

# U.S. DEPARTMENT of AGRICULTURE

*Invented 32 years Ago*

## USDA RESEARCHERS ALCOHOL INJECTION: GASOHOL ALTERNATIVE?

Washington--You've heard the pluses and minuses of gasohol -- the mixture of one part ethyl alcohol -- ethanol -- and nine parts gasoline you can burn in your present gasoline engine; How it helps your country conserve fossil fuel but may take a lot of farmland for fuel sources, how it may stop detonation or "knock" problems produced by low octane gasoline, burns away or prevents carbon build-up inside your engine and might even boost your car's mileage with certain carburation and other adjustments, although that's questionable,

You also may have heard about major automobile manufacturers converting engines in Brazil so they use water and ethanol as primary fuel in lieu of gasoline. Less mentioned is a third approach to burning alcohol in your engine. It uses an injector to spray 'wet' alcohol, such as ethanol and water -- some call it 'aquahol' -- into the fuel-mixing chamber. Alcohol-water injection also has advantages and disadvantages which should be considered in this country's calculations about how to become less dependent upon gasoline, according to some U.S. Department of Agriculture researchers as well as engineers outside government.

"The main advantage of water-alcohol injection over gasohol would be that we could use unleaded 75-octane gasoline instead of 87 to 89-octane gasoline," said William B. Roth one of two USDA scientists who invented a device for an alcohol-water injection method 32 years ago. He said their method provides the benefits of gasohol but can help save more fossil fuel and prevent potential problems with alcohol such as "phase separation", a chemical process -- when water and alcohol settle to bottoms of tanks in cold weather.

Although 'dry' -- anhydrous -- ethanol at virtually 200-proof is used in gasohol, it gradually dilutes itself by drawing water from the air and loses proof if left standing over a period of time.

"What we should be working toward," said Normand Waag, Florida inventor and engineer who has worked with the injection method more than 30 years, "is use of an alcohol-water mix as the primary fuel, in the main tank as the Brazilians are doing with gasoline in an auxiliary tank used only to start engines."

"Alcohol sometime will be the only fuel we have left for the automobile and is what we should have used in the first place instead of gasoline. In effect, we can get it from the sun's rays.

"Alcohol, of course, has been used as fuel for many years in race cars, but before we can use it on the highways, we really need more research on potential problems."

## RESEARCH GOING ON

Such research is going on, as at Iowa State University under agricultural engineers Stephen J. Marley and W. F. Buchele. They have tested wet grain alcohol with a 72-horsepower tractor to determine what proportion of alcohol and water works best as primary fuel -- not as a separate injection as in gasohol. They reported finding 90% ethanol and 10% water -- 180 proof -- as the most efficient mixture. Some farmers also are doing research, burning wet grain ethanol -- such as 160 proof to 190-proof -- instead of gasoline in their tractors and trucks. If injected properly, Waag said, it should cause no problems and, in fact, should improve engine performance over gasoline.

But Waag cautioned, "Whether you use alcohol as the main fuel or an alcohol-water injection mixture it must be put in under pressure rather than by suction. Under no circumstances must you disturb the proper air-fuel ratio. Too much air burns out valves.

And to avoid corrosion, Waag insists that a good inhibitor be added to either wet or dry alcohol used in any engines.

Using either wet alcohol as main fuel or the injector provides the same advantages gasohol has over gasoline, Waag said. It prevents and removes formation of heat-building carbon in engines and exhaust systems. Clean exhaust pipes on his injector-fitted cars bear witness to his contention. He said he has sold about 100,000 injection devices similar to that of the USDA scientists.

He said an engine burning gasoline plus injected wet alcohol emits less nitrogen dioxide in its exhaust than without the injector. The Environmental Protection Agency has confirmed this, said Bruce Everling, an EPA environment protection specialist, the EPA only tests and does not endorse any such devices.

Roth, a chemist with USDA's Science and Education Administration at Peoria, Ill., explained how alcohol injection saves fossil fuel. "First, less gasoline is used per with the separate injection than with gasoline alone. "Second, injection of alcohol with gasoline boost the octane so much that gasoline with lower octane rating than our 'normal' unleaded gasoline could be used.

## MAJOR ADJUSTMENT

"Industry sources indicates they use 7 to 11 % more crude oil to make high-octane than low-octane gasoline. The industry reportedly could provide 75-octane gasoline simply by eliminating extra processing that raises the octane rating to 88 or more, however that would mean changing federal regulations and making major industrial adjustments, as Brazil reportedly has done."

Gas savings would vary based on spark advance and other adjustments, engine conditions, driver habits. But it's the entire package that may offset the major disadvantage needing separate tanks for wet alcohol and gasoline. Separate tanks are essential because of the above-noted phase separation problem.

The water-alcohol injection system has an economic advantage over gasohol, according to both Roth and Alfred D. French, USDA research chemist at New Orleans, La

French said, "The alcohol would be consumed only during a small part of a car's operation -- acceleration. During starting, idling and cruising, the car can operate satisfactorily on low-octane gasoline.

A mixture of 75% alcohol and 25% water, for example, might be injected at a variable rate with 75 to 77-octane gasoline. This would give an average 85 to 87-octane fuel mixture. The octane would vary, becoming higher or lower than depending upon signals from the manifold.

"Because full throttle is used less than 10% in normal driving, the car might use only a gallon of alcohol in addition to regular gasoline every several hundred miles.

"Therefore, objections to gasohol based on industry's productive capacity would not be so relevant for alcohol injection. And, the more economic use of fuel in the engine and lower expenditure of energy during gasoline refinement would compensate for the energy costs of alcohol production."

Roth said, "**Research we did years ago indicated that using the alcohol by injection would be roughly 800% more efficient than through the gasohol approach, without regard for the extra costs of distilling alcohol to its driest state.**

"And rather than using 200-proof alcohol, motorist can use 160-proof -- 20% water -- or even 50-50 alcohol-water combinations -- all cheaper and simpler to distill than 200-proof."

Other alcohols besides ethanol -- made from grain or other sources -- including methyl or wood alcohol -- methanol -- and isopropyl alcohol. Methanol can be made from wood, coal or methane gas, which currently wastes into the atmosphere from some country's crude petroleum well-heads and also can be produced from livestock excrements.

Roth and James C. Porter, both then with the USDA's research laboratory in Peoria, applied in June 1948 for a patent to USDA but it has expired.

Roth, still at Peoria, now analyses whole botanical plants for chemical content. Porter, a mechanical engineer who left government, is "semi-retired" and lives in New Mexico.

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