

Health | Science

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... 'lean burn' for cleaner engines ...

By David L. Chandler

GLOBE STAFF

ARLINGTON — You've got to give Arlington-based inventor Michael Ward credit for one thing: He certainly is not a quitter.

For two decades, while others chased flashier technologies, such as cars that ran on solar power or electric batteries, Ward stuck to the research equivalent of plain vanilla: He wanted to make existing car engines cleaner and more fuel-efficient.

Now, after years of doggedness and disappointment, Ward at last may have found a practical,

affordable technology that could give nearly every vehicle on the road a 10 percent jump in fuel economy while reducing the toxic chemicals coming out of the tailpipe.

Ward, with a doctorate in applied physics from Harvard and more than 20 patents to his name, said that, in a series of lab tests over the last few months, his "lean-burn" engine has finally achieved results that were far beyond what even he thought would be possible.

Ward's engine in the shop of his small company, called Combustion Electromagnetics Inc.,

has already produced what he says is the best overall fuel economy ever achieved in a gasoline engine. With gas prices soaring and the mileage of new vehicles declining, dominated by the large and inefficient sports utility vehicles, Ward's success may have come at an opportune time.

"His results have been quite dramatic," said Anthony Jarrett, the retired former director of research and development at Lucas Industries, a British automotive technology firm that ran a series of tests on an earlier version of Ward's system.

ENGINE, Page F4

► ENGINES

Continued from Page F1

"The lean-burn engine that he has developed, in conjunction with his spark ignition system, together are quite unique and I think very impressive," Jarrett said in an interview.

The concept of lean-burn is deceptively simple. Basically, it means increasing the amount of air mixed with the fuel as it enters the car's cylinders. This ensures that the fuel burns more completely, improving efficiency and reducing the amount of unburned fuel that leaves the engine and must be controlled. But the problem has always been that the more diluted the fuel becomes, the harder it is to light.

To be sure, Ward has believed he was near a breakthrough before, only to find that daunting obstacles still remained, such as the size and cost of the technology. But, this time, Ward said the system has now been refined so that it is smaller, lighter and should cost no more than conventional

equipment.

But John Heywood, director of the Sloan Automotive Laboratory at the Massachusetts Institute of Technology, cautioned that it is often hard to tell whether a technology that looks promising in the lab will prove practical in the highly-competitive and hard-nosed automotive industry.

"People have tried conceptual changes to get lean-burn to work for a long time," he said. "Inventions in this area are hard to evaluate."

At various stages over the last few years, Ward's system, which he calls Eco-Fire, has been tested by engineers at major companies, including General Motors, Chrysler, and others. Gradually, he has improved its performance and solved problems — such as short spark-plug life and interference with car radios — that showed up in the earlier tests.

His ignition system alone, he said, can improve fuel efficiency by 5 to 10 percent, while decreasing emissions of hard-to-control

nitrogen oxides enough to meet pollution standards planned for the year 2004. It also cuts hydrocarbons and carbon monoxide at the same time. And it does so with a system so simple, he said, that it should add no more than \$10 to \$20 to the cost of a car, truck or SUV. And, with slight changes to the cylinder head that he has made in his test engine, the improvement in efficiency could rise to 10 to 20 percent.



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Michael Ward of Arlington holds a mockup of the top of his "lean-burn" combustion chamber.

'lean burn' for cars

Until now, most developments to improve either fuel efficiency or emissions — especially nitrogen oxides — would come at the expense of the other. For example, the other major effort to achieve lean-burning engines is a "stratified-charge" system developed by Japanese automakers. But, while it does improve mileage, it actually increases emissions from the engine, thus requiring more treatment.

Ward said that the proof of how his system works is in the test engine now running in his lab. Not only does it produce the benefits he anticipated based on earlier experimental work, but the results are even better than he had predicted.

The key to it all is a system that makes it possible for an engine — even a simple, basic two-valve pushrod engine, like those used in most SUVs — to run with twice the normal amount of air in the fuel-air mixture. Typical engines run at a ratio of 14.7 parts air for each part of fuel, but Ward's runs comfortably at ratios of up to 30 to 1. He said he expects that, in normal use, a car with his system would run up to 26 to 1.

That means less fuel is being burned at a time, increasing the gas mileage. It also causes the mixture to burn more evenly and at lower temperature, cutting the formation of nitrogen oxides in half. And because of the better mileage, carbon-dioxide emissions — considered the leading cause of global warming — also would be reduced.

Ward said that his ignition system — including a modified spark plug, coil and control circuit — can easily be retrofitted at low cost onto existing engines. For the maximum benefit in efficiency and pollution control, however, it requires a slight modification of the design of the cylinder head, in order to increase the flow of fuel and air past the spark.

Normally, a stronger flow past the spark plugs would be a bad thing. Like a match in a strong wind, the spark in an ordinary ignition system can be blown out by the force of the fuel-and-air mixture flowing past it. That's why spark plugs are usually recessed, keeping them sheltered from that flow. But Ward found, in a series of tests carried out painstakingly through the years, that placing his higher-powered spark right in the flow actually helps the flame to propagate uniformly through the cylinder.

Ward calls this "flow coupling," and he said it is the key to why his system works so well. "Flow-coupling is the missing link in combustion," he said.

One drawback, when he first introduced a version of his ignition system in the mid-1990s, was that it required an extra component. In order to produce the stronger spark needed to ignite the diluted fuel mixture, he had to boost the standard 12 volts from the car battery up to 42 volts. Although he developed a simple, patented converter to do this, it was an extra complication that added a bit to the cost of the system.

Not any more. Last year, the major automakers announced that over the next few years, they plan to convert their cars to dual-voltage systems, including both the now-standard 12 volts and the same 42-volt system Ward's ignition requires. The change is being made to accommodate the increasing use of power-intensive systems under the hood.

But the change means that the new ignition would add nothing to the cost of new cars. While it involves some new electronics, it also includes coils that are smaller and cheaper than today's versions, thereby offsetting the added cost, Ward said.

An earlier version of the system, which did not yet make full use of flow coupling, was tested in a lab at Chrysler Motors (now Daimler Chrysler). Chrysler's head of advanced ignition system development, Anson Lee, said in an interview last week that the ignition system is "very clever, a very good design." Although he said better fuel economy is "a big driving force for everything we do," he said that "I'm not sure how much his system will contribute" toward fuel economy. But, Ward noted, Lee has not seen the latest test results.

At the time of the earlier tests, Lee had said he thought that with further testing and development, Ward's system might "prove to be an enabling technology for the lean-burn engines of the future." Most of that additional testing and refinement has now been achieved, Ward said, and the system is now ready for development of a final production version. He is hoping to form a strategic partnership with one of the major manufacturers of ignition systems.

Fred Kern, an engineer with a doctorate from MIT's engine lab who worked with Ward years ago, is enthusiastic about the new system's potential. Kern said that Ward's system is "radically an improvement over what they've been doing all these years."