Society of Automotive Engineers Baja Competition

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Drivetrain Sub-System

Henry Van Zuyle, Ryan Fitzpatrick, Jarett Berger, Donovan Parker

Department of Mechanical Engineering, Northern Arizona University, Flagstaff, AZ 86011

Abstract

The Baja Collegiate Design competition is an event hosted every year by the Society of Automotive Engineers (SAE). The objective is to design and build a four-wheel drive single-seat, all-terrain vehicle that meets the requirements of the competition. The drivetrain team is tasked with designing a system to transmit power from the engine to all four wheels of the vehicle. The power is transferred from the engine to the eCVT, and then to the wheels through two reduction gearboxes and a belt driven four-wheel drive system. The finished vehicle will endure rigorous design and simulation testing to ensure that the vehicle's performance will exceed the requirements at competition [1].

Requirements

SAE has provided a set of rules that must be met to ensure the safety of the drivers, as well as guarantee a fair competition. The rules for the drivetrain are limited which promotes more innovation and creativity in designing a high-performance drivetrain. To have a fully functioning and competitive drivetrain, there are engineering requirements that will guide the team in the design process. The goal of the drivetrain is to be lightweight and maximally efficient to produce a competitive SAE Baja vehicle.

Table 1: Drivetrain Engineering Requirements

Engineering Requirement	Target
ER1 - Top Speed	40 mph
ER2 - Drivetrain Efficiency	80%
ER3 - Torque to the Wheels	400 lb-ft
ER4 - Service Life	100 Hours
ER5 - Total Drivetrain Weight (wo/ Engine)	60 lbs
ER6 - Total Transmission Range	4.50

Methods

The design process consisted of using MATLAB to determine correct gear ratios and geometry to achieve the desired engineering requirements. Further analysis using finite element analysis (FEA) was conducted to maximize performance of drivetrain components by decreasing unnecessary weight and choosing viable materials. The internal components of both reduction gearboxes are made from heat-treated 4340 steel for strength, and the gearbox casings are made from 6061-T6 aluminum for weight reduction. The front and rear reduction gearboxes, pulleys, and eCVT components are entirely CNC based and require knowledge of Mastercam to manufacture.

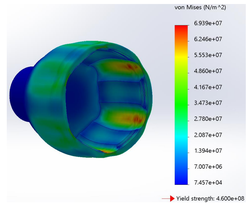

Figure 1: FEA Analysis on CV Cups

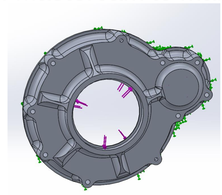

Figure 2: FEA Analysis Gearbox Casing

Results

The drivetrain is composed of four systems: the eCVT, front and rear reduction gearboxes, and 4WD system. A high range custom eCVT will transfer power to the two-stage rear reduction gearbox and a dog clutch will engage the 4WD system to transfer power to the single-stage front reduction gearbox. Inboard sprag clutches on the front reduction gearbox prevent understeer and allow for smaller front-end packaging. The rear CV cups are integrated into the rear reduction gearbox's output shaft to allow for longer camber links, enhancing suspension performance.

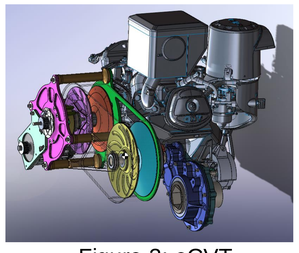

Figure 3: eCVT

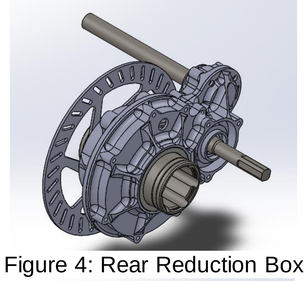

Figure 4: Rear Reduction Box

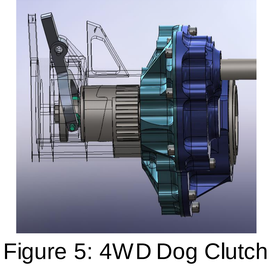

Figure 5: 4WD Dog Clutch

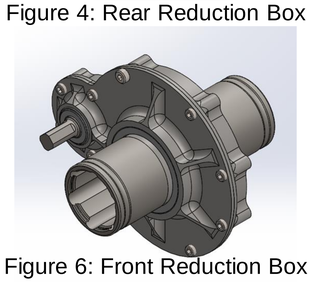

Figure 6: Front Reduction Box

Conclusion

The drivetrain systems are designed to provide maximum efficiency and reliability during the Baja Collegiate Design competition. The eCVT transmission allows for more variable tuning and the overall transmission ratio will allow for traction limited acceleration. The eCVT and rear reduction gearbox is designed to be tightly packed to shrink the width of the rear end to maximize suspension performance. The front reduction gearbox has inboard sprag clutches to prevent understeer and to optimize front-end steering. The drivetrain will undergo rigorous performance testing, and design validation will consist of technical inspection and driver testing. The drivetrain sub-system team is confident that the system's components will perform competitively at this year's Baja Collegiate Design competition.

Figure 7: Rear Gearbox / eCVT Assembly

Figure 8: Front Gearbox / 4WD Assembly

References

[1] Baja SAE, Collegiate Design Series, SAE Rules, 2024
[2] R. G. Budynas, Shigley's Mechanical Engineering Design. McGraw-Hill Companies, 2019.
[3] Matthew James Messick, An Experimentally-Validated V-Belt Model for Axial Force and Efficiency in a Continuously Variable Transmission, Virginia Polytechnic Institute and State University, Blacksburg, VA, 2018
[4] Skinner, Sean Sebastian, "Modeling and Tuning of CVT Systems for SAE® Baja Vehicles" (2020). Graduate Theses, Dissertations, and Problem Reports. 7590.
[5] E. Oberg et al., Machinery's Handbook. South Norwalk, CT: Industrial Press, Inc .,2020.

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