Unit C. Advantages of the Electric Drive Train

Assembly

Due to its simplicity of operation, the assembly of an electric vehicle drive train requires many less components that of an internal combustion drive train. Electric motors require no external liquid cooling, mufflers, or other lubrication sub-systems.

Electrics have fewer moving parts than internal combustion cars and trucks. Because of this, fewer replacement parts are necessary. The major components of the DC electric drive train are the motor, controller, and batteries.

Performance

Electrics are 90% efficient. One of the biggest questions among potential EV car buyers is the range – "How far will it go on a charge?" The answer to this question has become a tipping point for many potential EV owners. Studies show that the average driver in the US goes 29 miles per day. Most EVs can easily cover this type of commute; even with the simplest technologies most have ranges that will reach a minimum of 30-50 miles per charge.

Speed and acceleration have come under criticism of EV opponents. The truth is that most EV cars and trucks can accelerate to, and maintain, highway speeds in a manner similar to that of ICE technology. Better range is achieved with moderate speeds and limited acceleration, just as with ICE vehicles.

Electric motors produce high low-end torque, which means they can move vehicles from a dead-stop. There is no need to idle when they are not moving. By having this type pf profile electrics eliminate the need for complicated transmissions and gearing.

Integration - How the Parts Work Together

When you start to do your conversion you will see that we replace a lot of mechanical parts with electronic parts that run and control the system. The energy path we use to power EVs is much shorter and more direct than the one in an ICE vehicle. For example, we don't need to convert liquid fuel into a mist before it can be ignited by another system that makes a spark that is timed by another system that controls the timing of the spark and regulates the exhaust of the emission of the gas after the spark lights the fuel. In our conversion the fuel is used in the same state it is stored; and when it is used there is no need to mange anything left over.

A typical internal combustion engine has over a hundred moving parts. The electric motor has one moving part, its rotor. This means there are less parts that can break or wear out.

The battery stores the electricity for the motor. We will use two battery types in our conversion. The first is the traction battery, which is actually a series of smaller batteries wired together to make 144 volts. This battery stores enough energy for us to power our EV at highway speeds for short commutes. The design of this battery pack allows enough energy to flow from it safely to produce the power we need to drive our truck. We also keep the 12v DC battery for the accessories that came stock with the S-10.

We use lead acid batteries that require monitoring and maintenance. Other more exotic batteries are available, but at a much greater cost. The batteries in our conversion are a mature product, meaning they have been around for a long time, over 100 years. For this reason we know they are reliable, inexpensive, and durable.

DC motors are also a mature product, they have been around since 1827, when Hungarian inventor Ányos Jedlik started experimenting with electromagnetic rotating devices which he called electromagnetic self-rotors. The first real electric motor using electromagnets for both stationary and rotating parts was demonstrated by Ányos Jedlik in Hungary in 1828. Jedlik built an electric motor-propelled vehicle with his invention that same year.

The motor we use is a Warp9 DC. This is an "advanced" type of DC motor. It has several improvements over past DC motors such as greater capacity brushes and two drive shafts. The motor is pre-drilled with multiple bolt patterns to allow it to be used in many different types of vehicles.

The motor provides enough power to accelerate the S-10 truck to highway speeds in close to the same manner and performance as its previous ICE engine drive did.

The motor you see to the right is quite small for the performance it delivers. Its diameter is only 9 inches, and it fits securely into the engine compartment on the previous ICE drive train motor mounts.

One more important consideration of electric motors are their efficiency. The electric motor we use has efficiencies of between 80-90 percent. This means we use most of the "fuel" our battery pack to move the vehicle, it is not wasted as heat or noise.

For ease of conversion we will use the manual transmission that came stock with the S-10. Electric motors have a characteristic that would allow their use with no gears, simply performing within their power cycle at one speed. Keeping the stock transmission allows us to integrate the motor right into the existing drive train.

We use a controller as the "brain" of our system. It takes the motion of our foot on the accelerator pedal (it is no longer a "gas" pedal) and activates the electronics that regulate the flow of electricity to the motor and then the power to the wheels. To the driver the electric vehicle feels just like the ICE vehicle did. There is no new learning curve necessary before you can drive it.

The controller has a few subcomponents to help it run safely and efficiently. These are all stored in a control enclosure under the hood, and do not require any regular maintenance or service. There are no spark plugs or points of rotors to change or tune up.

Maintenance

Most EVs can be charged at home with regular a 20amp service outlet. Typical recharge time is 10-12 hours, which is ideal for commuters plugging in at home overnight. This also fits well with the electric utilities use patterns, where energy consumption is lowest. Current energy production capacity in the US could support many thousands of EVs without adding more power generation plants.

Environmental Impact

Electric vehicles reduce the effects of commuting on the environment. They do not produce emissions. The energy they require comes from electric plants that are strictly regulated. In many cases, electric can be charged with electricity that is already being generated anyway, such as off-peak at night. This is when most drivers will be charging.

The energy used by EVs is electricity. This electricity does not have to be sourced from foreign suppliers, it can be created in the United States. Electricity can be made by multiple suppliers, reducing the chance of artificial or real shortages. Multiple friendly suppliers also ensure a normalization in price. We rarely see dynamic changes in the supply and price of electricity the way we have in petroleum.

Electricity can be produced in multiple ways. We can create electricity wind water, wind, solar, geothermal, tides, oil and coal. Many of these sources are renewable, meaning the source can be reproduced multiple times (wind, flowing water, sunlight) whereas petroleum is not renewable.

Unit C Lesson Plans

Students will

- identify the basic assembly and components of the electric drive system;
- determine the systematic advantages of this drive system over ICE technology
- explain the differences in performance and function of individual components
- describe how the EV parts work together in the system

Materials

- Computer with Internet access (optional)
- Unit B text
- Appendix F Motor Specifications & Performance

Procedures

1. Electric motors work differently than internal combustion engines. Have students discuss the differences in motors and engines. What unique benefits do each present? What are the shortcomings of each type of technology? What could be done to improve motors or engines to make them work better in today's vehicles? Students should integrate social, economic, environmental, as well as technical factors into their discussion.

2. Have students design systems incorporating the results of their discussions. What technical improvements or innovations could they make to "invent" these new ideas? What challenges might they face?

3. Have students consider these questions:

   - ✓ How suitably does the DC electric motor act as a replacement for the gas engine?
   - ✓ What advantages and limitations does the electric motor present?
   - ✓ Are the limitations worth the advantages in tradeoff for using the electric motor?
   - ✓ What new technologies will come to the market as manufacturers build new cars.
   - ✓ How will the automotive buyer accept or reject these new technologies?

4. Divide the class into three groups, and have each group select a different system from the electric drive train (Motor, Controller, Battery). These groups can then discuss the improvements in they would incorporate into their respective system. Have students present these improvements as a group.

5. Have students answer the following questions about their system changes.

   - ✓ Exactly what is the technical change?
   - ✓ How would it make the system perform better?
   - ✓ What is the tradeoff (if any) of the improvement?

- ✓ How does it affect the other two systems?
- ✓ In what way would it change the way we use cars?
- ✓ How would automotive buyers in our society accept the change?

6. Now have each student group design and present a rough sketch to showcase its innovation. The sketch should clearly show design features and have descriptions of the benefits of each feature.

Evaluation

Use the following ten-point metric to evaluate students' work during this lesson.

- **Ten points:** Students worked both individually and cooperatively to research and select unique features of each drive system; exhibited above-average research skills; were able to answer all questions and clearly justify their choices; their product design was thorough and creative; their description of features and benefits complete, and their overall presentation was proven and acceptable. You would enthusiastically buy this product from this group.
- **Five points:** Students worked somewhat cooperatively to research and select unique features of each drive system; exhibited above-average research skills; were able to answer most questions and justify their choices; their product design was innovative; their description of features and benefits acceptable, and their overall presentation was comprehensive. You might buy this product from this group.
- **One point:** Students did not work cooperatively to research and select unique features of each drive system; exhibited limited research skills; were unable to answer most questions and justify their choices; their product design was similar to the original; their description of features and benefits was limited, and their overall presentation was not convincing. You would not buy this product from this group.

Extensions

- Have the class vote on the top five product improvements or select the most significant improvements. Have them justify their choices.
- Ask students to predict the component improvements that will mark the next 10 years.
- As a class, design/describe a car that incorporates the best-of-the-best of the groups' designs.

Vocabulary

system integration
Definition: bringing together separate individual parts to work effectively in a system
Context: The best EVs use excellent system integration by using as few parts as possible to produce efficient drive trains from battery to wheels.

efficiency
Definition: reducing the waste of energy

Context: EVs have a high efficiency because they do not require additional subsystems to control the heat and noise of unused energy.

infrastructure
Definition: the basic physical and organizational structures needed for the operation of a system or society
Context: The electrical infrastructure can be easily modified to meet the needs to charge larger numbers of electric vehicles.

environmental impact
Definition: the effects (positive or negative) that a system has on the natural environment
Context: by using off-peak energy for charging and by having zero-source emission EVs have a very low environmental impact.