BY **JIM RICKOFF**

Hydrogen-fueled Engines

Hydrogen Fuel Cell vehicles are currently under production by virtually every major automaker around the world... Is hydrogen our fuel of the future?

Writing an article like this one takes some patience and thought about how deep to go into details specifically on the fuel and where to start with background information. Well, I guess a little background history never hurt anyone and it may clear up some confusion on what hydrogen is and where it comes from.

Hydrogen is the simplest element known to man and the most plentiful gas in the universe. The sun is basically a giant ball of hydrogen and helium gases. A process called fusion takes place in the sun's core and this fusion gives off radiant energy. It is this radiant energy that sustains life on earth. This radiant energy is stored as chemical energy in fossil fuels. So, most of the energy we use today came from the sun's radiant energy. Hydrogen can be produced from a variety of resources (water, fossil fuels, biomass, etc). Hydrogen is all around us, but to use it, we must first separate the hydrogen from the other things bonded to it.

Today, the United States produces about 95% of the hydrogen it uses from natural gas. And like all fuels, it takes energy to produce hydrogen and deliver it to a vehicle. Primarily, the hydrogen produced today is used to make fertilizer. Since hydrogen is lighter than air, it rises in the atmosphere. This is why hydrogen as a gas is not found by itself on earth. Again, it is found only in compound form with other elements. Water is Hydrogen and Oxygen. And like electricity, hydrogen is an energy carrier and must be produced from another substance.

The two most common ways to produce hydrogen are Steam Reforming and Electrolysis (water splitting). Steam reforming is currently the least expensive method of producing hydrogen and accounts for about 95% of the hydrogen produced in the United States. However, there is a certain amount of greenhouse gas emissions formed with steam reforming. Electrolysis is a process that splits hydrogen from water. It results in no emissions but is currently a very expensive process.

Now, we must understand that there are two distinctly different types of hydrogen power plants that vehicles can utilize. Fuel Cell (FCs) and Internal Combustion Engines (ICE) are the two different types of power plants that can utilize hydrogen. Fuel cell vehicles are electric cars where hydrogen is pumped into a tank in the vehicle. The hydrogen gas is then fed into the fuel cell where it is electrochemically converted into electricity. There is no combustion, no moving parts and no emissions other than water vapor. Electricity is then used to power an electric motor and ultimately the vehicle. This system is 2-3 times more efficient than gasoline or natural gas and is truly the emission free vehicle.

The ICE vehicle uses a normal combustion engine modified to use gaseous hydrogen instead of liquid gasoline. In fact, these engines are much like a natural gas powered vehicle modification. You will find hardened valve seats, satellite exhaust valves and positive valve stem seals. These

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vehicles are about 30% more fuel efficient than gasoline vehicles. And hydrogen contains no carbon; there are no CO2 emissions and only trace amounts of NOx (oxides of nitrogen). And for the high-performance engine builders consider this — hydrogen octane rating is 130.

Currently, there are several companies that are supplying IC engines converted to run on hydrogen to the aftermarket. One company in Algona, IA called the Hydrogen Energy Center Inc. (HEC) introduced the first production hydrogen-fueled, spark-ignited, internal combustion engine for industrial uses. And in March of 2008, HEC partnered with Lynco Tugger to display an HEC hydrogen powered airplane tug unit at the Aviation Industry Expo in Dallas, Texas. Don Vanderbrook, President and CEO of HEC said HEC is the only supplier to offer the aviation ground support industry a new 4.9L engine as a replacement for existing Ford 300's in service today. You can learn more about HEC at their website www.hydrogenenginecenter.com.

Where will this technology take us? I don't have a crystal ball but I do know that BMW has introduced the BMW Hydrogen 7. This vehicle is an ICE V-12 that runs on either gasoline or hydrogen. Mazda has introduced an RX-8 which utilizes a rotary dual-fuel engine. But Honda has introduced the FCX Clarity which is powered by a front mounted 80 kW AC electric motor. Electrical energy is provided by a 100 kW hydrogen fuel cell. Many of the other OE manufacturers are split on where they are investing their dollars between FCs and Hydrogen ICEs. The environmentalists scream for FCs while economics still spell ICEs.

Delivery problems of the fuel are a main concern for hydrogen fueled vehicles. The cost to build fueling stations might be a big factor on which technology leads the way to our cars. In order to distribute hydrogen, the current fueling system would need to be replaced, or at least significantly supplemented with hydrogen fuel stations. Since it takes more room to store hydrogen than gasoline, hydrogen is a less than ideal fuel when it comes to storing and transporting.

However, at Purdue University in Indiana, Professor Jerry Woodall has discovered a method for producing hydrogen by adding water to an alloy of aluminum and gallium. This hydrogen generating technology potentially solves the hydrogen storage and delivery problems and when paired with advanced fuel cells, represents a potential future method for making the FC powered vehicle superior and ultimately the vehicle of the future.

Currently, FCs are expensive to produce and fragile. Freezing

conditions are a major consideration because FCs produce water and utilize moist air with varying water content. Most FC designs are fragile and cannot survive in such environments upon startup but since heat is a byproduct of the FC process, the major concern is startup capability. More refinement of this system needs to be completed before you will see them in any great numbers.

One thing that sticks in my simple mind is the question of how the Middle East, whose whole economic survival relies on their ability to sell oil, will react when these alternate fuel vehicles become affordable. If we see the price of oil drop significantly, we will probably be faced with more dual fuel ICEs than FCs at least in the near future.

Noordin Nanji, Chief Customer Officer for the Ballard Company, a research, development and production company in the field of FC technology, states, "I can see a world where you have ICE hybrids, plug-in hybrids, FCs, FCs hybrids, FCs plug-in hybrids, flex-fuels and alternate fuels such as ethanol, being part of the picture. We'll have a variety of different solutions. However, ultimately, FCs are the only way you can achieve true zero-emission transportation."

While the advantages of hydrogen are that it is widely available and the only tail pipe emission is water vapor, what it entails to store and transport compressed hydrogen are obstacles to overcome before fuel cell cars become a "real world" option.

I surely wouldn't throw out my engine building equipment yet. ICEs are an integral part of the world's transportation and power generation plants that are seeing a new energy carrier called hydrogen fuel come into play. So be it, and remember pure economics can easily take over when the new fuel tries pushing out traditional fossil fuels at least in the near future.

As always, good profitable selling.

Jim Rickoff is the Associate Editor of *Engine Professional* magazine and AERA's marketing consultant. If you have any questions, comments or concerns, please call 507-457-8975 or e-mail: jrickoff@ridge-runner.com