Rec 2/23/11

(17)

MTSU Clean Energy Initiative Project Funding Request

There are five (5) sections of the request to complete before submitting. See http://www.mtsu.edu/~sga/cleanenergy.shtml for funding guidelines. Save completed form and email to cee@mtsu.edu or mail to MTSU Box 57.

1. General Information	
Name of Person Submitting Request: Charles H. Perry	
Department/Office: ET, VET 145	Phone # 615-898-5683
MTSU Box # 19	Phone # 615-522-1230
E-mail: chperry@mtsu.edu	Submittal Date: 02-23-2011

2. Project Categories (Select One)			
Select the category that best describes the project.			
X	Energy Conservation/Efficiency		Sustainable Design
	Alternative Fuels		Other
	Renewable Energy		

3. Project Information

a. Please provide a brief descriptive title for the project.
b. The project cost estimate is the expected cost of the project to be considered by the committee for approval, which may differ from the total project cost in the case of matching funding opportunities. **Any funding request is a 'not-to-exceed' amount. Any proposed expenditure above the requested amount will require a resubmission.**
c. List the source of project cost estimates.
d. Provide a brief explanation in response to question regarding previous funding.

3a. Project Title: Universal Plug-In Conversion (UPIC)

3b. Project Cost Estimate: $50,000

3c. Source of Estimate: Materials ($10,000), electronics ($18,000), battery ($12,000), machining ($10,000).

3d. If previous funding from this source was awarded, explain how this request differs? Previous funding was for Bio-Bus build and evaluation. Second grant was for used cooking oil processing facility. This is new project.

4. Project Description

(Completed in as much detail as possible.)

a. The scope of the work to be accomplished is a detailed description of project activities.
b. The benefit statement describes the advantages of the project as relates to the selected project category.
c. The location of the project includes the name of the building, department, and/or specific location of where the project will be conducted on campus.
d. List any departments you anticipate to be involved. Were any departments consulted in preparation of this request? Who? A listing may be attached to this form when submitted.
e. Provide specific information on anticipated student involvement or benefit.
f. Provide information for anticipated future operating and/or maintenance requirements occurring as a result of the proposed project.
g. Provide any additional comments or information that may be pertinent to approval of the project funding request.

4a. Scope: Work to be accomplished: The goal of the MTSU ET UPIC program is to develop a kit to convert any car into a plug-in hybrid. Clean Energy Initiative funds will be used to convert current MTSU vehicles into plug-in hybrids. There are 12 Chevrolet Impalas presently in the MTSU motor pool. Funds will be used to convert at least one of these vehicles by adding plug-in hybrid capability. This will include addition of electric traction capability to the rear wheels, electronics to control and power the traction motors, and suitable battery pack. Depending on the costs of components, machining, electronics and batteries it may be possible to convert more than one vehicle with the requested $50K. This work is part of an ongoing research effort in ET that has been in progress for over two years. The State of Tennessee gave a $50K grant to MTSU/ET for the feasibility study of the UPIC technology. That work is complete and building working prototypes is the next step.

4b. Scope: Benefit Statement: This activity will advance the UPIC technology toward commercialization and provide on-campus demonstration of plug-in hybrid operation in State vehicles. Depending on how many vehicles can be modified, the gas savings will be realized by doubling the mileage while in hybrid operation. This has already been demonstrated in the feasibility study. In addition, student workers will be directly involved in the design, build, and installation of the UPIC systems. This will provide experience to MTSU/ET students in this new emerging technology. Media coverage will also enhance the image of MTSU as having an ongoing effort in technologies to reduce the dependence on foreign oil.

4. Project Description (continued)
4c. Location of Project (Building, etc.) The project will be located in VET 120 which is the research room for the ET department.
4d. Participants and Roles: Charles Perry, PI, Paul Martin III, automotive technician/coordinator, MTSU students who will develop CAD drawings and participate in machining, installation, battery research, and other activities.
4e. Student participation and/or student benefit: Student workers will be used extensively in this project. Since the inception of the UPIC program over the past two years, 6 students have participated in the project in various roles.
4f. Future Operating and/or Maintenance Requirements: Normal maintenance on the modified vehicles.
4g. Additional Comments or Information Pertinent to the Proposed Project: A project summary report is attached to this proposal to give the history of the UPIC project to date.

5. Project Performance Information
Provide information if applicable. a. Provide information on estimated annual energy savings stated in units such as kW, kWh, Btu, gallons, etc. b. Provide information on estimated annual energy cost savings in monetary terms. c. Provide information on any annual operating or other cost savings in monetary terms. Be specific. d. Provide information about any matching or supplementary funding opportunities that are available. Identify all sources and explain.
5a. Estimated Annual Energy Savings (Estimated in kW, kWh, Btu, etc.)The annual energy savings will be determined by how many miles a given vehicle is driven a year. If that is 6000 miles locally, the approximate fuel savings would be $500/year per vehicle at $3.00 per gallon fuel price.
5b. Annual Energy COST Savings ($) see 5a.
5c. Annual Operating or Other Cost Savings. Specify. ($) none
5d.Matching or Supplementary Funding (Identify and Explain): The UPIC Patent application has been filled with the U.S. Patent office. Funds are currently being sought to scale up the UPIC program for commercialization. This will involve $1,000,000 or more in funds which are currently being considered by investors. The present request from the Clean Energy Fund is to allow early prototype builds but these will not be suitable for manufacturing. It will give the UPIC team more opportunities to develop and optimize the technology, allow student involvement, and enhance MTSU's image.

Title: Universal Plug-In Conversion (UPIC)

Significance of the Proposed Innovation

The Engineering Technology Department of Middle Tennessee State University (MTSU) proposes a novel, economic method to convert any car or truck into a plug-in hybrid by adding electric traction to the rear wheels without major mechanical modification. The novel retrofit plug-in hybrid kit consists of compatible mechanical components to convert both rear wheels to electric traction, including: DC brushless motors, microprocessor controller, high current driver electronics, and lithium ion battery. All electronics and batteries are packaged together in a compact unit that may be as small as a medium suitcase for a typical passenger car.

The main challenge of retrofitting any car to add plug-in hybrid capability is the method used to add electric traction to the OEM design. Figure 1 is the rear wheel structure of a 2005 Chevrolet Impala.

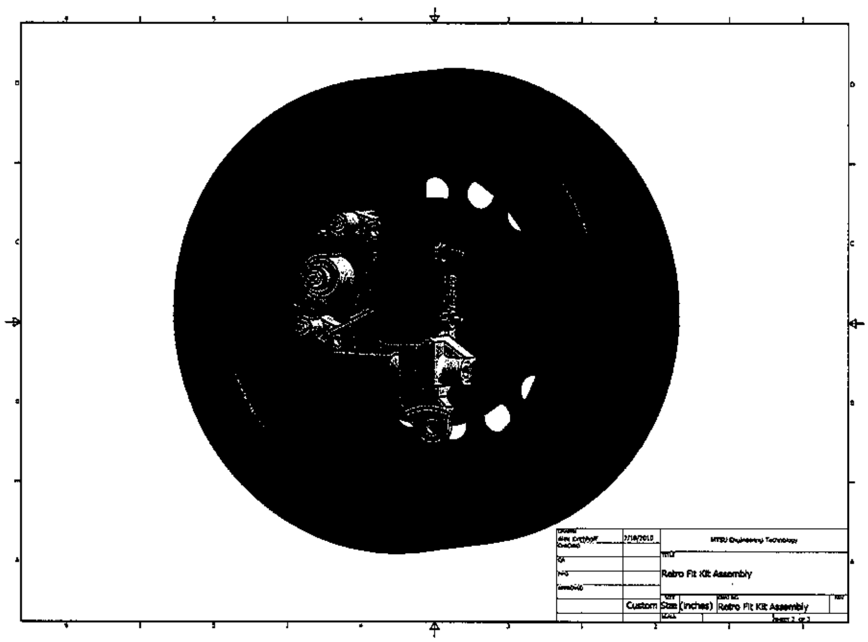

Figure 1. Rear wheel structure of 2005 Chevrolet Impala

Figure 1 illustrates the space between the spindle/brake assembly and the inner diameter of the wheel. In most cars this space is sufficient to package the components of a DC brushless motor. This approach does not change the brake, bearings or mechanical integrity of the OEM design. A DC brushless motor is integrated into the original design without major modifications.

Brief Comparison and Contrast to Current or Alternative Concepts

The Engineering Technology department at MTSU is well acquainted with the history and current status of plug-in hybrid retrofit technology. With regard to modifying a non-hybrid car to a plug-in hybrid, several approaches have been used. The Poulsen system is one of the best known commercially available systems, http://www.poulsenhybrid.com/. Electric traction is accomplished by driving the rear wheels via external motors mounted on the rear wheels using the lug nuts. This approach necessitates a lever arm to anchor the external motor so torque from the electric motor can be applied to the rear wheels. It is a workable system but visually unattractive, and the external motors could easily be stolen.

The second most common approach is interruption of the drive shaft on a rear wheel drive car. Converdant Vehicles is a typical example, http://www.converdantvehicles.com/hybrid.html. This system interrupts the mechanical connection between the transmission and differential and adds electric traction in parallel with the motive power delivered by the internal combustion engine. Again, this is a workable system but mechanically complex and expensive. All such approaches such as the two discussed share the same problem: mechanical complexity which translates to higher costs. The UPIC concept is a unique and elegant method to add electric traction with the following advantages:

1. Mechanically simple
2. Transparent in appearance and function
3. Does not change the OEM design
4. Applies to front and rear wheel drive cars
5. Inexpensive

Benefits to the Individual User

On an average day in the U.S., 80% of the drivers go 40 miles or less at a speed of 45 miles per hour or less. The UPIC technology is designed for this market. Energy from the grid stored in the battery pack will be used to augment the energy supplied by the internal combustion engine. In hybrid mode the mileage of a typical vehicle will double while the electric traction is operable. The battery pack in this application is only designed to have enough energy to go 30-40 miles at a speed of up to 45 mph. When the energy in the battery pack is depleted, or the vehicle speed exceeds a pre-determined value, the system automatically cuts off and the vehicle operates as it would without the hybrid system. The power of the electric motors in the rear wheels is sufficient to augment the power supplied by the internal combustion engine so as to reduce the fossil fuel usage in acceleration where the internal combustion engine is the least efficient.

Benefits to Society

All major automobile manufacturers design and produce automobiles based on platforms having common suspension components. Several different models are built on the same platform such as a sedan and SUV on the same frame and suspension. The electric traction components will be designed for the most common platform currently on the road for each major manufacturer. In this way, a relatively small number of UPIC designs (8-12) will cover up to 50% of the vehicles currently in use. The price target for the installed plug-in hybrid system is $3000 to $5000. This will mainly depend on the cost of the lithium ion battery since the battery is the most expensive component. This technology will allow the conversion of most cars currently on the road to plug-in hybrid capability. This will accelerate the use of plug-in hybrid vehicles and significantly reduce fossil fuel usage and the accompanying emissions because a much greater percentage of the driving population will be able to access hybrid performance without purchasing a new vehicle. Depending on fuel costs, the return on investment can be as short as 2-3 years. This is optimized if the cost for lithium ion battery technology continues to come down thus reducing the initial cost of the plug-in hybrid system closer to the $3000 figure.

Details of the Proposed Innovation

Figure 2 is an assembly drawing of how the electric motor components fit into the OEM design when adding electric traction to the rear wheel of a 2005 Chevrolet Impala.

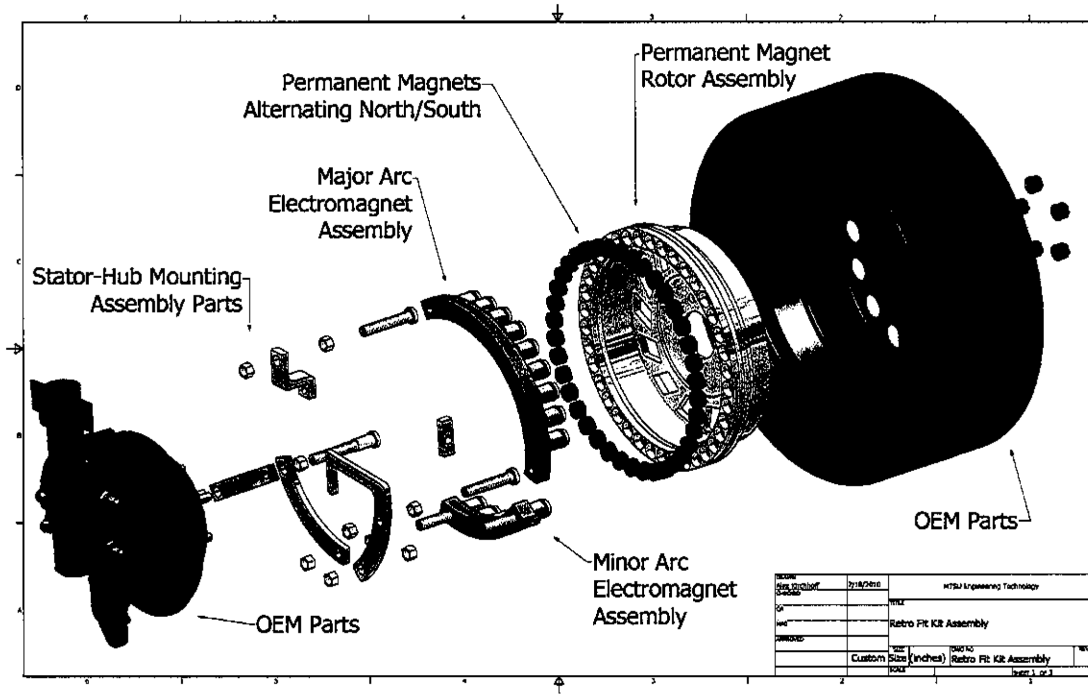

Figure 2. Assembly drawing of brushless DC motor retrofit to integrate electric traction drive into rear wheel of 2005 Chevrolet Impala.

The electromagnets of the motor are positioned behind the spindle/brake assembly. Note that the electromagnets do not cover the entire 360 degrees. Because of suspension and brake components the electromagnets cover a minimum of 180 degrees. This is sufficient to provide the needed torque. The electromagnets are held in place by brackets that attach to existing features (such as bolts) in the OEM design. The rotor is held in place between the brake disc and the wheel by the lug nuts that hold the wheel. Like a bowl, the rotor assembly wraps around the spindle/brake structure to be in proper proximity to the electromagnets thus forming a DC brushless motor. The bearings of the OEM design assure the mechanical integrity of the electric motor. This method of adding electric traction to an existing design does not compromise the OEM design, function, or reliability. Maintenance can be carried out in the usual way by removing the wheel and rotor thus exposing the brake assembly.

Figure 3 shows the components of the DC brushless motor installed in the rear wheel of a 2005 Chevrolet Impala. By comparison with the first figure above, it is noted that the attachment points for the brackets holding the electromagnet array are the existing bolts in the OEM design. Sometimes it is necessary to substitute a longer bolt in the same OEM location. Except for the permanent magnets and core of the electromagnets, all materials are lightweight and non magnetic. The most significant impact is adding weight to the wheel structure. This would only be significant in a high performance automobile used in racing. Otherwise, addition of the electric motor is transparent in both appearance and normal function. Reliability issues will be addressed as part of the development process.

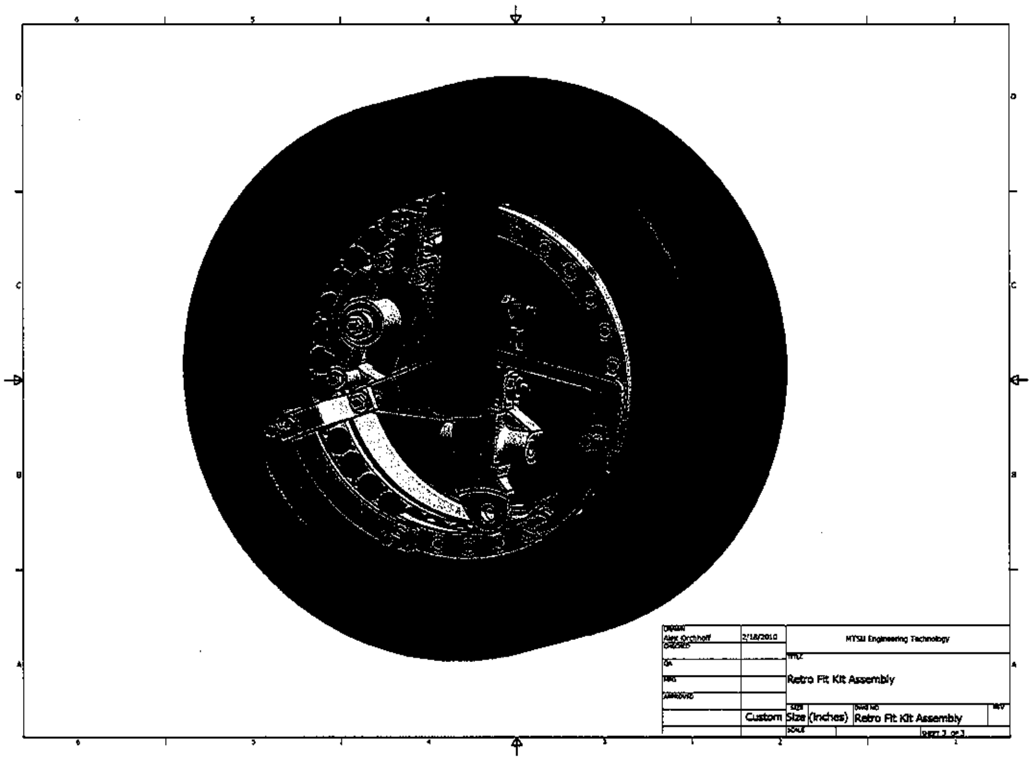

Figure 3. Assembled wheel hub motor into rear wheel of 2005 Chevrolet Impala.

Summary: The Universal Plug-In Conversion, UPIC, also known as the Wheel Hub Motor has been filed for U.S. Patent protection as "Machine for Augmentation, Storage, and Conservation of Vehicle Motive Energy." The Engineering Technology Department at Middle Tennessee State University under the direction of Dr. Charles Perry has demonstrated feasibility of the UPIC technology by designing a UPIC for a 1995 Honda Accord and a 2005 Chevrolet Impala. In addition, a table top UPIC suitable for installation in either vehicle has been developed.