Needs Assessment Report

Team 2

Electric Vehicle Optimization

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ABSTRACT

Team 2 is working with sponsor Dr. Michael Hays from Cummins, Inc. and faculty advisor Dr. Seungyong Hahn in order to improve the range of an electric vehicle using alternative power adders. The sponsor specifically asked Team 2 to research solar panels and regenerative breaking. Upon doing so, Team 2 is considering implementing both options but is also exploring other creative options for recharging the batteries and reducing power usage while the cart is in use. Team 2 has determined the needs from the sponsor and must begin testing in order to know the current range of the cart so that it may be extended by the necessary 15% without significant decrease in acceleration or top speed. Also, Team 2 is not allowed to change the amount of fuel supply. Moving forward, Team 2 must first get last year's project to work by making minor adjustments to wiring and code. Once complete, Team 2 will need to finalize options for increasing the range and then implement those options.

ACKNOWLEDGMENTS

Team 2 would like to thank our advisor, Dr. Hahn, along with our sponsor, Dr. Michael Hays, from Cummins, Inc.

1. Introduction

The purpose of this project is to improve the overall range of the electric vehicle by at least 15% of what can be achieved currently. Team 2 is hoping to focus on adding additional power sources, finding ways to regenerate power while in motion, improving the overall electric system, and reducing the weight in order to ensure that all aspects of the vehicle attribute to the range improvement. The sponsor has instructed that we begin by getting the vehicle to function properly, in order to begin testing its current range. So far, the team has been having problems accomplishing this feat, which is for the generator and battery tandem system to work together properly. As the batteries deplete and the generator turns on, the batteries should start to recharge themselves and keep charging until they reach capacity in order for the generator to turn off. So far the vehicle has been having problems achieving that goal as the generator continues to run when the batteries are fully charged. The team is focusing on solving this problem that was occurring from last year's group first, in order to begin to document and test the current range of the vehicle. Then, this data will be recorded and used as a benchmark in order to see how further improvements can be made.

2. Project Definition

2.1 Needs Statement

Our team has been approached by Dr. Michael Hayes of Cummins, Inc. to extend the range of an electric vehicle similar in size to a golf cart. The cart's range needs to be improved by 15% above its current capability. The project's sponsor requires us to do so without increasing the fuel capacity of the vehicle and minimizing the reduction in performance. With this information the following needs statement has been created.

"The current range of the cart is unsatisfactory and needs to be extended without adding fuel supply and minimizing the reduction in vehicle performance."

2.2 Background Research

2.2.1 Electric Vehicle Photovoltaics

Currently solar roofs are manufactured for instillation on carts similar to the one used by our team. Solar companies claim their solar cart roofs generate anywhere from 45 watts to 360 watts depending on cost [1]. Large solar roofs are 6ft by 4ft and weigh about 80lbs which could cause an issue in performance of our vehicle due to increased weight. There is a maximum theoretical efficiency of solar panels based on the amount of solar radiation that hits the earth's surface. On a sunny day at the equator there is a solar radiation density of about $1000W/m^2$. It is assumed that actual power generation will be less than the solar companies claim, however an accredited source attributed a noticeable increase in a carts range to the addition of a solar power source [2].

2.2.2 Drag Reduction

For long distance continuous travel, it is known that the largest friction force and loss of energy is wind resistance. If wind resistance and friction could be eliminated theoretically the cart could coast forever. This is impossible though it is possible to roughly determine the cart's coefficient of drag which would help us benchmark the cart's aerodynamics and with the help of Dr. Hahn, reduce the coefficient of drag [3]. Drag can also be reduced by making sure the cart is properly maintained. Lubrication of the joints and gearing with grease and oil will reduce the drag

associated with the cart's mechanical power transfer systems. Proper inflation of tires is also a simple fix and can greatly affect the cart's range.

2.2.3 Regenerative Braking

Many new high-end carts come with regenerative braking systems installed. It is believed that ours does not. Regenerative braking converts the vehicles kinetic energy back into electrical energy to be stored in the batteries when the operator decides to slow the vehicle down. This system is most commonly known due to the Toyota Prius and is ideal for stop and go driving environments. Complete regenerative breaking kits can be purchased for installation in our vehicle [4]. A new motor may need to be purchased because some older motors are not compatible with regenerative breaking addition kits. The amount of energy converted by a regenerative breaking kit is easily calculated through the change in kinetic energy.

2.3 Goal Statement and Objectives

After thorough discussion with our adviser and sponsor along with a needs assessment, our team formulated the following goal statement.

"Improve the range of the vehicle by at least 15% with minimizing the reduction in performance."

Objectives:

- Fix cart to operate as designed by last year's team.
- Explore ways to add power while the vehicle is operating (Solar Panels, Wind Turbine, regenerative breaking, etc.)
- Document the range and performance of the vehicle.
- Find ways to reduce the vehicle's weight.
- Find ways to reduce the vehicle's drag
- Identify how the efficiency of the vehicle's motor can be increased.
- Create a way to benchmark possible improvements and choose most cost effective options.

2.4 Constraints

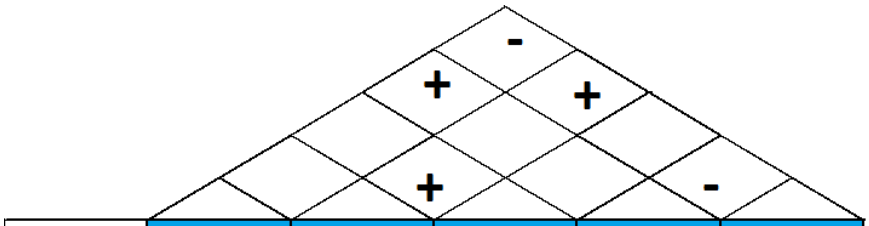
- Vehicle’s maximum speed cannot be lowered by more than 10%
- Fuel capacity of the vehicle cannot be increased
- Vehicle’s maximum acceleration cannot be lowered by more than 10%

3. Methodology

In order to improve the overall range of the vehicle, a methodology of how to accomplish the ultimate goal was developed. The steps in the process are as follows.

- Work with faculty advisor and last year's team leader to make the vehicle operable.
- Begin testing the current performance and range specifications of the vehicle.
- Document this data and use as a benchmark for further improvements.
- Perform extensive background research on additional power adders.
- Choose feasible power adder options to increase vehicle efficiency.
- Perform extensive analysis of effect of power adders to vehicle performance and overall efficiency.
- Procure necessary components.
- Assemble vehicle prototype.
- Test prototype performance.
- Document final performance of vehicle
- Make any additional adjustments to achieve max vehicle efficiency and range.

3.1 House of Quality (HOQ)



	Efficiency	Safety	Durability	Power	Weight
Reliability	2	3	4	1	0
Performance	5	1	2	5	2
Cost	4	2	4	4	0
Capacity	1	1	2	1	2
Range	5	1	3	5	3
Total	17	8	15	16	7
Rank	1	4	3	2	5

Figure 1: House of Quality diagram illustrating the relationships between our customer requirements listed down the leftmost column and our engineering characteristics listed along the top row.

4. Conclusion

With the help of our Sponsor, Dr. Michael Hays from Cummins, Inc. and our faculty adviser, Dr Hahn, our team is tasked with improving the range of our electric vehicle by 15% without losing much loss in top speed or acceleration. Our team must first get the vehicle to function properly based off of what was left from last year's team while extensively researching and analyzing possible power adders for our vehicle. These include but are not limited to adding solar panels, regenerative braking systems, wind turbines, etc. After testing has been done of the vehicle in its current state, these additional components can be added and final tests can be conducted to determine the improved performance of the vehicle.

References

[1] "235w/280w Solar Roof." *SolarEVSystems.com*. Solar Electric Vehicle Systems, Apr. 2016. Web. 29 Sept. 2016.

[2] Carelus, Julie. "Extending the Range and Efficiency of Golf Carts." *Prezi*. Prezi Inc., 17 Dec. 2013. Web. 29 Sept. 2016.

[3] "Measuring Drag Coefficient." *Instructables.com*. Autodesk, Inc., n.d. Web. 29 Sept. 2016.

[4] "Regenerative Breaking." *Buggies Unlimited*. Buggies Unlimited, n.d. Web. 29 Sept. 2016.