Introduction

Presenter: William Guess
IPRO 326 ORGANIZATION

- ADVISOR Simulations
- Jeep Liberty Technical Report
- Future Truck Competition
- Garage/Mechanical Works
- Hybrid Drivetrain Design
- Ultra-Capacitor Research & Design
MAIN GOALS

• Determine the optimal power distribution between the internal combustion and electric motors
• Develop a hybrid drive train based on the Jeep Liberty
• Lay simulation and design groundwork for the Challenge X competition sponsored by General Motors
Organizing Garage/Mechanical Works Team

Betsy Raju
Bill Guess
Dave Bartik
Grace Nijm
Matt Ayersman
Raul Gonzalez
Ryan Long
Goals

• Organize the IIT automotive garage
• Become familiar with the mechanical aspects of a hybrid vehicle
• Act as a resource for other team members
• Acquire an IPRO 326 project vehicle
Accomplishments

- Successfully reserved and organized a portion of the garage for IPRO 326
- Gained access to a Honda Insight and investigated certain aspects of its mechanical design
- Shared our knowledge and resources with other team members
- Acquired a 1990 GMC Safari van to serve as the official IPRO 326 project vehicle
Introduction to Hybrid Electric Vehicles

Presenter: Pavel Reytikh
What is a HEV?

- Hybrid electric vehicles (HEVs) combine the internal combustion engine with the electric motor.
- This results in an increased fuel economy when compared to conventional vehicles.
- Also offers the extended range and rapid refuelling that consumers expect from a normal vehicle, with most of the energy and environmental benefits of an electric vehicle.
- Can be used in a wide range of applications, from personal transportation to commercial hauling.
- 2 types of hybrids: series and parallel
ICE charges batteries or powers electric motor which drives the transmission
Parallel HEV Configuration

ICE and electric motor can both drive the transmission.
Electrical Power System

- HEVs contain a small electric motor
  - Acts as a generator as well
  - Uses battery energy to accelerate car
  - Uses generator properties to recharge batteries
- HEVs contain batteries
  - Used to power the electric motor
  - Recharged each time the brakes are pressed
- The electric component of the car takes over when driving in slow traffic or when you stop frequently
  - The electric motor can be used with the gas engine when accelerating the car
Gasoline Power System

• HEVs have the same internal combustion engine as a regular car
  - Slightly smaller – it isn’t doing as much work as in a regular car because the electric motor is able to take over or help in certain circumstances (i.e. accelerating or climbing a hill)
  - More efficient because of the size

Hybrids have a transmission that performs the same job as in non-Hybrid cars
Jeep Liberty Sport

- 2.4 L, 150hp engine
- Rear-wheel drive
- 19/24 mpg (city/highway, 5-spd)
Drive Train Design Team

Presenter: John Brandt

Team Members:
Allan Howard
Pavel Reytikh
Sanjaka Wirasingah
Series Hybrid

- 50-70 kW
- ICE
- ISA
- Drive Controller
- Charge Controller
- Battery
- 50-70 kW
- 50-70 kW
- 50-70 kW
Series Hybrid Pros/Cons

**Pro**
- Most Efficient Option
- Offers Braking Regeneration
- Fairly Compact Design
- Constant RPMs on ICE

**Con**
- Complicated System
- Requires near complete overhaul
- Energy changes drop efficiency
Hydraulic Baffle Turbine System

**Baffle Turbine Layout**

- Drive Turbine
- Gen. Turbine
- ICE
- Baffle to Direct hydraulic fluid
- Output up to Maximum RPM of ICE at ideal speed
- Generator
Baffle Turbine Pros/Cons

- Allows constant RPM
- Parts Readily Available
- Fairly Simple System
- Pretty Sweet

- Heavy
- Inefficient
- Never been done before
- No regenerative braking
Incomplete Parallel Hybrid

[Diagram showing the components of an incomplete parallel hybrid system, including Regen./Boost, ICE, and ISA.]
Incomplete Hybrid Pros/Cons

- Can offer partial regenerative braking (front only)
- Simplest plan
- Fewer modifications required
- Relatively lightweight

- INEFFICIENT
- No constant RPMs
- Power for battery recharge transferred through the road could cause excessive tire wear
- Possibly not powerful enough for a 4x4
Best Hybridization Factor

Presenter: Paul Reinhard
Team Member: Pavel Reytikh
Constant Vehicle Conditions

- **Engine:** Saturn 1.9L SOHC scaled to 112kW (FC_SI63_emis); peak efficiency 0.34
- **Batteries:** NiMH (ESS_NIMH93); 21 modules for $V_{\text{nom}} = 299V$
- **Parallel configuration**
Constant Variable Justification

• 299V nominal voltage chosen due to compliance with most rigorous test available (HL07)
• NiMH 93 batteries most powerful available to simulation program
• Saturn engine comparable; emissions data available in simulations
Variable Vehicle Conditions

- Motor: MC_AC75 varied incrementally from 0 (no motor) to 100kW
Drive Cycles

- All tests to be completed using the UDDS drive cycle in ADVISOR (city driving)
What is ADVISOR?

• ADVISOR is an ADVANCED VEHICLE SIMULATOR that simulates the performance of hybrid electric, conventional, electric, and fuel cell vehicles.

• Calculates the fuel economy, emissions released, acceleration times, and much more for a given drive cycle.

• Created the U.S. Department of Energy's (DOE) Office of Transportation Technologies' (OTT) Hybrid Vehicle Program
HF-Results

- Tests run in 10 kW increments
- SoC varied from approximately 0.7 (initial) to 0.66 (final) for all tests

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Emissions (grams/mi)
HF-Results

MPG vs. Motor Power

MPG / % Grade

Power (kW)
HF-Results

0 - 60 Time vs. Power

Power (kW)

0 - 60 (s)
HF-Conclusions

- Two cases:
  - Highest Fuel Economy:
    - Use 20kW motor; Hybridization Factor is 0.152
    - Gives 26.5% increase in fuel economy (21.1mpg to 26.7)
    - 6.6% decrease in 0-60 time (9.1s to 8.5s)
    - 11.6% increase in grade-ability (22.5% to 25.1%)
  - Performance:
    - Use 40kW motor; Hybridization Factor is 0.263
    - Gives 25.6% increase in fuel economy (21.1mpg to 26.5mpg)
    - 12.1% decrease in 0-60 time (9.1s to 8.0s)
    - 27.6% increase in grade-ability (22.5% to 28.7%)
• Increasing from 20kW to 40kW yields modest increase in performance
• Minor losses to fuel economy with increase in motor size
• Determining variable for hybridization factor would be cost of 20kW setup compared to 40kW setup
The Future Truck Competition

Presented by: Bhuan Agrawal
Team Member: Kavin Ammigan
• 5-year engineering competition to address growing energy-related and environmental concerns

http://www.futuretruck.org
Future Truck Team Objectives

• Examine past team designs
• Offer advice and input to Drivetrain Design Team
Our Recommendation

• Split-parallel hybrid design
• Maximum flexibility
• Minimum modification to the vehicle
Current Work

- Reference paper
- Will serve as a valuable learning resource for future hybrid work (Challenge X)
- To be presented at SAE World Congress 2005
Ultra-Capacitors

Presenter: Jesse Park
Team Member: Betsy Raju
Advantages of Ultra-Capacitors as a Component of the HEV Energy Storage Model

- Increased Power Delivery
- Increases the Life of the Battery
- Cheap and Efficient
- Overall Cost Reduction of the Energy Storage System
Energy Storage Model

- **DC/DC Converter**
  - Power Requested from Power Bus
  - SOC / Power Available
  - Max Limit of Converter
  - Power Available
  - Power Requested

- **Battery**
  - Power Delivered from Battery

- **Ultra-capacitor**
  - Power Delivered from Ultra capacitor
  - SOC / Power Available

- **Σ**
  - Power Delivered to Power Bus

- **Σ**
  - Power Delivered to Power Bus
Simulation with 10 year cost: Effect of Ultra-Capacitors on the Energy Storage System

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Conclusion

Presenter: Ryan Long
Accomplishments

• Acquisition of test vehicle for hybrid drivetrain designs
• Advisor simulations determining best hybridization factors and engine size
• Research of Future Truck Competition designs in order to determine feasibility of various design options
• Research of Jeep Liberty in order to assess options in hybridizing small SUVs
• Research on Honda Insight
• Preliminary design of hybrid drivetrain
Future Plans

- Use research from this semester in conjunction with research from previous semesters in order to compete in Challenge-X sponsored by General Motors
• Questions?

• Refer to Final Progress Report or check us out at:

http://www.iit.edu/~ipro326