ME410 Day 39

Future of the IC Engine

- Improvements in the current paradigm
- Competing technology - fuel cell
- Comparing technologies

Improvements in the Current Paradigm

We will read an excerpt for a lecture by Prof. John Heywood, author of our text.

List of Possible / Probable Improvements

1. Direct Injection
2. Variable Valve Timing

3. IC related Hybrids

See “http://www.ott.doe.gov/hev/hev.html”

Types:

- Series. Small engine drives alternator generating electricity. Electricity stored in battery or sent to electric motor driving the wheels. Engine operates in narrow and efficient range of speeds.
- Parallel. Engine and or electric motor can drive wheels. In one approach engine is used for long steady highway driving and electric for short trips.

Note: Regenerative braking is common. Energy flows from the wheels to charge the battery.

Energy Storage in

- Batteries
- Ultracapacitors
- Flywheels

Currently on the Market.

1. Toyota Prius
2. Honda Insight
3. Honda Civic: about 50 mpg. 80% less emissions.

4. Hydrogen Fueled IC Engines.

- BMW - runs on both hydrogen and gasoline. 12 cyl 750iL sedan. Hydrogen is liquified and stored in special tank. (Trunk space reduced now only can carry two golf bags.) Engine is same, tuned to compromise between fuels. Only 204 hp.

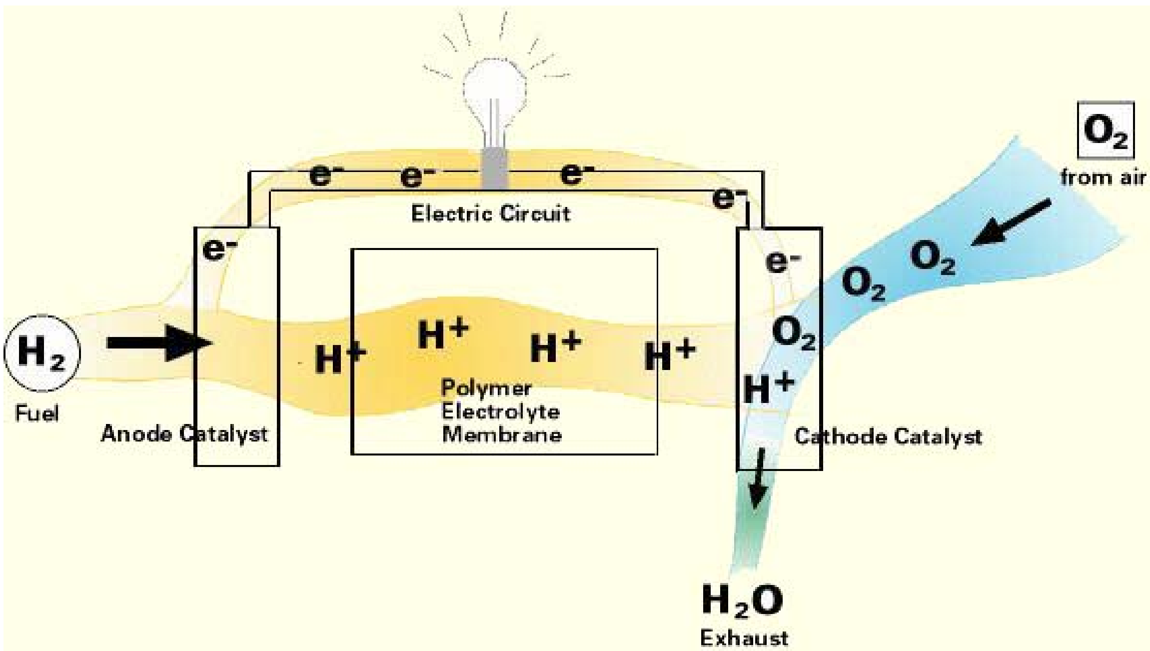
5. Others

- "Green diesel." Volkswagen Lupo. Sold in Europe. Nearly 90 mpg. Direct injection technology.

Competing Technologies

1. Fuel Cells

What is a Fuel Cell?



Source:

- Driven by the electrochemical potential associated with formation of water from H_2 and O_2.
- Runs on Hydrogen plus Oxygen from Air.
- Since Hydrogen has very limited availability need to “reform” fuel to get hydrogen. A chemical process which lowers efficiency and increases emissions.
- Quick starting may be a problem.

Fuel Cell Vehicles.

Development proceeding at the Big Three.

Comparisons

- Well to wheels efficiency
- Well to wheels emissions - esp Greenhouse Gas

1. Source - http://edj.net/sinor/sfr7-01a6.html

“A joint effort by General Motors Corporation, BP, ExxonMobil, Shell Oil and Argonne National Laboratory has resulted in a comprehensive report Well-To-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems, published in April.”

According to the sponsors, this study differs from prior well-to-wheel analyses in a number of important ways including:

The study considers fuels and vehicles that might, albeit with technology breakthroughs, be commercialized in large volumes and at reasonable prices.

The well-to-wheel analysis involved participation by the three largest privately owned fuel providers: BP, ExxonMobil and Shell.

The 15 vehicles considered in the study include conventional and hybrid-electric vehicles with both spark-ignition and compression-ignition engines, as well as hybridized and non-hybridized fuel-cell vehicles with and without onboard fuel processors. All 15 vehicles were configured to meet the same performance requirements.

The 13 fuels considered in detail (selected from 75 different fuel pathways) include low-sulfur gasoline, low-sulfur diesel, crude oil-based naphtha, Fischer-Tropsch (FT) naphtha, liquid/compressed gaseous hydrogen based on five different pathways, compressed natural gas, methanol, and neat and blended (E85) ethanol.

The following vehicle architectures and fuels were included in the study:

- Conventional (CONV) vehicle with Spark-Ignition (SI) gasoline engine (baseline)
- CONV vehicle with Compression-Ignition Direct Injection (CIDI) diesel engine
- CONV vehicle with SI E85 (85 percent ethanol and 15 percent gasoline) engine
- CONV vehicle with SI Compressed Natural Gas (CNG) engine
- Charge-Sustaining (CS) parallel Hybrid Electric Vehicle (HEV) with gasoline engine
- CS parallel HEV with CIDI diesel engine
- CS parallel HEV with SI E85 engine
- Gasoline Fuel Processor (FP) Fuel Cell Vehicle (FCV)
- Gasoline FP Fuel Cell (FC) HEV
- Methanol FP FCV
- Methanol FP FC HEV
- Ethanol FP FCV
- Ethanol FP FC HEV
- Gaseous Hydrogen (GH2)/Liquid Hydrogen (LH2) FCV
- GH2/LH2 FC HEV

TABLE 1

OVERVIEW OF VEHICLE FUEL ECONOMY
(Miles per Gallon Gasoline Equivalent)

No.	Vehicle Configuration	Fuel Economy
1	Gasoline CONV SI (baseline)	20.2
2	Diesel CONV CIDI	23.8
3	E85 CONV SI	20.2
4	CNG CONV SI	19.8
5	Gasoline SI HEV	24.4
6	Diesel CIDI HEV	29.4
7	E85 SI HEV	24.4
8	Gasoline FP FCV	27.2
9	Gasoline FP FC HEV	30.2
10	Methanol FP FCV	30.3
11	Methanol FP FC HEV	34.5
12	Ethanol FP FCV	28.6
13	Ethanol FP FC HEV	31.8
14	GH_2 FCV/LH_2 FCV	43.2
15	GH_2 FC HEV/LH_2 FC HEV	48.1

General observations based on Table 1 include:

FC systems use less energy than conventional powertrains because of the intrinsically higher efficiency of the FC stack.

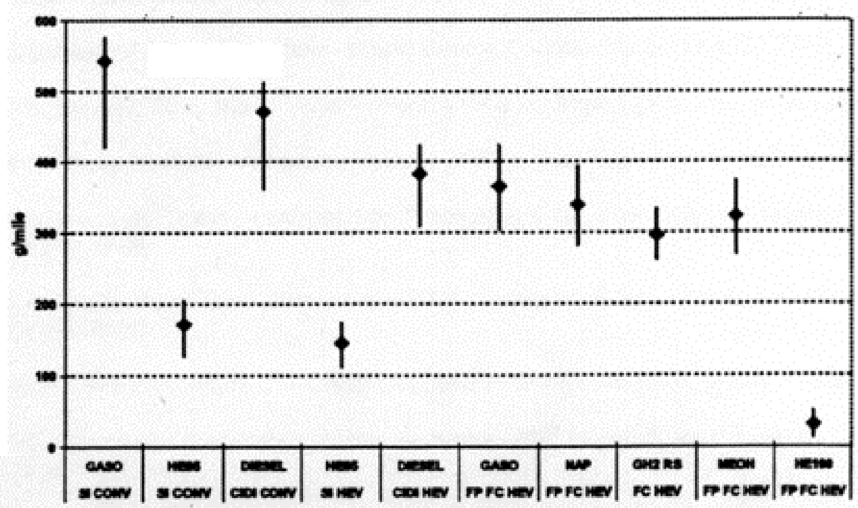
Hybrid systems show consistently higher fuel economy than conventional vehicles because of regenerative braking and engine-off during idle and coast periods.

In the case of the FC and FP systems, the gains resulting from hybridization are lower because the "engine-off" mode is present in bothsystems.

Hydrogen-based FC vehicles exhibit significantly higher fuel economy than those that employ an FP.

FIGURE 1

WELL-TO-WHEEL GHG EMISSIONS "SELECTED" FUEL/HVEHICLE PATHWAYS



Key GHG findings are summarized in Figure 1 and include the following:

- The ethanol-fueled vehicles, as expected, yield the lowest GHG emissions per mile.
- The next lowest are the two H2 HC HEVs (GH2 refueling station).
- The H2 FC HEVs are followed by the methanol, naphtha, and gasoline FP HEVs and the diesel CIDI HEV, in that order.
- The diesel CIDI HEV offers a significant reduction in GHG emissions (27 percent) relative to the gasoline conventional SI vehicle.