Discussion Forum: Electric Vehicles vs Hybrid Vehicles, 20 June 2008

Hybrid Electrical Vehicles

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Overview

- History
- Vehicle Powertrains
- HEV Configurations
- Degree of Hybridization
- Plug-in HEVs
- Electrical Motor Drives
- HEV Example at SU
- Conclusions
Historic Review

- First EV (1881)
- First 4WD EV (1898)
- HEV won hill climbing race (1902)
- First mass produced HEV (1997)
Vehicle Powertrains

- Conventional Vehicle
- Hybrid Electric Vehicle
- Battery Electric Vehicle
- Plug-In Hybrid Electric Vehicle
HEV Configurations

Series Hybrid

- ICE-assisted EV
- Simple drivetrain (no clutches)
- Flexible location of ICE
- 3 Propulsion devices
- Heavy-duty electrical machine
- Large battery pack
HEV Configurations

Parallel Hybrid

- ICE or Motor or both in Parallel
- Electrical-assisted ICE vehicle
- 2 Propulsion devices
- Sizing of devices depends
- Simple power converter
- Generally two clutches
- Small-medium battery pack
HEV Configurations

Series-Parallel Hybrid

- More complex and costly
- 3 Propulsion devices
- Three propulsion power
- Two clutches
- Smaller battery pack

NB: Power Flow Control
Degree of Hybridization

- **“micro”** HEVs: stop/start and variable charging capacity;

- **“mild”** HEVs: regenerative braking, engine start/stop, electric assisted driving;

- **“full”** HEVs: full electric launch/drive capability, a higher percentage of system power from the electric motor part of the propulsion system;

- **“series”** or **“range extender”** HEVs: a full-sized electric motor drive in addition to including regenerative braking and significant “All Electrical Range” (AER).
A Full Hybrid: 57 kW ICE, 50 kW electric motor, 1.5 kWh battery (2004)
Plug-In HEV (PHEV)  Converted Prius

Advantages:
- Advanced Engine
- Engine Downsizing
- Engine Idle-Off
- Electric Accessories
- Regenerative Braking
- Battery Recharge
- Fuel Flexibility

57 kW gasoline engine, 50 kW electric motor, 9.0 kWh battery (48km)
Plug-In HEV

- Matching motorist’s driving habit
- Reduction of petrol usage and thus related emission

Fuel Consumption Comparison

- CV
- HEV
- PHEV20
- PHEV40
Challenge for PHEV

Cost vs fuel saving

Gasoline Savings (%) vs Incremental Cost (%)

- HEVs
- PHEVs
- Prius (Corolla)
- Civic
- Escape
- Highlander
- Accord
- Vue

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Motor Design Requirements:
- Light weight / High power density
- High efficiency

Power Converter Design Considerations:
- Temperature sensitivity of bus capacitors;
- Environmental impact;
- Drive efficiency;
- EMC issues;
- Last but not the least COST.
HEV Example at SU

Parallel HEV

Parallel HEV developed by EMLab (1998)
HEV Example at SU

- **Power Electronic Converter and Batteries**
  60 kW Inverter with 22 x 12 V batteries (280V DC voltage bus, 420 kg, 90 km range)

- **Parallel HEV Configuration**
  30 kW peak, Reluctance Synchronous Machine and ICE
HEV Example at SU

Performance
Conclusions

- HEV is a near-term technology for improving fuel economy and emission.

- The mainstream powertrain topologies are power-split and parallel.

- There are different degrees of hybridization.

- PHEV is potentially a better system than normal HEV, but there are also challenges.

- Fuel prices vs battery cost will determine HEV configuration and user term.
Thank You

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