SAE Mini BAJA: Suspension and Steering

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Team 11

Problem Formulation and Project Plan Report

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design I – Fall 2014

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Introduction

Every year, the Northern Arizona University's Society of Automotive Engineers supports individual teams to compete in SAE national events. This year, they are supporting a team to compete in the mini baja competition. Dr. John Tester is the current advisor to NAU's SAE branch and will be our team's client for the project. Our team's goal this year will be to design and fabricate a lightweight and reliable suspension and steering system for the car.

Customer Needs and Project Goals

After speaking with our client, Dr. John Tester, he has developed a list of needs pertaining to the suspension and steering systems for the new SAE Baja vehicle. The previous Baja team did well last year, but there are many components and systems on the vehicle that could be improved.

The first need that Dr. Tester has stated is that the approach angle of the current Baja vehicle is too small. A vehicles approach angle is the angle of the line drawn from the leading part of the vehicle to where the front tire meets the ground. At the competition, we know we will encounter large boulders and rocks driving through the course. Our job is to make sure we have a large enough approach angle to not high-center on any obstacles during competition. To address this need, our goal is to increase the approach angle of the vehicle.

Another need that was stated is the lack of suspension mounts integrated into the current frame design. The existing Baja vehicle has extra bars welded to the frame specifically to mount the suspension system to the vehicle. Extra bars can add unwanted weight and provide no extra strength to the frame. To address this need, our goal is to work alongside the frame team to design suspension mounts into the new frame design. We hope, that by accomplishing this goal, we can minimize the overall weight of the vehicle and only have members that keep the frame and suspension structurally sound.

On the current Baja vehicle, the turning radius provided problems during the competition last year. Because of this, another need for the vehicle is that the overall turning radius is too large. The previous Baja team encountered multiple tight radius corners that required shifting the vehicle into reverse to get the right angle to make the corner. To resolve this need, our goal is to

design a steering rack with an increased turning radius for improved maneuverability, mainly around sharp corners.

One of the biggest complaints about last year's vehicle was the vehicle weight. Because of this, another need for the vehicle is that the suspension and steering components weight too much. The previous team's vehicle weighed 650 lbs. As an entire group, we would like to reduce weight drastically because reducing weight improves many key characteristics of the vehicle. To address this need, our goal is to design a suspension and steering system that is not only minimized in weight, but still provides high strength. We plan to reduce weight by using lighter materials for suspension components, and possibly designing a totally different suspension system requiring less suspension components.

Another need is that the track width of the existing vehicle is too wide. A specific trailer was rented in previous years in order to transport the vehicle to competition. This can become problematic, because money that could be spent on valuable vehicle components and testing was instead spent on transporting the vehicle to the competition. Due to this need, our goal is to design a suspension system that is minimized in track width. By achieving this goal, we will be able to fit the vehicle in the back of a pickup truck or trailer and not need to spend money renting a vehicle for transportation.

Finally, the last need from our client is that some of the suspension and steering components on the previous vehicle where not designed by our engineering team. In last years competition, the Baja team lost valuable points because some of the components were not designed but bought from a off-road vehicle manufacturer. To address this need, our goal is to design, build, and test suspension and steering components that were purchased by the previous Baja team. We hope that we can score higher in the competition provided we design all suspension and steering components.

Objectives

To quantify how we will measure the goals for our project, we have developed some objectives to accomplish before competition. All the objectives listed relate to a goal stated in the

previous section. The table below outlines our objective, how we will measure that objective, and the type of measurement system we plan on using to quantify our objectives.

***Table 1*- Objectives Table**

Objective	Measurement Basis	Units
Width	Track width of Mini Baja	in
Weight	Weight of all steering and suspension components	lb
Maneuverability	Turning radius	in
Approach Angle	Ride Height	in
Reliability	Repetition of suspension and steering components	reps

Constraints

To fully satisfy the customer and participate legally in the SAE Mini Baja competition, there are a few constraints. Many constraints are from the customer, who would like to see an improvements from the vehicle from last year. The track width of the vehicle must be 59'' or less. The previous car had a very long track width making it harder to turn. The customer would like the vehicle to be able to make a U-turn on a standard 2 lane road. All suspension mounts must be integrated into the frame with no extra bars for suspension only. The weight must be less than 450 lbs which is quite a significant decrease from the previous car weighing in at 650 lbs. Finally, the vehicle must conform to the rules laid out by SAE.

Testing Environment

Since the competition environment will be in Portland Oregon, the testing environment should be comparable to the region. This will be late spring so there should be an average amount of precipitation, and weather should be in the 50-70 degree fahrenheit range. Since the course is constructed only a few days before the competition, it is impossible to design a vehicle solely around the terrain. However, we can make educated guesses on what we expect to see on the course in Portland. We can assume that we will be spending the majority of the time in dirt, or mud if rain is in the forecast. We can also expect rugged terrain and many rocks. Taking this

into account, we will test the vehicle out in the forest where there is ample rocks and rough terrain. Testing will also occur on fire roads as there should be many similar roads in the competition. Accelerometers will be used to determine if the suspension is adequate for the competition. Aside from testing outdoors, Finite element analysis on Solidworks and other testing software will be used.

QFD and HOQ

The purpose of this section is to ascertain what aspects of the design deserve the most attention. From the previous years car, we have learned that weight, maneuverability, and size are things that can be improved on. In the figures below, the clients needs are related to each other and the design requirements to give a more concrete understanding of what is required.

Table 2- QFD

			Engineering Requirements					
		Weight	Yield Strength	Turning Radius	Ground Clearence	Suspension Travel	Weight	Cost
Customer Needs	Durability	9	9		3	3		
	Weight	10					9	3
	Cost Sensitive	7					3	3
	Safety	10	9		3	3		
	Manueverable	8		9	3	3		
		Score	18	9	9	9	12	6
		Weighted %	29	14	14	14	19	10

The QFD shows that strength and weight reduction should be the largest factors in producing a successful design. Cost is low in this calculation, because we are not working with a fixed budget and we have the ability to raise more money for parts.

Figure 1- HOQ (+ is a positive correlation, - is a negative correlation)

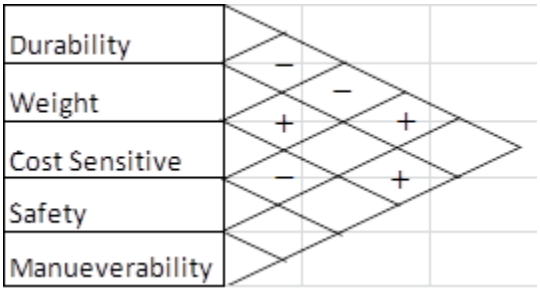

Figure 2 gives a great example that the top two aspects picked in the QFD have a negative correlation. That is, that we cannot increase the strength of the design without sacrificing on weight. The design will then have to find a good medium of weight savings and strength.

Conclusion

This report details the project problem formulation and planning. The client needs were used to identify the problem with last years vehicle. The problem was divided into goals, objectives and constraints. A QFD and HOQ are used to identify and correlate constraints and objectives with others to allow for a better designed product. Only after these tasks are completed a Gantt chart is used to plan the project from beginning to end. The chart begins September, 14 to May, 27 which is the day of competition.

References

- Dr. John Tester
- S. International, "2015 Collegiate Design Baja SAE Rules," 2014. [Online]. Available: http://bajasae.net/content/2015%20BAJA%20Rules%20.pdf.

Appendix A

Task Name	Duration	Start	Finish	Predeces
Start	0 days	Mon 9/15/14	Mon 9/15/14	
Research	**21 days**	**Mon 9/15/14**	**Mon 10/13/14**	
Pros/Cons of Previous Design	**10 days**	**Mon 9/15/14**	**Fri 9/26/14**	
Suspension	10 days	Mon 9/15/14	Fri 9/26/14	1
Steering	10 days	Mon 9/15/14	Fri 9/26/14	1
New Research	**11 days**	**Mon 9/29/14**	**Mon 10/13/14**	
Suspension	11 days	Mon 9/29/14	Mon 10/13/14	4
Steering	11 days	Mon 9/29/14	Mon 10/13/14	5
Design	**24 days**	**Tue 10/14/14**	**Fri 11/14/14**	
Suspension	10 days	Tue 10/14/14	Mon 10/27/14	7
Suspension Solid Model	6 days	Tue 10/28/14	Tue 11/4/14	10
Suspension FEA	8 days	Wed 11/5/14	Fri 11/14/14	11
Steering	10 days	Tue 10/14/14	Mon 10/27/14	8
Steering Solid Model	6 days	Tue 10/28/14	Tue 11/4/14	13
Steering FEA	8 days	Wed 11/5/14	Fri 11/14/14	14
Build	**15 days**	**Mon 11/17/14**	**Fri 12/5/14**	
Suspension	15 days	Mon 11/17/14	Fri 12/5/14	12
Steering	15 days	Mon 11/17/14	Fri 12/5/14	15
Sign up for competition	0 days	Tue 10/7/14	Tue 10/7/14