HFI
Hydrogen Fuel Injection
Canadian Hydrogen Energy Company Ltd.

The Addition of Fractional Amounts of Hydrogen to Promote Reduced Emissions and Decreased Fuel Consumption in Diesel Engines

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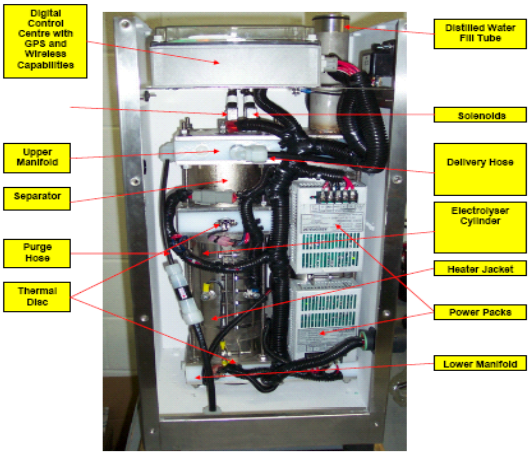
Canadian Hydrogen Energy Company Ltd.

The Hydrogen Fuel Injection System



OVERVIEW

Canadian Hydrogen Energy Company is the developer and marketer of high-performance, on-board hydrogen generator systems that have been sold in Canada for over eight years, with over 50 million miles of applied use in the long-haul trucking market. The technology has undergone continuous innovation and development since the first prototype was developed in 1983. Patented worldwide, the technology recently received Environmental Technology Verification (ETV) certification here in Canada – the highest such accreditation in our country and the US.

Small, easily installed and relatively inexpensive, these electrolysers were developed to meet two objectives – reduce fuel consumption and reduce emissions.

It could be argued that this is the only "hybrid" technology that is readily applied to any diesel or gasoline engine, as a retrofit, and the only emission-control technology that has the ability to sufficiently reduce fuel consumption to cover its acquisition and operating costs. This serves as a stark contrast to the price premium demanded of bio-fuels, hydrogen ICE or fuel cell technologies.

With commercialization of fuel cells not likely in heavy duty transport applications for 10-20 years, the addition of fractional amounts of hydrogen into existing gasoline or diesel engines represents the most commercially viable application of hydrogen in the marketplace today.

❑ HOW IT OPERATES

- The unit draws power from the vehicle's electrical system
- 13 amps is put into the power packs and converted to 2.5 V DC and over 50 amps
- Current is run from the anode through the electrolyte and water mix to the cathode, causing the hydrogen and oxygen molecules to disassociate and become gases.
- Hydrogen is produced from the anode and oxygen from the cathode
- The gases pass through the separator and are delivered to the air intake manifold
- Eventually, the water in the electrolyser is used up and must be replenished. This is done by pressure differential. When the unit is at operating pressure (22 psi), both the cell and the water chamber are equal
- A fill solenoid separates the cell side and the water side and is normally in the closed position. When the float in the cell calls for a fill, the fill solenoid will open, trapping the pressure in the water chamber, and the pressure in the electrolyser will be vented, thereby lowering its pressure. The higher pressure in the water chamber will force the water down through a check valve located in the UHMW lower manifold and up into the electrolyser.
- This continues until the cell float calls for a stop fill. The unit calls for a fill every 20 to 24 hours of operation and each fill cycle will take approximately 8 ounces of water out of the water cylinder.

- The unit has sufficient capacity to operate for a minimum of 150 hours.
- Designed to work on any internal combustion engine using hydrocarbon fuels
- Unit measures 12”w x 12”d x 24”h and weighs 90 lbs when filled
- Hydrogen burns 9 times faster than gasoline and 14 times faster than diesel
- The goal, in any internal combustion engine, is to convert chemical energy into kinetic energy. The high flame speed of the hydrogen causes the crank angle duration of combustion to be reduced by several degrees, resulting in an increase in torque, a 5 – 15 increase in horsepower and a more complete combustion of the fuel.
- Only maintenance required is the addition of distilled water (3.8 litres every 150 hours of operation which equals approximately 12,000 kms of driving.)
- Operates in any climatic condition – tested and proven in all weather conditions
- Gases are not produced until the engine is running
- Hydrogen is not stored under significant pressure, at any time, eliminating any safety concerns (plus there are three separate pressure valves or switches)
- The addition of fractional amounts of hydrogen will not void any engine warranty, (US manufacturers, especially, are banned under the Magnussen-Moss Warranty Act)

❑ VERIFICATION

The product has been subjected to numerous third party tests, including a variety of state/provincial emissions vehicle testing programs. In March 2004, a comprehensive 8-mode test was performed by California Environmental Engineering (a CARB certified and US EPA recognized testing laboratory in Santa Ana, California). The test utilized a Detroit 60 series engine, with only 20 hours since factory rebuild and used Ultra Low Sulphur (<15ppm) Diesel fuel and showed the immediate impact of HFI:

TEST	HC	CO	NOx	WCBSFC*	PARTICULATES
Baseline	0.0919	1.4120	7.2037	0.3807	0.0143
Pre-Turbo	0.0835	1.3346	6.8658	0.3636	0.0133
% Diff	-9.1	-5.5	-4.7	-4.5	-7.0

*Weighted Corrected Brake Specific Fuel Consumption

“A comparative database with and without the proprietary HFI system indicates reductions in ALL tailpipe emissions and an improvement in fuel economy”, CEE

In addition, over 50 million miles of applied use has been recorded, using the electronic control modules (on-board computers) of the transport trucks on which the HFI units have been installed.

Recent Ontario Drive Clean tests* showed decreases in opacity ranging from 38% to 92% immediately after the HFI system was installed on an ambulance in the City of Hamilton, Ontario

*Certificats 2331401425 and 233100427 – 2003 Ford E350 with Navistar 7.3DIT

Recent testing of a London taxi cab by the UK’s largest emissions testing facility, the Millbrook Emissions Testing Laboratory, showed reductions of approximately 50% of HC, PM and CO within the first 30 days of installation and a 14% reduction in NOx

HYDROGEN FUEL INJECTION TECHNOLOGY HAS NOW BEEN ETV (Environmental Technology Verification) CERTIFIED IN CANADA!

THE BENEFITS

Improved fuel economy

- Minimum 10% improvement is guaranteed
- Typical savings are much greater, and, depending on the age of the engine, with many engines showing 15 -20% improvement, or more

Increased horsepower and torque

- 50% of the hydrogen burns before the diesel combusts and the balance burns simultaneously with the diesel. Acting as an initiator, the heat given off from the combustion of the hydrogen ensures that a far greater percentage of the diesel combusts all at once, increasing the efficiency of the burn and the percentage of chemical energy converted to kinetic energy (rather than heat, light or sound)
- Typically, torque and horsepower increase by 3% (5-15 HP)

Decreased maintenance expenses

- The more complete burn means less soot and ash, meaning longer oil change intervals, lower incidence of sticking valves, clogged injectors or other internal engine wear

Reduced emissions

- Higher initial heat, and better distribution of that heat as a result of the homogenous mixture of hydrogen in the fuel/air mix means significant NOx reduction
- More complete combustion means fewer unburned gases, particularly CO, PM and all Hydrocarbons
- The reduction in SO2 and CO2 will be equivalent to % reduction in fuel used

THE MARKET

- Original market was long haul trucking – 800,000 trucks in Canada, 8 million in the U.S. and literally millions more around the world. This market was chosen, primarily, due to the consistently heavy fuel use by almost all participants.
- Due to increasing fuel prices and the demands by state/provincial and federal governments to reduce emissions from a wide variety of sources, the product is now viable on a much wider range of vehicles. Electrolysers are now in place on municipal buses and ambulances, as well as delivery vehicles and diesel generators and they are viable on any engine that consumes more than $1000 worth of fuel per month.
- The emissions reduction makes the product particularly well suited for the mining industry – both above and below ground
- The technology has an incredibly short payback period. For most transport trucks, it takes from nine to fifteen months to pay for the system.
- Recent studies have shown that ships and locomotives pose even greater health threats than cars or trucks, making an even stronger case for government emission reduction strategies for those sources. Larger electrolysers are currently under development for use in these markets.
- The technology is also being adapted for use with natural gas boilers in commercial and residential applications.

❑ THERMODYNAMIC EFFICIENCY OF THE HFI UNIT

Constants

- Power of Disassociation of Hydrogen: 39.2 kW-hr/kg
- Specific Volume of Hydrogen (standard conditions): 11967.4 L/kg
- Current Draw (HFI): 13 amps
- Current Draw (cell): 48 amps
- Charge (HFI): 12 volts
- Charge (cell): 2.3 volts
- Gas production (HFI/cell): 620 mL/min@22psig, 20C

- Step 1
- 600 mL of hydrogen/oxygen produced is composed of 400 mL of hydrogen and 200 mL of oxygen. 400 Ml of hydrogen at 22 psig is equivalent to 400mL *22/14.7 (standard pressure in psig). Therefore, hydrogen production is 598.64 ml/min, or 35.91 L/hr. Using the constant for the specific volume of hydrogen above, hydrogen production, in kg/hr, is 0.0030 kg.

- Step 2
- Power is equal to Current times Charge. The HFI draws 13 amps at 12 volts, so the Power is 156 watts for the device. The cell (electrolyser) draws 48 amps at 2.3 volts, or 110 watts.
- The power used in the device as a measure of Power per weight of hydrogen produced is therefore 0.156/0.0030 for the HFI and 0.110/0.0030 for the cell. This translates to 52.0 kW-hr/kg for the HFI and 36.6 kW-hr/kg for the cell

- Step 3
- The efficiency is calculated as Power of Disassociation divided by the Power consumed by the device for the equivalent mass of hydrogen. Therefore, the HFI efficiency is 68.5% for the complete device and the efficiency of the core electrolyser is 97.2%

❑ ABOUT CANADIAN HYDROGEN ENERGY COMPANY

With an R&D facility and its main manufacturing centre in Bowmanville, Ontario, CHEC is a world leader in the development of on-board hydrogen electrolysers. The company and its predecessors have been active in the field since 1983 and the current family of HFI units was first introduced into the long-haul trucking market over 8 years ago. The HFI units are currently operating on over 100 fleets, in Canada and the U.S., and the markets have expanded to include cars, light-duty trucks, SUV's, motorhomes, boats, ambulances and municipal buses. In the near future, the company expects to have units installed on steamships and locomotives – two of the heaviest emission sources globally. The company has a network of certified installation centres across Canada and the United States. In 2005, marketing has commenced in Europe, Australia/NZ, the Caribbean, and Central America.

For more information, please visit our website at www.chechfi.com or contact Steve Gilchrist at sgilchrist@chechfi.com.

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