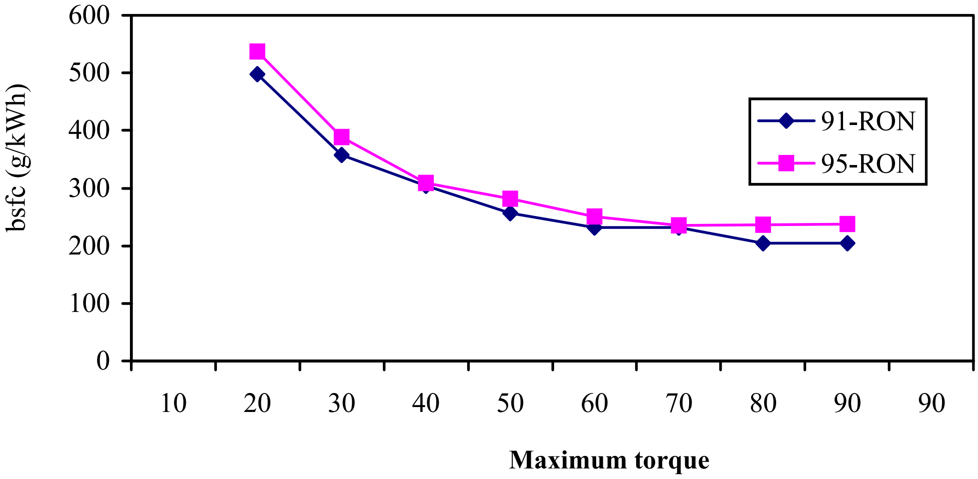


Figure 4. Relation between **bsfc** and maximum torque ratio at speed 1500 rpm.

To study details of combustion process in the cylinders when 91 and 95-RON gasoline were used, the cylinder pressure-time data for 300 consecutive cycles were recorded at operating conditions. The combinations of test conditions were set at speeds of 2500 and 3500 rpm and throttle positions of 25 % and 35 % WOT. The Results of analysis are shown in table 3. The values of P_{max} using 91-RON gasoline slightly greater than that using 95-RON. It shown that lower-octane rating gasoline produces higher peak cylinder produces.

Table 3. Results of engine test and cylinder pressure analysis.

Items	2500 rpm				3500 rpm			
	25 % WOT		35 % WOT		25 WOT		35 WOT	
Octane no	91	95	91	95	91	95	91	95
P_{max} (bar)	35.92	35.07	31.07	31.01	28.53	26.42	43.78	43.31

From the above test results of power output, bsfc and cylinder pressure data analysis, they all confirm that lower-octane gasoline produces slightly better power and fuel economy.

6. Conclusions

The effect of using higher-octane gasoline than engine requirement on power output and fuel economy was studied. The engine required was tested with 91-RON and 95-RON fuel.

When the engine was tested at given throttle position and speed, results show that 91-RON gasoline produced 4.2-4.8 higher power than 95-RON. When the engine was set at given speed and torque, it was shown that 91-RON gasoline produced 8.36 lower bsfc than 95-RON. Results from the cylinder pressure analysis also confirm the performance test results.

Therefore using corrected rating gasoline is more advantageous than higher-octane gasoline under all operating conditions.

7. Nomenclature

$\dot{m}$	Mass flows rate, kg/s
$\dot{m}_f$	Fuel mass flow rate. kg/s
d	diameter of the orifice plate, m
D_p	diameter of PVC pipe, m
Re_p	Reynoulds number in the PVC pipe
ε	Expansion factor
Φ	Orifice plate diameter ratio, d/Dp
ρ_a	Air density, kg/m^3
ρ_f	Fuel density, kg/m^3
Pe	Effective power, kW
μ	Dynamic viscosity
ΔP	Pressure drop across the orifice plate, Pa
V_f	Volume of consumed fuel, m^3
t	Fuel consumption period

8. Abbrevations

RON	Research octane number
WOT	Wide open throttle
rpm	Revolution per minute
bsfc	Specific fuel consumption, gr/kWh

References

1. Nagai. K., Seko. T., Trends of Motor Fuel Quality in Japan, JSAE Review 21, Japan 2000.
2. Heywood. J. B., Combustion ın Spark-Ignition Engine, Internal Combustion Engine Fundamentals, USA, McGrav-Hill, 1984.
3. Chanchaowna. S., Using Higher Octane Rating Than Engine Requirement: Loss or Gain, Thailand, Petroleum authority of Thailand, 1998.
4. Callison, J.C., Mcnally, M.J., The Effect of Gasoline Quality on Vehicle Acceleration, SAE paper No.012394, 1991.
5. Chanchaona, S., The Effect of Gasoline Octane Number on Engine Performance, King Mongkut's University of Technolgy, Thonburi. 1998.
6. ASME Standards, Measurement of Fluid Flow in Pipe Using Orifice, Nozzle and Venture, USA, MCF-3M 1984.
7. Kılıçaslam. İ., Sayın. C., An experimental study of Octane Rating Effect on Engine Performance, 7. International Combustion Symposium, Ankara, July, 8-12, 2002.