Baja SAE Drive-train

Abdulrahman Almuflih, Andrew Perryman, Caizhi Ming, Ruoheng Pan, Zan Zhu

Department of Mechanical Engineering, Northern Arizona University

Abstract

SAE Baja competition is a international competition in which student teams from many universities compete in a series of events designed to test the Baja vehicle to its limits. Student teams must engineer and build a single seat off-road vehicle. It must be able to traverse rugged terrain like rough roads or steep hills while offering the upmost level of safety for the occupant. A group of 15 students from NAU is participating in this competition at University of Texas, El Paso in late April. Three five person teams have designed the frame, drivetrain, and suspension. Our team is responsible to design the drive-train with the engine provided by SAE. The drive-train must meet the expectations in the acceleration, traction, maneuverability, and endurance events. Our final design employs a continuously variable transmission (CVT) and a differential for reverse. It can provide high torques and fast acceleration while maintaining durability.

Problem Formulation

The main objective of this project is to design and build a Baja vehicle that meets the client and stakeholders requirements and needs. The main goal of the drive-train is to have a max speed of 30 mph, a max torque of 290 lb-ft and also easy to drive. The team decided to use a CVT and a differential. The engine is provided by SAE. The CVT makes the driver driving without shifting. A differential will be connected to the shift cable for reverse ability. The throttle control system uses the throttle cable and the gas panel to control the engine's throttle.

Proposed Design

The final design of the drivetrain system meets all our goals and objectives. The Baja will still operate using the Briggs and Stratton 10 horse power engine in connection with CVTech-AAB's CVT. The CVT have a low ratio of 0.43:1 and a high ratio of 3:1.The shifting system includes a differential, a shifting cable and a shifting box. Dana Spicer H-12 FNR differential provides the vehicle with a forward ration of 13.25:1 and a reverse ratio of 14.36:1. The differential is connected by the shifting cable and then to the shifter box. The throttle control system uses the throttle cable and the gas panel to control the engine's throttle. Drive-train are assembled on a engine mount.

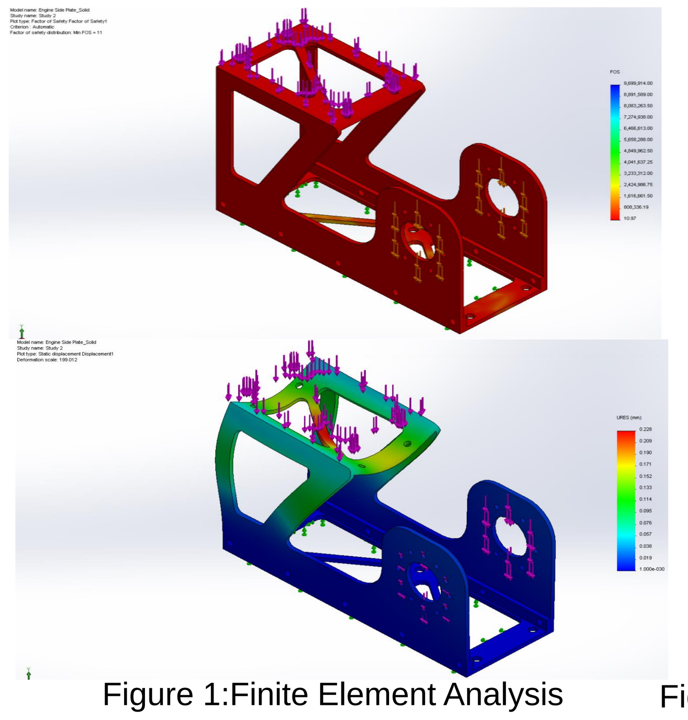

Figure 1:Finite Element Analysis

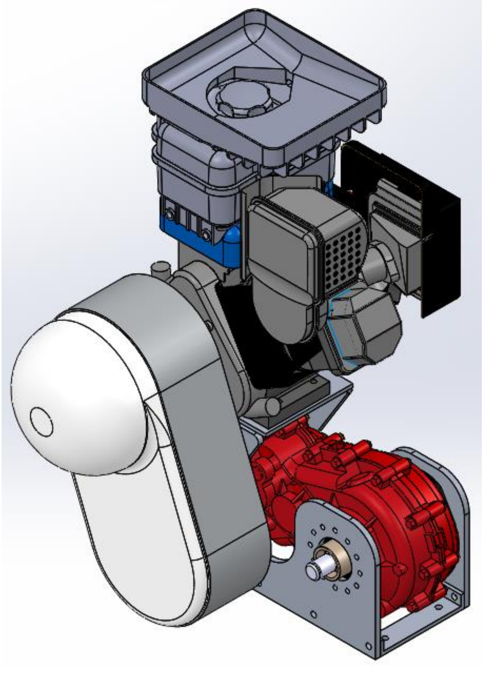

Figure 2: Final Assembly for Drivetrain

Numerical Results

The table tells us that at about 3400 rpm, the speed will be about 32 mph, which is what we want in the competition. The table below shows the max torque we can get on the wheel is 320 lb-ft, which meets our goals.

Table 1: Torque and speed calculation

Engine rpm	Torque output (lb-ft)	CVT ratio	Total ratio	Torque on wheel (lb-ft)	Speed (mph)
1800	13.20	2.082	24.278	320.467	5.06
2000	13.70	1.899	22.137	303.282	6.17
2200	14.10	1.715	19.997	281.956	7.51
2400	14.30	1.531	17.856	255.347	9.17
2600	14.45	1.348	15.716	227.096	11.29
2800	14.52	1.164	13.576	197.117	14.08
3000	14.50	0.981	11.435	165.809	17.90
3200	14.40	0.797	9.295	133.843	23.49
3400	14.20	0.614	7.154	101.590	32.43

Prototype Fabrication

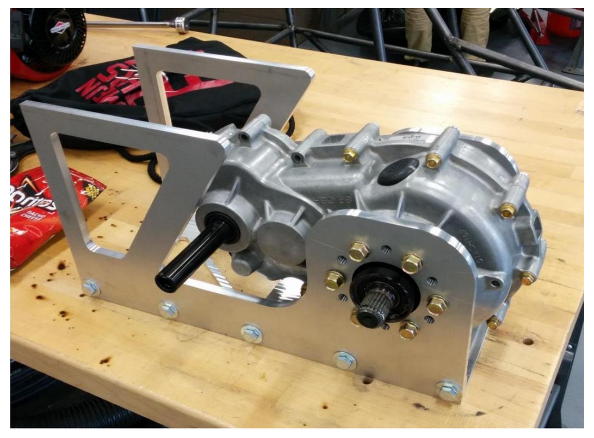

Figure 3:Differential with Mount

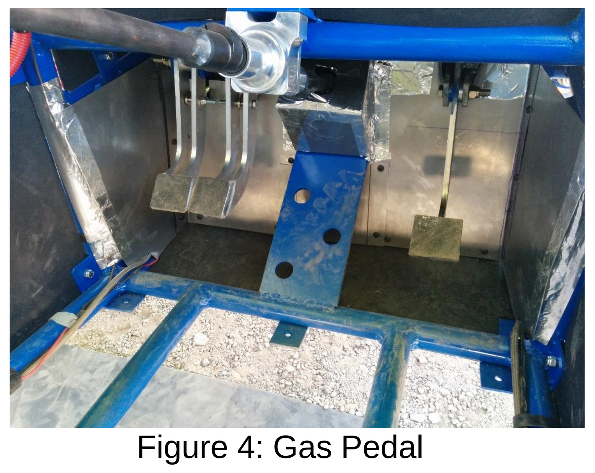

Figure 4: Gas Pedal

Figure 5:Shifter Box

Figure 6: Shift Cable Lock

Figure 7: Drip Pan

Figure 8: CVT guard

Figure 9: Drivetrain assembly

Testing and Results

116 teams had participated the SAE mini baja competition at UTEP. As a new team, the NAU mini baja team past the technical check and participated all the sub-events in the competition, including endurance, suspension, hill climb, land maneuverability, acceleration, sale presentation and design presentation. Our baja was not been able to finish the last event which is 4 hours endurance race. The shifter had a small issue after 8 laps and was fixed quickly. The most serious failure happened after 17 laps, the welding that connecting top piece and side wall of engine mount broke. The baja then lost power because the CVT belt is not tight enough to transfer the power. Although the team welded it again and got the baja back to race, it only last half lap and then been towed out.

Table 2: Result

Events	Ranking (out of 116 teams)
Endurance	46th
Suspension & Traction	56th
Hill Climb	58th
Land	27th
Acceleration	64th
Sale	17th
Design	45th
Cost	69th
Overall	**51th**

Cost Analysis

For the SAE Mini Baja competition as a competing team we are required to create and present a Sales Presentation to a hypothetical manufacturing company. This imaginary company is prospecting to produce a Mini Baja at 4000 units per year. The team assumed that out of 365 days this company would only be producing units for 261 days of the year. With these two criteria established we were able to create the following tables. In Table 3, because the system incorporates a differential, the manufacturing hours required per day were reduced to 30.75 hours. This is 30% more efficient than the original estimate. This equates to approximate savings of $350 per day just in labor. The improved system uses a Dana differential, causing the price to rise significantly. Luckily, this product was donated to us, thus or budget rose but the system was actually more cost effective. Though there were slight increases, the decrease in cost in all other areas still outweighs the increase in parts cost. Thus, our system was not only optimized to become more efficient and simplistic, but is cost effective as well.

Table 3. Manufacturing Hours

Part	Half Shaft	Keys	Hours per Unit	Hours per Day
Individual	.65 Hours	.25 Hours		
Drive Shaft	1.3 Hours	.75 Hours	2.05 Hours	30.75 Hours

Table 4. Budget for Drivetrain

	Price($)	Quantity	Comments	Total
Engine	200	1	Ship fee	200
Differential	1000	1	Dana	1000
CVT	250	1	CV-Tech	100
Key	5	4		20
Half-shaft	260	2	Polaris	520
Shipping	200		Fed Ex	200
Total Price				2040

Table 5. Bill of Materials

Half shafts	Engine	CVT	Differential	Key	Total
1,040,000	979,980	500,000	2,000,000	5836	4,525,816

Table 6. Total Estimated Man Hours

Total work units	Complete units per day	Total hours per person	Number of labors	Hrs per person per day	Hourly Wage ($)	Total cost of labors ($)
4000	15	2086	8	8	26	433,888

Conclusions

Our team along with the Frame team worked throughout the winter break and have come up with an optimized design where a gear box and secondary reduction system are replaced by a single differential. This was a step off the board from our original design but prevailed well. The updated concept not only simplified our design but reduced the weight drastically while still achieving our intended goals. As a result, the team was able to order many parts and move on to more simplistic but important tasks such as a throttle design and shifting mechanism. These strides allowed us to make up some lost ground and produce our design on schedule and perform at the competition in El Paso Texas. End up with 51th place out of 116 teams.

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Acknowledgements

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