A REVIEW ON MANUFACTURING OF EXPERIMENTAL SETUP FOR TESTING A CONTINUOUS VARIABLE TRANSMISSION (CVT) SYSTEM

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Abstract- ***Continuous variable transmission (CVT) drives serves with variable drive ratios to obtain distinct and best possible performance of an engine. CVT is a timely improvement and cost reduction which leads to further development for more desirable applications. Regarding research papers and through the actual concept of working of continuous variable transmission system, it highlights the advantages over stepped transmission system. Being introduced in the new world the CVT serves with good torque capability and good reliability. The CVT helps to give different speed ratios with the use of V-belt and pulley. The vehicles operational on CVT tends to serve better mileage and fuel economy with good acceleration compared to vehicles comprised with automatic transmission. This review paper serves the use of CVT to gain continuous gear ratios between the desired limits which enhances the economy of the transmission system. Also this paper focuses light on the transmission systems and its types, comparison of stepped & stepless transmission systems and working of CVT. Methodology for manufacturing of experimental setup for testing a CVT is discussed in detail.***

Key Words: CVT, Experimental setup, Conical pulleys.

1. INTRODUCTION

The CVT has continuous to be an object of considerable research interest within the mechanical design community driven primarily by the automotive industry's demands for more energy efficient and environmentally friendlier vehicles. Unlike conventional transmissions, in which transmission ratio can not be varied continuously due to fixed gear ratio, CVT has a continuous range of transmission ratio that can, up to device dependent physical limits, be selected independently of the transmitted torque transmitted[1]

1.1 Transmission System

The word transmission means the whole mechanism that transmits the power from the engine crankshaft to the rear wheels. However the 'transmission' is also being used very commonly in the literature for a mechanism which provides us with suitable variation of the engine torque at the at the road wheels, whenever required. This may be a gear box or an automatic transmission. The main purpose of the transmission is to provide a means to vary the leverage or torque ratio between the engine and the road wheels is required. The transmission also provides a neutral position so that the engine and the road wheels are disconnected even with the clutch in the engaged position[6].

1.2 Types of transmission system

The following figure shows the different types of transmission system -

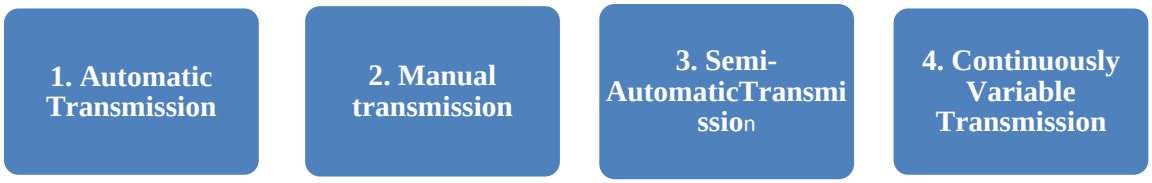


Fig-1.2.1-Digramatic representation of types of transmission system

The description of various types of transmission system area as follows,

1.2.1 Automatic Transmission

In this type of transmission system the engagement of the clutch during gear shifting happens with the help of fluid coupling torque converter. Instead of selecting gear manually, the gear ratio change can be obtained with a complete set of gear called as planetary gear. Due to automatic transmission it eliminates the worrying of the driver for gear selection during driving. For disable driver or new driver it serves the best to drive the vehicle much easier. An example of epicyclic gear train is shown in the figure. An epicyclic gear box consist two, three or even four epicyclic or planetary gear sets. a simple gear set(Fig-1.2.2) has a sun gear, about

which planets turn around .these planet gears are carried by a carrier and a shaft6 and are also in mesh internally with a ring gear which is also called as annulus or internal gear sometimes. Different torque ratio i.e. speed ratio are obtained by making one of the parts, viz, the sun gear, the planets and the annulus stationery. Similarly by locking two parts with other, a solid drive i.e. direct gear is obtained. [6]

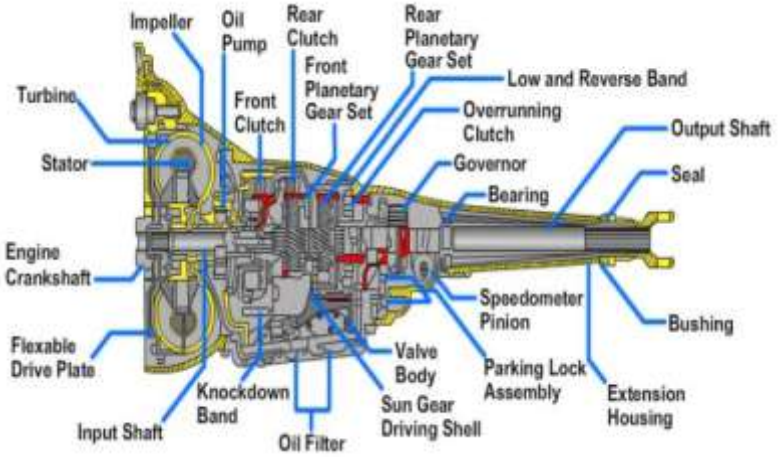


Fig-1.2.2-Automatic Transmission [7]
(Photo Courtesy: http://www.free-ed.net/)

1.2.2 Manual Transmission

It is the first invented transmission system. This transmission serves the purpose of disengaging the clutch from the engine to disconnect the power. In this system first select the target gear and engage the clutch again to perform the gear change. It needs some time to acquire the skill of new driver.

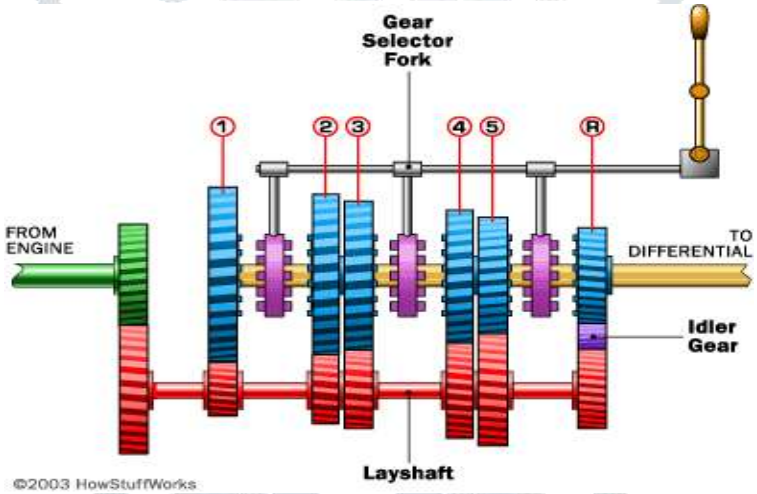


Fig-1.2.3-Manual Transmission
(Photo Courtesy: https://auto.howstuffworks.com/)

1.2.3Semi-automatic Transmission

This type of transmission system is the combination of both manual and automatic transmission system which utilizes advantage of both automatic and semiautomatic transmission system. Due to complicated design and high price it is only used in sport cars and luxury cars.

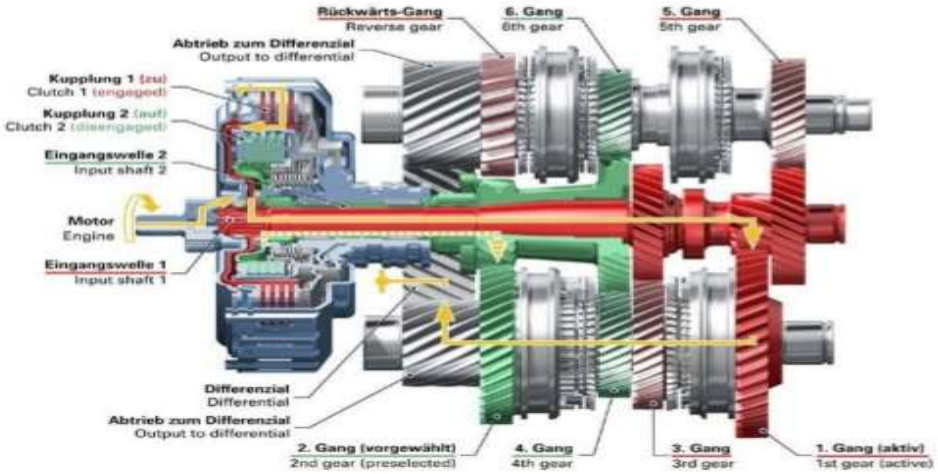


Fig-1.2.4-Semi-automatic transmission(Courtesy: https://www.slideshare.net)

1.2.4Continuously Variable Transmission

CVT is an automatic transmission that can select any desired drive ration within its operating range. Unlike a conventional four or five transmission, CVT is an 'infinite speed ratio' transmission.

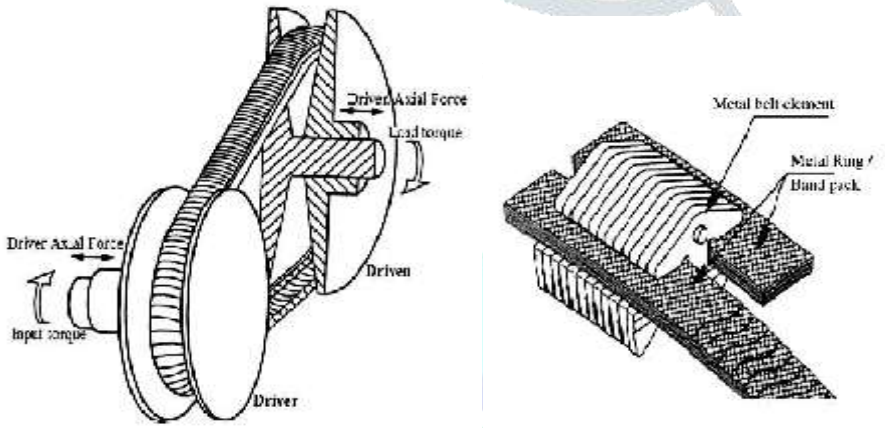
This type of transmission system is installed in low powered machinery like scooters and mopeds for long time due to its highly efficient gear changing. Because of the strength of driving belt it was challenging to install it on high speed machinery. But with the introduction and improvement in material technology the engineers have successfully installed it on the automobiles making the power transmission efficient.[6]

A continuous variable transmission is an automatic transmission system that can change continuously through a continuous range of effective gear ratio. This different than mechanical transmissions that offer a fixed number of gear ratios. The flexibility of a CVT allows the input shaft to maintain a constant angular velocity. In CVT ,transmission takes place with help of two conical pulleys and a belt. A belt-driven design offers approximately 88% efficiency, which, while lower than that of a manual transmission, can be offset by lower production cost and by enabling the engine to run at its most efficient speed for a range of output speeds. A CVT does not strictly require the presence of a clutch. Nevertheless, in some vehicles (e.g. motorcycles), a centrifugal clutch is added to facilitate a "neutral" stance, which is useful when idling or manually reversing into a parking space. So study of CVT is important by experimentally hence we fabricate CVT system.[2]

Principal of working of CVT:-

A simple CVT has three main components:

1. Variable-input driving pulley
2. Output-driven pulley
3. Belt



(a) Basic Configuration of CVT (b) Belt Structure

Fig-1.2.5-V-belt CVT drive (a) Basic configuration (b) Belt structure [1]

As the two pulleys change their diameter relative to each other, infinite number of gear ratios are obtained.

For example, when diameter is small on the driving pulley and large on the driven pulley, the speed of driven pulley is decreased, resulting in low gear ,similarly high gear is obtained when diameter on the driving pulley is larger than the diameters of driven pulley.[6]

Advantages

1.Constant stepless acceleration form start to high speed, eliminating shift shock to provide smoother ride. In fact the operation is much smoother than even conventional hydraulic automatic transmission.

2. It gives better fuel economy than hydraulic transmission by avoiding torque converter slippage.

3. Respond better to changing conditions, that is throttle and speed changes, which eliminates gear hunting while moving up an incline.

4. Less emission due to better control under all conditions.

Disadvantages

1. Torque handling capability of CVT is limited.
2. A CVT needs a relatively large central distance.
3. CVT is found to have much shorter life, say about 1,50,000 cycle

1.3 Comparison between Stepless and Stepped regulation transmission system

Steeples and stepped regulation is nothing but the types of transmission system .in stepped regulation transmission system shifting of gears is required to transmit torque and engine can not operate at pick power for wide range of vehicles speed.

Stepless regulation:- stepless regulation is the type of transmission system in which gear shifting is not required and transmission of torque is continuous , better fuel economy and better acceleration performance.

Table:1.3.1Comparison between Stepless & Stepped Regulation System

Sr. No.	Step less regulation	Stepped regulation
1	Gear shift is not required.	Shifting of gear is required.
2	Torque transmission is continuous.	Torque transmission is not continuous.
3	Control of engine speed independently of vehicle	Control of engine speed is dependent on vehicle

	speed.	speed.
4	Engines can operate at peak power and wide range of vehicle speed.	Engines can not operate at peak power for wide range of vehicle speed.
5	Can be operated at most fuel efficient point for required power.	Can not be operated at most fuel efficient point for required power.
6	Good fuel economy is achieved in stepless regulation.	Average fuel economy is achieved in stepped regulation.

2.OBJECTIVES

1.To study the constructional details of CVT.
2.To study the design and development of the experimental setup of CVT.
3.To understand the testing of the working model of CVT.
4.To understand and review accurate and precise speed variation by using continuously variable transmission.

3. LITERATURE REVIEW

1. **Da Wen.Ge sygng Ariyono and Daw They Mon,"a review on continuous variable transmission control",(2010) pp 543-554 ISBN:978-9675080-9501** review on the context of CVT design and configuration. Certain new configurations of CVT designs have been reported to achieve continuous variations in transmission ratio with lower losses, however, the range of applicability of such CVTs for high torque applications is yet to be analyzed/ verified. A continuously variable transmission is a promising automotive transmission technology that can provide higher fuel economy, reduced emissions, and better vehicle performance. The current paper not only addresses the state-of-the-art research accomplished towards understanding CVT dynamics and control. [1]
2. **B. Bonsen, R. J pulleys ,SW.H Simjohn "Implementation of slip control CVT production vehicles"(2003)** studied the slip control in a production vehicle has proven more difficult than previously anticipated. Several problems were encountered, but most of them are related to the ratio and torque converter control being separated. Future implementations should therefore combine these controls. Slip control would perform better if the hardware implementation of the hydraulic system would be optimized to lower pressures and faster response. Also pressure drops are unacceptable, but this holds for the current CVTs a well. Further research will focus on a combined approach to ratio and slip control. Furthermore, different hydraulics and actuators will be considered. [2]
3. **Brown Bonsen,"Efficiency optimization of the push belt by slip control(2006)",ISBN-1:90-386-3048-4** research on the stability of slip in a variator mainly depends on the slope of the traction curve. If this slope is positive, then slip will be stable. If the slope of the traction curve is negative, then slip will be unstable. The position measurement of the pulley or the belt are accurate enough for estimation of slip and ratio. The other methods do not work in all required operating points, are not conclusive, or require additional research. [3]
4. **Ehasan malkeipour,Sa'said glubi, "Examining the effects of continuously variable transmission",(2014) ISSN 2319-4847** studied of CVT is an ideal transmission system for vehicles which can on the one hand make bigger opportunity for automakers to improve their potential customers as well as improving the efficiency of their automobiles, firstly by equipping their current products with CVT instead of MT, and secondly by designing new products equipped with high efficient CVT; and on the other hand, CVT is a more environmentally friendly transmission system compared with the other kinds of transmission systems and it can help reduce air pollution. Furthermore, this paper reveals that this system can ameliorate even more by improving its mechanism and probably designing a new generation of it in the future. [4]
5. **Srishti Jha and Amrutha Gandhi R., "Continuously variable transmission control strategy review," (2015) ISSN:2278-0181** Analyzed in context to CVT design and configuration. A few configurations of CVT designs have been reported to achieve lower losses, but the range of applicability of such CVTs for high torque requirements is yet to be verified. This paper not only addresses the research accomplished towards understanding CVT control and dynamics but also tries to highlight the difficulties or directions for future research that might lead to better development of such system and their controllers. [5]

4.METHDOLOGY

Following methodology which is used for manufacturing of experimental setup of CVT are as follows

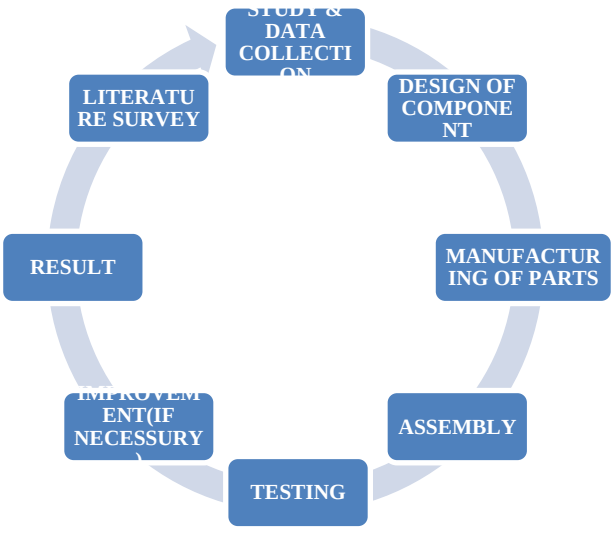


Fig-4.1-Methodoly for experimental setup of CVT

4.1 Literature survey:-Several research papers regarding the full development and study of CVT concludes different benefits, advantage and disadvantage and the working of CVT as a stepless power transmission in different vehicles. with the enhancement in the mechanical and automobile system the CVT has and is a revolutionary towards the improvement of automatic transmission .with further implementation to control of the slipped change in the gear ratio and torque, these problem where encountered and eliminated leading to the good and better working of the CVT system[1].

4.2 Study and data collection:-As several research paper reading the full development and study of CVT operates as step less regulation with less friction to give good power transmission and better fuel economy. The step less regulation in CVT to eliminate the need of clutch as the power transmission to through the drive belt varies with accelerating speed. The same time with small size, light weight and less moving part involved in the system, these mechanical parameters help to the CVT system and give its better performance with better efficiency and acceleration[1].

4.3 Design:-With further advent of studying through several research paper various mechanical components are required to design the experimental setup of CVT system. Some of the components to design the experimental setup of CVT are as follows .

1)Supporting frame
2)Pulley
3)V-belt
4)Variator
5)Footstep bearing required as supporting member
6)Epicyclic gear train
7)Motor required as per RPM

The above components serves the best interest in the design of any simple CVT system [5].

4.4 Assembly:-With the Knowledge of components to be used in the construction of CVT system, the next step leads to the assembly of the system for its working process. With all the process parameters and different considerations the parts are assembled where the actual working of the CVT system can be observed[2].

4.5 Testing:-The next step of methodology is the testing of the experimental setup of the CVT after the design and assembly of CVT components. Testing the various parameters like torque, speed, power and acceleration should be done on the system and the results are observed[1].

4.6 Improvement (If required) :-Improvement of experimental setup of CVT to gain the required process parameters like torque, speed, slip control and power as per the requirement.

4.7 Result:-the result obtained during the working of CVT validate with available standard data. The data obtained concludes the performance of the CVT system.

5.RESULTS AND DISCUSSION

Working with the experimental setup of CVT system and its component parts in the field of automobiles, the actual power transmission of the design was obtained. it also provide the valuable experience on power transmission system and awareness of work criterion, challenges and other activities performed during the working of experimental setup of CVT. Further implementation can be done regarding the slip control parameter and studied various advantage, disadvantage and application of CVT. Applicable knowledge was gained while working through the setup which were relevant to most of technical and practical concept.

Table 5.1 shows the power efficiency of a typical five speed automatic transmission, while reviewing through the research paper where the efficiency varies from 60% to 95%,but the best economy is obtained when the transmission varies from 3rd gear to 4th gear. This yields an average percentage of 86% compared with typical manual transmission with 97% efficiency. Table 5.2 shows the efficiency of several CVT design[1].

Table 5.1: Efficiency versus gear ratio for automatic transmission

Gear	Efficiency
1	60~85%
2	60~90%
3	85~95%
4	90~95%
5	85~94%

Table 5.2 : Efficiency of various CVT designs

CVT System	Efficiency
Rubber belts	90~95%
Steel belts	90~97%
Toroidal traction	70~94%
Nutating traction	75~96%

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