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**Adjustable Load on CVT Driven Project**

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ZIPS BAJA ADJUSTABLE LOAD ON CVT DRIVEN

By

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Final Report for MECE:461-001/002(Honors) Senior Design, Spring 2024

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May 2024 Project Group No. 3
Abstract

SAE Baja, also known as Baja SAE (Society of Automotive Engineers Baja), is a series of collegiate design competitions organized by the Society of Automotive Engineers (SAE). These competitions challenge teams of students to design, build, and race off-road vehicles that can withstand rough terrain and perform in various dynamic events. The objective of this Senior Design Project is to design, manufacture, and test an adjustable driven Continuous Variable Transmission (CVT) pulley to adjust the preload on the spring. This will allow easier adjustment on the CVT preload at smaller increments. This design could be used for future Zips Baja vehicles and multiple CVT tuning combinations. An adjustable CVT driven system can offer several benefits for SAE Baja applications including optimized power delivery, improved efficiency for different dynamic events, and adaptability to various driving conditions.
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1. Introduction

A continuously variable transmission or CVT is an automatic transmission that uses a pulley system to shift continuously through a boundless number of practical gear ratios while the vehicle is being driven. The concept is said to have been developed as early as the 15th century but wasn’t formally patented and conceptualized for another four hundred years. Preload is a critical aspect of a CVT that affects its ability to transition between gear ratios. For example, in a Baja hill climb competition, it is desirable to set a high preload to keep the car in a lower gear and maintain increased torque. In this project, our senior design group will be cooperating with the Zips Baja Off-Road Racing design team at the University of Akron to improve both the performance and functionality of its current CVT design by simultaneously reducing the time needed to modify the preload and creating the ability to better fine-tune that preload adjustment. The result will be a prototype that will be a significant contributor to the current competition season and ensuing vehicle designs, giving future Baja designers the ability to either improve upon it or focus their attention elsewhere in modifying other systems.

1.1 Project Description

The SAE Baja competitions typically consist of static events, such as design presentations and cost evaluations, as well as dynamic events, where teams demonstrate the performance and durability of their vehicles in various off-road challenges. These challenges often include hill climbs, rock crawls, maneuverability courses, and endurance races. The Zips Baja team is currently using a Comet 780/790 series CVT that allows spring pre-load adjustment in the driven pulley. Changing the preload determines the conditions under which the pulley will shift into a higher gear ratio. This is also the primary setting which will be changed between events at competition. The problem with the current driven CVT pulley is that, to change the preload, the pulley must be
removed from the car and almost completely disassembled. The preload can also only be adjusted in increments of 120°.

1.2 Design Requirements

The redesigned driven pulley for the Zips Baja car incorporates several key features to seamlessly integrate with the overall design while adhering to SAE rules. Its adaptability allows for the pulley to be covered without contacting the rear axles of the car, ensuring compliance with safety regulations. Moreover, the redesigned pulley system offers the capability to finely adjust preload in smaller increments, eliminating the need for disassembly during adjustments. This user-friendly feature streamlines maintenance and enhances overall efficiency. The design also ensures compatibility with the current CVT drive system on the Zips Baja car, facilitating a smooth integration process without requiring significant modifications. Additionally, the redesigned pulley retains the flexibility to change cams, providing versatility in tuning the vehicle's performance. Importantly, the weight of the new pulley design is carefully managed to not exceed that of the previous iteration, ensuring that the overall weight distribution and performance characteristics of the car remain consistent. These design considerations collectively contribute to the improved functionality and practicality of the Zips Baja car driven pulley system.
2. Design

2.1 Research

Our senior design project is the Ratcheting CVT, which will be applicable to the Baja car. Currently there is no easy way to change the loading on the CVT. The only way to change the loading is to tear apart the back end of the car and disassemble the entire powertrain to get to the CVT and disassemble that as well. This job is not only time-consuming but also can be dangerous as well. There is usually a lot of tension built up in the spring in the CVT, which can create a major safety risk when unbolting the CVT. Baja team members have suffered minor injuries in the past with the tensioner spring unleashing a high amount of force, often launching a part at the member, creating an unsafe environment for students to work in. With any job or task, safety should be the main priority, especially with student design teams, where they are primarily made up of students that usually are inexperienced with hands on maintenance work. In recent years, there has been a lot of progress towards safety in racing, and this ratcheting CVT can help with this effort to make racing, primarily off-road racing, safer in terms of working on the cars. The current CVT has large intervals of loading in the driven part of the CVT and are not always able to tune the CVT as precisely as the team would desire. The ratcheting CVT would have much smaller intervals of loading so the team can have more precise setups for each dynamic event at competition which consists of acceleration, maneuverability, suspension, sled pull, hill climb, and brake check.

We began by creating a conceptual design of the component we would make for the “push and crank” mechanism. We used this design as a baseline for the “push and crank” mechanism as well as what we used to compare to a “ratcheting” mechanism. We also considered the method in which the tensioning mechanism would be accessed while keeping the CVT assembled. This conceptual design for the “push and crank” mechanism can be seen in Figure 1.
A decision matrix was used to determine what design would be better of the two. The original design would use a ratcheting mechanism. The other design would be a ‘push and crank’ mechanism. The decision matrix consisted of 5 main categories. These included cost, size, reliability, and flexibility. The cost category considered the material, manufacturability, and outsourcing. The size category considers the dimensions and weight, with dimensions being more important due to space availability on the car. Reliability covers repairability and life span. The part must be strong enough to last during competition(s), however, if it breaks, we want it to be easy to fix or replace. Lastly, flexibility of the part was considered. This method needs to be universal across all the CVT cams and other Baja cars, must be easy to use, and be as simple as possible to reduce the potential for failure. The decision matrix gave each criteria a weight factor and a score that was then summed up to determine the best design. The results can be seen in Table 1 below.
Table 1. Weighted decision matrix used to determine method of setting preload

<table>
<thead>
<tr>
<th>DESIGN CRITERIA</th>
<th>WEIGHT FACTOR</th>
<th>1. Push and Crank Method of Preloading CVT Driven</th>
<th>2. Ratcheting Method of Preloading CVT Driven</th>
</tr>
</thead>
<tbody>
<tr>
<td>COST</td>
<td></td>
<td>SCORE</td>
<td>RATING</td>
</tr>
<tr>
<td>Manufacturability</td>
<td>0.50 0.0075</td>
<td>4 0.30</td>
<td>1 0.0075</td>
</tr>
<tr>
<td>Material</td>
<td>0.20 0.030</td>
<td>5 0.15</td>
<td>3 0.09</td>
</tr>
<tr>
<td>Outsourcing</td>
<td>0.30 0.0045</td>
<td>4 0.3</td>
<td>1 0.075</td>
</tr>
<tr>
<td>SIZE</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>0.60 0.50</td>
<td>5 0.75</td>
<td>3 0.45</td>
</tr>
<tr>
<td>Weight</td>
<td>0.40 0.100</td>
<td>2 0.2</td>
<td>4 0.4</td>
</tr>
<tr>
<td>RELIABILITY</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repairability</td>
<td>0.50 0.15</td>
<td>4 0.6</td>
<td>2 0.3</td>
</tr>
<tr>
<td>Life Span</td>
<td>0.50 0.15</td>
<td>5 0.75</td>
<td>3 0.45</td>
</tr>
<tr>
<td>FLEXIBILITY</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universal</td>
<td>0.60 0.18</td>
<td>4 0.72</td>
<td>3 0.54</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>0.20 0.06</td>
<td>3 0.18</td>
<td>4 0.24</td>
</tr>
<tr>
<td>Simplicity</td>
<td>02 0.06</td>
<td>5 0.3</td>
<td>2 0.12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.00</td>
<td>4.13</td>
<td>2.755</td>
</tr>
</tbody>
</table>
2.2 Current Design Iteration

The current design iteration uses an existing Comet 780 series CVT cam which has been modified to include 6 equally spaced holes with 3 slots. The holes offer a place for extrusions on the plate, a place to lock into, and the slots allow the plate to be rotated using a tool which will be discussed later. The force of the spring will push against the inside of the plate, thus keeping the plate engaged with the cam. The spring will engage with the extrusion on the inside of the plate which is what will hold the tension in the spring at a given setting. The assembly is shown below as Figure 1.
To be able to adjust the preload using this mechanism, it was determined that we would need to also manufacture a special tool. This tool is designed so that there are three 18-8 Stainless Steel studs with 8-32 threads screwed into a plate. The stud lengths are sized so that once the tool is inserted and pressed to where the plate is flush against the cam, the 6 extrusions on the plate will be approximately 1/8” past the modified face of the cam. The diameter of the studs is sized to fit in the corresponding holes made in the extrusions on the plate, and to fit in the 3 slots connecting the holes in the cam. To be able to apply both radial and axial forces on the tool at the same time, the decision was made to weld a 1/2” nut onto the center of the tool. By using a 9/16” ratcheting wrench and socket, the user would be able to accomplish this. The tool is shown below in Figure 2. The indent on the inside of the tool was added to allow extra clearance with the cam as needed.
2.3 Codes and Standards

Engineering codes and standards cover a broad spectrum of areas, including civil, mechanical, electrical, aerospace, and environmental engineering, among others. They address design principles, materials, construction methods, testing procedures, and performance expectations applicable to specific industries or applications. Engineering codes and standards are foundational elements of the engineering profession. They play a crucial role in ensuring that engineering practices adhere to recognized principles, promoting safety, reliability, and quality across diverse industries and applications. Engineers must remain abreast of the latest revisions and updates to these codes to ensure the continued improvement of engineering practices. Engineers are obligated to adhere to relevant codes and standards in their work. Compliance is often a legal requirement,
and regulatory bodies enforce adherence through inspections, certifications, and licensing. Non-compliance can result in legal consequences and jeopardize public safety.

The design and development of a Continuously Variable Transmission (CVT) system in the field of engineering are subject to various codes and standards to ensure safety, reliability, and compliance with industry norms. SAE sets standards for automotive engineering. For CVTs, standards such as SAE J637 (CVT Nomenclature and Terminology) and SAE J1930 (Electrical/Electronic Systems Diagnostic Terms, Definitions, Abbreviations, and Acronyms) may be applicable. ISO Standards (International Organization for Standardization) provides international standards for various industries. ISO 17025, for example, outlines general requirements for the competence of testing and calibration laboratories, which may be relevant for CVT testing and validation. ASME Standards (American Society of Mechanical Engineers) develops standards for mechanical engineering. ASME B56.3 (Safety Standard for Rough Terrain Forklift Trucks) may be applicable for off-road vehicles, including those with CVTs.

3. Design Verification

The adjustable driven CVT will be used in an outdoor, rugged application that will have rough conditions on the Baja car, so it will be vital to make the CVT to be durable enough to survive all conditions that the Baja car may face at competition. The group will do field testing of the adjustable CVT, which would be comparable to what our CVT typically goes through every year. Field testing will do the best in terms of proving our design because field testing will put the ratcheting CVT through the worst conditions possible and most comparable to the conditions that will be experienced at competition. Through these verification techniques, it will ensure success of the ratcheting CVT driven.
3.1 Finite Element Analysis

To ensure the CVT Driven modifications would hold up to the loads applied and stresses incurred through operation of the CVT, a Finite Element Analysis or FEA, was conducted using the Ansys Workbench software. First, the models, consisting of the modified cam and manufactured drive plate, were imported from SolidWorks. Next, using the SpaceClaim feature, these two models were assembled and uploaded to the Ansys Mechanical simulation software. The inner diameter of the cam that would be fixed onto the input shaft on the gearbox was then assigned as a fixed support and a load of 72 lbs. was applied against the appropriate tab on the drive plate. This applied load was calculated using the geometry and material composition of the preload spring, obtained from the manufacturer and physical properties, and some mathematical equations. The first of which, shown below, was used to calculate the spring constant.

\[ k = \frac{d^4 \times E}{64 \times D_m \times Na} \]

Where \( k \) is the spring constant, \( d \) is the diameter of the wire, \( E \) is the longitudinal modulus of elasticity, \( D_m \) is the mean diameter of the spring, and \( Na \) is the number of active coils. Next, the following equation was used to calculate the maximum torque the spring would apply given a specified amount of torsional deflection, which in the case of the Baja vehicle is a maximum of 240 degrees, or approximately 4.19 radians of load:

\[ T = k \times \theta \]

Where \( T \) is the torque, \( k \) is the spring constant, and \( \theta \) is the angular deflection. Once the torque was calculated, it was converted to force through dividing by the mean radius of the spring and the result was approximately 72 lbs. Once this was applied to the assembly, the simulation was initiated, and the results of equivalent (Von Mises) stress and total deformation are shown below.
Maximum stress and maximum total deformation were found to be 2277.1 psi and $6.21 \times 10^{-5}$ inches respectively.

Figure 4. Equivalent (Von Mises) stress on CVT driven

Figure 5. Total deformation of CVT Driven
### 3.2 Time Trials

Table 3. *Time comparison table*

<table>
<thead>
<tr>
<th>Trial</th>
<th>Prior Method (sec)</th>
<th>New Design (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45.10</td>
<td>8.60</td>
</tr>
<tr>
<td>2</td>
<td>50.40</td>
<td>8.40</td>
</tr>
<tr>
<td>3</td>
<td>31.30</td>
<td>8.90</td>
</tr>
<tr>
<td>4</td>
<td>110.50</td>
<td>7.50</td>
</tr>
<tr>
<td>5</td>
<td>109.50</td>
<td>8.50</td>
</tr>
<tr>
<td>6</td>
<td>69.40</td>
<td>8.20</td>
</tr>
<tr>
<td>7</td>
<td>36.50</td>
<td>7.30</td>
</tr>
<tr>
<td>8</td>
<td>65.10</td>
<td>8.30</td>
</tr>
<tr>
<td>9</td>
<td>51.00</td>
<td>7.40</td>
</tr>
<tr>
<td>10</td>
<td>55.20</td>
<td>11.50</td>
</tr>
<tr>
<td>11</td>
<td>72.00</td>
<td>8.10</td>
</tr>
<tr>
<td>12</td>
<td>29.00</td>
<td>7.70</td>
</tr>
<tr>
<td>13</td>
<td>50.30</td>
<td>8.40</td>
</tr>
<tr>
<td>14</td>
<td>60.10</td>
<td>8.80</td>
</tr>
<tr>
<td>15</td>
<td>37.40</td>
<td>10.20</td>
</tr>
<tr>
<td>16</td>
<td>74.30</td>
<td>8.20</td>
</tr>
<tr>
<td>17</td>
<td>42.10</td>
<td>10.40</td>
</tr>
<tr>
<td>18</td>
<td>41.10</td>
<td>7.20</td>
</tr>
<tr>
<td>19</td>
<td>55.50</td>
<td>11.50</td>
</tr>
<tr>
<td>20</td>
<td>28.50</td>
<td>7.60</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>58.12</strong></td>
<td><strong>8.64</strong></td>
</tr>
</tbody>
</table>

The time trials that were performed involved one person adjusting the CVT Driven preload to $120^\circ$ while another used a stopwatch to record the time that it took to make the adjustment. The trials were conducted under ideal circumstances, with brand new components, free of significant contamination (mud, oxidation, wear), that would be present under normal operating conditions. We chose to do this to make the results directly comparable between the two methods while eliminating as many uncontrollable variables as possible. However, it is worth noting that the time required to adjust the unmodified driven would be much more negatively impacted by factors such as wear and contamination.
Once all the trials were performed and the data recorded, it was noticed that the unmodified driven had much more variation in the amount of time it took to make the preload adjustment as compared to our new design. An analysis to quantify this variation was performed and the results are shown in Figure 6. From this, we can conclude that our new design not only decreased the amount of time a preload adjustment took, but also made the time more predictable. The reason for the high variability in the time to change the preload on the unmodified driven is most likely to be created by the number of components which need to be moved. A snap-ring must be detached to remove the cam, and the cam has the risk of becoming dislocated from the main shaft entirely. The snap-ring also has the possibility of slipping off the pliers being used to remove it, resulting in the snap-ring flying off in an unpredictable direction. This not only requires a significant amount of additional time and effort to resolve, but also poses a safety hazard to those standing close by.

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**Figure 6. Variance analysis**

![Variance analysis chart](chart.png)
4. Costs

The costing and budget considerations for implementing an Adjustable Load on a CVT Driven system involve a meticulous assessment of material expenses, particularly aluminum and steel stock, and the procurement of a critical component, the Comet Industries 790 Series Driven Clutch with a 3/4” Bore, identified by the part number 302603-C. Aluminum stock, chosen for its lightweight and corrosion-resistant properties, contributes to the fabrication of the adjustable load mechanism, ensuring optimal performance. Steel stock is strategically employed for its strength and durability, addressing the robustness required for the mechanism's structural elements. Additionally, the acquisition of the Comet 302603-C Driven Clutch is a key component in the budget, as it plays a pivotal role in the overall functionality of the CVT driven system. A judicious balance between material quality, component sourcing, and manufacturing processes is essential to maintain an effective budget while ensuring the durability and efficiency of the Adjustable Load mechanism.

4.1 Parts

The procurement list comprises three essential components for the assembly process, each sourced from distinct vendors and manufacturers. Firstly, the Comet 302603C, a critical element from Comet Industries' 790 Series Driven Clutch, with a 3/4” bore, is obtained through Belt Palace, acting as the vendor. The retail and actual costs for this item remain undisclosed until the manufacturing process starts. Additionally, the Driven Plate material, a pivotal component, is sourced singularly from McMaster-Carr, with in-house manufacturing contributing to its production. The same holds true for the material for the Pre-Load Tool, also procured from McMaster-Carr and manufactured in-house. Regrettably, specific details regarding retail and actual
costs for both the Driven Plate and Preload Tool are not provided until the manufacturing phase starts. In summation, the overall quantity tallies to three items, and while the vendor and manufacturer details are specified, the costs associated with the components remain unknown at this juncture. The retail costs of the components used in this project are listed in Table 4.

Table 4. The total cost of the components for this project

<table>
<thead>
<tr>
<th>Part</th>
<th>Quantity</th>
<th>Vendor</th>
<th>Manufacturer</th>
<th>Retail Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comet Industries 790 Series Driven Clutch</td>
<td>1</td>
<td>Belt Palace</td>
<td>Belt Palace and In-House</td>
<td>250.00</td>
</tr>
<tr>
<td>3/4” Bore. Comet/Salsbury Part 302603-C.</td>
<td></td>
<td></td>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Driven Plate</td>
<td>1</td>
<td>McMaster-Carr</td>
<td>In-House Manufacturing</td>
<td>39.08</td>
</tr>
<tr>
<td>Preload Tool</td>
<td>1</td>
<td>McMaster-Carr</td>
<td>In-House Manufacturing</td>
<td>47.93</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td></td>
<td></td>
<td>337.01</td>
</tr>
</tbody>
</table>

4.2 Labor

The manufacturing process consisted of using a computer numerical control (CNC) mill to machine slots in an existing 32-degree cam from Comet to allow our Driven Plate to fit inside it. The slots were the main features machined on this cam, and the rest of the cam remained stock. The Drive Plate also had to be machined on the mill CNC from a 3” round aluminum bar, with a two-face operation. The Preload Tool was machined on a manual mill and lathe machine. The length of time the CNC machine took to machine the cam was twenty minutes and to machine the Driven Plate was forty-five minutes. The amount of time the Preload Tool took on the manual lathe process was twenty minutes and the time it took on the manual mill process was ten minutes. According to the U.S Bureau of Labor Statistics a 51-4041 Machinists’ hourly wage is $26.25. With the assumption of this hourly wage and the length of time it took to manufacture the
components for this project, the total cost to manufacture this part (excluding the cost of the CNC mill, manual lathe, and manual mill) is $41.56. If the group decides to scale up production of this component for mass manufacturing, several factors will need to be considered to reduce costs and make the process more economically viable. Assessing different manufacturing methods and selecting the most efficient and cost-effective process can lead to significant cost savings. For instance, exploring alternatives to machines such as casting, forging, or injection molding may offer lower production costs while maintaining quality standards. Also, simplifying the design without compromising functionality or performance ensures efficient production without unnecessary expenses. Streamlining the component's design to minimize complexity and reduce the number of machining operations can help decrease manufacturing time and labor costs.

5. Conclusion

In conclusion, all the parts of the Adjustable Load on the CVT were finalized in design in addition to being machined out of aluminum alloy 7075 T6. After completing the manufacturing, the group was able to compare the time to make proper load adjustments on an old cam CVT and our new cam and drive plate. This testing showed that the tool was significantly quicker to adjust compared to driven CVTs without our Drive Plate capability. Using our Drive Plate, we were also able to adjust the loading in much smaller increments, which leads to more precise tuning of the CVT. This allows our Baja team to get better CVT combinations that would better suit our car for different events at competition, making our car more versatile.

5.1 Accomplishments

The Zips Baja Senior Design Group successfully engineered a mechanism for the CVT driven system, introducing the capability to adjust preload on the driven portion. In tandem with this
innovation, the group designed a practical tool that seamlessly collaborates with the CVT driven mechanism, facilitating the adjustment process. After 3D printing our original prototype to test basic functionality, we proceeded to machine another prototype out of 7075 aluminum to complete further testing of durability and performance. With the machined prototype we completed several tests comparing time to adjust, tuning precision, and durability between our prototype and the existing cam layout. With the addition of this newly designed adjustable CVT driven component, the amount of time to adjust the preload on the driven has decreased significantly. Based on our testing, as displayed in the table below, the average time to adjust the previous CVT driven by 120 degrees was 58.12 seconds. While the average time to adjust the newly designed adjustable CVT driven by 120 degrees is 8.64 seconds and the time it takes to adjust it by 60 degrees is 6 seconds. This is a time decrease of 85.14%. This time decrease allows for a streamline and quick adjustment of the CVT driven.
Figure 6. Machined 32-degree cam, supplied from Comet, top view
Figure 7. Machine 32-degree cam supplied from Comet, bottom view
Figure 8. The Drive Plate from the viewpoint of the spring
Figure 9. The Drive Plate from the viewpoint of the tool in which will contact the spokes on the face of the tool
Figure 10. The custom tool with replaceable studs that screw into the base
Figure 11. The top view of the custom tool with the nut welded on the top of the base, so that a simple socket or wrench can be used to adjust the load.
Figure 12. All of the individual components that were machined for this project. From left to right: Drive Plate, Custom Tool, Modified 32-Degree Cam
Figure 13. The Driven part of the CVT with our Drive Plate and the Modified Cam
While incorporating an adjustable load feature into a CVT driven design offers several advantages, there are potential uncertainties and challenges that engineers should consider during the design and implementation process. Some uncertainties include wear, temperature effects, and environmental factors. The repeated adjustment of preload may introduce additional wear and tear on the CVT components, particularly the belt or chain. Over time, this could impact the longevity of these components and necessitate more frequent maintenance. Changes in preload may
influence the friction and heat generated within the CVT system. Managing temperature variations and ensuring that the system remains within optimal operating conditions is crucial to prevent overheating and premature component failure. The CVT-driven system may be exposed to various environmental conditions, such as moisture, dust, or extreme temperatures. Evaluating how these factors might affect the adjustable load mechanism is essential for ensuring long-term reliability.

5.3 Ethical considerations

Adjustable pre-load on a driven portion of a continuous variable transmission (CVT) can have several potential effects on society, depending on the context in which it is implemented. Adjustable pre-load can help optimize the CVT's performance, leading to better fuel efficiency. This can help reduce fuel consumption and greenhouse gas emissions, contributing to environmental sustainability. According to www.fueleconomy.gov, one of the advantages of having a CVT in your vehicle is “better fuel efficiency (benefits stop-and-go driving more than steady-speed highway driving).” Optimizing CVTs can reduce noise levels in vehicles and machinery. This contributes to noise pollution reduction in urban and industrial environments, ultimately improving the quality of life for people living and working in these areas. The implementation of adjustable pre-load in CVTs can lead to the development of new technologies, manufacturing processes, and jobs related to CVT design and optimization, potentially boosting economic growth. Adjustable pre-load can be used to extend the lifespan of CVTs by reducing wear and tear on components. This can lead to less frequent maintenance and repair, which in turn reduces costs and the environmental impact associated with manufacturing replacement parts. Research and development in CVT technology may stimulate advancements in related fields, including materials science, mechanical engineering, and control systems. These innovations can have far-reaching effects on various industries and society. Continuing in this kind of research can
ultimately lead to mass a CVT design to for mass production complement a fully electric vehicle platform. The global engineering and technology company, Bosch says; “Whether it is (light) duty vehicles driving up steep roads, sports cars demanding high top speeds, or a trailer or caravan needing to be towed. Here, a CVT can provide the solution.” Improving the efficiency of CVTs can help reduce the carbon footprint associated with transportation and manufacturing, contributing to global efforts to combat climate change.

5.4 Future work

As Zips Baja vehicles continue to evolve, the addition of an Adjustable Load on CVT Driven system reflects a commitment to pushing the boundaries of a Baja vehicle. This enhancement not only elevates the performance of the vehicles in competition but also sets a new standard for adaptability and efficiency in the realm of SAE Baja racing, in which most teams that run a CVT on their cars do not have adjustable loading capability. This innovative addition aims to enhance the overall performance, adaptability, and efficiency of Baja vehicles, aligning with the pursuit of excellence in engineering and competition success centered at the University of Akron. Due to the indifferent deadlines of the senior design project and the completion of the Zips Baja vehicle for the 2024 season, the planned dynamic testing phase with the adjustable CVT on the Zips Baja vehicle had to be deferred. This delay will occur until the Zips Baja vehicle reaches a stage of readiness where integration of the newly designed CVT system becomes feasible. Once this integration phase is reached, both the senior design group and the Zips Baja team will embark on a comprehensive testing regimen to evaluate the performance of the newly implemented CVT system. This testing will mirror the conditions and challenges encountered during actual SAE Baja competitions, ensuring a thorough assessment of the component's functionality across various dynamic events. These dynamic events include but are not limited to hill climbs, endurance trials,
sled pulls, suspension tests, acceleration trials, and steering assessments. By subjecting the vehicle to these diverse scenarios, the team aims to gather extensive data on the performance of the CVT system under real-world conditions, enabling them to refine and optimize its functionality for maximum efficiency and reliability. Ultimately, the conclusion of these rigorous testing procedures will enable the team to fine-tune the CVT system, identifying the most effective combination of parameters to enhance the overall performance of the Zips Baja vehicle. This iterative process underscores the team's commitment to delivering a competitive and robust vehicle for the upcoming 2024 Baja season and beyond, while also ensuring the successful completion of the senior design project.
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