Designing continuously Variable Transmission for All-Terrain-Vehicle – A Review

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Abstract— Continuously new developments in gear reduction and manufacturing have led tomore robust CVTs, which allows them to be used in more automotive applications. CVTs uses variable adjustable drive ratios instead of discrete gears to obtain optimal engine performance. As CVT development proceeds, costs will be reduced timely and performance will always going to increase which makes further development and application more desirable. CVTs are also being developed in connection with hybrid electric vehicles. Regarding paper evaluates the advantages of CVTs over manual transmission and gives the detailed design of the components of CVT. The CVTs are not new for automotive world, but their torque capabilities and reliability have been limited in past. For good automotive fuel economy and emissions, the continuously variable transmission, or CVT, becomes a key technology by improving the fuel efficiency of automobiles with internal combustion (IC) engines. When the engine runs at the more efficient number of revolutions per minute in case of the given vehicle speed, CVT equipped vehicles maintain better gas mileage and acceleration compared to cars with traditional transmissions

Key words: CVT, Manual transmission, Pulley, Shaft, V Belt

I. INTRODUCTION

The configuration of a CVT consistof two variable diameter pulleys kept at a fixed distance apart from each and connected with a power transmitting belt or chain device. One of the sheaves on each pulley is movable. The belt can undergo both tangential and radial motions as per on the torque loading conditions and the axial type of forces on the pulleys. This causes continuous variations in the transmission ratio.

In an engine for a specific speed and propulsive force, a certain transmission ratio which provide more fuel economy, also for any type of speed for the given vehicle, one transmission ratio will be giving maximum level acceleration. Since a CVT with the proper ratio range can provide the desired transmission ratios makes it more popular for better economy and performance of the vehicle. A CVT is not only desirable but essential for vehicles using flywheel as speed can be changed as and when energy is supplied. A CVT is required to match the flywheel and vehicle speeds under all possible operating conditions.

The word continuously variable transmission usually mean that torque may be controlled independently with the speed ratio and vice versa. In the other words, the torque converter of the conventional automobile should not be considered as a CVT because the speed ratio is set by the torque transmitted. In this most common CVT system, there are two pulleys that are split along perpendicular plane to their axes of rotation, connected with a V belt. The speed ratio is changed by moving the diagonally opposite pulleys away and close from the fixed pulleys linearly. This changes the effective diameters of the pulleys without the change in center distance between them.

As CVT plays an important character in the scene to improve fuel economy of a vehicle, its total potential has not been realized in a vehicle for mass production. A continuously variable transmission (CVT) gives a continuum of gear ratios between desirable limits, which enhances the fuel economy and dynamic performance with better matching of engine operating conditions to the variable driving scenarios of a vehicle.

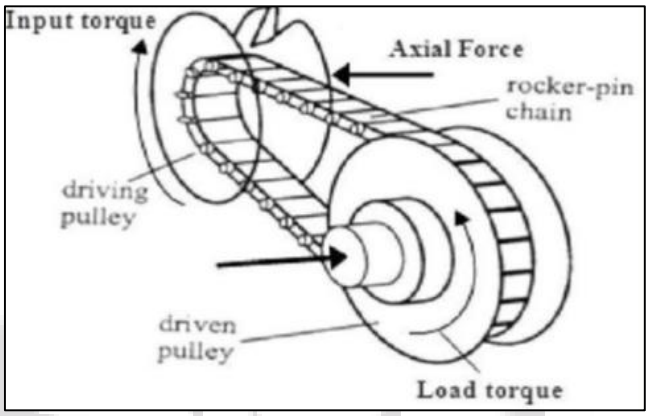

Fig. 1: CVT System

Thus methodology adopted in this study can be divided into three phases. In "Phase I"which is ―theoreticalanalysis", designed the components of CVT using the engine torque and other parameters. This includes designing shafts and the pulleys after the specifications of the vehicle are decided.In "Phase II", it is ―Simulation or Numerical analysis"of proposed design, is done by using the software named ―ANSYS". It gives the values for the maximum stress and deformation that the components may have to bear in their operation and thus provides the factor of safety.

At last, in "phase III"as it is "comparative analysis" which gives the comparative study of saw profile diagram of the transmission compared with the saw profile diagram of the CVT and conclusions are cleared

A. Vehicle Specifications:

- Vehicle type : ATV (All-terrain-vehicle)
- Seating capacity of the vehicle: Single seater.
- Weight of Driver= 75 Kg.
- Kerb Weight of vehicle = 225 Kg
- Gross Vehicle Weight = Kerb Weight + Seating capacity. =225 + 75 = 300 kg.
- Load on each wheel for 1G : 300/4 = 75 Kg (7500 N)
- Tire Size (Rear): Tire Dia.* Width * Rim size: =25"*10"*12"
- Dynamic rolling radius: 0.283 mt
- Engine Power : 7.46 kw
- Engine Torque : 19 N-m

– Engine RPM (Max.) : 3700 RPM
– Gear ratios:

Gear ratio 1: 33.66
Gear ratio 2: 18.08
Gear ratio 3: 10.32
Gear ratio 4: 6.76
Reverse gear: 27.66

Based on the above specifications, the shafts and pulleys of the CVT are designed using the PSG design data book.

The following are the vital parameters considered during designing:

– Engine Power.
– Engine input and output torque
– Centre distance between two pulleys.
– Driving pulley rpm.
– Driven pulley rpm.
– Material for driving pulley.
– Material for driven pulley.
– Shaft material.
– Angle of "V" belt.

The designing and modelling of the components is done using CATIA V5.

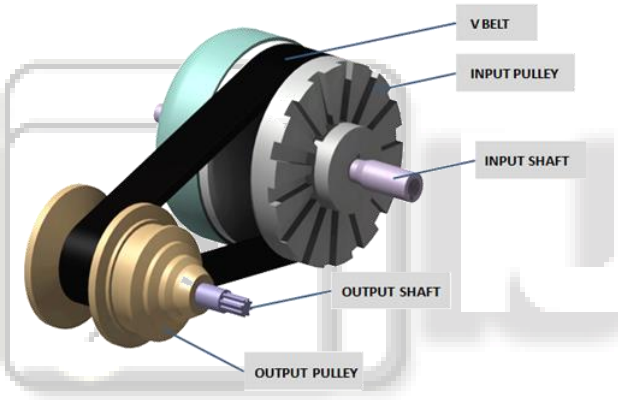

Fig. 2: CVT assembly in CATIA

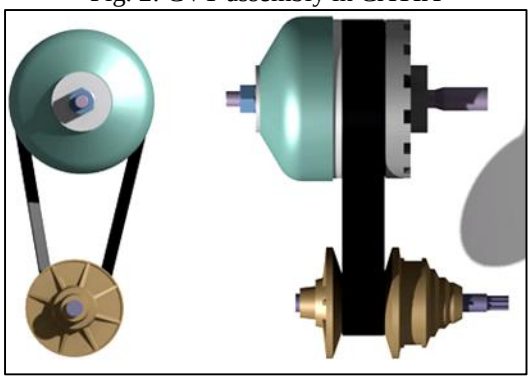

Fig. 3: CVT 3D views in CATIA

II. LITERATURE REVIEW

Da Wen Ge, SugengAriyono and Daw ThetThet [1]The paper addresses the state-of-the-art research accomplished towards understanding CVT dynamics and control. Certain new configuration 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 for high torque application is yet to be analysed/verified.

Nilabh Srivastava ,Imtiaz Haque [2] It highlights the challenges and directions for future research, which could gives better understanding and designing of given type of systems and their controllers. Since belt and chain CVT fall under the category of friction limited drives, it is crucial to understand the influence of varying contact zone friction characteristics on the dynamics of such CVT system.

H. Komatsubara, T. Yamazaki, S. Kuribayashi [3] This paper Found the bearing and various spin loss in the traction area, which conclude power transmission efficiency reduction. Here the calculated efficiency for designed CTC-CVT will be 93%.

Sameh Bdran, Samo Saifullah, and Ma Shuyan [4] In this there is considerable disparity in the type of CVT models that have been used for control development. The continuously variable transmission gives a promising automotive transmission technology that gives higher fuel economy with reduced emissions and better vehicle performance. The new research should be investigated in the context of CVT design and configuration.

Ehsan Maleki Pour,Sa'id Golabi [5]This paper stating that CVT is an ideal transmission system for vehicles which on the one hand gives bigger opportunity to automakers for improving their potential customers as well as efficiency improvements of their automobiles, startly by equipping their latest products with CVT inspite of MT, and then by designing new products equipped with the highly efficient CVT and on the other hand, CVT is more environment friendly transmission system comparing with the other kinds of transmission systems and it can help in reducing air pollution as well.

Christopher Ryan Willis ,Dr. Charles F. Reinholtz, Chair Dr. Richard M. Goff Dr. Mehdi Ahmadian [6] This paper analysis used to develop software which can be used to tune a CVT as per user specifications. The software basically gives the user that which type of primary and secondary springs have to use also what weight may be used to make the current flyweight.

P.Setlur, J.R.Wagner, D.M.Dawson and B. Samuels [7] A simplified model for the vehicle having a spark ignition engine and a cvt for a power split configuration has been presented also the road angle further,aerodynamics drag effects and its grades have been explored well.Further work include the experimental testing of the proposed control stratergy on a hybrid vehicle powertrain.

Nur Cholisa, Sugeng Ariyonob, Gigih Priyandokoc [8] The design of single acting pulley actuator (SAPA) of CVT gives combinations of DC motor system, power cam mechanismsand gear reducers for actuating primary movable pulley sheaves on the transmission shaft. The simulation results has significantly improved the performance of the conventional PD controller to complete75.08□ rotation of the CAM from lower gear ratio to top gear ratio is less than 6.79 sec (CVT ratio from 0.9 up to 2.8), in terms of percent overshoot and steady state error, both controllers perform well for the Single Acting Pulley
Actuator (SAPA).

D. Rockwood, N. Parks, D. Garmire [9] In this paper it gives the use of bicycles over powered vehicles that would decrease the energy use and gives cleaner and most sustainable urban transportation. The experience of eDrive users promises to be enhanced over existing transmission

solutions by being lighter, safer, intuitive to use, and allow more efficient operation. In addition, those desiring to gather more information about their rides– such as those on exercise regimens or those participating in cycling sports – would benefit from the data harvesting and communications functions incorporated into the drive.

Continuously variable transmission or CVT continues to derive a important technologies for improving fuel efficiency of automobile. CVTs uses drive ratios instead of discrete ratio to obtain optimal performance of engine. Vehicle with CVT attain better mileage and acceleration than traditional transmission. CVTs are not unknown to the automotive world but their capability and reliability have been limited in past. As CVT development continues, performance will increase. This project work helps in finding out the current state of CVTs and upcoming research and developments. Manual transmissions have manual controls, where the desired gear ratio totally depends on the driver to shift it and automatic transmissions have relatively simple shifting algorithms between three to five gears. A CVT is a promising automotive technology that can further provide improved vehicle performance with restricted emissions. New research frontiers must be 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 systems and their controllers.

III. CONCLUDING REMARK

As a final note, one might hypothesize that to enjoy ride while driving a car it is necessary to eliminate the number of operations performed during driving. Some of these operations are: operate clutch and joystick lever at a time for shifting gears, this is the only basic mechanisms we used in almost all cars. By use of CVT, the clutch and gear shifting mechanismcan be eliminated and overall cost can be saved. The comparison has been done between results of Manual gearbox and CVT.

All the dynamic components of CVT are checked with FEA tool ANSYS V14 to ensure the safety of component. After the detailed study and analysis of transmission system, it can be concluded that use of CVT is advantageous over the Manual gearbox.

On the basis of this conclusion the benefits of CVT can be utilized. With proper tuning improved efficiency and optimize performance of vehicle these targets meet through this study.

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