Hydrogen Injection

The technology of using hydrogen as a combustion enhancement in internal combustion engines has been researched and proven for many years. The benefits are factual and well documented. Our own utilization of this technology. i.e. the hydrogen injection system, has also been tested and proven both by institutions and in hundreds of practical applications in road vehicles.

Here is a synopsis of a sampling of the research that has been done:
In 1974 John Houseman and D.J/Cerini of the Jet Propulsion Lab, California Institute of Technology produced a report for the Society of Automotive Engineers entitled "On-Board Hydrogen Generator for a Partial Hydrogen Injection Internal Combustion Engine".
In 1974 F.W. Hoehn and M.W. Dowy of the Jet Propulsion Lab, prepared a report for the 9th Inter society Energy Conversion Engineering Conference, entitled "Feasibility Demonstration of a Road Vehicle Fueled with Hydrogen Enriched Gasoline."

In the early eighties George Vosper P. Eng., ex-professor of Dynamics and Canadian inventor, designed and patented a device to transform internal combustion engines to run on hydrogen. He later affirms: "A small amount of hydrogen added to the air intake of a gasoline engine would enhance the flame velocity and thus permit the engine to operate with leaner air to gasoline mixture than otherwise possible. The result, far less pollution with more power and better mileage." In 1995, Wagner, Jamal and Wyszynski, at the Birmingham, of University Engineering, Mechanical and Manufacturing>, demonstrated the advantages of "Fractional addition of hydrogen to internal combustion engines by exhaust gas fuel reforming." The process yielded benefits in improved combustion stability and reduced nitrogen oxides and hydrocarbon emissions.

Roy MacAlister, PE of the American Hydrogen Association states the "Use of mixtures of hydrogen in small quantities and conventional fuels offers significant reductions in exhaust emissions" and that "Using hydrogen as a combustion stimulant it is possible for other fuels to meet future requirements for lower exhaust emissions in California and an increasing number of additional states. Relatively small amounts of hydrogen can dramatically increase horsepower and reduce exhaust emissions."

At the HYPOTHESIS Conference, University of Cassino, Italy, June 26-29, 1995, a group of scientists from the University of Birmingham, UK, presented a study about hydrogen as a fraction of the fuel. In the abstract of that study it stated: "Hydrogen, when used as a fractional additive at extreme lean engine operation, yields benefits in improved combustion stability and reduced nitrogen oxides and hydrocarbon emissions."

In the Spring of 1997, at an international conference held by the University of Calgary, a team of scientists representing the Department of Energy Engineering, Zhejiang University, China, presented a mathematical model for the process of formation and restraint of toxic emissions in hydrogen-gasoline mixture fueled engines. Using the theory of chemical dynamics of combustion, the group elaborated an explanation of the mechanism of forming toxic emissions in spark ignition engines. The results of their experimental investigation conclude that because of the characteristics of hydrogen, the mixture can rapidly burn in hydrogen-gasoline mixture fueled engines, thus toxic emissions are restrained. These studies and other research on hydrogen as a fuel supplement generated big efforts in trying to develop practical systems to enhance internal combustion engine performance. A few of them materialized in patented devices that didn't’t reach the level of performance, safety or feasibility that would allow them to reach marketing stages.

California Environmental Engineering (CEE) has tested this technology and found reduction on all exhaust emissions. They subsequently stated: "CEE feels that the result of this test verifies that this technology is a viable source for reducing emissions and fuel consumption on large diesel engines."

The American Hydrogen Association Test Lab tested this technology and proved that: "Emissions test results indicate that a decrease of toxic emissions was realized." Again, zero emissions were observed on CO. Northern Alberta Institute of Technology. Vehicle subjected to dynamometer loading in controlled conditions showed drastic reduction of emissions and improved horsepower.

Corrections Canada tested several systems and concluded, "The hydrogen system is a valuable tool in helping Corrections Canada meet the overall Green Plan by: reducing vehicle emissions down to an acceptable level and meeting the stringent emissions standard set out by California and British Columbia; reducing the amount of fuel consumed by increased mileage."
Additionally, their analysis pointed out that this solution is the most cost effective. For their research they granted the C.S.C. Environmental Award.

We also conducted extensive testing in order to prove reliability and determine safety and performance of the components and the entire system. As a result of these tests, we achieved important breakthroughs as far as the designs of the components were concerned. We have since increased the hydrogen/oxygen production significantly. This has resulted in increased effectiveness on engine performance.

The results of these tests were able to confirm the claims made about this technology: the emissions will be reduced, the horsepower will increase and the fuel consumption will be reduced.

From researching the Internet we also found the following information

To best describe how Hydrogen Enhanced Combustion works, we are providing this excerpt from a University Technical Report, written by Mr. George Vosper, P.Eng.;

...a Hydrogen Generating System (HGS) for trucks or cars has been on the market for some time. Mounted on a vehicle, it feeds small amounts of hydrogen and oxygen into the engine's air intake. Its makers claim savings in fuel, reduced noxious and greenhouse gases and increased power. The auto industry is not devoid of hoaxes and as engineers are sceptics by training, it is no surprise that a few of them say the idea won't work. Such opinions, from engineers can't be dismissed without explaining why I think these Hydrogen Generating Systems do work and are not just another hoax. The 2nd law of thermodynamics is a likely source of those doubts. Meaning *...the law -would lead you to believe that it will certainly take more power to produce this hydrogen than can be regained by burning it in the engine. i.e. the resulting energy balance should be negative*. If the aim is to create hydrogen by electrolysis to be burned as a fuel, the concept is ridiculous. On the other hand, if hydrogen, shortens the burn time of the main fuel-air mix, putting more pressure on the piston through a longer effective power stroke, and in doing so takes more work out, then this system does make sense.
Does it work? Independent studies, at different universities, using various fuels, have shown that flame speeds increase when small amounts of hydrogen are added to air-fuel mixes. **A study by the California Institute of Technology, at its Jet Propulsion Lab Pasadena, in 1974 concluded:**

> The J.P.L. concept has unquestionably demonstrated that the addition of small quantities of gaseous hydrogen to the primary gasoline significantly reduces CO and NOx exhaust emissions while improving engine thermal efficiency

A recent study at the **University of Calgary by G.A. Karim** on the effect of adding hydrogen to a methane-fuelled engine says
... The addition of some hydrogen to the methane, speeds up the rates of initiation and subsequent propagation of flames over the whole combustible mixture range, including for very fast flowing mixtures. This enhancement of flame initiation and subsequent flame propagation, reduces the Ignition delay and combustion period in both spark ignition and compression ignition engines which should lead to noticeable improvements in the combustion process and performance

What happens inside the combustion chamber is still only a guess. In an earlier explanation I suggested that the extremely rapid flame speed of the added hydrogen oxygen interspersed through the main fuel air mix, gives the whole mix a much faster flame rate. Dr. Brant Peppley, Hydrogen Systems Group, Royal Military College, Kingston, has convinced me that insufficient hydrogen is produced to have much effect by just burning it. He feel's that the faster burn is most likely due to the presence of nascent (atomic) hydrogen and nascent oxygen, which initiate a chain reaction. I now completely agree. Electrolysis produces "nascent" hydrogen, and oxygen, which may or may not reach the engine as nascent. It is more probable that high temperature in the combustion chamber breaks down the oxygen and hydrogen molecules into free radicals (i.e. nascent). The chain reaction initiated by those free radicals will cause a simultaneous ignition of all the primary fuel. As it all ignites at once, no flame front can exist and without it there is no pressure wave to create knock.

The results of tests **at Corrections Canada's, Bowden Alberta Institution** and other independent tests reinforce the belief that combustion is significantly accelerated. They found with the HGS on, unburned hydrocarbons, CO and NO, in the exhaust were either eliminated or drastically reduced and at the same R. P.M. the engine produced more torque from less fuel.

Recently I took part in the highway test of a vehicle driven twice over the same 200-kilometre course, on cruise control, at the same speed, once with the system off and once with it on. A temperature sensor from an accurate pyrometer kit had been inserted directly into the exhaust manifold, to eliminate thermal distortion from the catalytic converter. On average, the exhaust manifold temperature was 65°F lower during the second trip when the Hydrogen Generating System was switched on. The fuel consumption with the unit off was 5.13253 km/li. and 7.2481 km/li. with it on, giving a mileage increase of 41.2% and a fuel savings attributable to the unit of 29.18%

From the forgoing, the near absence of carbon monoxide and unburnt hydrocarbons confirms a very complete and much faster burn. Cooler exhaust temperatures show that more work is taken out during the power stroke. More torque from less fuel at the same R.P.M. verifies that higher pressure from a faster burn, acting through a longer effective power stroke, produces more torque and thus more work from less fuel. The considerable reduction in nitrous oxides (NOx} was a surprise. I had assumed that the extreme temperatures from such a rapid intense burn would produce more NO.,. Time plus high temperature are both essential for nitrous oxides to form. As the extreme burn temperatures are of such short duration and temperature through the remainder of the power stroke and the entire exhaust stroke, will, on average, be much cooler. With this in mind, it is not so surprising that less NOx is produced when the HGS is operating.

Assume a fuel-air mix is so lean as to normally take the entire power stroke (180°) to complete combustion. Educated estimates suggest the presence of nascent hydrogen and oxygen decreases the burn time of the entire mix by a factor of ten (10). If a spark advance of 4° is assumed, the burn would be complete at about 14° past top dead centre. Such a burn will be both rapid and intense. The piston would have moved less than 2% of its stroke by the end of the burn, allowing over 98% of its travel to extract work. The lower exhaust manifold temperatures observed when the Hydrogen Generating System was in use can be viewed as evidence for this occurrence.

Power consumed by this model of the electrolysis cell is about 100 watts. If an alternator efficiency of 60% is assumed, then 0.2233 horsepower will produce enough wattage. Even on a compact car, a unit would use less than 1/4 % of its engine's output, or about what is used by the headlights. The energy regained from burning the hydrogen in the engine is so small that virtually all of the power to the electrolyser must be considered lost. That loss should not, however, exceed V4%, so that any increase in the engine's thermal efficiency more than 1/4 %, is a real gain.

An engineering classmate suggested a grass fire as a useful analogy to understand combustion within an engine. The flame front of a grass fire is distinct and its speed depends in part on the closeness of the individual blades. If grass is first sprayed with a small amount of gasoline to initiate combustion, then all blades will ignite almost in unison. In much the same way, small amounts of nascent oxygen and hydrogen present in the fuel-air mix will cause a chain reaction that ignites all the primary fuel molecules simultaneously. Faster more complete burns are the keys to improving efficiency in internal combustion engines. Power gained from increased thermal efficiency, less the power to the electrolysis unit, is the measure of real gain or loss. It follows from the foregoing paragraph that even a modest gain in thermal efficiency will be greater than the power used by an electrolysis unit. The net result should therefore be positive. Thus onboard electrolysis systems supplying hydrogen and oxygen to internal combustion engines, fuelled by diesel, gasoline or propane, should substantially increase efficiencies.

While the auto industry searches for the perfect means of eliminating harmful emissions, consideration should be given to what these systems can do now, since the HGS considers reduction of harmful emissions even as the engine ages. Almost all unburned hydrocarbons, CO and NO,, are eliminated. Reducing hydrocarbons and CO causes a slight rise in the percentage of CO2 in the exhaust, but as less fuel is used, the actual quantity of CO2 produced is reduced by roughly the same ratio as the savings in fuel. In brief, noxious gas is almost eliminated and greenhouse gas is decreased in proportion to the reduction in fuel consumption. Nothing I have learned so far has lessened my belief that the benefits of using electrolysis units to supply hydrogen to most types of internal combustion engines are both real and considerable.

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Roy E. McAlister, P.E.

President of American Hydrogen Association

INTRODUCTION

The carbon equivalent of 180 million barrels of oil are burned each day to support the Earth's growing population of 5 billion persons search for prosperity. Carbon dioxide built up in the atmosphere has reached levels that are about 30 per cent higher than at any time in the last 160 years. Environmental damage and health threats due to air pollution have reached every area of the planet. Continued dependence upon fossil fuels is detrimental to public health and is a dangerous experiment that may have no point of return for civilization, as we know it. Nine Americans die each hour due to air pollution.

U.S. Energy expenditures amount to about 440 billion dollars per year. About 50 percent of our energy is produced from foreign oil. U.S. military presence throughout the planet's oil-rich areas to secure the oil-supply lines costs hundreds of billions of dollars each year. These great expenses curb investment in capital goods and our economy suffers.

Finding a solution to the difficult problems of energy sufficiency, environmental damage, and air pollution is imperative. The solution must provide convenience for near-term market acceptance and utilize renewable resources.

HYDROGEN AS A COMBUSTION STIMULANT

Hydrogen burns more rapidly than hydrocarbon fuels because it is smaller and enters combustion reactions at higher velocity, has lower activation energy, and incurs more molecular collisions than heavier molecules. These characteristics make it possible to use mixtures of hydrogen with conventional hydrocarbon fuels such as gasoline, diesel and propane to reduce emissions of unburned hydrocarbons. Transition from fossil fuels to renewable hydrogen by use of mixtures of hydrogen in small quantities with conventional fuels offers significant reductions in exhaust emissions. Using hydrogen as a combustion stimulant makes it possible for other fuels to meet future requirements for lower exhaust emissions in California and an increasing number of additional States.

Mixing hydrogen with hydrocarbon fuels provides combustion stimulation by increasing the rate of molecular-cracking processes in which large hydrocarbons are broken into smaller fragments. Expediting production of smaller molecular fragments is beneficial in increasing the surface-to-volume ratio and consequent exposure to oxygen for completion of the combustion process. Relatively small amount of hydrogen can dramatically increase horsepower and reduce emissions of atmospheric pollutants.

Reprinted from an AHA Newsletter

More information is available at http://www.greencarcongress.com/2005/11/hydrogenenhance.html#comment-11093310