Chapter 9

HIGH OCTANE FUEL BLENDS

9.1 INTRODUCTION

The normal two stroke SI engines cannot be operated on lean mixtures at high CR[131], since the flame speed decreases in lean mixtures and use of homogeneous charges of Gasoline and air near the lean limit result in erratic combustion and increase in Hydrocarbon emission. So some high octane fuels are suggested to improve the combustion process by blending them with Gasoline. Methanol, Ethanol, Eucalyptus oil and Orange oil are the high octane fuel blends suggested to blend with Gasoline. Use of Methanol improves octane quality, flammability limit and flame speed under lean conditions which will result in higher brake thermal efficiency. But the drawbacks of Alcohol-Gasoline blend are phase separation, vapour lock, cold starting, increased emission of unburned Methanol.

Hence, use of other blends such as Eucalyptus oil, Orange oil and Turmeric oil are analyzed as blends with Gasoline. They have high octane values and they are miscible with Gasoline easily without phase separation. Experiments are conducted with all blends mentioned above to find out performance and emission characteristics.

9.2 PROPERTIES OF HIGH OCTANE FUEL BLENDS

The properties of high octane blends such as Orange oil, Eucalyptus oil, Methanol, Ethanol and Turmeric oil are discussed below.

9.2.1 Orange Oil

This oil is extracted from the peal of orange fruits and the main ingredient of Orange oil is d limonene (C\textsubscript{10} H\textsubscript{16}). Orange oil has Specific gravity of 0.845, lower
calorific value 45267 KJ/kg. Octane value 106, flash point of 54°-56°c and initial distillation point is 175°C. The distillation properties of 10% and 20% Orange oil blended with Gasoline is equal to the pure Gasoline. Orange oil has higher flame speed than Gasoline and addition of Orange oil by 20% with Gasoline will give better performance.

9.2.2 Eucalyptus Oil

It is extracted from Eucalyptus leaves and the main ingredient is Cineol (C_{10} H_{16} O).

Eucalyptus oil has Specific gravity of 0.916, lower calorific value 39265 KJ/kg, octane value 100, flash point is 54°C and initial boiling point is 167°C. Flame propagation velocity is slightly higher than that of Gasoline. Water tolerance level of Eucalyptus oil is higher than Gasoline and Alcohols.

9.2.3 Methanol

This can be prepared from natural Gas, Coal, Solid waste etc. It has a lower calorific value 19674 KJ/kg. Methanol has octane value 106-115. Its latent heat of evaporation is nearly four times that of Gasoline. Methanol as a single fuel can not create any vapor lock. But low concentration of Methanol in Gasoline-Methanol blend have effects on Gasoline volatility since the vapour pressure of the blend is higher than either component. Methanol has tendency to phase separation in the presence of very small concentration of water. Pure Methanol as fuel, needs major modifications to the engine. But blending Methanol up to 20% may not require any modification to the engine.
9.2.4 Ethanol

It can be manufactured from any feed stock containing Carbohydrates, such as Corn, Wheat, Sugar beat, Sugar cane, Potatoes etc. Ethanol has a lower calorific value of 26790 KJ/kg. It can be used as a single fuel or can be blended with Gasoline. By using Ethanol there will be decrease in power out put and increase in specific fuel consumption. But this draw back can be over come by using higher CR. Because of problem of phase separation the mixture of Ethanol Gasoline should be handled by select techniques.

9.2.5 Turmeric Oil

Huge quantity of leaves obtained after harvesting Turmeric remain largely under utilized but a part of it is used as a fuel while converting rhizomes in to commercial grade Turmeric. Major chemical composition of Turmeric leaf oil is Phelandrenes (47.14%), Cineole (11.15%), P-Cymbe (11.35%), Terpineolene (9.12%), Myrecene (2.83%), L-Pinene (2.57%), Pinene (2.42%). The oil is having pale yellow colour and has got specific gravity of 0.863.

9.3 PHASE SEPARATION CONTROL

If even small quantities of water is available at room temperature the solubility of Alcohols in Gasoline is limited. The phase separation in fuel system can not be tolerated since Alcohol rich phase leads to a different stoichiometric mixture requirements. The general methods to increase the water tolerance limit of Alcohol Gasoline blends are:

i) By using additives such as isopropanol and Tertiary Butyl Alcohol [124].

ii) By using emulsification devices to emulsify both phases [132].
But both the methods are complex and expensive. Hence Eucalyptus oil is suggested as an additive to reduce the phase separation problems linked with the blend of Alcohol Gasoline as Eucalyptus oil is having co solvent which will prevent phase separation. The Eucalyptus oil of 5% and 20% by volume at room temperature is sufficient to prevent phase separation of blends of 20% Methanol and 20% Ethanol with Gasoline. The blend of Ethanol/Methanol – Eucalyptus oil – Gasoline is stable and may not create any problem in the fuel supply system.

9.4 EXPERIMENTAL PROGRAMME

Experiments are conducted on the engine with high octane fuels such as Orange oil, Eucalyptus oil, Methanol, Ethanol, Turmeric oil blended with Gasoline by 20% volume and performance characteristics, emission properties are analysed at constant engine speed of 3000 rpm.

The following five fuel blends are used for experiments.

1. 20% Orange oil + 80% Gasoline + 3.5% SAE30
2. 20% Eucalyptus oil + 80% Gasoline + 3.5% SAE30
3. 20% Methanol + 75% Gasoline + 5% Eucalyptus oil + 2.8% SAE30+0.7% Castor oil.
4. 20% Ethanol + 60% Gasoline – 20% Eucalyptus oil + 2.8% SAE 30+0.7% Castor oil.
5. 20% Turmeric oil + 80% gasoline + 3.5% SAE 30.

The above blends are made by using volumetric flasks and mixed blend is agitated by using compressed air.
9.5 RESULTS AND DISCUSSION

The performance of the engine with different fuel blends in comparison with normal Gasoline engine is discussed as follows.

9.5.1 Test Results with Various Fuel Blends at the Compression Ratio (7.4)

The performance, emission and combustion parameters of the engine with different fuel blends in comparison with normal Gasoline engine are discussed below.

9.5.1.1 Brake thermal Efficiency:

Figure 9.2 shows the variation of brake thermal efficiency with brake power for various fuel blends, viz., Orange oil blend, Eucalyptus oil blend, Turmeric oil blend, Methanol and Ethanol blends with Gasoline at constant engine speed of 3000 rpm. Eucalyptus oil and methanol blends give an improvement in the brake thermal efficiency. Ethanol blend performance is nearly to Gasoline fuel, and Orange oil blend shows an inferior performance at higher loads compared to Gasoline engine. The maximum improvement in the brake thermal efficiency obtained with Turmeric oil blend is from 17.0% to 22.7% at 1.5 kw power output. With Methanol fuel blend the improvement in brake thermal efficiency is very marginal. The percentage drop in brake thermal efficiency for Orange oil blend is about 6.9% at 2.2 kw power output.

The effects of fuel blends on brake thermal efficiency can be explained by their energy content on volume basis and stoichiometry of the blends, the flame propagation velocities and ignition limits. Among the different fuel blends tested, Turmeric oil blend give maximum improvement in the thermal efficiency due to higher flame propagation velocities, lower air requirement (lean operation) for a given fuel for complete combustion and high energy density (volume basis). During part loads, the
improvements are less significant due to poor volatility as it can also be seen from the distillation curves depicted in Fig. 9.1. However, at higher outputs, the vaporization of the fuel mixture is better and combustion is more complete and hence improvement in the brake thermal efficiency. The Methanol-Gasoline blend also give better performance due to the intrinsic properties of the Methanol fuel, Orange oil, although it has a higher heating value than Gasoline, perform inferior to Gasoline possibly because of poor vaporization characteristics due to the higher specific gravity Fig. 9.1. The flammability limits are narrow and high requirement of air-fuel stoichiometry made the combustion process slower compared to other fuel blends. Ethanol Eucalyptus-Gasoline blend shows only a marginal improvement in the brake thermal efficiency because of the variation in mixture strength and energy content of the blend.

From the above test results of different fuel blends, the improvement in brake thermal efficiency is in the following descending order: Turmeric oil (21%) Eucalyptus oil (20.5%), Methanol (20%), Ethanol (6%), Orange oil (5%) blends with gasoline.

9.5.1.2 Exhaust Emissions:

Exhaust emissions of Hydrocarbons (HC) and Carbon monoxide (CO) are shown in Figs 9.3 and 9.4 for four different fuel blends at a constant engine speed of 3000 rpm. Hydrocarbon emission is lower with all the fuel blends compared to the normal Gasoline engine Fig. 9.3. Among the four different fuel blends, Turmeric-Gasoline blend shows the maximum reduction in Hydrocarbon emission over the entire range of engine operation, in particular at higher throttle openings. At wide open throttle (WOT) condition, corresponding to 2.2 kw power output, Hydrocarbon emission decreases from 7800 ppm to 3500 ppm for Eucalyptus oil blend. Similarly the reduction in Hydrocarbon emission is about 4500 ppm for Ethanol, 4100 ppm for Orange oil 3400 ppm for Turmeric oil and 4500 ppm for Methanol fuel blends respectively at WOT condition. These significant reductions in Hydrocarbon emission
is attributed to the mixture equivalence ratio effects and due to complete combustion of the mixtures with Turmeric oil-Gasoline blend.

The Carbon monoxide emission is generally lower with all the five different blends compared to normal Gasoline fuel. The Turmeric oil-Gasoline blend shows a considerable reduction in Carbon monoxide emission over the entire range of engine operation at this constant engine speed of 3000 rpm as presented in Fig. 9.4. The maximum reduction in Carbon monoxide emission obtained with Turmeric oil blend is about 3.1% vol. at 2 kw brake output. Orange oil blend also exhibits lower Carbon monoxide emission at all the operating conditions than Gasoline fuel but these reductions are less than with those with Turmeric oil blend. Both Methanol and Ethanol fuel blends show a reduction in Carbon monoxide emission in most of the operating range except at WOT positions where a slightly higher Carbon monoxide emission level is recorded. The increase in Carbon monoxide emission at higher outputs can be verified from the mixture strength. Fig. 9.5 shows the variation of equivalence ratio (fuel-air ratio) with brake power which indicates slightly rich mixture operation of Methanol and Ethanol fuel blends at high outputs.

9.5.1.3 Combustion Parameters:

The combustion parameters such as cylinder peak pressure, ignition delay and combustion duration are plotted against brake power in Fig. 9.6 for the five different fuel blends at 3000 rpm. The results are compared with normal Gasoline engine. Both Turmeric oil and Orange oil give higher cylinder peak pressures whereas Methanol and Ethanol fuel blends perform nearly equivalent to that of normal Gasoline fuel engine. The increase in maximum pressure is the highest for Orange oil and Turmeric oil and is about 4.5 bar followed by Eucalyptus oil, 3 bar at 2.2 kw power output. As expected, the higher flame propagation speeds associated with Orange oil
and Turmeric oil helps to burn the mixture more completely and hence higher peak cylinder pressures.

Ignition delays are generally higher by about 2 to 4° Crank angle in the entire range of engine operation for all the fuel blends compared to normal Gasoline fuel operation. The poor volatility characteristics due to high specific gravity makes the physical delay of the mixtures longer than their chemical delay and hence an overall increase in ignition delay for all the fuel blends compared to normal Gasoline fuel. The combustion duration is marginally lower than the normal Gasoline fuel for all the fuel blends.

9.6 CONCLUSIONS

The high octane fuels such as Eucalyptus oil, Orange oil, Methanol, Ethanol and Turmeric oil of 20% by volume blended with Gasoline gives improvement on the performance of the engine.

1. The high octane fuels such as Eucalyptus oil, Orange oil, Methanol, Ethanol and Turmeric oil of 20% by volume blended with Gasoline gives improvement on the performance of the engine.

2. Brake thermal efficiency is improved by 21% (at 1.5 k.w) with Turmeric oil, 20.5% (at 1.5kw) with Eucalyptus, 20% (at 2kw) with Methanol, 5% (at 2kw) with Orange oil and 6% at 2kw) with Ethanol at 3000 rpm compared to normal Gasoline engine.

3. Hydrocarbon and Carbon monoxide emission levels are lower for all the fuel blends. The maximum reduction in Hydrocarbon emission is about 4400 ppm with Turmeric oil 4300 ppm with Eucalyptus, 4200 ppm with Ethanol, 3700 ppm with Orange oil and 3300 ppm with Methanol at 2.2 kw, 3000 rpm.
4. Eucalyptus oil of 5% is required for blend of 20% Methanol and 20% is required for blend of 20% Ethanol to prevent phase separation.

5. Eucalyptus oil, Turmeric oil, Methanol blends provide high efficiency with low exhaust emissions among all the fuel blends tested.
Fig. 9.1 Distillation characteristics with different fuel blends

Fig. 9.2 Variation of brake thermal efficiency with Brake power for different blends.
Fig. 9.3 Variation of Hydrocarbon emission with brake power for different fuel blends.

Fig. 9.4 Variation of Carbon monoxide emission with brake power for different fuel blends.
Fig. 9.5 Variation of equivalence ratio with brake power for different fuel blends.

Fig. 9.6 (a) Variation of cylinder peak pressure with brake power for different fuel blends.
Fig. 9.6 (b) Variation of ignition delay with brake power for different fuel blends.

Fig. 9.6 (c) Variation combustion duration with brake power for different fuel blends.