Running on petrol–alcohol blends

The first of what may soon be many.

You may be advised not to mix your drinks, but a Ford Falcon ranging the streets of Melbourne can imbibe a multitude of mixtures of unleaded petrol and ethanol without a hiccough.

The Victorian Solar Energy Council believes that, when petrol supplies dwindle in a decade or two, the most practical alternative fuel will be ethanol. To help pave the way for that day, the Council (VSEC) commissioned engineers at the CSIRO Division of Construction and Engineering to convert a current-production fuel-injected sedan into what they call a 'flexible-fuel car'. This test vehicle is a forerunner of what we may be driving at the turn of the century.

Success of the conversion depended upon two key components. Number one was a commercial fuel sensor, of Dutch origin, that continuously measures the percentage of alcohol in the fuel line. The second was an electronic engine management system (EEMS), produced by the Orbital Engine Company of Perth, that responds to the sensor and adjusts the settings of the electronic fuel-injection system accordingly.

In the event, the weakest links proved to be the fuel sensor and the vehicle's catalytic converter. Initially, the sensor's reliability gave cause for concern, but this problem appears to have been substantially overcome. As for the catalyst, it couldn't cope with alcohol concentrations above 40% without exceeding prescribed emission limits. However, the engineers believe they can get around this limitation by substituting a different catalytic converter, or by mixing extra air into the exhaust-gas stream.

Essentially, the Australian EEMS is a computer memory that stores the appropriate combinations of ignition timing and fuel mixture-richness settings, and it performs the same job as the Ford unit that it replaced. The advantage of using the Orbital Engine Company's version was that the company was prepared to disclose the inner workings of its EEMS; these proprietary technical data allowed the CSIRO engineers to reprogram the unit to cope automatically with any blend of unleaded petrol and alcohol.

In other modifications, the engineers involved — Dr Ron Johnson, Dr Pratish Bandopadhayay, Mr Trevor Crowle, and Mr Eric Christie — also:

- replaced the plastic fuel tank and fuel lines with stainless steel equivalents (ethanol degrades some plastics)
- replaced the fuel gauge's sensor, which operated by measuring conductivity, with one that used a float (since alcohol's conductivity is very different from that of unleaded petrol)
- modified the distributor to provide an engine timing signal (top dead centre) required by the new EEMS

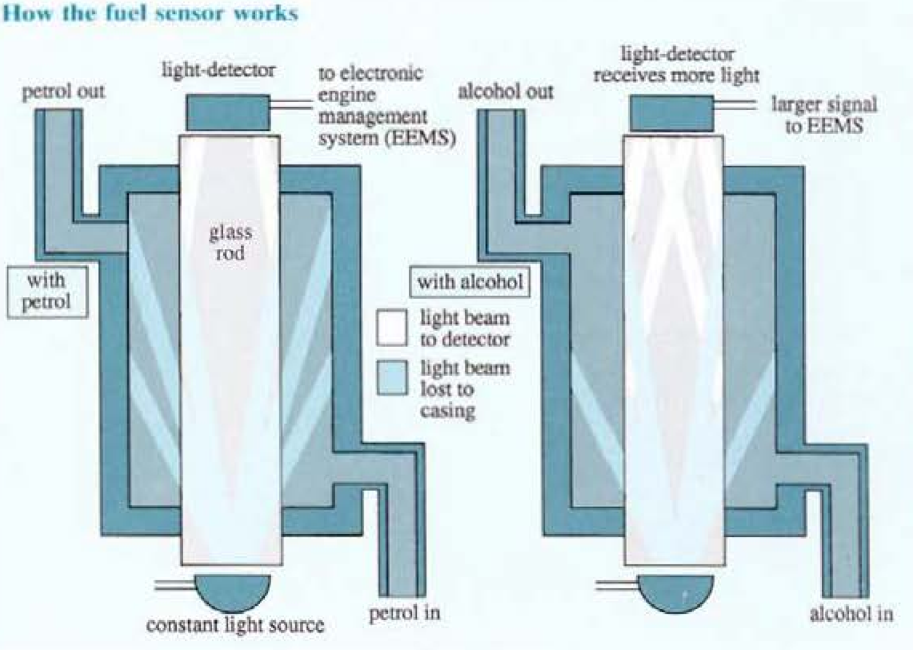
Although not strictly necessary, they also installed a more sensitive gauge for measuring the air flow into the engine. And, to allow easy adjustment of the EEMS during vehicle testing, it was linked to a portable microcomputer.

Mapping engine performance

The EEMS' task is to tell the electronic fuel-injection system how rich to make the air–fuel mixture and what spark advance to

Alcohol and petrol have different refractive indexes. The fuel sensor gauges the percentage mix by measuring the amount of light transmitted along a glass rod by total internal reflection; this depends on the refractive index of what surrounds the rod.

How the fuel sensor works



Jerusalem artichokes and wheat straw — both potential sources of ethanol fuel.

use. This information is stored in the form of engine-performance 'maps', which provide appropriate values of the two settings according to the engine speed and engine load. Each map covers 289 different combinations of these variables.

The EEMS has a different map for each 10% increase in ethanol concentration; the voltage from the ethanol sensor tells the EEMS which map to use. Early in the piece, the engineers encountered pollution problems in running the car on more than 60% ethanol, so only seven maps (covering the range 0–60%) were plotted.

Even so, determining the optimum settings of spark advance and air : fuel ratio for 289 × 7 × 2 different engine and fuel characteristics (4046 in all) was a major undertaking. Ford Australia, as well as providing the test vehicle free of charge, made available a second, identical, engine for this task. It was installed on CSIRO's computer-controlled dynamometer at Highett.

First, engine load and speed were set, and then monitoring equipment kept a watch on how the engine's fuel consumption and exhaust emissions changed as the fuel injection's timing and air : fuel ratio were altered. The optimum values were those favouring high fuel economy and low concentrations of pollutants (hydrocarbons, NO_x, and carbon monoxide) in the exhaust.

When the optimum settings were programmed into the test vehicle's EEMS, the car ran sweetly and smoothly on any fuel mixture between 0 and 60% ethanol. An experienced test driver rated its acceleration and general 'driveability' to be close to, if not the same as, those of its conventional equivalent.

The Environment Protection Authority ran tests on its dynamometer, running the vehicle through standard drive cycles and monitoring its exhaust purity with different fuels. Emissions stayed within EPA limits using ethanol concentrations up to 40%, but exceeded them at higher blends.

This problem with high-proof blends relates to large quantities of water vapour in the exhaust. The vapour tends to reduce the catalytic converter's effectiveness.

The driver of a flexible-fuel car can take advantage of whatever's going.

Mr Ron Mendelsohn, leader of VSEC's flexible-fuel car project, thinks a possible way around the difficulty is to adjust the amount of air that is passed through the converter. Alternatively, a catalytic converter specifically designed for use with alcohol fuel could be fitted.

Weaning off petrol

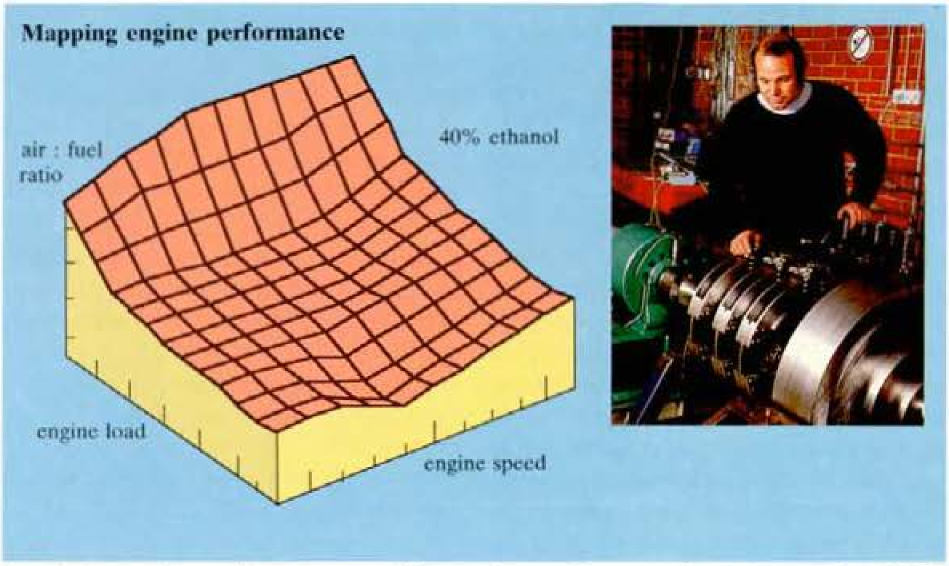
Mr Mendelsohn believes that making a vehicle able to run on any blend of unleaded petrol and alcohol will greatly ease what he sees as the inevitable transition to alcohol fuel.

In Victoria, reserves of economically recoverable Bass Strait oil are expected to be exhausted by the mid 1990s; on a national level, our self-sufficiency in crude oil is likely to decline from its present 70% to 20–30% by the year 2000, unless major new discoveries are made.

Fermenting biological materials into ethanol currently appears to be a viable alternative to petroleum fuels. A VSEC study in 1985 estimated that ethanol could be produced for 26–45 cents per litre from Jerusalem artichokes — a perennial tuber crop — using a solid-phase (no added liquid) fermentation process. This process was developed through research by Mr Kevin Kirby of the CSIRO Division of Biotechnology.

Alternatively, using enzyme hydrolysis, fermentation of cereal-crop residues — such as wheat straw — could be done for as little as 41–65 cents per litre. Processing 40% of Victoria's current cereal residues would be enough to supply all the State's motorists with a 10% blend.

On the global scene, many countries have already turned to fuel alcohol as a way of extending their oil supplies. Mixed as a 10% blend with petrol, alcohol can be used



The CSIRO researchers used a computer-controlled dynamometer (inset) to produce engine-performance 'maps' like the one shown.

in existing engines without any modification; indeed, it acts as an octane-booster, restoring to petrol the high performance once granted by lead additives. The Victorian Solar Energy Council is currently conducting a trial in which it is supplying a 10% alcohol blend to that State's Electricity Commission so that the Commission can operate three unmodified fleet vehicles on the fuel.

Low-percentage alcohol blends now flow from bowsers in the United States, Canada, Japan, and most major countries of Europe. Some countries have already proceeded further, and vehicles powered by neat alcohol can be found in increasing numbers in Brazil, the United States, some parts of Europe, and Japan. These cars need alcohol-resistant fuel tanks and piping, and require special tuning.

The flexible-fuel car is an idea gaining favour in a number of countries. With electronic fuel injection now popular, providing flexibility of fuel type is a simple step, and offers a major benefit.

The big plus is that it does away with the need for separate, reliable distribution networks for alcohol, petrol, and a fixed percentage blend (or blends). Instead, the driver of a flexible-fuel car can take advantage of whatever's going and whatever's cheapest at the time — just 'fill 'er up'.

A weak link

That's the theory; how did the first practical step towards its realisation in Australia shape up?

Council staff have now driven the Falcon in excess of 10 000 km, and it has worked perfectly on fuels ranging from 0 to 40% alcohol. No deterioration of the engine attributable to corrosive alcohol fuel has been noted during close inspection. Monitoring includes analysis of the engine oil every 2000 km by the Shell Company's special 'Check Plus' service.

As indicated earlier, a major problem encountered in the conversion operation relates to the reliability of the alcohol sensor. The sensor presently in the car is operating satisfactorily, but its two predecessors had problems. The first could not give repeatable readings, whereas the second was unduly influenced by temperature and couldn't operate satisfactorily between alcohol concentrations of 30 and 70%.

Given that all the sensors are prototypes, some faults may be forgiven, but Mr Crowle thinks that the Dutch unit has an intrinsically unreliable principle of operation. It relies on an electro-optical arrangement for measuring the fuel's refractive index, and if any impurity in the fuel forms a coating on the optical components then the instrument's accuracy will go awry — an avenue for an inventor's ingenuity, perhaps?

Andrew Bell

More about the topic

Demonstration of a flexible-fuel car. P.C. Bandopadhayay, R. Mendelsohn, M.P. Southern, and R.R.M. Johnston. *Proceedings, 4th International Pacific Conference on Automotive Engineering, Melbourne, November 1987.*