SAE Mini Baja - Drivetrain

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Team 11

Project Definition and Project Planning

Document

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1.0 Introduction

On behalf of the Society of Automotive Engineers (SAE) Dr. John Tester contracted our group to design and develop a single seater all terrain vehicle. The design project is sponsored by SAE to help bridge the gap for students between analytical book work and actual design work of professional engineers. This task is accomplished by having the students design the vehicle so a fictitious company would be interested enough to purchase the design and manufacture 4,000 units per year. Having so many design areas and specifics our design group is broken up into three sub groups: frame, drive train, and suspension. We are the drive train team and therefore will be focusing on the vehicle design from the engine to the wheels, and every part in between.

2.0 Customer Needs

Dr. John Tester is the current customer and advisor that the Mini Baja transmission team must consult before making any design or manufacturing decisions.

Dr. Tester expressed a need for an improved drivetrain this year, stating that last year's drivetrain was too heavy and must be more lightweight in order to improve vehicle performance. Also last year's reverse gear could have been better designed and engaged in a cleaner, more effective manner, so this year's reverse must be better designed and more integrated within this year's gearbox. Finally, the drivetrain needs to be safe and more reliable than last year's, as a broken engine/drivetrain mount prevented the team from achieving a better scoring position in competition.

2.1 Project Goal

In last year's competition the NAU Mini Baja placed 58th in the acceleration test and 64th in the hill climb test. The goal the team has for this project is to design a drivetrain that will be competitive and place in the top 10 for the acceleration and hill climb tests against other competing universities.

2.2 Objectives

- The Drivetrain team has chosen six objectives for the 2014-2015 Mini Baja project: size, weight, cost, the acceleration and hill climb tests, and safety. For size, the team defined it as the volume the gear box occupies, in inches cubed (in^3). Weight was decided to mean

the weight of the entire gearbox, in units of pounds. Cost is the cost to produce the drivetrain, in dollars. The acceleration test was decided to be the number of seconds it takes for the Mini Baja to travel 100 feet. The hill climb challenge is how far the Mini Baja can make it up an incline, in units of feet. Safety is defined to be a factor of safety of at least 2 in every component of the drivetrain.

2.3 Constraints

For this year's Mini Baja transmission there were a few constraints the team had to consider before proceeding with a QFD and HOF evaluation.

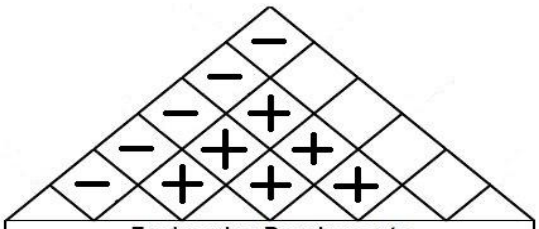
- Use provided/donated Briggs and Stratton 10hp OHV model 20 engine. The team must use the provided engine and cannot alter the engine in any way to allow for a performance advantage against other competing teams.
- The drivetrain must be designed within the SAE baja rules. The only rules that pertain to the drivetrain portion of the Mini Baja include covering any moving components.
- The baja must complete a 0-100 foot acceleration trial in 4 seconds on dry level pavement. The team has found that top placing competing schools have completed the 0-100 foot acceleration challenge in around 4 to 4.5 seconds. Since the acceleration challenge relies so heavily on gear ratios and weight, it will be the teams responsibility to choose the right ratios in order to achieve an acceleration time of 4 seconds.
- The Mini Baja must be able to climb an incline of 60 degrees. From research of recent competitions the greatest incline at a given competition was around 60 degrees. The team must choose gear ratios that will allow the Mini Baja to complete the hill climb, as well as complete the hill climb in a competitive time against other Universities.
- The drivetrain must be manufacturable. The team needs to design components for the drivetrain that will be practical and manufacturable, preferably in the NAU machine shop. Though the team is not limited to only producing parts in the machine shop, it is ideal because it will cost less money and allow the team to spend its resources in other needed areas.

3.0 Operating/Testing Environment

As the drive train design team we are focusing on our static requirement, the Briggs and Stratton 10 Hp engine. We are currently planning ot have the engine dyno tested to find out what the exact power curve is for our specific engine. In prior years teams have gone off what the manufaturer posts to their web pages. We have found these given curves to be very general and not specific enough to design a drive train with. From the dyno we hoep to find out what torque we have at specific rpms resulting in the ability to determine desired gear ratios for fast acceleration and the ability to climb steep grade hills.

We are also hoping to tune the motor within the rules to achieve max power. Given the limited size engine any improvements would result in large performance gains. We will be looking at valve timing and seating, as well as armature gap and timing. We are curently looking for an expert in the area to assit with the engine work.

4.0 QFD/HOQ



			Engineering Requirements						
High -9 Medium - 5 Low - 1 None - 0			Cost	Weight	Volume	Acceleration	Hill Climb Angle	Safety	NAU Baja 2013-14
		Weighted %	↓	↓	↓	↑	↑	↑	
Customer Needs	Lightweight	30%	9	9	9	9	9		
	Reverse Gear	20%	5	9	9				X
	Reliable	30%	9	9	1			9	X
	Manufacturing Limitations	10%	9	9	9	9	9		X
	Inexpensive	10%	9	9	5	9	9	9	
		Units	$	lbs	in^3	sec	Degrees	F.O.S.	
		Score	8.2	9	6.2	4.5	4.5	3.6	
		Weighted Percentages	22.78%	25.00%	17.22%	12.50%	12.50%	10.00%	
		Targets	2500	100	1000	4	65	>2	
		NAU Baja 2013-14	3000	160	1809.5	5.879	40	10	

Figure 1 QFD-HOQ

As you can see form Figure 1 we have listed out customer requirements and out engineering requirements with their weighting. We have determined that our largest impacts on desired outcomes depends on our cost and weight. This makes sense since we are trying to cut weight this year and money is always a challenge. As you can also see from our HOQ that these two parameters are negatively correlated. This will be a challenge to overcome, but due to the ability to raise more money it shouldn't hinder our final product to harshly.

5.0 State of the Art Research

- State of the Art (SOTA) Research
  - Transmissions textbook, “Automotive Transmissions: Fundamentals, Selection, Design and Application” by G. Lechner and Harald Naunheimer
  - SAE 2015 Mini Baja Rules
  - SAE 2013-2014 Mini Baja NAU Chapter Webpage
  - Previous SAE Mini Baja projects from other universities

6.0 Project Planning

The Gantt chart is a useful tool that shows our entire project plan for this semester. The Drivetrain team, Dr. Kosaraju, and Dr. Tester can track our progress through the designing and building processes of the 2014-2015 Mini Baja’s drivetrain by observation of the teams Gantt chart.

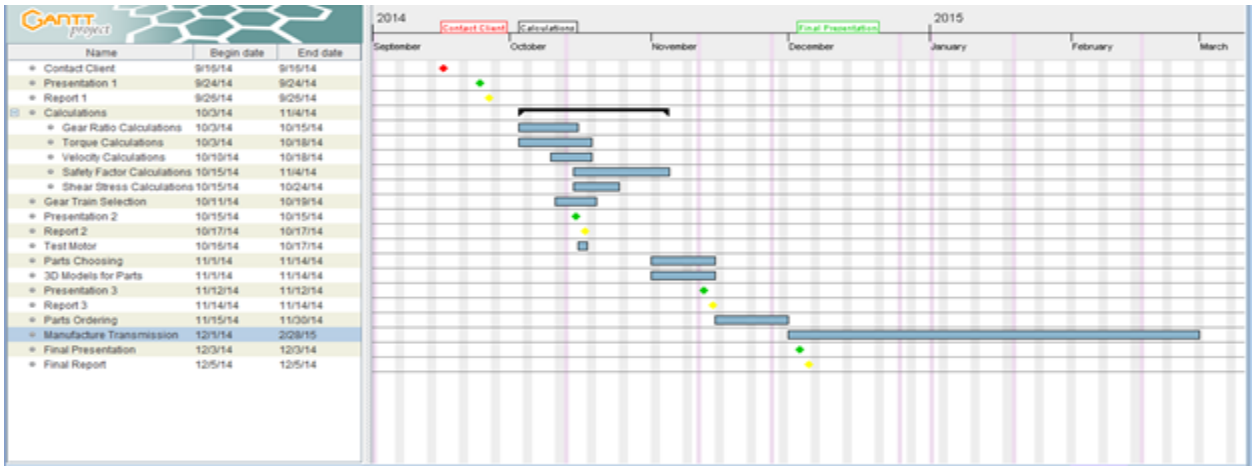


Figure 2 Gantt Chart

1) The Gantt chart begins with the Drivetrain Team meeting with Dr. Tester on September 16, 2014 to understand what our customer's needs are.

2) Wednesday September 24, 2014 through Friday, September 26, 2014 are the due dates of the first presentation and report.

3) Then, the Drivetrain team will be doing calculations for the gear ratio, torque, velocity, safety factor, and shear stress requirements that we have set for our transmission – this will all be started by October 3, 2014, and done no later than November 4, 2014.

4) By October 11, 2014, the team will have selected its gear train to be used on the 2014-2015 Mini Baja. The following week will include the second presentation and report due dates.

5) Between October 15 and 17, the Drivetrain Team will be testing the motor supplied to us by SAE. Once this is completed, we will have all of our parts chosen for the transmission by November 14, 2014, as well as developing the 3D models of the parts in Solidworks.

6) The third presentation and report due dates are between November 12-14, 2014. The team then plans to have all of the parts ordered by November 30, 2014.

7) The Drivetrain Team then plans on beginning to manufacture the transmission starting December 1, 2014 and to have it completed by the end of February 2015.

8) Finally, the last presentation and report due dates are set between December 3-5, 2014.

7.0 Conclusion

As you can tell this is a very challenging and also rewarding design project. We will be busy in the coming months testing and calculating what power transmission design will be the most adequit fit for our applicatio. We will have to over come the challenge of our main two design factors conflicting. The other obstacles will be reducing the weight of our entire design to 100 lbs or less, and also be capable to place in the top ten in the acceleration challenge and the hill climb.

8.0 References

2015 Collegiate Design Series: Baja SAE Rules
http://bajasae.net/content/2015%20BAJA%20Rules%20.pdf

Tester, John T., PhD, Associate Professor Northern Arizona University, personal communication, Sept. 2014.

SAE Mini Baja 2013-2014 NAU Chapter Webpage:
http://www.cefns.nau.edu/capstone/projects/ME/2014/SAE-MiniBaja/

Transmissions Textbook: Lechner, G., Harald Naunheimer. Automotive Transmissions: Fundamentals, Selection, Design and Application. Berlin: Springer, 1999.

NAU Student Chapter of SAE "2006 Mini Baja," www.cens.nau.edu/~jtt3/Minibaja06, April 2006