Hydrogen-Powered Vehicles at Least a Decade Away

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Washington Post
http://www.washingtonpost.com/wp-dyn/articles A635122003Jan29.html
Thursday, January 30, 2003; Page A09

President Bush's vision of a hydrogen-powered, non-polluting "Freedom" car for the next generation of American motorists pulled out silently from a Newport Beach, Calif., garage with Gregg Kelly at the wheel, bound for his office 10 miles away.

Kelly, president of a California robotics company, happens to drive a Toyota prototype of a hydrogen-fueled car, one of a handful in the United States today.

It will take at least a decade before a host of technological, economic and political barriers are overcome, permitting a fleet of these revolutionary vehicles to appear on U.S. highways, industry experts said. But by including the goal of hydrogen fuels in his State of the Union message Tuesday, Bush has opened the door to a fledgling movement that has already attracted a surprising coalition of supporters.

Environmentalists, automakers, oil companies and coal producers, engineering labs and strategists have seized on hydrogen as an almost too-good-to-be-true power source. It is abundant in water and air, it burns cleanly and it could free the nation from its dependence on Middle Eastern oil.

"For President Bush to frame the goal as he did is significant," said Jeremy Rifkin, consultant and author of a book advocating a transition from oil and gas to hydrogen. "How much is made of this, time will tell."

The president said he hoped that Americans born today would learn to drive in hydrogen-powered cars, a schedule that auto experts said could technically be met. But whether these vehicles will be commercially available depends on a huge array of variables.

First, the technology is still incomplete and unaffordably expensive. The specially equipped Toyota Highlander that Kelly drives has no price tag. The Japanese manufacturer, after investing millions of dollars in research, lent the vehicle to a University of California research project that Kelly's company supports. "My checkbook isn't fat enough," Kelly said.

The car is powered by electricity generated in a fuel cell by chemically combining hydrogen and oxygen. The engine spits out water drops instead of the carbon dioxide and other pollutants generated by burning gasoline.

With foreign manufacturers committed to press ahead, Detroit's carmakers have had to accelerate their research programs. In June, Ford Motor Co. will unveil a prototype car that uses hydrogen to power an internal combustion engine – part of a "bridging strategy" to help ease hydrogen into the marketplace until fuel cells are fully developed.

General Motors Corp. has developed a fuel cell-powered, car-sized "skateboard" – four wheels attached to a platform less than a foot thick, to which any kind of car body could be buckled.

Rather than use fuel cells, BMW has refitted 10 of its $70,000 Model 745 sedans with hybrid engines that burn either gasoline or liquid hydrogen directly. It could be mass producing them by the end of the decade at a "reasonable" cost for its customers if there were enough hydrogen fueling stations to power them, said spokesman Gordon Keil. "We're trying to get [fuel suppliers] interested in hydrogen. We've not met with a lot of enthusiasm."

As daunting as the engineering challenge is the need for a national hydrogen fuel infrastructure – factories to produce the fuel, pipelines and trucks to distribute it and stations to store and sell it. Environmentalists dream of a totally "green" strategy in which solar or wind power is used to separate hydrogen from water – an approach whose costs now would be prohibitive. A nearer prospect is producing hydrogen from natural gas or coal, however in either case, the carbon dioxide byproduct would have to be injected underground to avoid a huge increase in greenhouse-gas emissions, experts say.

Rifkin argues that an eventual scarcity of oil and gas, decades ahead, will push prices of these fuels up to a point where hydrogen becomes cost-competitive. "It isn't a problem that will yield to technology alone," agreed David M. Nemtzow, president of the Alliance to Save Energy.

While all the major automakers are developing fuel-cell technology, most are cautious about hyping it. "We don't want to get too exuberant about it in that sense, overselling it," said Greg Dana, vice president for environmental affairs at the Alliance of Automobile Manufacturers.

Fresh in some minds is the experience of the Clinton administration, which launched a high-profile, $1.5 billion research venture with the

Detroit automakers a decade ago to produce an 80 miles-per-gallon family car. No cars emerged, and the Bush administration halted the venture in favor of its hydrogen strategy.

Some of the president's political opponents contend the hydrogen option is a way of deflecting criticism over administration policies favoring energy production over conservation. "The president seems content with the auto industry's approach: 'Don't make us do anything today'," said the Sierra Club's Daniel Becker. Others say it does not go nearly far enough. Sen. Byron L. Dorgan (D-N.D), chairman of the Democratic Policy Committee, said recently, "It's moving in the right direction. But his proposal is rather timid. I think we need a bolder plan."

Bush's spending plan for the hydrogen project, $1.5 billion over five years, represents a $500 million increase over his current budget. The administration proposes to earmark $273 million for the 2004 fiscal year, but did not offer many specifics yesterday. The funding would support research on fuel cells, vehicle technology and distribution issues.

The magnitude of the goal demands an effort on the scale of the Apollo Moon project, Dorgan said yesterday. "You have to set benchmarks for five, 10 years out."

UNUSUAL PERMANENT MAGNET MOTORS

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Abstract

Permanent magnet motors that try to achieve unusual overunity efficiencies with changes in wiring geometry, electronic switching schemes and magnetic configurations often are not successful. There are some designs that should be regarded as conventional and others as promising. Hopefully this article will help the reader to tell the difference before investing or accepting investment. Note: patents can be viewed for free at www.uspto.gov and also http://gb.espacenet.com/espacenet.

Introduction

An article about permanent magnet (PM) motors would not be complete without first reviewing the basic configurations that are present on the market today. Commercial PM motors are necessarily DC motors since their magnets are permanently polarized before assembly. Many PM motors which use brushes are switching to brushless motors that promise less friction and wear. Brushless motors include electronic commutation or step motors. A step motor, often used in the automotive industry, offers more continuous duty torque per unit of volume than any other electric motor but it is often a lower speed motor. The electronic commutation design is applicable to the switched reluctance (SR) motor. The SR motor substitutes soft iron in the place of higher cost permanent magnets for the outer stator and instead has an inner PM rotor.

Brushless motors in general produce torque from current in the armature by the application of Faraday's Law. The ideal PM motor has a linear torque vs. speed curve. There are both outer rotor and inner rotor designs that are standard in PM motors.

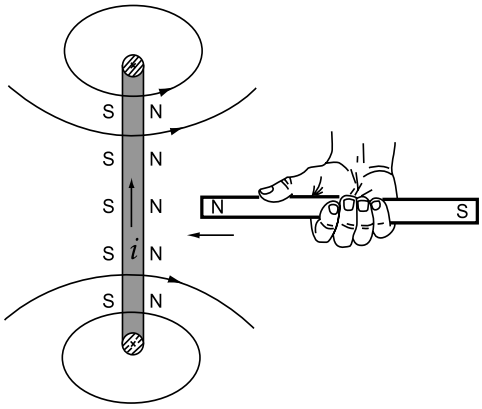

Fig.1

Lenz's Law
Induced B-field opposes motion.

To point out the focus of many of the problems with analyzing motors, the *Motion Control Handbook* (Designfax, May, 1989, p. 33) says that there is a "very important relationship between torque and back emf that is sometimes not understood." This relates to the electromotive force (emf) that is produced by the application of a changing magnetic field (dB/dt). In engineering terms, the "torque constant" (N-m/amp) equals the "back emf constant" (V/radian/sec). In physics, the motor terminal voltage