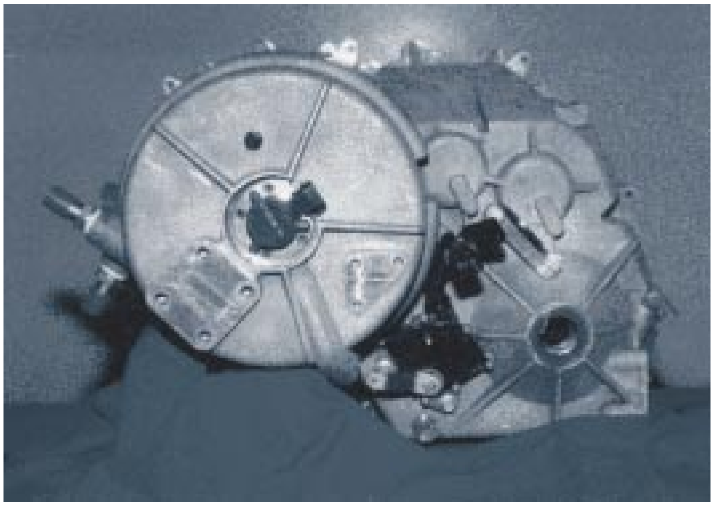
Hybrid Electric Vehicles
Electric Drive System Components and Vehicle Accessories

In order for Hybrid Electric Vehicles (HEVs) to attain the performance, economy, comfort, and convenience levels necessary to win widespread consumer acceptance, highly efficient and economical electric drive systems and vehicle accessories need to be developed. Some of the components of these key systems have no counterpart in conventional vehicles, so new systems and control strategies need to be created which take into account everything from system integration and cost to the development of a maintenance infrastructure.

Motors Are the "Work Horses" of an HEV Drive System

In an HEV, an electric traction motor converts electrical energy from the generator and/or the energy storage unit to mechanical energy that can help drive the wheels of the vehicle. Unlike a traditional vehicle, where the engine must "ramp up" before full torque can be provided, an electric motor can provide full torque at low speeds. This characteristic gives the vehicle excellent acceleration from standstill.

Other characteristics, which are important for an HEV motor, are good drive control and fault tolerance, low noise, high efficiency, and flexibility in relation to voltage fluctuations. Motor technologies, currently being evaluated for HEV applications, include the AC induction, permanent magnet, and switched reluctance motors. Electric machines in use today are typically driven by AC induction motors, which are inherently difficult to optimize for power and efficiency. Replacing them with permanent-magnet, switched-reluctance, or other advanced machines will result in lighter weight, more cost-effective systems with the higher efficiency and power density needed for HEVs. DOE is working to develop materials and manufacturing practices for motors to reduce noise and cost for automotive traction drive applications.



Electric drive unit for the General Motors HEV.

Regenerative Braking Reclaims Energy

One of the most important differences between an HEV and a traditional vehicle is the ability to reclaim a portion of the energy otherwise lost to braking. In an HEV, when the driver brakes, the motor becomes a generator, using the kinetic energy of the vehicle to generate electricity, which can be stored in the battery for later use. Traditional friction brakes are necessary, as well as a strategy to blend the two braking mechanisms smoothly. Regenerative and friction brakes need to be controlled electronically so that stopping ability is maximized while dual brake operation is made transparent to the operator.

Power Electronics and Controllers Are the "Brains" of an HEV

With the evolution of such advanced features as anti-lock brakes, air bags, and computerized engine controls, the conventional automobile has become more and more dependent on sophisticated electronics over the past several years. This trend will accelerate in HEVs, which rely heavily on electronic controllers to distribute the proper amount and type of power into and out of the appropriate sub-system at the appropriate time. Because of automotive complexity, HEVs require control devices with faster semiconductor chip operation, higher power density, and more power dissipation per device. Direct current is supplied by the battery and must be converted by power electronics to the alternating current required by the motor. The power electronics determine the exact nature and timing of the current and voltage waveforms to the motor. Many discrete devices, including application-specific integrated circuits, mixed analog/digital devices, and other power devices are required. High power density and low-loss switches, capacitors, and inductors are also needed for automotive high speed switching applications. The key to achieving this is a device called an Automotive Integrated Power Module (AIPM), one of a new class of Power Electronic Building Block (PEBB) technologies that integrate many of the controls, power components, drivers, and bus work of the power electronics system into a single package. Refer to the AIPM fact sheet for further information on this emerging technology.

Development of Advanced Vehicle Accessories Is Critical

While often non-essential to actual vehicle operation, "hotel features" such as heating and cooling are obviously essential in any vehicle seeking to gain consumer acceptance. The accessory loads (air conditioning, etc.) of tomorrow's vehicles will become a much larger percentage of the total energy used. If not reduced, these loads could have a dramatic impact on the fuel economy a customer would experience. Innovative development, for example, in climate control system operation, is needed to improve passenger comfort and fuel economy. In addition, current systems are designed around heat engines only, not HEV propulsion systems combining heat engines with electric motors (or even fuel cells). Frequent shut-down and start-up of the HEV heat engine complicates the management of electrical energy for propulsion systems and accessories, such as air conditioning and power steering. This requires advanced monitoring and control systems. The following are projected payoffs of vehicle accessory development:

- Passenger thermal comfort models can facilitate a "systems" approach to the design of propulsion and auxiliary systems.
- New coatings and glazing materials can reduce solar heat gain and allow lower power air conditioning systems.
- Novel passenger heating and cooling strategies and controls can improve comfort and reduce power requirements.
- New air conditioning machinery can improve packaging efficiency, integration, and control flexibility.

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