SAE Eco-Marathon

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Project Formulation and Project Plan

Document

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Mechanical Engineering Design I – Fall 2013

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Contents

PROJECT DESCRIPTION

Need Statement:

Due to the significant number of vehicles running on finite resources as a means of transportation, it has become necessary to research and develop means to stretch those finite resources further. The Shell Corporation has sponsored a competition to promote this research and development in the field of fuel efficiency. The scope of this project is to design, build, test, and present a vehicle that conforms to the set requirements and constraints to produce a vehicle that will produce extremely high fuel efficiency.

OBJECTIVE

The objective of this team for the overall project is to design propulsion, braking, and electrical systems for a vehicle that will safely:

- Start-up and engine at desired rpm within 5 seconds
- Achieve a maximum average speed of 17mph
- Stop the vehicle within 50ft from a speed of 17mph
- Hold a vehicle stationary on a 20% incline
- Completely shut down all vehicle systems within 1 second

Goal:

The team's goal for this semester is to accurately and appropriately design an internal combustion engine powered vehicle for the Shell Eco-Marathon Competition that will have several subsystems working together to reach a fuel efficiency of at least 500 mpg. The team will be focusing on the power train, fuel, electrical, braking and the technical documentation for the competition. The team will work in conjunction with another team from Northern Arizona University (NAU) that will be working on the remaining systems to complete the vehicle design.

BACKGROUND

One of the biggest problems in today's society is the quest to stretch the use of finite resources. One application in specific is designing a vehicle that maximizes the vehicle's fuel efficiency. The more fuel efficient that vehicles can be designed means that the consumption rate of finite resources will decrease, providing a longer use-time of said finite resource. The main finite resource that is showing to be problematic is fossil fuels. With reserves having decreasing standing levels, the price required to acquire these fossil fuels is increasing. This related directly to the prices shown at fuel pumps.

The Shell Corporation puts on a competition, known as the Shell Eco-Marathon, to have engineering students from around the world design and build a vehicle that produces extremely high fuel efficiencies. The competition originally started in 1939 as a bet between 2 Shell engineers. Over time it evolved into an international competition with events held in Europe, the Americas, and Asia. Starting in 2007, a competition was held in the United States, from that point, colleges in the US were able to compete. The Shell Corporation hopes that this competition will help spur new and cutting edge vehicle designs and vehicle systems.

OPERATING ENVIRONMENT

Our operating environment can be broken into 4 main sections: design, build, test, and competition. The bulk of design and fabrication work will be done at the NAU campus in Flagstaff, AZ. The design work will consist of weekly group and team meetings. This is to insure that all of the team's member's independent work will be appropriate to the overall design and has yielded accurate results.

All of the fabrication of the design vehicle will be done at the student build shop located on the NAU campus. This is where the design vehicle will take form, having all of the separate systems coming together. The team will assemble ordered parts, fabricate custom parts, and install systems on the vehicle. The initial engine break period will be held here. The team's drivers will also gain experience driving and operating the integrated systems in the vehicle to ensure they are easy to operate.

The team will perform initial quality tests in Flagstaff, but will travel down to Phoenix, AZ to get a more accurate tune for the competition location. Since the competition is located in Houston, TX, elevation 43 feet above sea level, tuning the vehicle for Flagstaff's elevation of 7000 feet above sea level would not yield the best engine efficiency results come competition. Thus, the team will take the vehicle and tune it to an elevation of 1200 feet above sea level in Phoenix. The reasoning behind this is so that there will not be a severe change in tuning as compared to an extremely high elevation of 7000 feet.

The final operating environment will be the Shell Eco-Marathon Competition located in downtown Houston. Here the vehicle will be tuned and have several practice laps before the actual competition. This is also where the team will present the technical documentation for the vehicle.

DESIGN CONSTRAINTS

The following is a list of constraints set by the Shell Eco-Marathon Competition. The vehicle must conform to these constraints, if not the vehicle will not be allowed into the competition. They are broken into several systems that the team is responsible for designing.

Drive train Constraints (Transmission & Clutch):

- Effective transmission chain or belt guard(s):
  - Protect driver or technician
  - Made of metal or composite material
  - Rigid enough to withstand a break

- Manual Clutch:
  - Must not have the starter motor operable with the clutch engaged.
- Automatic clutch:
  - Motor starting speed below speed engagement of the clutch.

Braking Constraints:

- 2 Independent Systems
  - Front Wheel(s)
  - Rear Wheel(s)
  - All wheels must have braking force applied
  - Simultaneous Engagement

Fuel System Constraints:

- Fuel must be Shell Regular Gasoline (87) or E100 (100% Ethanol)
- Fuel tank must be APAVE certified and a volume of either 30,100,or 250 cc
- Fuel tank must be mounted in a zero degree position and at least 5cm below the roll bar
- Air Intake must not contain any fuel or blowby gas
- Internal and external emergency shut-down systems must shutdown the ignition and fuel supply
- External system must be permanently mounted to body
- External system must have a latching red push button and be labeled with a 10cm by 3cm wide red arrow on a white background·
- Fuel line between tank and engine may not contain any other elements
- Fuel lines must be flexible and clear in color and not prone to expansion
- Teams cannot increase or decrease the fuel temperature
- Float chambers must include a drain valve at the bottom of the carburetor to ensure fuel level goes down in the fuel tank

Electrical System Constraints:

- Maximum on-board voltage must not exceed 48V nominal
- Only one on-board battery and the battery must maintain a constant ground
- Electrical circuits must be protected from short circuit and overload
- Electric horn must be 85 dBa and pitch of 429 Hz
- Electrical starter can only operate when ignition and fuel systems are activated
- Electrical starter must not provide propulsion
- A red starter light must be installed on the rear of the vehicle with a luminescence of 21W and be clearly visible from both sides
- Starter and starter light must be extinguished by the time the rear wheel crosses the start line

Technical Documentation Constraints:

- Fuel System
  - Full description and detailed schematic from tank to motor
    - Including pressurized air bottle, pressure relief valves, air pressure gauges, fuel tank, valves, injectors, float chambers, and pumps
  - Description of vehicle clutch operation
  - Specifically showing starter motor does not engage clutch
- Electrical System
  - Circuit diagrams with all components listing voltage, current, and power ratings
    - Show emergency stop switch locations for inside and outside of car
    - Show battery location with type and rated voltage
    - Show starter motor location
- All documentation must be current, have printed copies, and be displayed on a poster

PLANNING

The project has already begun with initial research. The project is slated to end with the demonstration of a high mileage vehicle in the SAE Eco-Marathon competition in Houston, Texas. There are many steps in between the ends. A quick summary of those items is: developing alternatives, choosing the best systems, working up full drawings, ordering/making parts, and fine tuning the system. It is possible to make a more granular breakdown of the steps it is going to take, however at this point in development that is unnecessary due to the large amount of unknowns still needing to be fleshed out. A Gantt Chart is provided in Appendix A with approximate dates as to when different sections of the project that this team is responsible for are expected to start and complete.

Quality Function Development:

Based on the QFD, as show in Appendix B, it can be seen that weight is the most relevant of the engineering requirements to satisfy the customer needs. Therefore, the weight component of our design has to be maximized the most compare to the rest of the engineering requirements identified above. It can also be seen that accessibility and steering geometry are the least important of our engineering requirements which means they are not relevant to our client. As for the rest of the engineering requirements, our QFD shows that they are all of same importance which means we have to do our calculations carefully for all of them as they will all be very important to satisfy our client.

CONCLUSION:

The Shell Eco-Marathon competition is designed to foster new ideas for how to improve the efficiency of the modern vehicle. The drive train sub-team for the SAE Eco-Marathon NAU Capstone team is dedicated to creating the most fuel efficient vehicle possible within the constraints put forward by SAE and NAU. Fuel efficiency is of paramount importance to every human being that drives a vehicle that runs on fossil fuels, not only because it’s getting more expensive, but because there isn’t an infinite amount available to use for fuel. This is a huge reason that fuel efficiency needs to be constantly getting better. There have been a lot of advances in this area since the Eco-Marathon competition started 75 years ago as a bet between engineers, and hopefully in the next 75 years there will be exponentially more progress made to improve fuel efficiency.

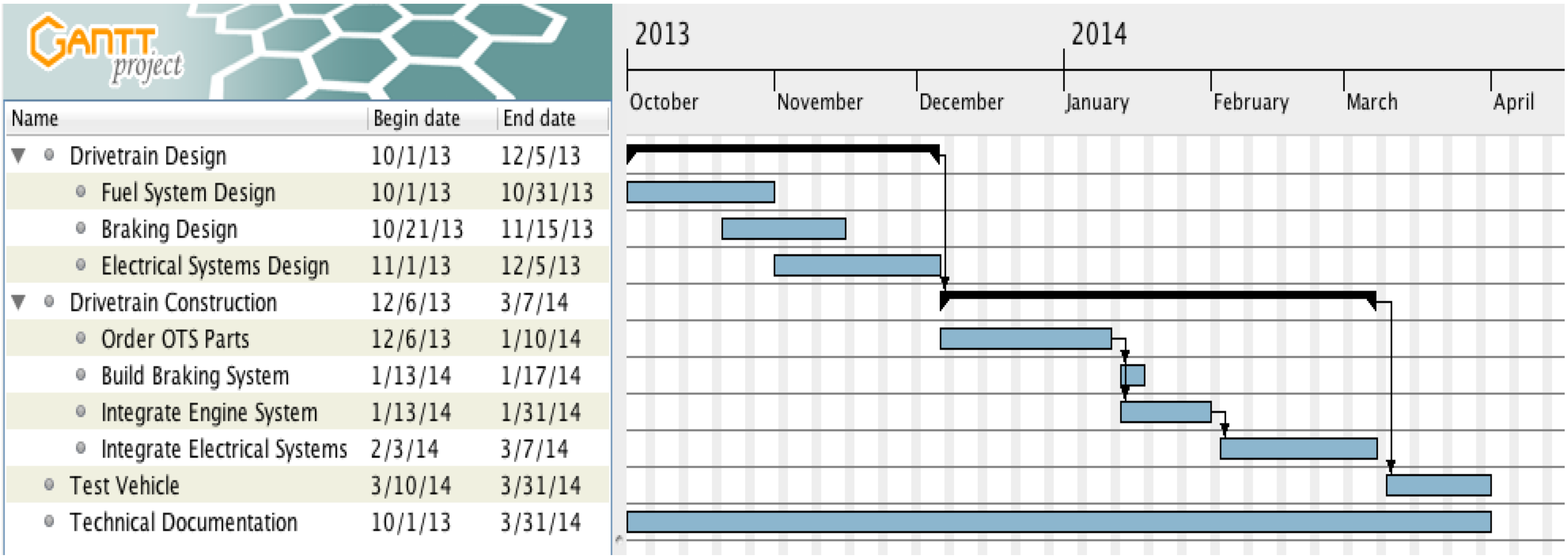
REFERENCES

Shell Eco-marathon, "Official Rules 2014 Chapter 1,"http://s01.static-shell.com/content/dam/shell-new/local/corporate/ecomarathon/downloads/pdf/sem-global-official-rules-chapter-1-2014.pdf, 01 Oct. 2013.

"Sources." EPA. Environmental Protection Agency, n.d. Web. 03 Oct. 2013.

APPENDIES

Appendix A: Gantt Chart



Appendix B: QFD Chart

			Maximum Efficiency Vehicle								
			Requirements								
	Customer Needs	**Customer Weights**	Accesibility	Part strength	Horse Power	Torque	Weight	Velocity	Friction	Steering geometry	Gear Ratio
Drive	Maintain average lap time	7	0	1	8	6	10	5	2	1	7
	Complete course efficiently	10	0	1	9	6	10	6	6	1	10
	Manuever course	7	0	3	6	8	7	8	8	10	5
Braking	Braking distance	6	0	5	0	0	8	0	10	0	0
Safety	Operate safely	6	10	10	1	3	1	0	0	0	0
	Be stable	5	0	8	0	3	8	4	7	3	0
		Raw score	60	168	194	191	313	171	225	102	184
		Relative Weight	4%	10%	12%	12%	19%	11%	14%	6%	11%
	*U.L. ; Stands for unitless	**Unit of Measure**	s	psi	hp	lbf	lb	fps	U.L.*	U.L.*	U.L.*