PERFORMANCE OF AN ETHANOL-GASOLINE BLEND IN AUTOMOBILES AND LIGHT TRUCKS

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INTRODUCTION

The proposal that ethanol be used as a blending component in automotive fuel is almost as old as the automobile itself. In 1907 the U.S. Department of Agriculture published a report entitled "Use of Alcohol and Gasoline in Farm Engines"(5). Over the intervening years many laboratories tests on the performance of stationary automobile engines operating on ethanol-gasoline mixtures have been reported in the literature. In 1964 a series of papers on the use of ethanol and hydrocarbon motor fuels were published(4) by the SAE. In 1971 the American Petroleum Institute prepared a review of alcohol fuel studies(1). The most recent comprehensive laboratory study was that work done by Dr. H.B. Mathur in connection with his Ph.D. thesis in New Delhi, India(2). Mitre Corp. prepared a new survey(3) of alcohol fuel technology in 1974 including both ethanol and methanol.

To date no statistically designed fleet test of ethanol-gasoline mixtures have been reported in the literature. Contact with automotive and petroleum companies indicate that they too know of no such comprehensive test. Because of the knowledge to be gained from a well designed program, a two million mile road test using a mixture of 10% ethanol-90% unleaded gasoline was designed by the authors and is now in progress.

TEST PROGRAM

The Nebraska two million mile ethanol-gasoline road test program is being conducted with 36 vehicles supplied by the Nebraska Department of Roads and is being financed by the Nebraska Agriculture Products Industrial Utilization Committee. The fuel being tested is a mixture of 10% anhydrous ethanol and 90% unleaded regular grade gasoline. This blend is known by the name GASOHOL. The gasohol is being blended for the test program by the Cooperative Refiners Assoc. in Phillipsburg, Kansas. The no-lead base gasoline used in the preparation of the gasohol is the same no-lead which they market through their normal outlets.

The objectives of the two million mile road test are to obtain the following information:

1. The quantitative effect on fuel consumption of the addition of sufficient anhydrous ethanol to produce a 10% solution by volume with unleaded gasoline meeting specifications for sale after 30 June, 1974.
2. The quantitative effect of this ethanol addition on cylinder wear.
3. The quantitative effect of this ethanol addition on exhaust gas composition.

4. The qualitative effect of this ethanol addition on engine valves.

5. The qualitative effect of this ethanol addition on spark plugs.

6. The qualitative effect of this ethanol addition on the exhaust system.

7. The drivers comments on the effect of this ethanol addition on general vehicle performance.

The quantitative information is being gathered in sufficient quantity and in such a way as to allow statistical analysis of the reliability and significance of the data. The test is to extend over a period of 10-15 months. The qualitative observations are being made sufficiently often to establish any visible trends.

The road test program is making use of a total of 36 vehicles; 10 half-ton pickup trucks and 26 passenger cars. These vehicles are located in three different parts of the state of Nebraska i.e. Lincoln, North Platte, and Sidney. The reason for including vehicles in these three cities is to incorporate into the test an effect for altitude. Lincoln has an altitude of 1160 feet above sea level, North Platte is 3000 feet and Sidney is 4300 feet. Table I summarizes information on the year, make, and model of vehicles included in the test program. As the Department of Roads acquires additional 1974 and 1975 vehicles, some of these will be added to the test program.

The vehicles have been divided into three groups; those vehicles which will run on gasohol only for the entire life of the test program, those vehicles which will run on unleaded fuel only during the entire program and those which will be changed from one fuel to the other about midway through the test program. Table I includes the fuel assignment of each of these vehicles.

Those vehicles running on gasohol fuel will obtain their fuel from new storage tanks which have been buried at state service stations in Lincoln, North Platte and Sidney. Special care has been taken to insure that the tanks remain dry through the initial cleaning and by continued observation of the contents. To date no special driers have been needed on the vents. The drivers of those vehicles running on no-lead gasoline buy their fuel at local commercial outlets since the state service stations do not have facilities for storing and dispensing an additional no-lead grade. Data on the number of gallons of gasoline added to each vehicle and the corresponding odometer reading is maintained by each driver and sent weekly on a standard form to the authors for processing.

VEHICLE MAINTENANCE AND INSPECTION

All normal vehicles maintenance such as oil change, lubrication, etc. is carried out on the test vehicles in the same fashion as other vehicles belonging to the Department of Roads. In addition, each 90 days (± 5 days) from the beginning of the test program a visual inspection is made of the exhaust system on each vehicle. Spark plugs are checked and the compression on all vehicles is also measured. On straight six cylinder engines cylinders two and four are checked while on eight-cylinder engines, three and six are checked. Any V-6

engines in the program have the middle cylinder of each bank checked.

On 10 of the Lincoln vehicles there will be additional inspections made. These include the visual inspection of valves and seats on all cylinders and the measurement of the diameter on all cylinders. In this case six micrometer readings are made at approximately equal spacings on the circumference of the cylinder and at approximately the center of the piston travel. The vehicles undergoing these inspections have been indicated in Table I. One of the objectives of this test is to obtain quantitative information on the exhaust gas composition of vehicles powered with gasohol and with no-lead gasoline. An analytical procedure for obtaining detailed component analyses of exhaust gases using a high resolution mass spectrometer has been developed for the authors by Dr. Michael L. Gross in the Analytical Section of the Department of Chemistry at the University of Nebraska. All exhaust gas samples in this program are being obtained from Lincoln based cars. A fitting has been installed on 10 of the test cars to permit attaching a vacuum gauge to the engine manifold while the exhaust samples are being gathered. The samples themselves are taken from the exhaust pipe and lead through a stainless steel pipe and plastic hose to a set of sample bags in the rear seat of the car. In this way the exhaust samples can be gathered over an extended period of time (typically five minutes) while the car is being driven at a constant speed and a constant load as indicated by the vacuum gauge. Earlier tests with small samples which were gathered in a matter of seconds showed too much variability and uncertainty about the exact speed and vacuum when the sample was caught. The vehicles from which exhaust gas samples are being taken are indicated in Table I.

It is also planned to include standard EPA emissions tests in this test program. These will be obtained through an outside laboratory and will include the usual schedule of warm up and driving in a climate controlled dynamometer.

DATA PROCESSING

Based on the results of preliminary testing of about 250,000 miles, a computer program has been developed to process the fuel consumption and mileage data. Through the use of linear regression it has been found that the significant factors in the fuel consumption are the driver, the vehicles, average daily temperature, average relative humidity and maintenance schedule. Tire pressure while known to be significant cannot be accounted for. Normal fluctuations in atmospheric pressure, precipitation, and visibility were not found to be significant. When the significant factors have been accounted for in the fuel consumption the significance of the residuals will be tested for the unleaded gasoline and gasohol fuel. With the data available from the vehicles it is expected that we will have results with a confidence limit of 99+% for a fuel consumption of $\pm$ 0.1 miles per gallon. Data are processed weekly and quarterly reports are issued to the Nebraska Agricultural Products Industrial Utilization Committee.

LITERATURE CITED

1. American Petroleum Institute, "Use of Alcohol in Motor Gasoline - A Review", Pub. No. 4082, August 1971.

2. Mathur, H.B., "Effects of Ethanol Blending on the Performance and Exhaust Emission of Spark Ignition Engine", Ph.D. Thesis, Dept.

of Mechanical Engineering, Indian Institute of Technology, New Delhi. June 1971.

3. Mitre Corp. "Survey of Alcohol Fuel Technology" Interim Report July 1974.

4. Society of Automotive Engineers, "Alcohols and Hydrocarbons as Motor Fuels", Pub. SP-254, June 1964.

5. U.S. Department of Agriculture, "Use of Alcohol and Gasoline in Farm Engines", Farmers' Bulletin 277, 1907.

TABLE I

Vehicles, Fuels and Tests in
2 Million Mile Gasohol Road Test Program

Model Year	Vehicle Make and Type	Location	Fuel (Note)	Valve & Cylinder Inspections	Exhaust Gas Analyses
1973	IHC ½T Pickup	Lincoln	A	Yes	Yes
1973	IHC ½T Pickup	Lincoln	U	Yes	Yes
1973	IHC ½T Pickup	No Platte	U/A	No	No
1973	IHC ½T Pickup	Sidney	A	No	No
1974	Dodge ½T Pickup	Lincoln	A	No	Yes
1974	Dodge ½T Pickup	Lincoln	U	No	No
1974	Dodge ½T Pickup	Lincoln	A/U	Yes	No
1974	Dodge ½T Pickup	Lincoln	U/A	Yes	No
1974	Dodge ½T Pickup	No Platte	A/U	No	No
1974	Dodge ½T Pickup	Sidney	A	No	No
1974	Dodge Coronet	Lincoln	A	Yes	No
1974	Dodge Coronet	Lincoln	A	No	Yes
1974	Dodge Coronet	Lincoln	U	Yes	Yes
1974	Dodge Coronet	Lincoln	A/U	No	Yes
1974	Dodge Coronet	Lincoln	A/U	No	No
1974	Dodge Coronet	Lincoln	U/A	No	Yes
1974	Dodge Coronet	Lincoln	U/A	No	No
1974	Dodge Coronet	No Platte	A/U	No	No
1973	AM Ambassador	Lincoln	A	Yes	No
1973	AM Ambassador	Lincoln	U	Yes	No
1973	AM Ambassador	Lincoln	A/U	Yes	Yes
1973	AM Ambassador	Lincoln	U/A	Yes	Yes
1973	AM Ambassador	No Platte	U/A	No	No
1973	AM Ambassador	Sidney	A	No	No
1972	AM Ambassador	Lincoln	A	No	No

TABLE I (Con't)

Model Year	Vehicle Make and Type	Location	Fuel (Note)	Valve & Cylinder Inspections	Exhaust Gas Analyses
1972	AM Ambassador	Lincoln	U	No	No
1972	AM Matador	Lincoln	A	No	Yes
1972	AM Matador	Lincoln	A	No	No
1972	AM Matador	Lincoln	U	No	No
1972	AM Matador	Lincoln	A/U	No	No
1972	AM Matador	Lincoln	U/A	No	No
1972	AM Matador	No Platte	U/A	No	No
1972	AM Matador	Sidney	A	No	No
1973	Plymouth Fury III	No Platte	A/U	No	No
1974	Passenger Car (To be Rec'd)	No Platte	A	No	No
1974	Passenger Car (To be Rec'd)	Sidney	A	No	No

Note: A - Vehicle to be run on alcohol blended fuel only

U - Vehicle to be run on unleaded fuel only

A/U - Vehicle to be run initially on alcohol blended fuel and then unleaded fuel

U/A - Vehicle to be run initially on unleaded fuel and then alcohol blended fuel