ALTERNATIVE AUTOMOTIVE TRANSPORTATION FUELS IN THE EASTERN HEMISPHERE

R J Organ and E J Saunders
Product Engineering Department,
Caltex Petroleum Corporation, PO Box 619500, Dallas, Texas

ABSTRACT

Alternative transportation fuels being used in the Eastern Hemisphere are described. These projects include: CNG usage in New Zealand; synthetic gasoline in New Zealand; SASOL diesel and alcohols in South Africa; coconut oil as a diesel extender in the Philippines; and ethanol gasoline blends in various areas. All of these alternative fuels are reviewed with respect to quality and the application problems that have been experienced.

INTRODUCTION

Alcohols and other uncontentional fuels are finding extensive use in the Eastern Hemisphere. In New Zealand, Caltex Oil (NZ) Limited has a service station network selling compressed natural gas (CNG). New Zealand is also on the verge of producing gasoline from methanol. In South Africa, the SASOL plants as well as producing a mixture of alcohols which are blended into gasoline also produce synthetic diesel which is blended with petroleum derived diesel gas oil.

In this paper, alternative energy projects are discussed by product and by country. Most of these projects relate to extending gasoline supplies, but diesel fuel blends which include components from alternative sources eg coal, tar sands, shale oil, oxygenates, vegetable oils, etc, can be expected to gradually enter the markets. Perhaps the first "pure" product alternative to petroleum crude derived diesel will be remote natural gas converted to methanol and used in hybrid diesel engines in buses.

ETHANOL GASOLINE BLENDS

Kenya, Philippines, Zimbabwe and Malawi are using anhydrous ethanol derived from the fermentation of sugar cane or sugar molasses in gasoline (Palmer; Unzelman et al; Sage 1984).

Ethanol In Kenya

Gasohol was launched in Kenya in May 1983 and replaced premium gasoline at oil company service stations in the Nairobi area. Commercial and government consumers were changed over to Gasohol over a period of time. The consumption of Gasohol started at 170,000 litres/day in June 1983 and has averaged 177,000 litres/day since then.

Gasohol (RON 93) is composed of: 10% volume Ethanol; 65% volume Premium Gasoline (93 RON); and 25% volume Regular Gasoline (83 RON). Ethanol (Power Alcohol as it is called in Kenya), is manufactured from molasses. The plant, a joint government/Agro Chemical Food Company venture, has a design capacity of 60,000 litres per day. Current production is approximately 20,000 litres per day.

Ethanol is transported to Nairobi by road tankers and stored at the Kenya Pipeline Company (KPC) tank farm. It is transferred to adjacent oil company depots by pipeline on a daily basis. An in-line blender, provided by the KPC, is installed before the loading rack in each depot.

The Kenya Bureau of Standards has establied: a. KS03-382 Kenya Standard Specification for Power Alcohol; and b. KS03-515 Kenya Standard Specification for Gasohol. A typical Kenyan gasohol blend is shown in Table 2.

There have been very few problems. Initial problems of fuel filter blockage have now largely been resolved. At the time of introduction of Gasohol, all oil companies used thief pumps to clean out all traces of water in the underground tanks at retail outlets. Motorists were advised to drain their fuel tanks but in practice very few did so. There have been no complaints regarding vapour lock even with the high altitude and high temperatures in Nairobi. Plastic fuel lines on certain cars have elongated and it is a common site to see Ford Cortinas with sagging fuel lines almost touching the road. Claims have also been made that fuel gauges of Citroens have been affected as the floats tend to stick when the plastic fuel pipe in the fuel tank distorts. The in-line blenders provided by KPC have had problems. From time to time failures occur and then normal premium gasoline is supplied to the service stations.

The lack of operational problems is credited to a careful series of procedures laid down by oil companies to cover the quality control and handling of Gasohol at retail outlets.

Ethanol in the Philippines

In the Philippines an anhydrous ethanol-gasoline blend called Alcogas is sold. The Philippines was intending to emulate Brazil and create a very large Alcogas programme. However, because of financial problems the whole programme has been reduced in scope. As of now, Alcogas is only available as regular gasoline, containing 20 vol % ethanol, and the supply area of Alcogas is limited to the sugar producing islands of Negros and Panay in the central Philippines. Premium gasoline without ethanol is also available in these areas.

Ethanol produced in alcohol distilleries adjacent to the sugar farms is bought by the Philippine National Oil Company (PNOC) and sold to the oil companies at a price which will allow the oil company to sell Alcogas at 0.25 pesos (about 1.6 US cents) per litre less than gasoline.

There was a considerable amount of customer resistance centred around the relatively small price differential between Alcogas and normal gasoline and the energy value (kilometres per litre) obtained by vehicles using Alcogas. There were so many complaints it was impossible to judge which represented genuine dissatisfaction. The price difference was adjusted slightly and the programme changed so that customers could buy premium gasoline without ethanol. While the complaints have been reduced there still remains a general dissatisfaction with Alcogas.

There is now a proposal to re-orient the Alcogas programme along an octane-enhancer route and this is being evaluated. In this approach, the levels of tetraethyl lead in gasoline would be reduce and the octane difference restored with ethanol.

Other areas

Other areas such as Zimbabwe and Malawi are including ethanol in their gasoline. In Zimbabwe the cost of gasoline to the country represents 21% of the value of exports and the importance of reducing the foreign currency drain has outweighed production cost considerations. Since 1979, Triangle Limited, a sugar cane growing and milling company, has been the sole producer of ethanol in Zimbabwe (Wenman 1984). It sells anhydrous ethanol to the government which resells it to oil companies for blending into gasoline. Initially added at 15% volume this has now dropped to around 12%. Forty million litres of ethanol are produced per year. A second distillation plant is being evaluated for possible inclusion of ethanol in diesel.

METHANOL

From 1983 onwards there has been a shift in methanol production from the US, Europe and Japan to resource-rich countries utilising inexpensive natural gas Itatani 1984; Koba-yashi 1984; Strith 1984). Saudi Arabia, Soviet Union, New Zealand, Trinidad and Tobago, Bahrain, Indonesia and Malaysia are entering the market with large scale methanol plants. Methanol is likely to become a major commodity traded worldwide.

In the Eastern Hemisphere (excluding Europe), there is no large scale commercial usage of methanol as an automotive fuel either directly or blended with gasoline. However, this could change very rapidly depending on the relative economics of methanol production and transportation of the methanol to its normal markets. Currently, there are a number of methanol plants being constructed and some have already started operations. There is predicted to be a world over supply of methanol (Table 3), much of this produced in the Middle and Far East. Utilisation of methanol as an octane booster and blending additive for gasoline in Japan and possible other parts of the Eastern Hemisphere, is a logical development.

Methanol as a transportation fuel

Methanol can be blended into gasoline or used as a neat fuel. There are drawbacks. To use neat methanol as a transportation fuel requires specifically designed vehicles and engines and a suitable fuel distribution system. Methanol is expected to be 60-65% of gasoline price on a volumetric basis. After accounting for the lower volumetric energy content of methanol, the savings in fuel cost with methanol are less than 10%. This does not provide much economic incentive to develop this application. However, neat methanol fuel markets such as centrally fueled fleets are forecast to develop in Canada, the United States and later possible other gas-rich and crude-short countries such as New Zealand, Thailand and Malaysia.

Methanol as a diesel substitute

Although methanol has a poor cetane rating, it is feasible to use methanol in modified engines as a diesel substitute. However, tests to date indicate that mileage achieved with methanol is only 40% of diesel fuel.

Thus, methanol use as a diesel substitute will not be favourable, except perhaps in gas-rich and crude-poor regions. The first commercial uses will be in MAN or Daimler Benz buses which are currently being tested in South Africa and New Zealand (see below).

MIXED ALCOHOL BLENDS IN SOUTH AFRICA

Sasol Fuel Alcohol (SFA) marketed over a wide area of South Africa, is derived from Sasol coal-fuels plant. It is a mixture of the following alcohols; ethanol - 70%; propanol and isopropanol - 27%; and butanol and isomers - 3%. This mixed alcohol fuel is blended into gasoline at approximately a 10% alcohol, 90% gasoline ratio.

Problems with mixed alcohol fuels

Initial problems with water contamination have been resolved by routine checks on storage tanks on a daily basis and immediately after severe rain storms. Corrosion problems were experienced, mainly in vehicle carburettors. Dry corrosion occurred as a result of chemical reaction between anhydrous alcohol and aluminium to form alkoxides which revert to aluminium oxide leading to carburettor blockages. This problem was solved by addition of a small amount of water or ethylene glycol to the fuel to inhibit the reaction. Wet corrosion ocurred in certain areas of the carburettor where under the influence of low temperatures, induced by fuel evaporation, small amounts of water condense out. Electrolytic attack can occur at these sites, especially when dissimilar metals are present. This problem was cured by treating carburettors with a material referred to as Bonderite.

High speed and acceleration knock have been reported and since SFA provides negligible MON gain, a minimum MON of 85 is the current specification requirement. Gasoline/alcohol blends with RON 93 min are supplied throughout the Transvaal and Orange Free State regions. It is the only premium grade motor fuel available on the highveld which accounts for the major portion of the gasoline market in South Africa. The blend is actually produced from a hydrocarbon blendstock specifically manufactured to be mixed with SFA. The SFA content is nominally 10% but the actual ratio may vary from 8 to 12% by volume for supply reasons.

SYNTHETIC DIESEL FUEL IN SOUTH AFRICA

Probably the greatest success for Fischer-Tropsch (F-T) technology has been the Sasol complex in South Africa. First begun in the 1950's, the complex has now completed its third construction phase. Subbituminous coal is supplied from the nearby Bosjesspuit mine.

The primary reaction in the F-T synthesis is usually written as:

$$nCO + 2nH_2 = (CH_2)n + nH_20 + 48n\ kcal$$

Further information can be found in Haggin 1981.

The quality of sasol diesel and problems experienced

The quality of the diesel, specification and typicals, are comparable to petroleum derived diesel gas oil. Nevertheless, there continue to be some problems with Sasol Secunda Diesel fuel.

For example, a recent widespread problem was experienced in the Secunda supply area in which high pressure in-line pump plungers and injector components became stuck because of fine deposit build-up. This problem is currently being investigated. The deposits were initially suspected to be of lubricating oil origin, but it now appears that an additive required for lubricity improvement may be the cause of the deposits.

Sasol now maintain that their current production of 2.2 cSt diesel need not be dosed with a lubricity additive. However, the oil industry is not yet satisfied with Sasol's test work and various field tests are proposed or under way to check the validity of Sasol's claim, and until such time pure Secunda diesel has been withdrawn from the market and a 50/50 blend of Secunda and Natref products is being marketed.

VEGETABLE OIL IN DIESELS

In the Philippines, the addition of coconut oil to all diesel was mandated under a government sponsored programme called "Cocodiesel". (The programme has now been set aside because of the relatively high prices of coconut oil in world markets.) The programme required the addition of up to 5% "raw" coconut oil to diesel fuel, with the blending being done at oil company depots. The coconut oil/diesel fuel mixture developed sludges and microbial growth. This resulted in widespread complaints of clogged diesel engine fuel filters.

While the commercial cocodiesel programme has been set aside, two field test programmes have been completed which monitored the storage/handling and performance of two diesel fuel blends: a. up to 20% "dieselite" - an esterified coconut oil; and b. up to 20% "cochin" - a caustic washed coconut oil. After three to six months of observation in actual storage tanks and microbial testing and service in several fleets in various bus companies, both of these blends were considered satisfactory. But no further activity is planned because coconut oil currently has a high price on world markets.

In Malaysia, current studies are centreed on the transesterification of crude palm oil (CPO) and palm oil stearin with methanol. Products produced are ethyl, isopropyl and methyl esters. A pilot project to produce palm oil diesel (methyl esters) is scheduled to commence mid 1985 with an initial production of 3000 tonnes per annum. All current engine tests (on Fiat agricultural tractors, Toyota Land Cruisers and Hino trucks) are being conducted using methyl esters purchased from Germany. With the present high price of CPO (and steady petroleum crude price), this project is expected to remain an academic exercise until at least 1990.

Considerable work on the use of vegetable oils has been done in Brazil but success has been somewhat limited. Additional information is given in Pischinger et al.

ALCOHOLS IN DIESELS

MAN and Mercedes Benz have introduced methanol fuelled buses into South Africa and New Zealand. In these areas, and possibly others, methanol could be an attractive substitute for petroleum derived diesel, particularly if severe refinery imbalances occur (Toepel et al; Neitz and Chmela 1984; Bergman and Holloh). Preliminary fuel consumption figures for the Mercedes Benz buses are given Table 4.

A programme is being proposed for methanol buses in the Los angeles and the feasibility has been assessed by the US Department of Energy (Eckland).

CONCLUSIONS

A considerable number of alternative fuels are entering the automotive fuel market in the Eastern Hemisphere. There have been some minor teething problems with the introduction of these alternative fuels, but in most cases they have been remarkably successful and trouble free.

Methanol appears to be a fuel of promise in specific countries particularly those with natural gas reserves but little oil. With lead phase downs, both methanol and ethanol may find increasing use in Caltex areas as octane enhancers.

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TABLE 1: MTG gasoline properties

Research Octane Number			
-	Unleaded	93	
-	+0.84g Pb/1 (3.17 g/USG) as TEL	100	
-	+0.84g Pb/1 (3.17 g/USG) as TML	99	
Motor Octane Number			
-	Unleaded	83	
-	+0.84g Pb/1 (3.17 g/USG) as TEL	91	
-	+0.84g Pb/1 (3.17 g/USG) as TML	91	
Front-End (IBP-100° C Fraction) Research Octane Number			
-	Unleaded	87	
-	+0.84g Pb/1 (3.17 g/USG) as TML	95	
Distillation °C (°F)			
-	10% Evaporated	46	(115)
-	50% Evaporated	99	(210)
-	90% Evaporated	166	(330)
-	EP	204	(400)
Existent gum mg/100 ml		1	
Sulphur % wt		< 0.001	
Nitrogen % wt		< 0.001	
Saturates Vol %		60	
Olefins Vol %		8	
Aromatics Vol %		32	

TABLE 2: Typical Kenya gasohol blend

Tests	Regular MSR TK 306	Premium MSP TK 301	Gasohol Blend 10% ETOH 25% MSR 65% MSP
Density	0.7016	0.7283	0.7249
Octane Number	83.6	93.1	93.6
Distillation:-			
IPB	42°C	40°C	40°C
10% Evaporated	58°C	64°C	52°C
20% Evaporated	64°C	72°C	58°C
50% Evaporated	87°C	96°C	76°C
90% Evaporated	139°C	153°C	141°C
End Point	169°C	180°C	174°C
Residue	0.8	1.0	0.6
Recovery at 70°C	28% vol	18% vol	45% vol
RVP	7.0 psi	7.1 psi	7.6 psi
Induction period	> 240	> 240	> 240
Copper strip	1a	1a	1a
Doctor Test	Negative	Negative	Negative

TABLE 3: Operation rate projection for methanol (10,000 tons)

Year		1982	1983	1984	1985	1986	1987
Demand	Existing	1,056	1,077	1,099	1,121	1,143	1,166
	New*	104	109	114	120	126	132
	Total (A)	1,160	1,186	1,213	1,241	1,269	1,298
Capacity	(B)	16,166	16,583	18,334	20,954	20,954	20,954
(A)/(B)		0.72	0.72	0.66	0.59	0.61	0.62

* For automobile fuel (including that for MTBE), SCP, other.

TABLE 4: Results of Mercedes Benz buses running on methanol

	Auckland, NZ Hilly, pure methanol	Berlin, Germany One route which is flat MeOH+5 to 8 vol % isopentane	Pretoria, S Africa One route hilly and at high altitude, pure methanol
Max Fuel Consumption litres/100 km	125.4	104.9	146.7
(Diesel Equivalent) litres/100 km	(57.0)	(47.7)	(66.7)
Min Fuel Consumption litres/100 km	95.4	91.8	114.2
(Diesel Equivalent) litres/100 km	(43.4)	(47.7)	(51.9)
AVERAGE	**108** **(49.1)**	**99.1** **(45.7)**	**128.4** **(58.4)**

FIGURE 1: Comparison of calculated and measured road octane ratings for commercial unleaded gasoline and gasoline from methanol