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Manufacturing, Testing and Tuning of A Customizable Continuously Variable Transmission CVT for an All Terrain Vehicle ATV

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Abstract

Continuously variable transmission (CVTs) has always been the first choice for All Terrain Vehicle (ATVs), because of their wide variety of gear ratios, seamless gear changes, and improved control. Unfortunately, there is a lack of customizability and performance issues still in the ATVs that are present in the market which gave us the reason to perform the research on the topic which is Manufacturing, testing, and tuning of a customizable Continuously Variable Transmission (CVT) For an All-Terrain Vehicle (ATV). The objective of this research is to address the issues of customizability, Weight reduction, and minimizing the owning cost of the CVT keeping in mind this research will also look into the attainable manufacturing techniques, material selection, and machining process that will be evaluated to ensure toughness and performance. Methods like Machining, CNC, Laser cutting, and Wire cutting are used keeping in mind the convolution and cost. The paper deduces by evaluating the performance of the customizable CVT system through CAE analysis before manufacturing and testing on an ATV after manufacturing. The CVT-equipped ATV demonstrates enhanced versatility, suitable for recreational, agricultural, and industrial use. This research contributes to ATV engineering by highlighting CVT advantages and their potential for broader applications in versatile off-road vehicles

Keywords: CVT, Primary Clutch, Secondary Clutch, Cost Effectiveness, Weight Reduction, Material Selection, Ansys, Stress, Deformation, FOS etc.

1. INTRODUCTION

1.1.Basic Terminology

Continuously variable transmissions (CVTs) have played a pivotal role in revolutionizing power delivery across various applications. Their origin can be traced back to the late 19th century, with the invention of the Williamson Disc Revolving Gear by Wilfred Williamson in 1866 [1]. During the early times at first, the use of precise speed was paramount to industries like textiles [2], and the operations of CVT were used. Speaking of the main core CVT that the automotive world adopted in the early 20th century, with vehicles like the Adams-Farwell (1904) and one of the most famed varomatic scooters (1914) specifically to take advantage of the seamless gear ratio that the CVT provides. [3,4]

Unfortunately, the main hindrance in the power handling and durability concerns were the reasons that initially shackled the major and even the minor spread of the use of CVTs in the automobile industry but the evolution of material science and control systems in the later half of the 20th century led to rebirth of CVTs in scooters and small vehicles.[5]Research by Eriksson et al.(2006) inspected the prospect of CVTs for improved fuel efficiency and drivability mainly in passenger cars, because of their booming demand and growth in the market.[6]

1.2 The Emergence Of Continuously Variable Transmission (CVT) in All Terrain Vehicles (ATV)

The use of CVTs has not only captured small vehicles like scooters or small commercial vehicles but has also been administered in all-terrain vehicles (ATVs). Unlike the traditional manual gearboxes that require a clutch to change the gear accordingly a CVT not only provides a smooth gear change but also yields uninterrupted gear ratios that ensure superior control to the driver and an unmatched drivability.[7]

A study by Eris and Kocabey(2007) emphasized the design considerations for CVTs that were specifically tuned for ATVs that focused on refining transmission efficiency and receptive demands in the off-road environment.[8]

CVTs offer unquestionable advantages for ATVs that we discussed in the beginning but the commercially available models lack a lot of things that can also lead to more positive outcomes in the industry like the customization options.

Stock CVTs that are present in the market right now are typically designed to provide an equal proportion between performance and fuel efficiency, which might not be ideal for all individuals.

For instance, riders prioritizing heavy towing might benefit from a lower gear ratio for increased torque, while those emphasizing high-speed performance might prefer a higher gear ratio for improved acceleration [9].

1.3 The Road Ahead: A Customizable CVT For a New Age

This research addresses the issues and limitations that the design and manufacturing of the CVTs present in the market lack and gives out the best results possible from our design, testing, tuning, and manufacturing. The main focus during all the processes is 3 of them that concern the most to the rider:

1. Cost-effectiveness
2. Weight reduction
3. Easily customizable

Throughout this research, we showcased the step-by-step approach to attaining all of these results.

Speaking of the cost-effective nature of the CVT that we are manufacturing hasn't been as much as the CVTs that are available in the current market. The initial cost of the manufacturing is also less in our prototype. As the cost of the prototype is less compared to the CVTs that are present in the market the final cost will also be less and can be easily accessible.

Now, coming up to the part of weight reduction usually, CVTs are made up of cast iron which makes them a bit heavy which results in lacking efficiency and potential that can be attained from the transmission. To attain maximum potential and efficiency both in fuel consumption and giving out maximum power we have used Aluminum as the core material of our CVT, the 7 series aluminum helped in attaining our weight reduction goals resulting in better handling, agility, and improved maneuverability. Al also gave the properties of good ductility, high strength, and toughness. All the spiders and sheaves of CVT are made of Al 7075, weights are made of brass and some parts like rams and rollers are made of mild steel.

Last and one of the most important processes is attaining customization, as we discussed in the last few paragraphs about the problems, that a driver might encounter while driving an ATV. To come to all these solutions we have manufactured a customizable CVT that is rider-friendly and can be tune able, like increasing or decreasing the brass weights, tuning the spring(spring constant) and the angle of the ramp can also be varied. This helps the rider to achieve what he wants with his vehicle be it changing the upshift/downshift, procuring the top speed, or wanting more torque.

The performance of the manufactured CVT is evaluated through rigorous testing on an ATV. This involves real-world testing to analyze factors like acceleration, efficiency, and drivability under various operating conditions.

The journey doesn't end there. The following sections will delve deeper into the technical aspects of this endeavor, paving the way for a new generation of ATVs that cater to the diverse needs of riders across various applications

2. Methodology

Before moving towards the actual steps to proceed in our following research we kept in mind the principles of how transmission worked how we have to carry out our research and what we have to do to further advance the following process.

We designed the components using the software called SolidWorks, keeping in mind the measurements and the measures that we have to keep in proper designing so that we don't get much error when going to the next step of our research which is analysis.

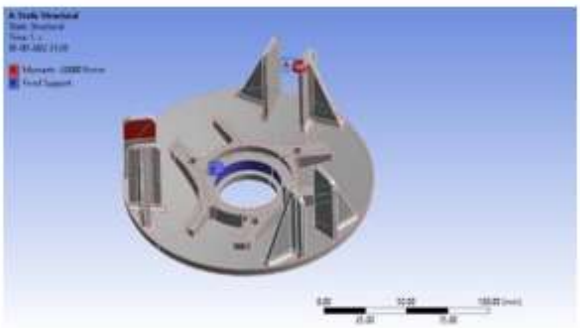
For the proper verification of our calculations and analysis, we used various software. One of them was Ansys.

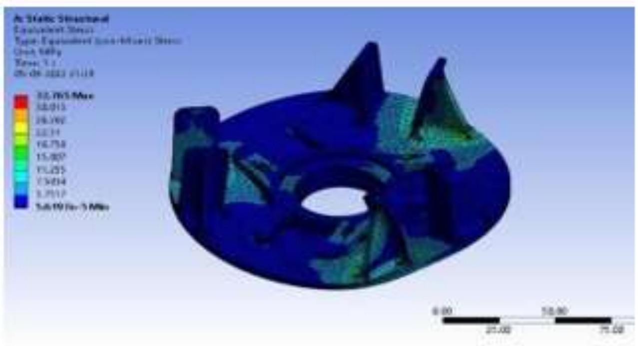
To check the overall places where we can reduce weight, we took the help of Ansys Workbench software and also have a deep analysis of all the components that are to be analyzed.

Through analysis we got an idea about what should be the thickness of various components to withstand the overall forces acting upon it for this purpose we analyzed our components.

For the moving sheave of the primary clutch, we added 2 situations for the torque transfer we added the value of torque on the pillars while taking the center point fixed.

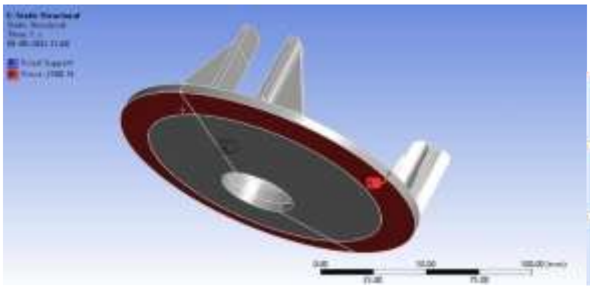
Iterations for the wall thickness were performed and we settled for the thickness where optimum and satisfactory results could be seen taking the overall Factor of safety not less than 1.5.





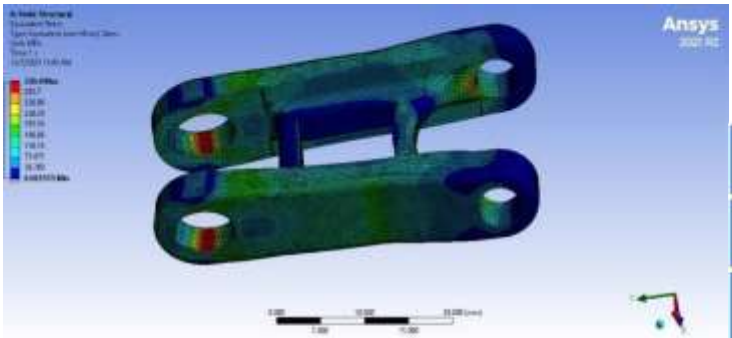
Deformation	0.07mm
Stress	33.7MPa
Factor of Safety	8.29

We also simulated the belt force acting upon the sheave through which we could check the weight reduction and its impact on the safety of the component by varying the thickness of the sheave



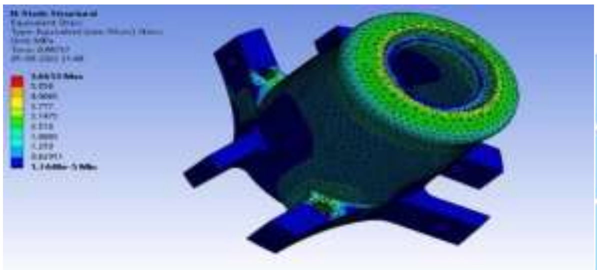
Deformation	0.15mm
Stress	41Mpa
Factor of Safety	6.89

Secondly weight arms were fixed from the spring cage end and then centrifugal forces were added to the pair to check that our overall design could withstand the 1.5 times the force acting upon it for worst-case scenarios.



Deformation	0.076mm
Stress	330.4Mpa
Factor of Safety	1.52

For the spring cage, we used the forces that the spring would cause on the face of the spring cage.
We iterated for the thickness of the spring cage and hence weight reduction was performed.



Deformation	0.004mm
Stress	5.64Mpa
Factor of Safety	15+

For the secondary clutch,
Force on the moving sheave was added taking into consideration the worst-case scenario and the thickness of the sheave was optimized to get the best results and achievement of satisfaction.
For the cam, we iterated the angles to have proper upshift and backshifting angles.

3. Result And Conclusion:

As a result of the following tests performed, we were able to make the changes with respect to its Factor of safety and the forces acting upon the individual components.

The main aim of this project was to create a CVT with the following characteristics:

1. Low Owning Cost
2. Highly Tunable

3. **Reduced weight**

And as per our requirements and conclusion, our CVT completes all our aims. I hereby share some pictures of our final model.


References

1. Williamson, W. (1866). Improvements in machinery for transmitting motive power. US patent US59246A
2. Nahal, T. (2014). Automotive transmissions: Fundamentals, selection, design, and application (3rd ed.). McGraw-Hill Education.
3. Nunney, M. J. (2007). Light and motorcycle weight reduction techniques. Butterworth-Heinemann.
4. Holmes, A. (2007). Automotive transmissions and transaxles. Cengage Learning.
5. Eriksson, L., Bodin, L., & Igra, O. (2006). Design and control of CVTs for improved fuel efficiency and driveability in passenger cars. Oil & Gas Science and Technology, 61(1), 127-136.
6. Raine, R. R., & Reece, D. (2012). All-wheel drive vehicles. Routledge.
7. Eriş, S., & Kocabey, H. I. (2007). Design of a continuously variable transmission (CVT) for all-terrain vehicles (ATVs). Mechanism and Machine Theory, 42(12), 1528-1540.
8. Barnes, K., & Bradshaw, A. (2014). The ATV handbook. Haynes Publishing.