SAE Baja Design

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Team Drivetrain

Problem Definition and Needs Identification

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design I – Fall 2013

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I. Introduction

The Baja Vehicle Design is a competition sponsored by the Society of Automotive Engineering (SAE) and hosted in different locations across the country. Teams of students from different universities will design and build a Baja vehicle to compete against each other. All teams will use the 10 hp OHV Intek provided by Briggs & Stratton Corporation. The teams will have to build the vehicle to fit that engine and maximize their designs to meet the design objectives and win the competition. For the capstone senior design project, the Baja vehicle was assigned to three teams each with a separate task. All teams must collaborate together to design the vehicle. The tasks assigned to the teams are the frame design, suspensions design, and drive-train design. In this report, drive-train first stage analysis is discussed where customer needs, product specifications, and project plan will be identified and explained.

II. Objectives

The main objective of this project is to design and build a Baja vehicle that meets the client and stakeholders requirements and needs. Our client is the Society of Automotive Engineering (SAE) and they are the sponsor of the competition who sets the rules and regulations. The stakeholder is Dr. John Tester who will oversee the project progress to make sure that our teams design will win the competition. To win the competition, the Baja vehicle will be run through a series of events to see if it finishes them successfully. These events include acceleration, traction, maneuverability, specialty, and endurance events. Our team will design and build a drive-train with all these objectives in mind to ensure winning the competition. Based on the information obtained from the stakeholder and provided by the SAE, specific objectives are set by our team to maximize the drive-train design. Objectives include choosing a transmission that can have reverse so that the Baja vehicle can succeed in the maneuverability event. Moreover, the gear ration has to be maximized so that the resulted torque will win the acceleration and traction events. Finally, the sprocket materials will have to be chosen carefully so that the drive-train will have better endurance. This will result in low maintenance to be needed and will successfully complete the endurance and specialty events.

III. Needs Identification

- Customer Needs described by Engineering Requirements
    - These are the needs that the team has discussed and established as what the customer wants to see in this product. Requirements are needs that are nonnegotiable and in this case describe the engineering properties we use to measure the established needs.
- Safety: No matter how well the system works, if it's not safe than it can't be used. Safety is of large importance.
    - Related specification: Material strength (Kpa) - Any number of tests can be done to make sure that the product is durable. It would not make sense to do long term test so some equivalent short term stress test would measure what kind of stresses the system could potentially handle.

- Desirable Acceleration: For our Baja vehicle project to be successful, the vehicle must reach the peak acceleration of the engine provided. It is a key point to win the acceleration competition.
    - Related specification: Power efficiency- The efficiency will be measured by calculating the amount of power transferred from the motor to the wheels.
- Ability to climb the hill: In order to complete all the events in the competition, the vehicle must be able to climb a hill with the highest velocity that it can. The vehicle also needs to complete the whole hill course to even place no matter how great the velocity is.
    - Related specification: Torque (N.m) - To measure the transferred torque, the team will calculate it by using gear ratio from the CVT transmission and secondary gear box.
- Ability to pull an excess load: The traction event will be provided, if local terrain does not support a significant hill climb. Therefore, for our project to be successful, the vehicle must be able to pull an excess load on a flat surface as fast as it can.
    - Related specification: Torque (N.m) - To measure the transferred torque, the team will calculate it by using gear ratio from the CVT transmission and secondary gear box.
- Durability: Since the Baja vehicle needs to complete multiple events in the competition, it must be able to uphold peak performance during the tests as well as competition events.
    - Related specification: Cost ($) - To measure the cost, a breakdown of each material used on one product will be calculated. It will be measured in dollars per unit.
- Long Maintenance Period: Since the Baja vehicle will go through many tests and competition events, a longer maintenance period will save much of our time. It will also make the whole system more reliable.
    - Related specification: Cost ($) - To measure the cost, a breakdown of each material used on one product will be calculated. It will be measured in dollars per unit.
- Large max Velocity: For our Baja vehicle to win the competition, it must go as fast as possible.
    - Related specification: Velocity (m/s) - To measure the velocity, the team will time how long it takes to go through a significant distance.
- Ability to reverse: In order to handle all the different competition events, the vehicle must be able to reverse and adjust its position. Optimally this will save time the case of a misjudged obstacle or is the vehicle gets stuck.
    - Related specification: Torque (N.m) - To measure the transferred torque, the team will calculate it by using gear ratio from the CVT transmission and secondary gear box.
- Inexpensive: Because of our limited budget, the team must consider the cost of all the materials used. Making it performs the best under the limited budget is the largest point we should focus on.
    - Related specification: Cost ($) - To measure the cost, a breakdown of each material used on one product will be calculated. It will be measured in dollars per unit.

The QFD is a chart that takes the weighted importance of all customer needs and plots them against engineering properties required to compute the required analysis of those needs. It can be useful to define the needs but more importantly it makes for a great communication tool. For instance you would draw up a QFD and display the weighted importance of each need. Then you would present this to your customer. If the customer believes that the weights are sufficient and accurate then you may move as planned in you project.

	Engineering Requirements for Drive-train							
Customer Needs	**Customer Weights**	Cost	Size	Torque	Weight	Velocity	Material strength	Power efficiency
Safety	7	3			3	1	9	
Accelarate fast	8	1	3	9	3	3		9
Able to climb the hill	10	1		9	3	3		3
Able to pull an excess load	10	1		9	3	1		3
Durability	9	3					9	
Long maintenance period	5	3	3				9	
Drive fast	10	1		3	3	9		3
Able to reverse	8			9				
Inexpensive	7	9	1		1		3	
	Raw score	164	46	354	142	161	210	162
	Relative Weight	13%	4%	29%	11%	13%	17%	13%
	Unit of Measure	Dollors	m^3	N.m	kg	m/s	Kpa	ul
	***ul--> Unitless by method**							

Figure A-1: The Quality Function Deployment (QFD)

IV. Product Specification

- Introduction
  - The requirements and constraints described below are in accordance with the 2014 Collegiate Design Series Baja SAE rules. See References for link for these provided rules.
- Requirements
  - As a competing university SAE requires us to design a transmission that is compatible with the ten horse power motor, which provided by Briggs and Stratton. This motor requires us to consider using a secondary reduction system or other means to increase the torque and maximum velocity. Because this project requires you to design the drive-train, it is very open ended and most of the constraints come from the constraints of other parts.
- Constraints
  - The constraints for this competition are fairly loose as far as the design of the transmission goes. Thus we pull most of our defining information from specification of the motor. For instance each motor is governed at 3800 RPMs so this provides one boundary for the design of our drive-train.

V. Project Plan

- The Gantt chart is a diagram, as seen below, that shows the whole project plan laid out over time. We did this because the Gantt chart can keep us on track, and it will remind us what we should be doing next. The purpose of this item is to be able to track our progress good or bad and so that

superiors are able to track you as well. These projections can also be used to estimate cost of labor and salary if this is applicable.

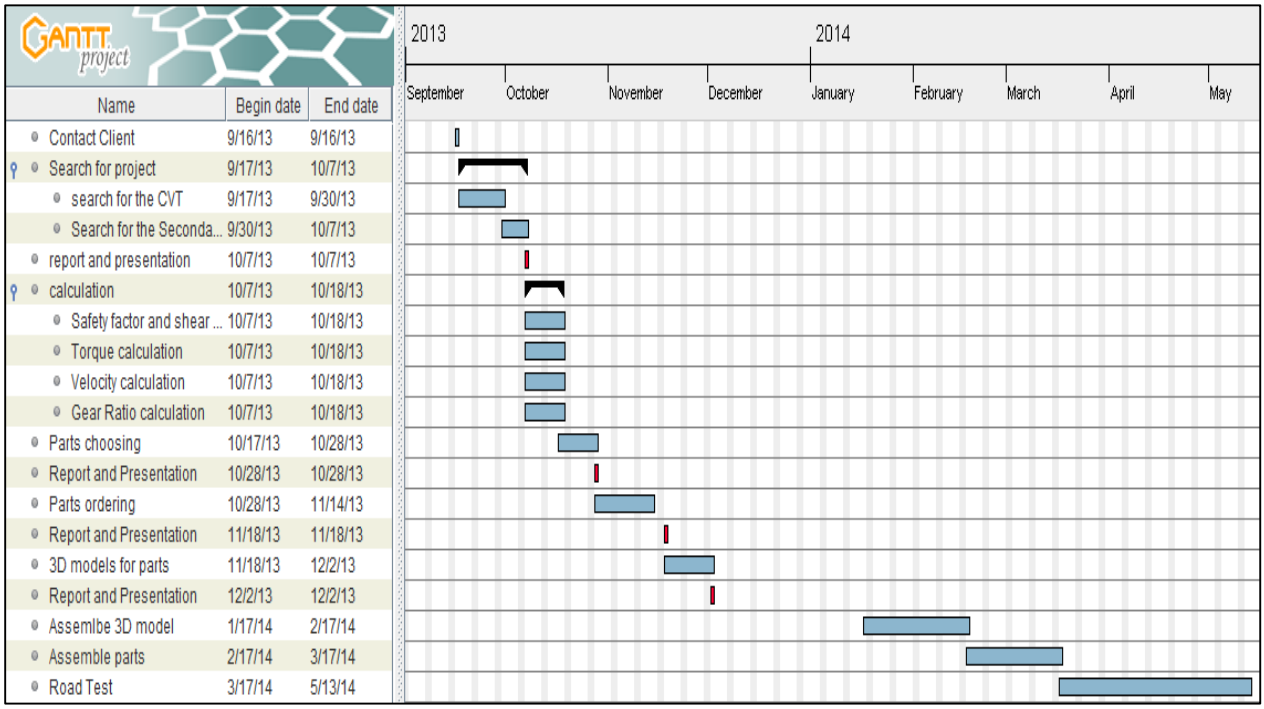

Figure A-2: This diagram depicts our project plan over the course of the school year.

- Based on the Gantt chart, the first step is to meet with the client, because we need to figure out what the customer needs are. And this will be done at 9/16/13.
- During the period, 9/17/13 to 10/7/13, we will do project research, which is included the search of CVT and Secondary reduction, since our group is working on the drive train part.
- After we finished the searching part, we will do calculations by using equations to figure out what the gear ratios for our secondary reduction are, and how many torque we can transfer from engine to the wheels, and how fast the car can run. We are also going to calculate the safety factor for our drive train parts and the shear forces add on the rear axle. The calculations will be finished between 10/7/13 to 10/18/13.
- In the final analysis process, we will spend 4 days to rerun the numbers and equations to make sure we order the right parts for our project.
- From During 18 days, we will do the parts choosing and ordering. The parts choosing is by using the data we get from our calculation to choose the parts we need from different company's products. And then, we order the parts.
- 3D models for our parts will be done in 18 days. We will make 3D models for parts and assemble them will be on next semester.
- In the next semester, after we finished the 3D assembly, we can start to build the secondary reduction from 11/15/13 to 12/20/13.
- Installing the CVT will be our next task. It will take about one week. We will spend another week to install the secondary reduction after we finish the CVT installation.

- Different tests will be done until from 3/5/14 to 4/17/14, which is included the manual testing and fuel testing.

VI. Conclusion

Based on the information presented above the drive-train section of the Baja Competition Team has identified exactly what is expected of us. We have a firm grasp of how long these needs will take to be met and exceed our stakeholders' expectations. In the Baja design project all teams are provided with the same 10 horsepower engine, but the key to win the competition is by optimizing the rest of the vehicle's design aspects. Based on the client needs and the engineering requirements that were established, we were able to identify the major points where we need to optimize the calculation to successfully complete all the tasks. This will obviously be different for every aspect of the cart and will need to be taken on by each of the three teams. In the case of the drive-train we will be optimizing; the gear ratio to provide proper torque and power distribution, sprocket materials to provide low maintenance and ensure durability, lastly install reverse to achieve maneuverability.

VII. References

1. **2014 Collegiate Design Series: Baja SAE ® Rules**
   http://www.sae.org/students/2014_baja_rules_8-2103.pdf