ALCOHOL AS A MOTOR FUEL

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Is the current alcohol promotion a grand political gesture destined for a technical flop? Alcohol is being used in ever increasing amounts and expanding geographical areas.

The present gasohol marketing scale is in the order of 1000 and more outlets. This is in effect test marketing to get information on public acceptance , production and economics. In addition, it affords an opportunity for the petroleum and automobile industries to make plans for distribution, design and manufacturing changes. In the meantime, the public will have to muddle through the uncertain future waiting for the government, industry, special taxes, supply and demand to settle down.

Gasohol's recent popularity, state and federal tax free incentives may work to make this new fuel a permanent part of the US energy supply. Certain raw material supply and technical factors will limit gasohol's share of the supply. At best, gasohol can only be expected to stretch gasoline supplies by about 10 percent.

The Department of Energy (DOE) estimates supplies of alcohol to increase from 100 to 600 million gallons per year from now to 1985. This is a product penetration of fuel use amounting to 0.58% now and 5.84% in 1985. Calculated in relation to 1977 consumption, the base year used by DOE.

The two alcohols of greatest long range interest, methanol and ethanol and to some extent and purposes, alcohols to C-4 have important differences as motor fuels as well as supply resources.

Ethanol is mostly made by hydration of ethylene, less than ten percent by fermentation. Batch fermentation product is typically 10 percent alcohol, 90 percent water. Distilled it yields a 95% azeotrope. This azeotrope can be pushed to 98-99 percent with vacuum distillation, complete dehydration is achieved by distillation with benzene.

Fermentation of the entire 1977 supply of grains (wheat, sorgum, barley corn) amounting to 9×10^9 bushels and 7×10^6 tons of sugar could yield 74×10^6 gallons/day of alcohol with an energy equivalent of 48×10^6 gallons of gasoline/ day. This is 15 percent of the total gasoline needed. Ethanol from grain consumes twice the energy to manufacture as it delivers in energy. Only sugar yields more energy than is used to make alcohol. Some energy economies can be achieved however, by burning agricultural and process wastes and residues.

Methanol from wood would add another 14 percent to the domestic supply. This assumes the conversion of the entire U.S. wood harvest, 11.6 billion Cu.Ft.

The DOE in its March, 1978 "Position Paper on Alcohol Fuels" states "If all practically available farm land were used for farm crop plantings in excess of those for food production, the ethanol produced from crops and crops residue would satisfy no more than 8% of todays total liquid fuels energy demand". In terms of gasoline demand, this figures to be 16% of gasoline energy requirements.

Methanol made from coal has the greatest future potential. Coal is almost in unlimited supply. Coal reserves in the US converted to petroleum energy equivalence amounts to 130 to 320 times the 1977 petroleum fuel demand (5000 to 12,000 Quads, 10^{15} BTU). Methanol from natural gas costs something less than gasoline. Its energy release is roughly half that of gasoline, obviously a poor use for natural gas. Mixed C_1 to C_4 alcohols from coal derived synthesis gas is the most likely long range substitute. Coal liquifaction by hydrogenation is promising.

Typical synthesis gas yields alcohols of varying composition depending upon process conditions and catalyst selectivity. Typically, the reaction of synthesis gas proceeds from methanol to a practical limit of C_4 alcohols. The overall reactions are:

$$\begin{array}{ll} CO + 2H_2 & CH_3OH \\ 2CO + 4H_2 & C_2H_5OH + H_2O \\ 4CO + 8H_2 & C_4H_9OH + 3H_2O \end{array}$$

Alcohols share many of the liquid properties of gasoline fuels, however, they differ markedly with gasoline as motor fuels. Neither alcohol is suitable for diesel engines without substantial blending with cetane improvers and provisions for starting. There is a greater potential for alcohol in large motor fleets and in stationary equipment such as gas turbines.

PROPERTIES

		Ethanol	Methanol	Gasoline
Stiochiometric	Air/Fuel Ratio	9	6.5	14.6
Combustion	BTU/G	76,000	56,600	115,000
Vaporization	BTU/G	2,400	3,300	900
Dist. Range	°F	173	149	90-410
Water Solubility		Inf.	Inf.	Nil

In the conventional automobile, methanol and ethanol can be used either as (1) blends of 5 to 15% (gasohol is 10%), (2) straight, with additives to improve cold starting and water solubility

Conventional cars cannot drive on straight alcohol or fuels that are mostly alcohol. Carbureted A/F mixtures are too lean to fire. The heat of vaporization is too high. Heated induction systems are needed. A engine system retrofit is possible, but costly. The cost for change over in new cars at the factory is more reasonable.

Drivability suffers when the A/F ratio varies ±10 percent of the stiochiometric A/F. Fuel injection with A/F control from exhaust oxygen sensors may overcome some of the problems associated with carburetion.

It is next to impossible to cold start methanol fired engines below 48°F because of its low volitility. The same is true for ethanol below a temperature of 63°F. Blends with pentanes and gasoline up to 15 - 17 percent work down to temperatures of 14°F. More additives are needed at lower temperatures. Butane is undesirable due to its high volitility and resulting problems in distribution and storage of the blended fuel.

Water in gasoline commonly is in the range of 0.1 to 1.0 percent. When mixed with alcohol it becomes extracted and forms a heavy alcohol rich bottom layer amounting to over half of the entire volume. Water, fuel tolerance depends on the type of alcohol, its percentage and the amount of aromatics. Aromatics improve solubility characteristics along with cosolvents such as isobutanol.

Alcohols form low boiling azeotropes with gasoline. Severe vapor lock can be expected in warm weather and city driving as temperatures rise in the fuel pump and carburetor. Blending gasoline components to adjust for seasonal temperature changes can overcome this problem.

Alcohols have excellent octane ratings. This antiknock quality is also exhibited in gasoline blends. Compression ratios of 13 are possible for straight methanol. This is lessened by dilution with gasoline.

Popular reports and product promotions attribute improved fuel economy to alcohol blends. These claims are not borne out by DOE reports of dynamometer tests. Blends often give better results on a volume basis. The gain in energy efficiency is offset by lower heat of combustion of the blend. The EPA reports volumetric losses in the range of 0.2 to 6 percent for both methanol and ethanol blends.

Any alcohol based fuel distribution system in which alcohol is the major energy contribution, 75% or greater, need to be retrofitted and provide additional storage capacity. This is due to the corrosive nature of methanol. Methanol is corrosive to most metals now in storage and distribution service and auto fuel tanks and engine systems. Polyester bonded fibreglass tanks delaminate.

The EPA allowed a waiver of the Clean Air Act rules on evaporative emissions to permit the marketing of gasohol. Methanol, due to its greater volitility and azeotrope formations can be expected to create greater evaporative emission losses.

Many technical developments are needed to improve engines and alcohol blends with gasoline before alcohol can be an acceptable motor fuel replacement in "conventional" automobiles.

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