Revised Project Plan and Product Specification

Team 2

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Abstract

Team 2 will focus this semester on designing and fabricating a power generation prototype for Cummins, Inc. This will be done using the exhaust gases created at the Cummins Technical Center to generate electricity from a turbine. Team 2 will simulate this design using the exhaust from a generator to power a small turbine. By demonstrating a successful prototype along with a large scale simulation, Team 2 hopes to prove the feasibility of generating power from the engine exhaust.

1. Problem Statement

The Cummins Technical Center (CTC) is looking to reduce their power consumption. Team 2 has been asked to introduce a plethora of energy saving ideas in order to maximize the reduction of the CTC's power consumption. These ideas have included the feasibility of solar panels, installing absorption chillers, updating the insulation, and employ the unused energy from exhaust gases. The challenge Team 2 faces this semester involves developing a system to convert the thermal energy from the exhaust gases into electrical energy.

2. Background

Team 2 visited the CTC on November 14th, 2014 in order to see how Cummins, Inc. measured their energy consumption and investigate any overlooked areas in the testing facilities to save energy. The CTC testing floor has 88 engine test cells along with 8 auxiliary cells. During Team 2's visit, it was discovered the exhaust gases from these test cells were not utilized for energy generation. The ability to recapture the exhaust gases for regeneration purposes promises to provide a significant amount of energy for the CTC. By generating energy from the exhaust gases, this idea can be used throughout Cummins, Inc. Generating energy from the engines will provide the company a way to convert thermal energy into electrical energy which can either be used to power other machinery or be placed back into the grid.

It should be noted that due to the nature and uniqueness of the project, which did not initially require a designed prototype, the team was not required to start procurement until the spring 2015 semester following a change in scope of the project to include a prototype in the final presentation of the project.

3. Objectives

The first objective for this semester is to design a piping system to reroute the exhaust gases through a power generation cycle in order to utilize the thermal energy. The group will run a simulation in MATLAB and SolidWorks to determine the efficiency of the system and its

components. A thermal and material analysis in SolidWorks will be completed in order to determine the best material.

Team 2 also intends to build a prototype with an engine that will be provided by the team's advisor, Dr. Ordonez, to prove the practicality of the simulation. Additionally, the cost of implementation will be analyzed for a full scale application. Finally, the development of energy saving ideas will be used in order to further reduce Cummins, Inc. energy usage.

4. Project Plan

Team 2 will begin the design process by collecting necessary information from John Lashbrook, the CTC's facilities manager. This includes a detailed schematic of the exhaust vent locations on the roof, the temperature of the exhaust gases exiting into the atmosphere, and an approximate engine testing schedule. This information will be used to assist in the design of a piping network that will capture the exhaust gases and route them to a heat exchanger. The heat exchanger will heat water that will vaporize and exit to an energy generation cycle. This energy cycle will be designed by Team 2 and will use the vapor from the heat exchanger to run a turbine to generate electricity.

Figure 1 shows the Gantt Chart that Team 2 has developed in order to complete this project on time. Team 2 will meet daily in order to complete the necessary inspections, calculations, and designs. Once a design has been finalized, a simulation will be created using a CAD program and MATLAB to demonstrate the efficiency of the piping network and energy generation cycle. Team 2 also plans to fabricate a working prototype of the system in order to demonstrate the practicality of the system. The prototype will transfer exhaust from a generator through a piping system to generate power from a turbine. The generator has been donated by Dr. Gupta and the remaining materials for the prototype will be purchased using Team 2's remaining budget of $600. If more money is necessary to complete the project, a detailed funding request will be presented to Cummins, Inc. A work break down is displayed below in Figure 1, which highlights the project plan for the upcoming semester.

Task Name	Duration	Start	Finish
Component Inspection	9 days	Wed 1/7/15	Mon 1/19/15
Exhaust Gas Capture Design	12 days	Sat 1/17/15	Sat 1/31/15
Piping Design	11 days	Mon 1/19/15	Mon 2/2/15
Piping Material Selection	4 days	Sat 1/31/15	Wed 2/4/15
Component Selection	6 days	Mon 2/2/15	Mon 2/9/15
Revise/Edit Material and Design	4 days	Mon 2/9/15	Thu 2/12/15
Cost Analysis	4 days	Mon 2/9/15	Thu 2/12/15
Order Material	10 days	Thu 2/12/15	Wed 2/25/15
Simulation Work	27 days	Thu 2/12/15	Fri 3/20/15
Capture Design Construction	16 days	Wed 2/25/15	Wed 3/18/15
Testing / Simulation Finalized	23 days	Wed 3/18/15	Fri 4/17/15

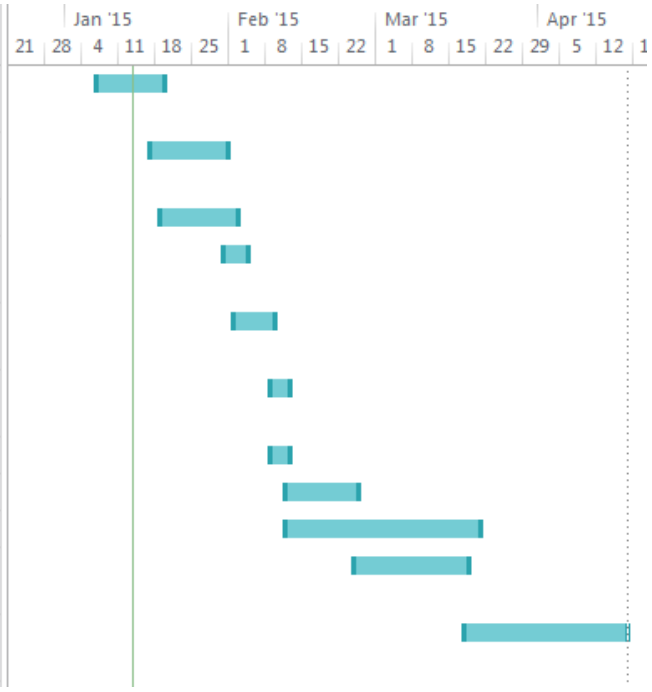

FIGURE 1: GANTT CHART FOR SPRING 2015 SEMESTER

As mentioned previously, the team has started procurement this semester due to the shift in scope of the project. The team plans on meeting with advisor Dr. Ordonez to acquire an engine that will serve as the power source in the prototype exhaust capture system. After the team has finalized the exhaust gas capture design, the team will acquire the necessary components for a functional prototype. This includes the piping, heat exchanger, pumps and valves, and any other components. In order to deal with the challenges of having time to machine components, the team will reach out to local machine shops in addition to the engineering school machine shop to ensure that the prototype can be fabricated in a timely manner. Obviously, timeliness will be a great challenge; however, it is imperative that the team meets all objectives in a successive manner in order to have a successful final presentation.

5. Project Updates

The following section describes challenges overcome and project updates that were developed from the challenges faced.

5.1 Challenges Overcome

Throughout the first semester the team continually ran into small speed bumps halting the design process. Several of the problems encountered were based on a goal oriented dilemma. For instance, one of the objectives had been tweaked from originally requiring a prototype grid monitoring system, which was removed due to the fact that the Cummins Technical Center has a whole room designated just for grid monitoring, and the proposed prototype would not be helpful towards the original goal. The team then began to focus on saving Cummins, Inc. energy solely without the concern for a prototype or actual simulation. However, this pulled the team in too many different directions without a clear path towards reaching an achievable goal. Now, the team's goal is to focus on capturing the exhaust gas thermal energy and converting it to electricity to be put back into the grid. A vast amount of time and headaches were wasted working towards frivolous goals, but this semester Team 2 will not encounter the same issues.

One way Team 2 can avoid any future path confusion starts with better communication. Last semester, the team, advisors, and sponsors were lacking in synergy. That has changed this semester through constant communication and weekly meetings with both advisors and instructors. The team has also scheduled weekly phone calls with the sponsors at Cummins, Inc. Finally, the team has begun to meet on a daily basis in order to help make up for the time lost in the previous semester.

Another major problem the team had was simple formatting errors. For instance, several times the Gantt chart came out on 3 pages or paragraphs were awkwardly spaced on the final printed version of a report. This semester the problem will be avoided by having each member serve as a final proofreader before the document is submitted.

5.2 Revised Project Scope

From the original goal of reducing the energy consumption by 10% by researching a multitude of energy savings ideas, the team decided to focus primarily on capture of the exhaust gases released from the engines being tested at the CTC. This allows the team to have a more solid presentation of data, along with the opportunity to develop a prototype system for the engine exhaust capture.

In addition, the team will use a simulated model that will be validated by an experimental prototype system. Therefore, the newly revised scope is as follows:

“Provide an engine exhaust capture system design supplemented with other energy saving ideas that will assist in decreasing the overall energy usage at the Cummins Technical Center.”

6. Conclusion

This semester the group has taken a different direction for the project, shifting the attention from the original project of reducing the Cummins Technical Center electrical consumption by 10% to creating a gas recovery system for the exhaust gases emitted by the testing cells in the technical center. The technical center has 88 main testing cells along with 8 auxiliary cells in which they test a wide variety of engines. This semester, the group will design a recovery system to reroute the hot gases coming out of the test cells to a Rankine cycle in order to produce electrical energy. The team will also create a simulation that will replicate the conditions that will be encountered in the technical center to have more accurate results for the electrical output. Team 2 will also test the simulation by running a small scale experiment that will recreate the simulation and the conditions of the technical center. The experiment will serve as a prototype system consisting of a piping network that will run the gases through a heat exchanger to heat up water that goes through a turbine thereby producing electrical energy. From this experiment, the simulation will be validated to show the amount of energy Cummins, Inc. can save by implementing a gas recovery system at the CTC.