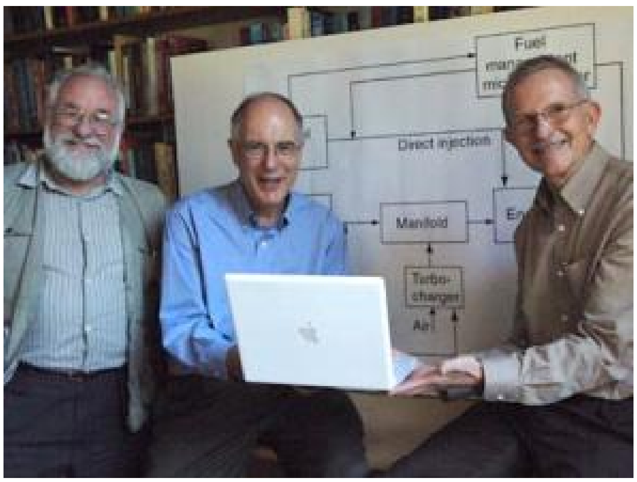
Pint-sized car engine promises high efficiency

October 25 2006



MIT researchers have developed a half-sized engine that performs like a full-sized engine but offers the fuel efficiency of a hybrid electric car. The team includes, from left to right, Leslie Bromberg, principal research engineer at the Plasma Science and Fusion Center (PSFC), Daniel Cohn, division head and senior research scientist at the PSFC, and John Heywood, director of the Sloan Automotive Lab and professor of mechanical engineering. Photo / Donna Coveney

MIT researchers are developing a half-sized gasoline engine that performs like its full-sized cousin but offers fuel efficiency approaching that of today's hybrid engine system--at a far lower cost. The key? Carefully controlled injection of ethanol, an increasingly common biofuel, directly into the engine's cylinders when there's a hill to be climbed or a car to be passed.

These small engines could be on the market within five years, and consumers should find them appealing: By spending about an extra $1,000 and adding a couple of gallons of ethanol every few months, they will have an engine that can go as much as 30 percent farther on a gallon of fuel than an ordinary engine. Moreover, the little engine provides high performance without the use of high-octane gasoline.

Given the short fuel-savings payback time--three to four years at present U.S. gasoline prices--the researchers believe that their "ethanol-boosted" turbo engine has real potential for widespread adoption. The impact on U.S. oil consumption could be substantial. For example, if all of today's cars had the new engine, current U.S. gasoline consumption of 140 billion gallons per year would drop by more than 30 billion gallons.

"There's a tremendous need to find low-cost, practical ways to make engines more efficient and clean and to find cost-effective ways to use more biofuels in place of oil," said Daniel R. Cohn, senior research scientist in the Laboratory for Energy and the Environment and the Plasma Science and Fusion Center (PSFC).

Cohn, John B. Heywood, the Sun Jae Professor of Mechanical Engineering and director of the Sloan Automotive Laboratory, and Leslie Bromberg, a principal researcher at the PSFC, have an engine concept that promises to achieve those goals.

For decades, efforts to improve the efficiency of the conventional spark-ignition (SI) gasoline engine have been stymied by a barrier known as the "knock limit": Changes that would have made the engine far more efficient would have caused knock--spontaneous combustion that makes a metallic clanging noise and can damage the engine. Now, using sophisticated computer simulations, the MIT team has found a way to use ethanol to suppress spontaneous combustion and essentially remove the knock limit.

When the engine is working hard and knock is likely, a small amount of ethanol is directly injected into the hot combustion chamber, where it quickly vaporizes, cooling the fuel and air and making spontaneous combustion much less likely. According to a simulation developed by Bromberg, with ethanol injection the engine won't knock even when the pressure inside the cylinder is three times higher than that in a conventional SI engine. Engine tests by collaborators at Ford Motor Company produced results consistent with the model's predictions.

With knock essentially eliminated, the researchers could incorporate into their engine two operating techniques that help make today's diesel engines so efficient, but without causing the high emissions levels of diesels. First, the engine is highly turbocharged. In other words, the incoming air is compressed so that more air and fuel can fit inside the cylinder. The result: An engine of a given size can produce more power.

Second, the engine can be designed with a higher compression ratio (the ratio of the volume of the combustion chamber after compression to the volume before). The burning gases expand more in each cycle, getting more energy out of a given amount of fuel.

The combined changes could increase the power of a given-sized engine by more than a factor of two. But rather than seeking higher vehicle performance--the trend in recent decades--the researchers shrank their engine to half the size. Using well-established computer models, they determined that their small, turbocharged, high-compression-ratio engine will provide the same peak power as the full-scale SI version but will be 20 to 30 percent more fuel efficient.

But designing an efficient engine isn't enough. "To actually affect oil consumption, we need to have people want to buy our engine," said Cohn, "so our work also emphasizes keeping down the added cost and minimizing any inconvenience to the driver."

The ethanol-boosted engine could provide efficiency gains comparable to those of today's hybrid engine system for less extra investment--about $1,000 as opposed to $3,000 to $5,000. The engine should use less than five gallons of ethanol for every 100 gallons of gasoline, so drivers would need to fill their ethanol tank only every one to three months. And the ethanol could be E85, the ethanol/gasoline mixture now being pushed by federal legislation.

Through their startup company, Ethanol Boosting Systems LLC, the researchers are working with their Ford collaborators on testing and developing this new concept. If all goes as expected, within five years vehicles with the new engine could be on the road, using an alternative fuel to replace a bit of gasoline and make more efficient use of the rest.

Source: MIT