Electric Vehicle Optimization

Team Number: 2

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Abstract

Dr. Michael Hays of Cummins is directing group 2 in its efforts to maximize the efficiency of an electric vehicle in extreme weather conditions. Group 2 is working in tandem with a group of electrical engineers. The electrical engineers are going to handle battery management of the vehicle, whilst the mechanical engineers are responsible for the rest of the project. Group 2 has conducted research on possible routes for the project but no specific aspects of the assignment have been established pending the testing of the vehicle's performance.

1 Introduction

The objective of the project is to enhance the system by improving the current range and operable temperatures of an electric vehicle. The team is looking to optimize the vehicle with the potential implementation of a secondary power source, minimizing weight, and ensuring that all of the additions to the vehicle are cost effective. The problem that the group has been faced with is that the vehicle must be operable in very low temperatures and have its range increased beyond its current amount. This is cause for background research on battery technology and ways to regenerate power while in motion in order to meet the necessary design objectives for the vehicle. The team intends to document the current range and operating capacity of the vehicle and then use that data as a benchmark for further improvement.

2 Project Definition

2.1 Background research

2.1.1 History of the Electric Car

The concept of a battery powered vehicle dates back to the 1800's, where inventors from different countries were playing with the idea of electric locomotion. Robert Anderson, a British inventor, is accredited with generating a small scale battery powered vehicle. From there, electric vehicles transformed, and by the 19th century, electric cars were so popular that New York City had a fleet of 60 electric taxis. [1] The movement of the personal car played a big role in this evolution; however the electric car was competing with gasoline powered vehicles. The first vehicles that were developed in the early 1700's either ran off of steam or gasoline. [1] Soon, it was clear that steam would be impractical if applied to a small personal car, however gasoline seemed promising. Nonetheless, electric cars didn't possess the same harmful side effects of gasoline powered vehicles. This includes pollutants from exhaust to the drilling of natural gases and oil. Electric cars provided a quiet, safe, and efficient way to travel around the city on short trips, and with the rise of availability in electricity, electric cars became more readily used. The fall of electric cars came with the production of the Model T. Henry Ford developed a highly efficient manufacturing line that lead to extremely affordable gasoline cars. [1] By 1912, the electric car cost more than double what the Model T did, and with this, the electric car industry took a small fall due to supply and demand. [1] Once oil was discovered in Texas, electric cars began to disappear, and by 1935 there were no electric cars on the roads.

2.1.2 Modern Technology

With the recent shortages in oil reservoirs, electric cars are making a comeback. Clean energy is becoming a highly advanced technology that is being utilized for many applications, including transportation. Some of the leading transportations companies in the United States are moving towards a cleaner, efficient way of travel. With that being said, Cummins has provided the design team the opportunity to take part in improving the current operation of a small scale electric vehicle. The concept of an electric powered vehicle is not farfetched, given that many companies today have electric cars on the road. However, a big challenge in the design process is the operation of these batteries in low temperatures. The design team was told the vehicle must start and remain fully operation in -40˚F conditions. Current electric vehicles were researched in order to understand how temperature can affect the range of the vehicle. Figure 1 below shows that as the outside temperature decreases so to does the daily range of the vehicle. [2]

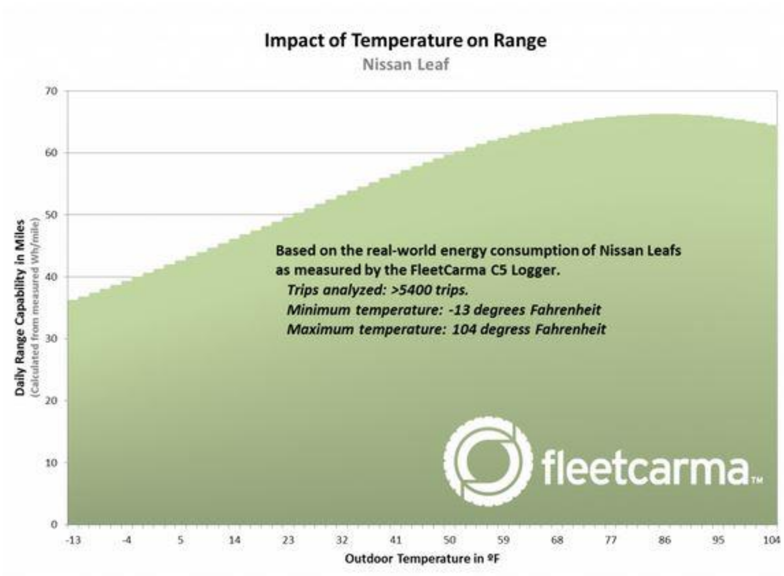

Figure 1 Impact of temperature on the range of the Nissan Leaf

2.2 Need Statement

This project is sponsored by Cummins under the supervision of Dr. Michael Hays along with the assistance of Dr. Claus Daniels from Oak Ridge National Laboratory. The team's faculty advisor is Dr. Juan Ordonez. At present the electric vehicle cannot operate at cold temperatures, and its range is more limited that is desired. As such Team 2 has formulated a need statement for the project:

"The current range and operable conditions of the electric vehicle are unsatisfactory and require improvement."

2.3 Goal Statement & Objectives

After further discussion with Dr. Hays we were informed that Cummins would be providing our choice of generator to be installed onboard the vehicle. Additionally Dr. Hays requested the generator activate when the battery charge is low and that there be a system which indicates the level of charge in the batteries. After this meeting we formulated our goal statement and our objectives to accomplish this goal.

Goal Statement:
"To increase the current range and operable conditions of the electric vehicle by utilizing a secondary power source."

Objectives:

- **Document current performance.**
- **Minimize weight of modifications.**
- **Integrate a generator into the vehicle.**
- **Develop a battery monitoring system.**
- **Increase the operable temperature range.**

3 Constraints

After discussing the project with Dr. Hays a list of constraints was compiled. The constraints play an important role in the determination of both the design and performance specifications. The constraints affect both which generator will be selected as well as which new batteries will be implemented into the design.

- **The system must operate at -40˚C.**
- **Project budget is $2000.**
- **Primary power source must be the 48V battery set.**

3.1 Design Specifications

After dialogue with our sponsor Dr. Hays and after extensive research it was decided that the best way to meet the goal and the various objectives was to integrate a small generator into the electrical vehicle. The generator that will be used has not yet been selected however the various parameters in the selection process have been listed below:

- **Lightweight.**
- **Outputs at least 1,600W**
- **Dimensions cannot exceed 685-mm x 360-mm x 400-mm**
- **Can operate at low temperatures (≈ 40˚C).**

Several of the parameters have not yet been quantified, however some factors are more of guidelines rather than limits. The parameters that do have limits such as the output voltage and amperage will be quantified once the vehicle is tested, which is expected to be completed by the second week of October.

Another necessary component of the design are the batteries that power the vehicle. The selection of the batteries has been delegated the electrical engineering team. The details of the selection will be done by this team, however the selection will be based on some of the following specifications:

- **Outputs necessary amperage.**
- **Outputs necessary voltage.**

- **The batteries are rechargeable.**
- **The batteries have a long lifetime.**
- **The batteries can function at low temperatures (≈ 40˚C).**

In addition to the selection of the generator and batteries the integration of these components into the current system is also important. As mentioned specific generators and batteries have not yet been chosen so this aspect of the design has not been fully examined. As the choices for generators and batteries are narrowed their integration into the system will be investigated and will become a deciding factor in the final selection.

3.2 Performance Specifications

The first and possibly one of the most important steps to improving the overall range of the vehicle is determining the current performance. By testing the following parameters, the design team will then have a bench mark to compare future improvements. Accurately testing and recording these parameters will ensure that the design team has the necessary data to develop a more efficient system. The following includes the parameters that will be tested.

- **Time needed to fully charge current battery**
- **Current range on full charge**
- **Operating voltage at different temperatures**
- **Cycle life**

The design team considered these parameters to be important because this will be the scale for future progress. Understanding the performance of the current vehicle will provide the design team a basis to start improving the range. Since the battery is one of the major aspects that will be changed, the performance specifications are heavily based on the current battery. Also, the operating temperature of the vehicle is an important factor that needs improvement. The best way to improve a system is to fully understand the current system. Once these performance specifications are recorded, the electrical engineering design team will start the battery selection process in order to improve the operation. The current system however, does not involve a generator. This is one tool the design team will integrate in order to improve the overall range of the vehicle and its operating temperatures. The mechanical design team will be in contact with Cummins during the generator selection process to ensure smooth progress.

4 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 highlighted below.

- **Perform general research on charge while running and low temperature operable batteries.**
- **Document performance of the vehicle.**
- **Generate possible improvements.**
- **Determine which improvements to implement.**
- **Conduct extensive analysis of improvements.**
- **Procure components.**
- **Assemble prototype.**
- **Document final performance of the vehicle.**
- **Make any additional adjustments to achieve the goal.**

4.1 Schedule

In order to ensure that the project be completed in a timely manner a schedule was developed. The schedule is in the form of a Gantt chart, which includes ME deliverables and Team deliverables. ME deliverables are items that team 2 will turn in for a grade, such as reports and presentations. These items are in red on the Gantt Chart. Team deliverables are items that must be completed however they are not directly turned in. Tasks such as, performing general research, begin detailed design, and order components all fall into this category. The team deliverables are in blue on the Gantt Chart. The arrows on the chart show the relationship between tasks, a the arrows indicates that the earlier task must be completed, or at least underway before the proceeding deliverable can be started. The Gantt Chart does not include team meeting which occur throughout the project. It was decided to omit the meetings because there are a large number of them and their inclusion would muddle the Gantt Chart. Due to the general nature of the team deliverables every member is currently assigned to them until such time that the design develops, and the deliverables can be broken up into smaller tasks.

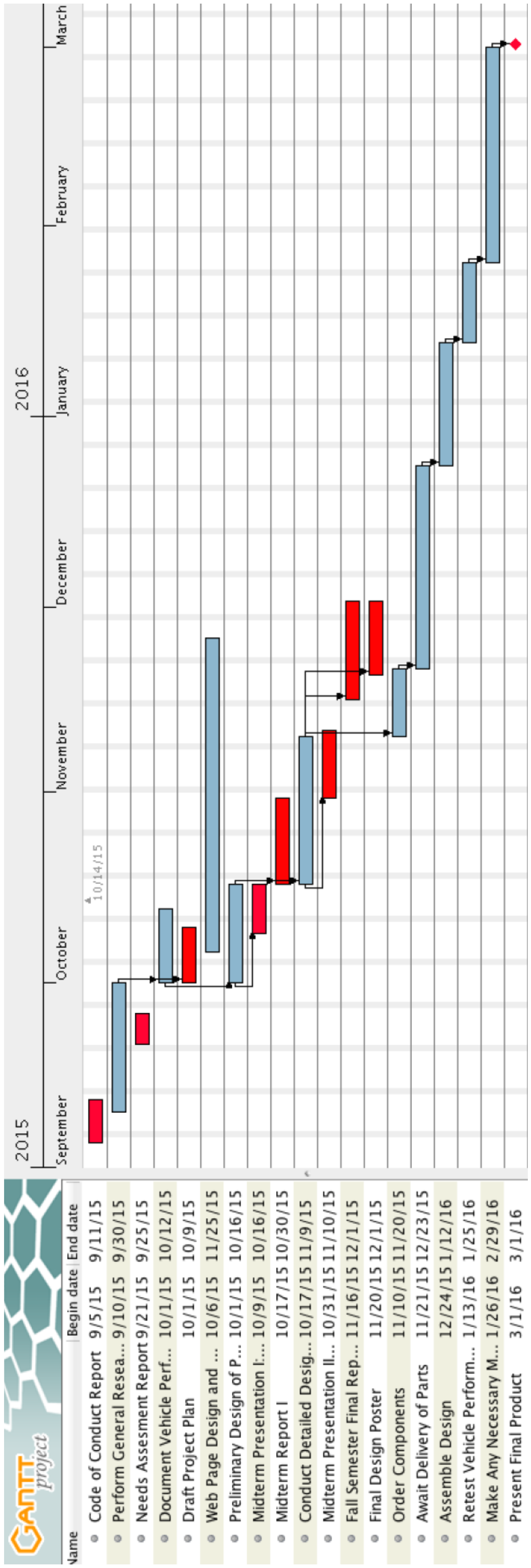

Figure 2 Gantt Chart

4.2 Resource Allocation

While the Gantt Chart is a good representation of the schedule it does not include who is assigned to each task. Table 1 shows which team member is assigned which task. For ME deliverables every member of the team will work equally to complete them, however certain team deliverables and presentations, will be completed by specific team members. In addition to their specified tasks team members have also been assigned general roles.

Jakob Consoliver-Zack is the Project Leader. He manages the team as a whole; develops a plan and timeline for the project, delegates tasks among group member according to their skill sets; finalizes all documents and provides input on other positions where needed. He keeps the communication flowing, both between team members and Sponsor. The team leader takes the lead in organizing, planning, and setting up of meetings. Finally he gives or facilitates presentations by individual team members and is responsible for overall project plans and progress.

Samantha Beeler is the team Treasurer. She manages the budget and maintains a record of all credits and debits to project account. Any product or expenditure requests must be presented to the advisor, whom is then responsible for reviewing and the analysis of equivalent/alternate solutions. They then relay the information to the team and if the request is granted, order the selection. A record of these analyses and budget adjustments must be kept.

Tyler Mitchell is the lead ME. He takes charge of the mechanical design aspects of the project. He is responsible for knowing details of the design, and presenting the options for each aspect to the team for the decision process. Keeps all design documentation for record and is responsible for gathering all reports.

Jeremy Randolph is the team Webmaster and Historian. He is responsible for maintaining website and electronic records. Any and all digital documentation will be filed, stored, and catalogued electronically for easy access through the webpage. In addition, he is responsible for keeping a record of all correspondence between the group and 'minutes' for the meetings. Lastly the historian distributes the meeting minutes to the group via email.

Eugene Moss is the Electrical Engineering Liaison. He is in charge of the electrical engineering team that is working independently from the mechanical engineering team. He is responsible for communication between teams to ensure that no design modifications by either team inhibit the other.

Table 1 Resource Allocation

Category	**Task Name**	**Duration**	**Start**	**Finish**	**Resource Names**
Team Meeting	1	1	9/1/15	9/1/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	2	1	9/3/15	9/3/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	3	1	9/8/15	9/8/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	4	1	9/15/15	9/15/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Meeting	5	1	9/22/15	9/22/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	6	1	9/24/15	9/24/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Meeting	7	1	9/29/15	9/29/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	8	1	10/6/15	10/6/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	9	1	10/8/15	10/8/15	Jakob, Jeremy, Samantha, Tyler
Team Meeting	As Needed	1	As Needed	As Needed	Jakob, Jeremy, Samantha, Tyler, Eugene
ME Deliverable	Code of Conduct	6	9/5/15	9/11/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Perform General Research	20	9/10/15	9/30/15	Jakob, Jeremy, Samantha, Tyler
ME Deliverable	Needs Assesment Report	4	9/21/15	9/25/15	Jakob, Jeremy, Samantha, Tyler
ME Deliverable	Project Plan Report	9	10/1/15	10/10/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Document Vehicle Performance	11	10/1/15	10/12/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Preliminary Design of Possible Improvements	15	10/1/15	10/16/15	Jakob, Jeremy, Samantha, Tyler, Eugene
ME Deliverable	Midterm Presentation I: Conceptual Design	7	10/9/15	10/16/15	Jakob, Tyler
ME Deliverable	Midterm Report 1	13	10/17/15	10/30/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Detailed Design of Desired Improvement	23	10/17/15	11/9/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Initial Web Page Design	9	10/6/15	10/15/15	Jeremy

ME Deliverable	Final of Webpage Design	41	10/15/15	11/25/15	Jeremy
ME Deliverable	Midterm Presentation II: Interim Design	10	10/31/15	11/10/15	Samantha, Tyler
Team Deliverable	Order Components	10	11/10/15	11/20/15	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Await Delivery of Parts	32	11/21/15	12/23/15	Jakob, Jeremy, Samantha, Tyler, Eugene
ME Deliverable	Final Design Poster Presentation	11	11/20/15	12/1/15	Jakob, Jeremy, Samantha, Tyler
ME Deliverable	Fall Semester Final Report	15	11/16/15	12/1/15	Jakob, Jeremy, Samantha, Tyler
Team Deliverable	Assemble Design	19	12/24/15	1/12/16	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Retest Vehicle Performance	12	1/13/16	1/25/16	Jakob, Jeremy, Samantha, Tyler, Eugene
Team Deliverable	Make Any Necessary Modifications	34	1/26/16	2/29/16	Jakob, Jeremy, Samantha, Tyler, Eugene

5 Conclusion

The objective of the project is to enhance the system by improving the current range and operable temperatures of an electric vehicle. The given constraints will be optimized and will allow the design team the opportunity to progress the electric vehicle. The vehicle performance will be tested so that the parameters necessary for the selection of the generator and the batteries can be quantified.

6 References

[1] The History of Electric Car. The United States Department of Energy. September 15, 2014. energy.gov/articles/history-electric-car

[2] How do Extremely Cold Temperatures Effect the Range of an Electric Car. Megan Allen. January 31, 2013. www.fleetcarma.com/electric-car-range-in-bitter-cold/