A review on Continuously Variable transmissions (CVT)

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ABSTRACT

Any transmission system's primary goal is to couple a high speed flywheel to a vehicle's drive train, also to achieve high engine efficiency, responsive gear changes, and transmission efficiency. The unique way of achieving this task to use switch mode CVT.,which is mechanical analog of DC DC power electronic converter.

Use of CVT increases fuel efficiency and it provides high transmission ratio. It varies progressively the transmission ratio. It allows selection of a infinite number of ratio (between a minimum and a maximum value).

The flexibility of a CVT allows the driving shaft to maintain a constant angular velocity over a range of output velocities. This can provide better fuel economy than other transmissions by enabling the engine to run at its most efficient revolutions per minute (RPM) for a range of vehicle speeds.

CVT systems are used in small tractors, snowmobile vehicles, scooters, harvesters, go-karts, drill presses, in aircraft electrical power generating systems,etc. Types of CVT systems are Variable-Diameter Pulley (VDP) or Reeves Drive, Toroidal or Roller-Based CVT, Infinitely Variable Transmission (IVT), Ratcheting CVT, Hydrostatic CVT, Variable toothed wheel transmission, Cone CVT.

In this paper, we will do modeling and analysis of major componenets of full size passenger vehicle's Switch mode CVT.

Keyword: - *Continuously Variable transmissions(CVT) ,Ratcheting CVT,Torque Adjuster Mechanism,Torque Adjuster Vehicle*

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1. Introduction

Many small tractors for home and garden use have simple hydrostatic or rubber belt CVTs. For example, the John Deere Gator line of small utility vehicles uses a belt with a conical pulley system. They can deliver a lot of power and can reach speeds of 10-15 MPH, all without need for a clutch or shift gears. Many new snowmobiles and motor scooters use CVTs. Virtually all snowmobile and motor scooter CVTs are rubber belt/variable pulley CVTs.

Some combine harvesters have CVT's. The CVT allows the forward speed of the combine to be adjusted independently of the engine speed. This allows the operator to slow down and speed up as needed to accommodate variations in thickness of the crop.

CVTs have been used in aircraft electrical power generating systems since the 1950s and in SCCA Formula 500 race cars since the early 1970s. More recently, CVT systems have been developed for go-karts and have proven to increase performance and engine life expectancy. The Tomcar range of off-road vehicles also utilizes the CVT system.

Some older drill presses contain a pulley-based CVT where the output shaft has a pair of manually-adjustable conical pulley halves which a wide drive belt from the motor loops through. The pulley on the motor, however, is usually fixed in diameter, or may have a series of given-diameter steps to allow a selection of speed ranges. A handwheel on the drill press, marked with a scale corresponding to the desired machine speed, is mounted to a reduction gearing system for the operator to precisely control the width of the gap between the pulley halves. This gap width thus adjusts the gearing ratio between the motor's fixed pulley and the output shaft's variable pulley, changing speed of the chuck; a tensioner pulley is implemented in the belt transmission to take up or release the slack in the belt as the speed is altered. In most cases, however, the drill press' speed cannot be changed without the motor running.

Fig.1.1 CVT System

1.1 **Background And Brief History:**

In 1910, Apex Cruisers made a V-twin engined bicycle with the Gradua-Apparatus, which was a CVT. In 1912, the English bicycle maker Rudge-Whitworth gathered the Rudge Multigear. The Multi was an altogether better type of Apex's Gradua-Apparatus.

In 1926, George Constantinesco conveyed the Constantinesco vehicle with a smooth, beneficial, inertial masses CVT, which he had made in 1923, fused with the two-chamber engine. During the last part of the 1940s and mid 1950s, Charles H. Digger of Denver, CO made basic headways in making a CVT by building up the "Variable Speed Grasp Pulley". He archived and was permitted various US licenses for his CVT structure using steel balls and spiral capacity to control the moveable side of the force end of his V-belt hold. A CVT, called Variomatic, was arranged and worked by Center van Doorne, individual supporter of Van Doorne's Automobiel Fabriek (DAF), in the last part of the 1950s, expressly to make a modified transmission for a little, sensible vehicle.

In the year 1490 Leonardo da Vinci had sketched his idea of a CVT. In early 1930s, General Motors had developed a fully toroidal CVT and conducted extensive testing before eventually deciding to implement a conventional steppedgear automatic transmission due to cost concerns. General Motors did research on CVTs in the 1960s, but none ever saw their production. British manufacturer Austin used a CVT for several years in one of its smaller cars, but it was greenhouse gas emissions from the transportation sector [1]: (a) Increase the energy efficiency of transportation vehicles. (b) Substitute energy sources that are low in carbon for carbon -intensive sources (i.e. the use of alternative fuel technologies). (c) Reduce transportation activity.

The first DAF vehicle using van Doorne's CVT, the DAF 600, was conveyed in 1958. Numerous snowmobiles use a versatile belt CVT. In 1974, Rokon offered a bicycle with a versatile belt CVT.

In summer 1987, the Passage Holiday and Fiat Uno transformed into the central standard European vehicles to be outfitted with steel-belted CVT.

For the 2019 Toyota Corolla Hatchback Toyota made an all new CVT with a "dispatch gear" or a physical first apparatus from a customary modified transmission near to the CVT pulley. From 0-25 mph the transmission would stay in this dispatch mechanical assembly to help in speeding up from a stop and improve quality of the CVT. After 25 mph, the transmission would switch over to the CVT pulley.

Types of CVT are:

1. Variable-Diameter Pulley (VDP) or Reeves Drive
2. Toroidal or Roller-Based CVT
3. Infinitely Variable Transmission (IVT)
4. Ratcheting CVT
5. Hydrostatic CVT
6. Variable toothed wheel transmission
7. Cone CVT

1.2 System Components

The various components of torque adjustor Vehicle are as follows:

1. Motor (120 watt, 0-6000 rpm variable speed, 230Volt AC
2. Belt
3. Reduction Pulley
4. Crank Shaft
5. Connecting Rod (2No's)
6. Connecting link (2No's)
7. Driven link (2No's)
8. Driver gear (2No's)
9. Driven gear (2No's)
10. UD clutch housing (2No"s)
11. UD Clutch (2No's)
12. Driven Shaft
13. Frame / Chassis
14. Front wheel (2 No's)
15. Rear Wheel (2No's)
16. torque-adjuster

1.3Description of Parts:

1.3.1 Motor (l phase Ac motor ,120 Watt,230 Volt,0-6000 rpm(variable)

Motor is an single phase AC motor Power 120 Watt , Speed is continuously variable from 0-6000 rpm. The speed of motor is variated by means of an electronic speed variator. Motor is an commutator i.e. the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator, thereby the speed also changes. Motor is foot mounted and is bolted to the motor base plate welded to base frame of drive.

1.3.2 Belt Drive

The power from the motor is supplied to the input Shaft of the mechanism by means of an open belt drive. The drive comprises of the motor pulley mounted on the motor shaft, the belt Fz 6x400 and reduction pulley mounted on the input shaft.

1.3.2 L H Bearing Housing

The L H Bearing housing is a structural steel member (EN9), that supports bearings 6002 zz. The upper end of the bearing housing receives the torque adjuster slide arrangement, where as the bottom end is received on the frame or chassis, Plates.

1.3.3 R H Bearing Housing

The L H Bearing housing is an structural steel member (EN9), that supports bearings 6003 . The upper end of the bearing housing receives the torque adjuster slide arrangement , where as the bottom end is received on the frame or chassis plates.

1.3.4 Connecting Rod

Standard part made of steel connects the crankshaft to the connecting link by connecting pins, connecting rods are held in place by external circlips on the crankshaft.

1.3.5 Crankshaft

Crankshaft is high grade steel part held in ball bearings 6003 & 6002 in LH & RH bearing housing, and connects the connecting rod

1.3.6 Connecting Link

Connecting Links are structural grade steel elements that are connected to the torque adjustor at their top end, connecting rod at the centre and driver link at the lower end.

1.3.7 Driven links

Driven links are structural grade steel element that are connected to the connecting links at one end, whereas they carry river gears and are held on the intermediate shaft.

1.3.8 Driver and Driven Gears

1.4 Torque adjuster Mechanism:

This is in the form of torque adjuster pins , helical compression springs which hold the central pins connected to the connecting links at their top ends, which slide in the torque adjuster slide.

4.11 Front & Rear Wheels:

These are standard parts made from PVC, held on the front and rear wheelshaft respectively.

4.12 Steering Mechanism

Steering Mechanism is a simple four bar linkage driven by the central crank held on the steering wheel shaft which is held on the frame. Turning the steering wheel turns the crank and thereby steering mechanism works.

2. Actual Mechanism

2.1 Ratcheting CVT:

Principle:

These CVTs convert uniform motion to reciprocating motion, and when rectify it back to an "almost" uniform motion. Firstly, there is a mechanism that produces reciprocating motion from rotational input. This mechanism allows adjustable reciprocating stroke.Secondly, the reciprocating motion is rectified by a mechanism such as a one-way-clutch (or free-wheel). Thus, the reciprocating motion is rectified to a unidirectional rotational output. It is possible to adjust the speed of this rotational output simply by adjusting the reciprocating stroke. To obtain a smoother output motion, several out-of-phase cranks are used.

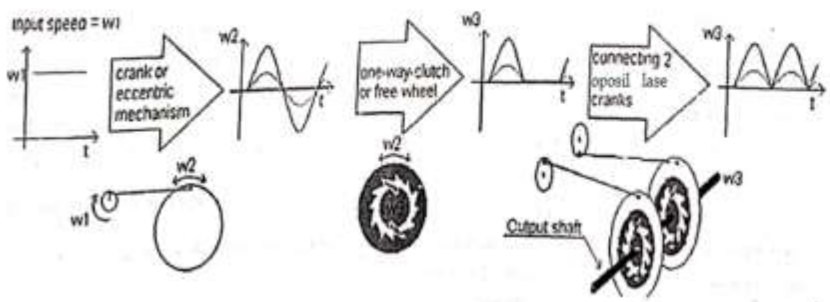

Fig.2.1 CVT Mechanism

2.2 Design Process:

2.1Design of Ratcheting CVT:

In our attempt to design a special purpose machine we have adapted a careful approach, the total design work has been divided into two parts mainly:

- System design
- Mechanical design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine no of controls position of these controls ease of maintenance, scope of further improvement; height of m/c from ground etc.

In Mechanical design the components are categorized in two parts.

- Design parts
- Parts to be purchased.

For design parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market this simplifies the assembly as well as post production servicing work. The various tolerances on workpieces are specified in the manufacturing drawing. The process charts are prepared and are passed onto the manufacturing stage. The parts are to be purchased directly are specified and selected from standard catalogues.

Driver and Driven Gears are high grade steel members with following specifications.

Table -1 GEAR DATA

Addendum Diameter	Pitch Circle Diameter	Module	No.of teeth
39	6	1.5	4

2.2 System Design Process:

The system design Comprises of development of the mechanism so that the given concept can perform the desired operation. The mechanism is basically an inversion of four bar kinematic linkage hence the mechanism is suitably designed using Grashoff's law and the final outcome is shown in the figure below.

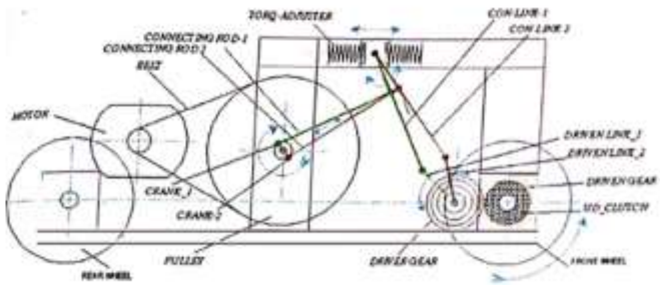

Fig.2.2. Actual Assembly of Torque Adjuster Mechanism

3. Construction & Working:

Torque adjuster mechanism comes into picture when vehicle is offered resistance to motion for example vehicle is climbing in ascent, during this period the resistance offered to the wheels is transferred to the connecting links, which makes the pivot point to shift towards left, this results in reduction of the speed whereas amplifies the torque. The torque adjuster sp rings automatically compensate the deficit force

3.1 Construction of Torque Adjuster

The Torque- Adjuster mechanism comprises of the following parts:

A) Torque — Adjuster pins

B) Torque Adjuster Bracket or slide:

The torque- adjuster slide or bracket is an arrangement to hold and slide the slider pin that it connected to connecting link at the top end. Slider pin slides on the adjuster and thereby operates the springs

C) Slider pins

The slider pins slide on the adjuster pins and operate the helical compression springs on both sides of the pin, one end of the slider pin engages in the connecting link top end whereas the other end s lides in the slider bracket mounted.

D) Helical Compression springs:

Thee helical compression springs are with both end ground and have a flat Seat, they are mounted on either sides of slider pin.

3.2 Working of Torque Adjuster Vehicle:

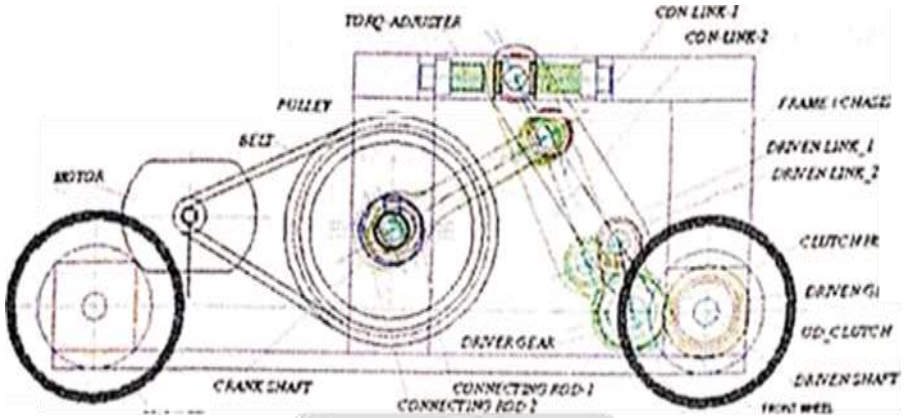

Fig 3.1 Torque Adjuster Vehicle

When the motor is started the crank shaft rotates thereby imparting the oscillatory motion to connecting link, the top end of this connecting link is pivoted in the slider pin which slides on the adjuster pins. The lower end of the connecting link drives the driven link which drives the wheels via gears and clutch arrangement.

Initially when the motor speed is low the connecting link moves to and fro and the motion in form of small oscillation is imparted to the driven link and there by the wheels rotate and vehicle moves forward as either of the connecting rods operate alternatively. When the speed of motor increases there by the frequency of oscillation of the connecting link and thereby number of impulses provide to the output clutches increases hence the speed of the wheels increases. In the above case the pivot point of the linkage remains at the slider pin center.

When the load on the vehicle increases or vehicle ascends an inclination, the wheels offer resistance to motion i.e., the driven links will offer resistance to oscillation, at this time the pivot point of the linkage which was earlier at the center of the slider pin shifts to the connecting pin-1 center i.e., the connecting for an instance will now pivot about the connecting pin-1 and transmit this resistance force to the slider pin which will change its position towards the right hand side thereby compressing the spring , the spring stores this resilient energy during its compression force, this happens during the idle stroke of mechanism (i.e., when ud-clutch goes free) i.e. 0 to 180 degree rotation of crank, for the next 180 to 360 degree rotation i.e.; the productive stroke (i.e., when ud -clutch drives the wheel shaft) the connecting rod force (l92N) iS added with the spring force which was stored in the earlier part of the motion is delivered to the lower end of the connecting linki.e. force is amplified thereby product of force and leverage i.e. torque is amplified) and thereby deliveied to the wheels. More the load on the vehicle more will be the deflection of the spl'ilags and thereby more will be torque applied by the adjuster mechanism. If observed keenly when vehicle in running condition is stopped against its wall or some very heavy object the ft out wheels i.e., driver wheels a e momentarily lifted in air fo deliver the torque.

As already mentioned the cranks on the crank shaft are phased at IS0 degrees ,hence they operate alternately in above mentioned fashion.

4. CONCLUSIONS

In this paper, ratcheting CVT's vary the stroke of reciprocating motion ,which is connected to free wheel(uni-directional clutch) resulting in a uni-directional rotation. The ratcheting CVT improves the efficiency as it allows the engine to operate always in its optimum RPM irrespective of the variation in vehicle speed .A CVT is formed and infinite number of gear ratios are obtained by varying the pulley diameter. Unlike conventional, CVT offers smooth drive. We obtained range RPM from 55 to 220.

When engine runs at optimum speed, following benefits are obtained

- Lower consumption of fuel
- Less greenhouse gas emissions.
- Better performance

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