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Role of Octane Rating in Fuel Efficiency of Otto Engine

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ABSTRACT

The annual consumption of oil and gas in the country is increasing at high growth rate of 6 to 8% per year. The present consumption of liquid fuels is more than 10 million tonnes a year. Significant amount of oil can be saved through energy conservation programme. Some fuels can perform thermodynamically more efficiently after requisite changes in their specifications are made. The paper reviews variation of Research Octane Number (RON) of motor fuels and its impact on fuel consumption.

INTRODUCTION

Low boiling gasoline fraction of the petroleum is the major motor fuel used worldwide. This trend will continue as long as adequate supply of the petroleum is available and a suitable alternative is not found. Early motor gasoline engines had starting and steady operation problems. With the improvement of the engines and the qualities of the gasoline such as antiknock value, chemical stability and controlled volatility have significantly contributed to overcome these difficulties (Kirk and Othmer, 1980). The development of fuels and engines are mutually interdependent. Gasoline is usually a blend of the hydrocarbons boiling within the range of 40-200°C. The composition of the gasoline is dependent on the nature of the crude from which it is derived and the refinery process through which it is refined (Gruse, 1960).

There are large number of hydrocarbons occurring within the range C_4 to C_{12}, gasoline is potentially a very complex mixture (Lane, 1946). The production of gasoline depends basically on separating the usable fractions by fractional distillation from crude oil. Various physical and chemical treatments of petroleum fuel are carried out to make the product according to specification. Petroleum fractions used as motor fuels vary from natural gas, liquefied petroleum gas, gasoline, kerosene and gas oil used for turbojet and automotive diesel engines. The performance of these fuels depends on various chemical and physical characteristics (Eur. Chem. News, 1979). In this paper the effect of knocking characteristics on fuel consumption has been investigated.

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EXPERIMENTAL

To study the performance of gasoline, Labeco CLR L-38 single cylinder gasoline engine was selected. Labeco CLR L-38 is a standard engine used for performance testing of petroleum oils (Labeco CLR L-38 Test Manual). Following engine conditions were maintained during the experiments:

Air fuel ratio	14.0 ± 0.5
Jacket coolant temp. °C	93.3 ± 1.1
Difference between jacket Inlet and jacket outlet coolant temp. °F	10 ± 2
Oil pressure (psi)	40 ± 2
Crankcase Vacuum in H_2O (psi)	2 ± 0.5
Exhaust back pressure in Hg (mm)	0 to 1
Crankcase oil	API SF/CC
Compression ratio	8 : 1

Table 1 shows some of the physical properties of the crankcase lubricating oil used (API/SF). The high octane blending component and motor gasoline were obtained from refinery sources and their properties are given in Table 2. From these, various octane rating fuels were prepared.

RESULTS AND DISCUSSION

Among the various factors such as volatility, air fuel mixture and oxidation stability, which control the

Table 1. Lubricating oil properties.

Kinematic Viscosity @ 100 °C(cSt)	17.64
Kinematic Viscosity @ 40 °C(cSt)	159.62
Viscosity Index	121
Flash point COC (°C)	230
Sulphated Ash Wt.%	0.75
Total Base Number mg (KOH/g)	12.0

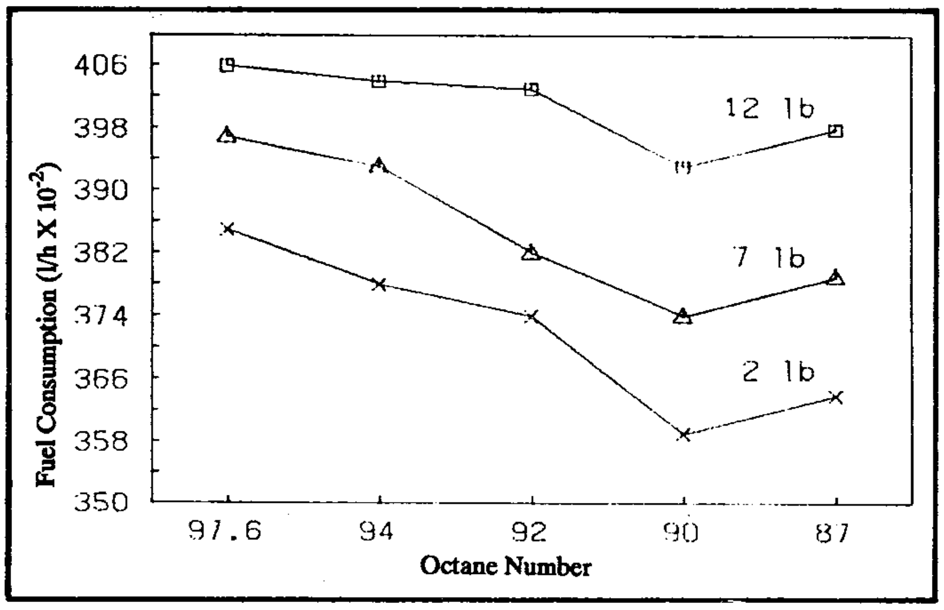

Figure 1— Effect of octane number on fuel consumption at 3150 rpm, at different load.

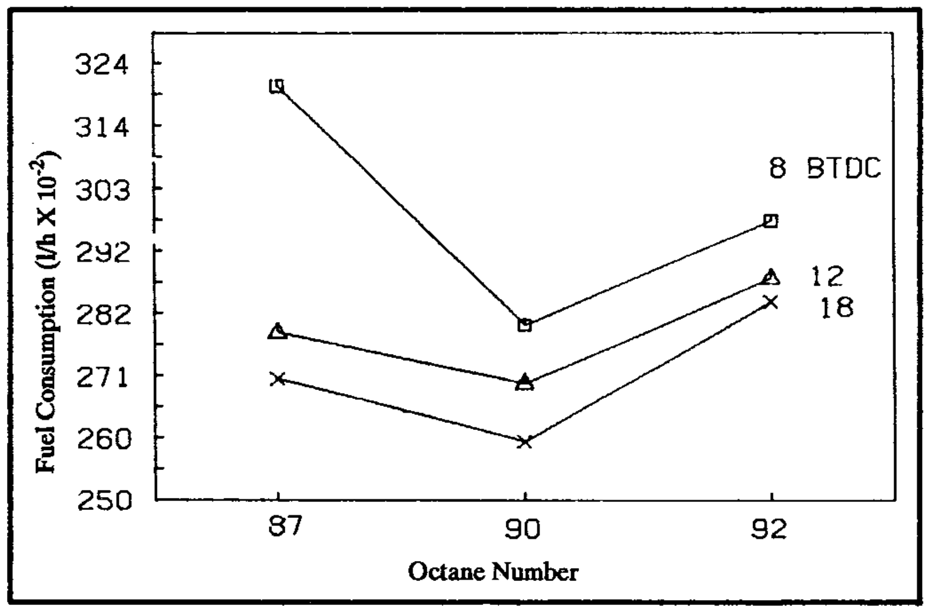

Figure 4— Effect of octane number on fuel consumption at 2500 rpm, 2 lb load at different spark advances.

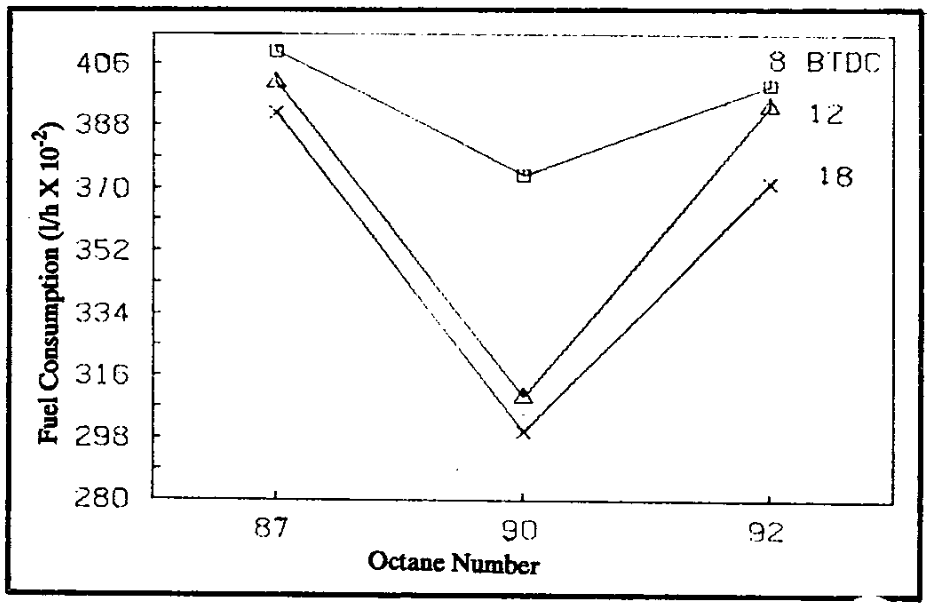

Figure 2— Effect of octane number on fuel consumption at 2500 rpm, 12 lb load at different spark advances.

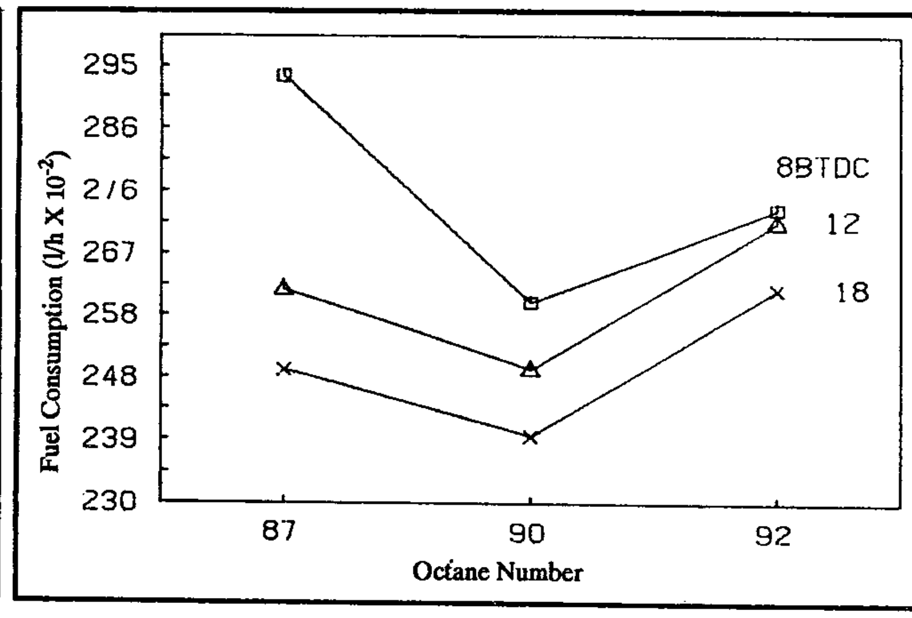

Figure 5— Effect of octane number on fuel consumption at 2500 rpm, 0 lb load at different spark advances.

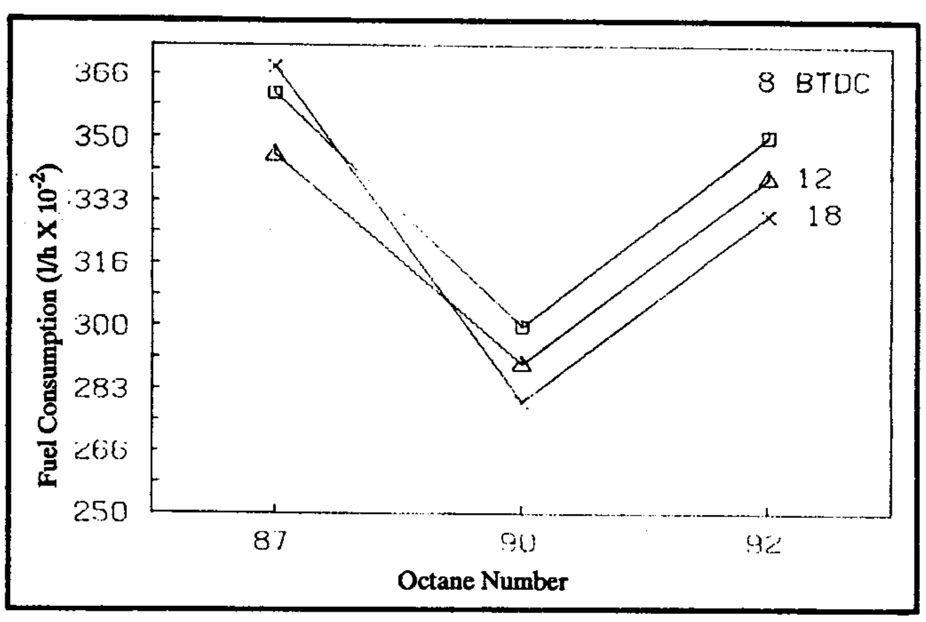

Figure 3— Effect of octane number on fuel consumption at 2500 rpm, 7 lb load at different spark advances.

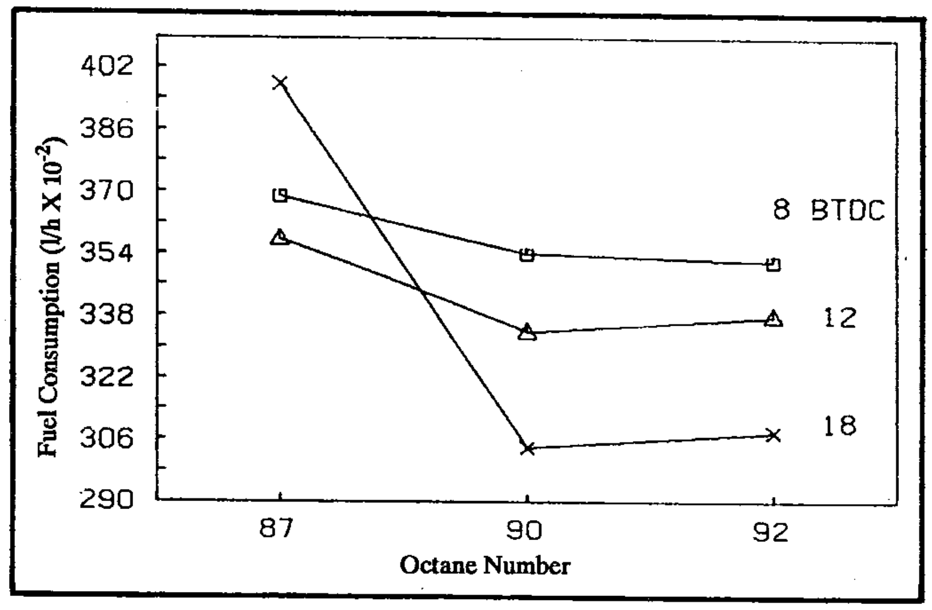

Figure 6— Effect of octane number on fuel consumption at 2000 rpm, 12 lb load at different spark advances.

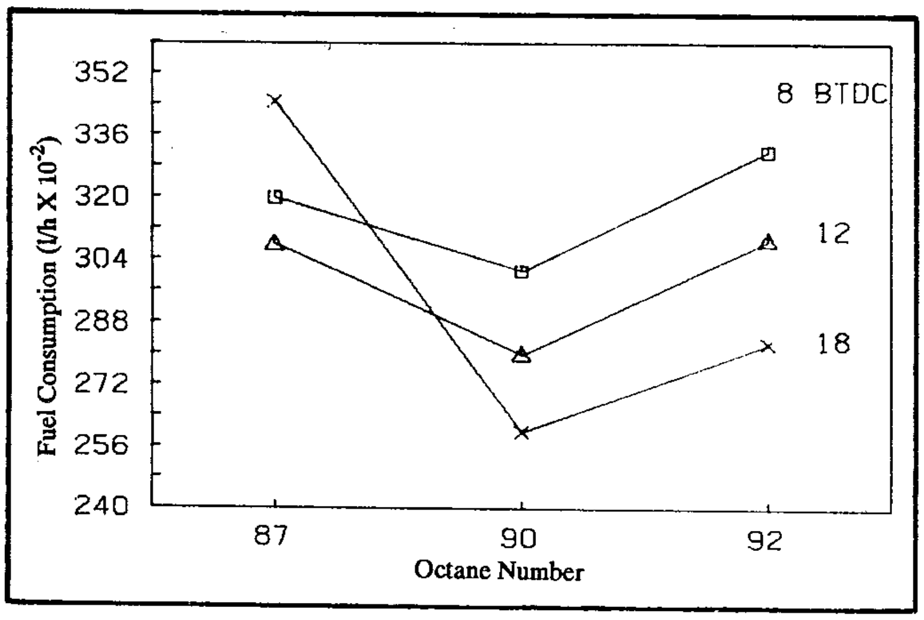

Figure 7— Effect of octane number on fuel consumption at 2000 rpm, 7 lb load at different spark advances.

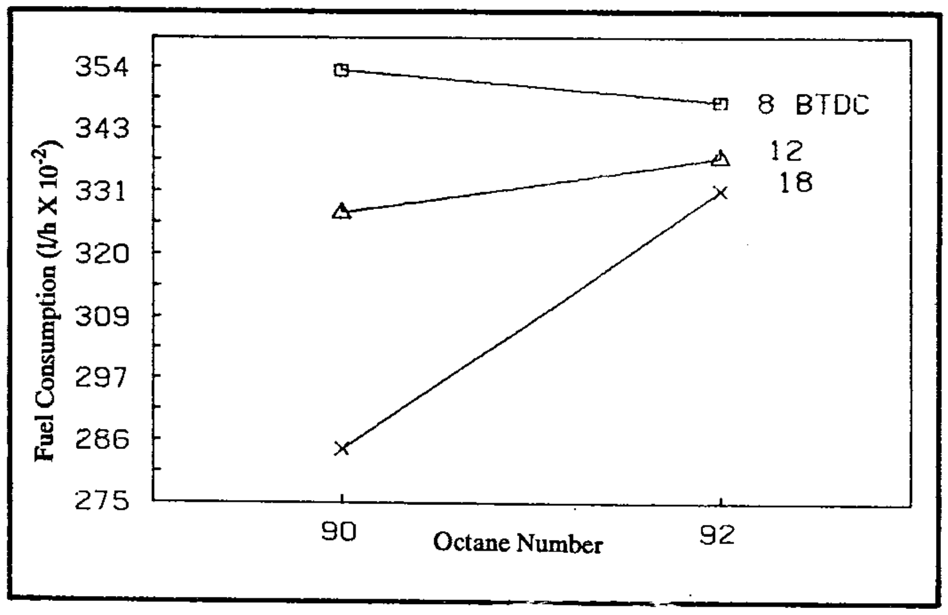

Figure 10— Effect of octane number on fuel consumption at 1500 rpm, 12 lb load at different spark advances.

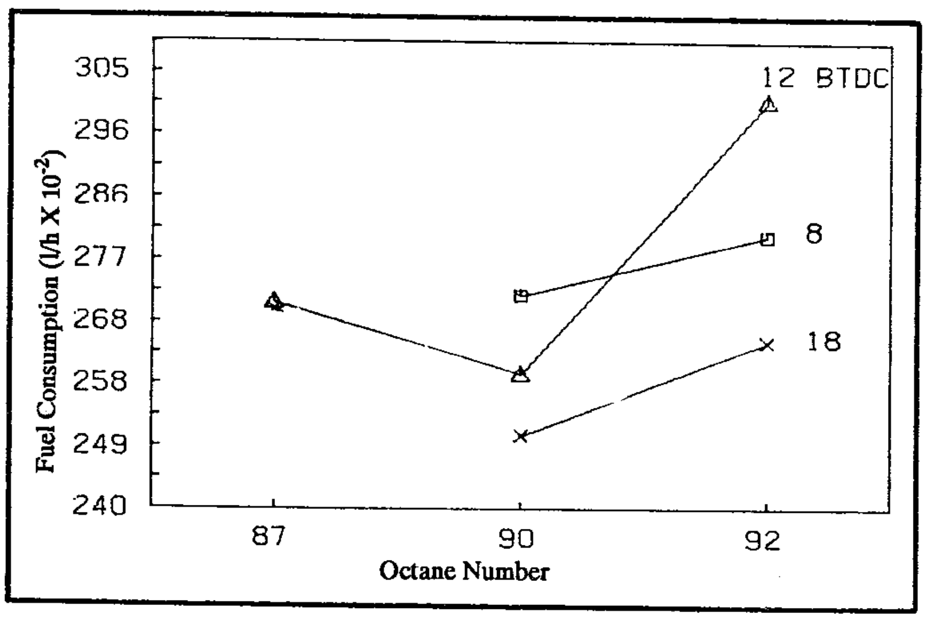

Figure 8— Effect of octane number on fuel consumption at 2000 rpm, 2 lb load at different spark advances.

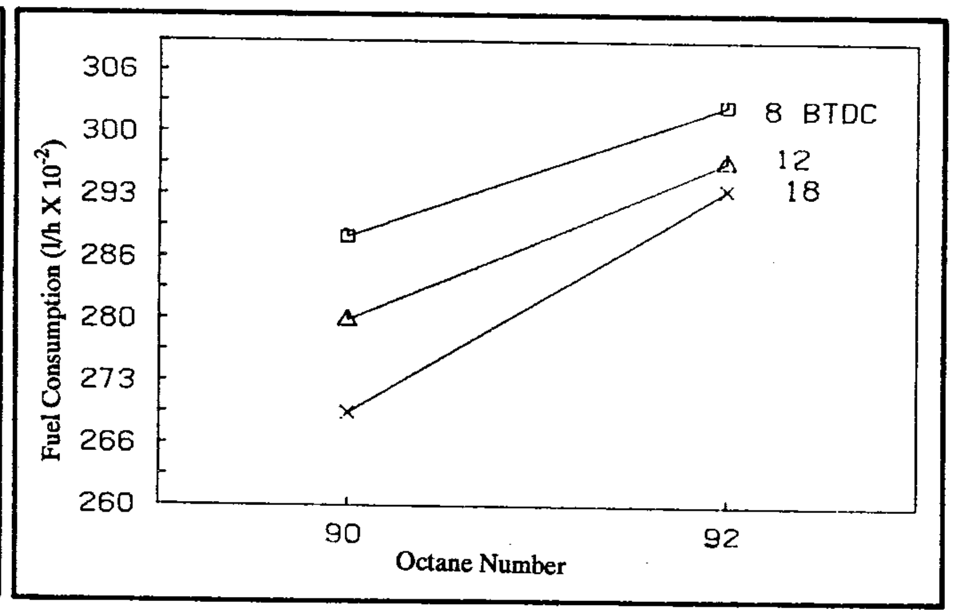

Figure 11— Effect of octane number on fuel consumption at 1500 rpm, 7 lb load at different spark advances.

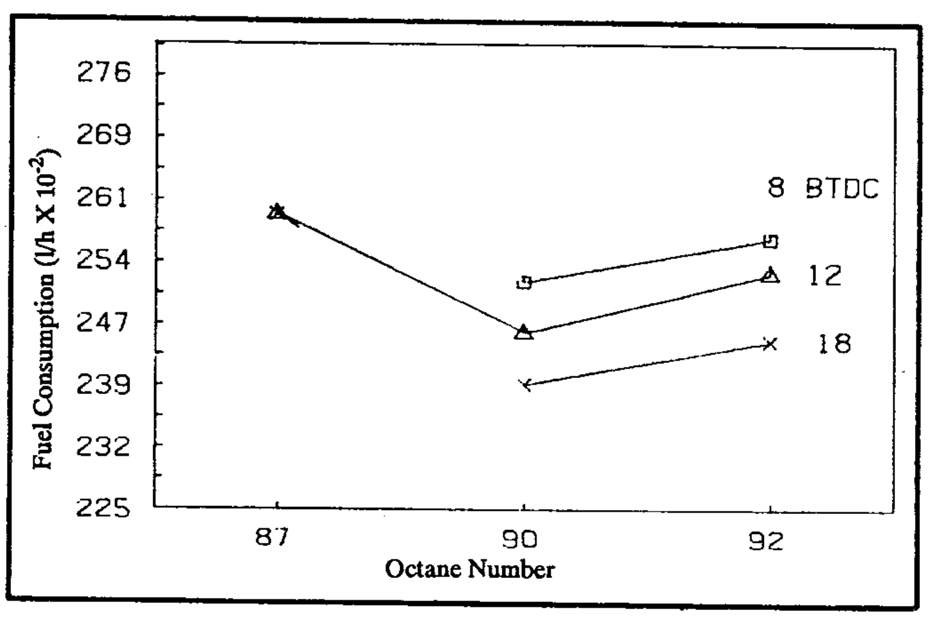

Figure 9— Effect of octane number on fuel consumption at 2000 rpm, 0 lb load at different spark advances.

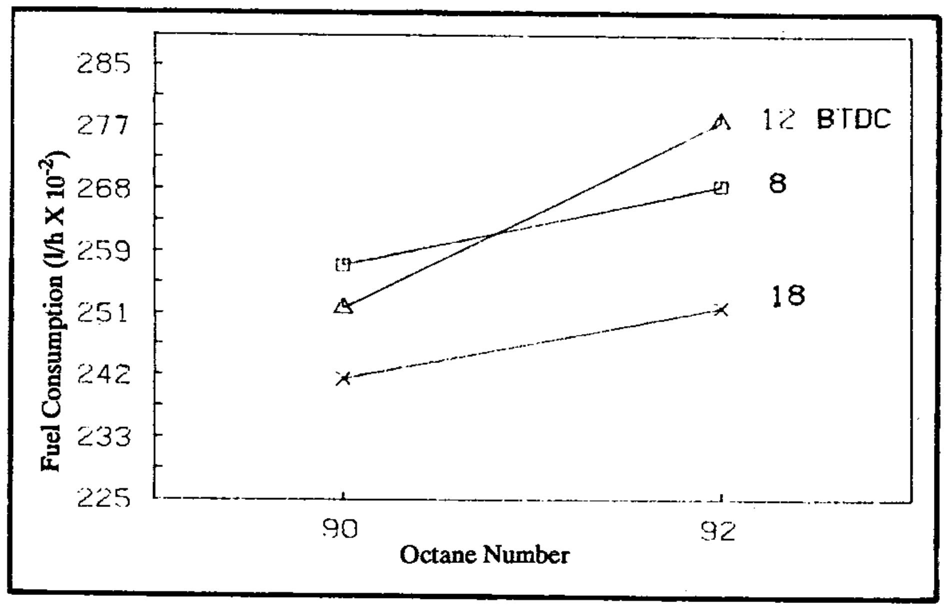

Figure 12— Effect of octane number on fuel consumption at 1500 rpm, 2 lb load at different spark advances.

Table 2. Physical properties of gasoline.

	Motor Gasoline Regular	High Octane Blending Component
Specific Gravity @ 15°C	0.7096	0.754
Research Octane Number	80.0	97.6
Distillation: (°C)		
I.B.P.	44	44
10% Recovery at	62	64
30% Recovery at	74	86
50% Recovery at	87	106
70% Recovery at	105	132
90% Recovery at	135	157
F.B.P.	168	190
Total Recovery vol.%	99	99
Residue/Loss vol.%	0.5/0.5	0.5/0.5

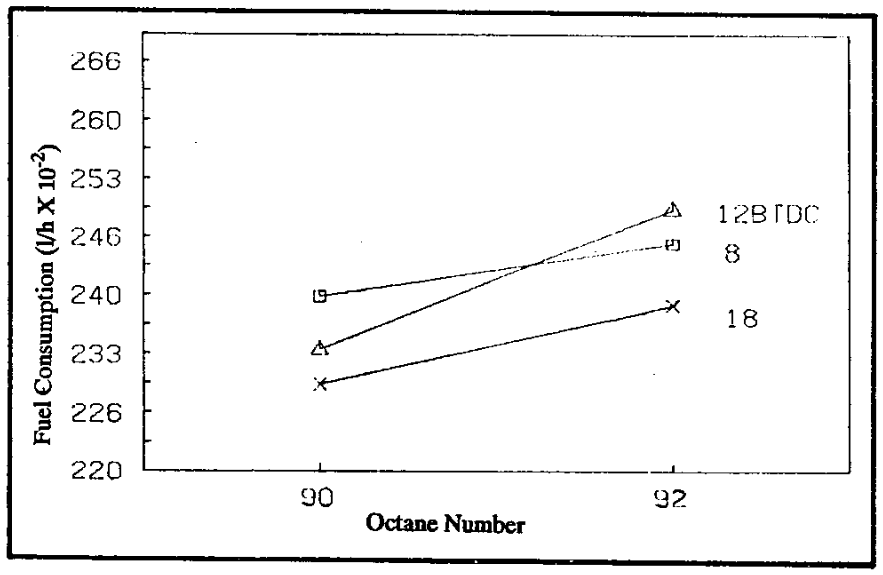

Figure 13— Effect of octane number on fuel consumption at 1500 rpm, 0 lb load at different spark advances.

combustion behaviour of the fuel, knocking characteristic is the most important. Knocking of gasoline engines is the metallic sound of varying pitch, accompanied by over heating and loss of power. It is injurious to the engine parts such as piston, bearings etc. and adversely affects the engine performance and fuel consumption. Studies of the kinetics of hydrocarbon oxidation show the process to have the characteristics of a chain reaction. When such a chain is established it will continue, until broken generally by wall contact. As long as termination proceeds as fast as propagation, normal combustion will take place. If, however, deactivation is not as fast as propagation, a time will come when the number of chains will reach a concentration sufficient to raise the reaction velocity, the unburnt gases may then oxidize to complete the reaction with sudden violence. This is a knocking situation. What actually happens is not known with certainty. Knock is a sudden explosion in the end zone. Knocking differs from detonation. It is slower and less violent than detonation. It was observed that spontaneous oxidation occurred before spark ignition in an internal combustion engine, and a preoxidized material is more likely to ignite spontaneously. These preflame reactions will not alter the total energy released in the combustion but they do reduce the engine performance. Precombustion reactions mean loss of energy and these reactions are very complex in nature. The rate of release of this energy can be lowered by increasing the octane level of the fuel. Within each fuel class, increasing the octane number lowers the total heat of precombustion reactions. The magnitude of the change is related to the octane number. The effect of the octane number ranging from 87 to 97.6 at various engine operating conditions has been investigated. It has been observed that as the octane number is increased, knocking is reduced and also with the same octane number, with increase in load, knocking is observed.

It is evident from Figure 1 that at various torque loads there is a consistent trend that fuel consumption of motor gasoline at RON 90 tends to become minimum. This tendency has also been confirmed by varying ignition timing between 8 to 18 degrees Before Top Dead Centre (BTDC), at engine speed of 2500 rpm and at 2, 7 and 12 lb torque loads (Figures 2-5).

Similar experiments were performed at 2000 rpm. Fuel consumption was measured during change in load and spark advance conditions. The results are shown in Figures 6-7. Again the optimum value of fuel efficiency was found at 90 RON level. However at torque load 2 and 0 lbs the engine became unstable, therefore consumption measurements were not possible at 87 RON and below (Figures 8-9).

Similarly, Figures 10-13 show that knocking and over heating at 87 RON and below prevented engine to be run at 18 BTDC because at these conditions knocking was so high that stable engine running was not possible.

CONCLUSION

From this study it is concluded that in order to conserve motor gasoline a rational octane number could save motor gasoline in substantial quantities and present octane rating of 80 and 87 are too low to meet the requirement of contemporary automobiles. In order to further confirm our finding we intend to do more field trials so that a more realistic octane number for motor gasoline could be suggested for the country.

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