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TITLE: CONTINUOUSLY VARIABLE TRANSMISSIONS (REVIEW)

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Abstract

This thesis describes the basics of Continuously Variable Transmissions (CVT) with its Construction, Working Principle; its Advantages and Limitations over other moving– off elements like Clutches, Torque Converters, etc. It also shows the effect of using Continuously Variable Transmission (CVT) on the Vehicle Performance, Fuel Consumption, Drivers Effort, etc. As CVT development continues, costs will be reduced further and performance will continue to increase, which in turn makes further development and application of CVT technology desirable. This paper evaluates the current status of CVTs and upcoming state and development, set in the context of past development and problems traditionally associated with CVTs. The underlying theories and mechanisms are also discussed

Index Terms: *CVT, moving- off elements, clutches, torque converters, etc.*

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1. INTRODUCTION

Continuously variable transmissions (CVT) are torque and speed converters whose ratio can be continuously varied without interrupting the power flow [4]. It plays the most important part in the performance of vehicle. It is the vital link in a vehicle that constantly changes speed powered by engine which ideally should be operated at a constant speed. With the narrow power band of a modern engine it is important that the engine is kept on the power peak and the power transmitted in the most efficient manner for maximum performance. With growing demand for environment friendly technologies, automobile manufacturers today are increasingly focusing on "Continuously Variable Transmissions" (CVT) as an alternative to conventional gearbox transmission; to achieve a balance between fuel economy and vehicle performance. By allowing for a continuous band of gear ratios between the driver shaft and driven shaft, a CVT permits the engine to operate for the most part in a region of high combustion efficiency resulting in lower emissions, and higher fuel economy.[1]

2. CONSTRUCTION AND WORKING

Major components of CVT are Primary/Driving clutch, Secondary/Driven clutch and the Belt.
Following are the sub-components used in the CVT:
1) Primary Clutch: Stationary Sheave, Movable Sheave, Flyweight/Cam, Follower/Roller, Pressure Spring, Torque Transfer Button, Sliding Surface.
2) Secondary Clutch: Stationary Sheave, Movable Sheave, Torque Spring, Spring Retainer Plate, Slider Button. Torque Feedback Ramp.
3) Belt [2]

3. FUNCTIONS OF VARIOUS COMPONENTS

As CVT is different than the conventional transmission system, components used in the CVT has some definite functions to do. The design of those components varies from the conventional design of components like pulleys, cam, belt etc.[2]

3.1 Function of Primary Clutch and Secondary Clutch

The driven clutch consists of two stamped steel sheaves with the fixed sheave often duplicating in function as a brake disc.

A straight pressure spring pushed against the movable sheave and controls the belt movement. The driving clutch also consists of two stamped steel sheaves, a fixed and a movable. As the Engine starts to rotate, the movable sheave starts to travel. A pressure spring pushes the movable sheave away from the belt, and a centrifugal mechanism works against the spring. This centrifugal mechanism first have to overcome the pretension of the pressure spring to engage the belt, and then revolute higher until it overcome the spring in the driven sheaves and start to shift the belt into higher ratios.[1]

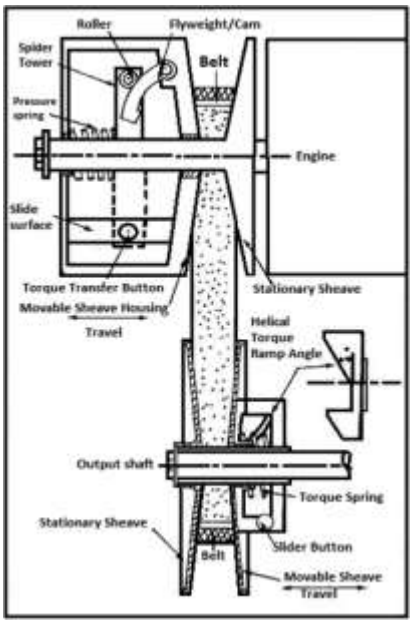

Fig-1: Components of CVT

Fig. shows the variation of speed ratio achieved in CVT. At start when the speed of the engine is minimum or zero the belt is at minimum diameter in primary clutch and at maximum diameter in secondary clutch, hence it has maximum speed reduction. Now when the speed of engine is increased due to throttling the belt shifts in clutches such that it has contact at maximum diameter in primary clutch and minimum diameter in secondary clutch, so it has minimum speed reduction. The spring in the engine clutch controls the engagement speed. The spring in the driven clutch controls the shift speed which should coincide with the engine's power peak for the best performance. The sheaves are cast in aluminium to reduce the rotating weight and to remove the heat more efficiently from the belt surface. Sliding surfaces are provided on the movable sheave to improve the back shifting response. The sliding surfaces are provided as far out toward the outside diameter as possible. The further away from the centre the sliding surface is located, the less force is required on the surface to transfer the torque as the sheave is moving. [1]

Free Running (disengaged): The driving clutch is disengaged below the engagement speed, to permit the engine to be started and to idle when the vehicle is at a standstill. [1]

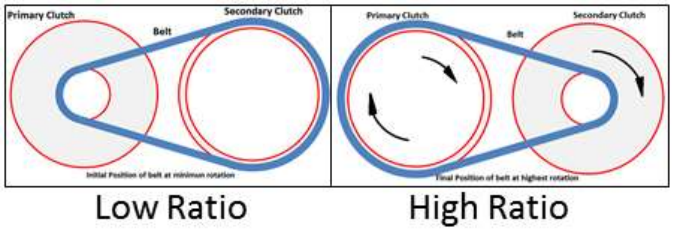

Fig-2: Low Ration& High Ratio

3.2 Function of Pulley

Pulleys are the main components of the CVT. There are basically two types of pulleys used in CVT. One is fixed pulley and another is movable pulley in both primary and secondary clutches. The primary function of pulleys is to transfer power from input shaft to output shaft by means of belt. These pulleys are different from conventional pulleys in terms of variable distance between two contact surfaces.

Fixed pulley is used in both primary and secondary clutches and it cannot slide on the shaft. The main function of the fixed pulley is to give support to the belt and to the secondary pulley. It has internal splines which meshes with the splines on the shaft and thus transmits the power and motion to the belt.

Movable pulley is also used in both primary as well as secondary clutches. The main function of this pulley is to change the contact diameter of the belt on the pulleys i.e. to change the speed ratio. The pulley can slide on the shaft. Thus the distance between the pulleys can vary and due to this the belt will move up or down due to wedge action. The primary clutch movable pulley moves on the shaft due to cam which works on centrifugal force and comes back to its original position by means of primary spring. While in secondary clutch the movable pulley will move due to the belt tension generated by the primary the pulley movement and it comes back to original position by means of secondary spring which is shown in the fig. [5]

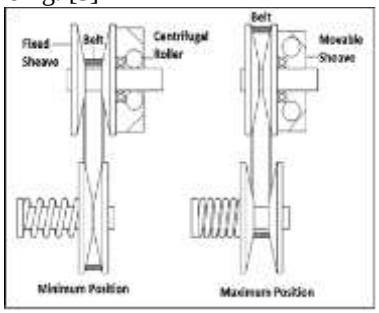

Fig-3: Function of Pulley

3.3 Function of Spider Tower

Spider Tower is used in the primary clutch. Its function is to support the cam and keep the cam in the correct position. It keeps the cam aligned with the movable pulleys during the rotation of the clutch. Spider is fixed on the shaft so when the cam moves due to centrifugal force it actuates the movable pulley rather than moving itself.

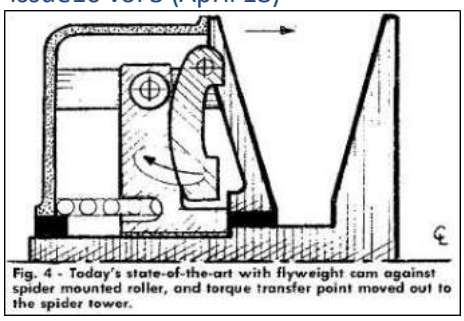

Fig-4: Function of Spider

3.4 Function of Cam and Follower

Function of cam is to actuate the primary clutch movable pulley. This is done by the centrifugal force. Means due to centrifugal force the cam moves apart and actuates the movable pulley, which shifts the belt outward and increases the contact diameter of belt on the pulley. Fig. shows the cam shape used in the CVT. Follower used in the CVT is of cylindrical shape which is mounted on the movable pulley. Three cams and followers are used and followers are aligned with the cam and spaced 120˚apart. [1]

Centrifugal Force (F) = mass(M)* radius(R)* speed2(V2)

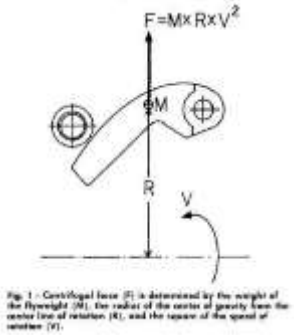

Fig-5:Centrifugal Force

3.5 Function of Belt

Function of belt is to transmit the power from input primary clutch to the output secondary clutch. The power is transmitted by friction and pressure between belt and pulleys. Generally rubber belts are used for lower capacity CVTs and for higher capacity CVTs metal belts are used. Normal V rubber belts cannot be used as they are not capable to withstand the higher tension and the squeezing forces generated by pulleys to shift the belt, so special variable speed rubber belts are developed. For high torque transmission metal belts are used.

Fig-6: Rubber Belt & Metal Belt

3.6 The Pressure Spring

The pressure spring and flyweight mechanism work against each other in opposite directions. To achieve a free running condition and an engagement speed, the flyweight force must opposed by the pressure spring. Engagement speed is determined by the amount of pretension the spring has been compressed to when installed in the clutch. Engine speed has to increase until the flyweight forces can overcome the pretension pressure and the sheave will then start to move and engage the belt.

- **Belt pressure= flyweight force- spring force.**
- **Centrifugal Force increases proportionally with the weight,**
- **Centrifugal Force increases proportionally with the radius,**
- **Centrifugal Force increases proportionally with square of the speed.**

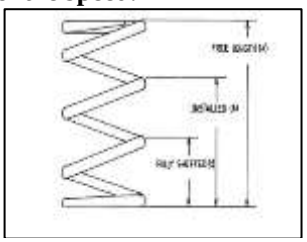

Fig-7: Pressure Spring

3.7 The Pretension Spring

Some initial pressure is needed on the belt before the torque feedback can begin to increase the belt pressure. A driven clutch has a combination of ramp and spring. The spring works primarily in torsion although a small amount of side pressure is also present. Usually a number of holes are available to adjust the pretension from 11.5 N to 111.5 N of pull on the outside diameter of the sheave. **Spring Rule: The stiffer the spring the higher the pretension, the higher the side force.[3]**

Fig- 8: Pretension Spring

3.8 The Torque Feedback Ramp

The Torque Ramp consists of three ramps spaced around a cylindrical surface, and working against sliding buttons in the movable sheave. The angle of the ramps and the radius they work at both have an influence on hw much side force is fed back into the sheaves from the torque. **Ramp Rule: The smaller the ramp angle the higher the side force.** Fig. shows the relationship between the cam angle and the side force. Side force is equal to the force produced at the ramp divided by the trigonometric function "Tangent of the ramp angle."[3]

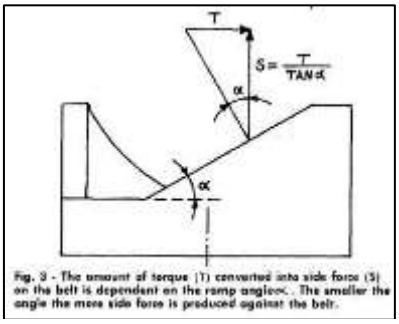

Fig- 9: Torque Feedback Ramp.

4. EFFECTS OF CVT TRANSMISSION

A conventional four speed transmission would have a different speed diagram. Low Ratio would correspond to first gear, and the high ratio would be fourth gear. In between the two lines we would have the second and third gear ratios. As the clutch is released in 1st gear and the vehicle starts moving, the RPM is climbing along the 1st gear ratio line.

The driver must rev the engine to 10,500 RPM and then shift into 2nd gear. When he shifts the engine speed will drop to 6000 RPM and then climb up the 2nd gear ratio line. At 10,500 he shifts into 3rd gear and the speed drops to 6500 RPM. In 3rd gear the speed builds slower along the 3rd gear ratio until the vehicle is again is shifted into 4th gear at 10,500 RPM, and the speed then drops down to 7000 RPM. With 4th gear engaged the vehicle continues to slowly accelerate until top speed is reached in 4th gear.

When comparing the 4 speed gear box to the variable speed transmission a couple of things becomes apparent. With the 4 speed box, very little time is spent at 9000 RPM where the power is. With the variable speed transmission, all the time is spent at the power peak from low ratio to high ratio. Efficiency of a belt drive and a gear box is about the same, and it becomes quite apparent that a lot more is delivered to the ground with the variable speed transmission. By following the power curve and plotting it with 4 speed variable drive transmission the difference can be seen.

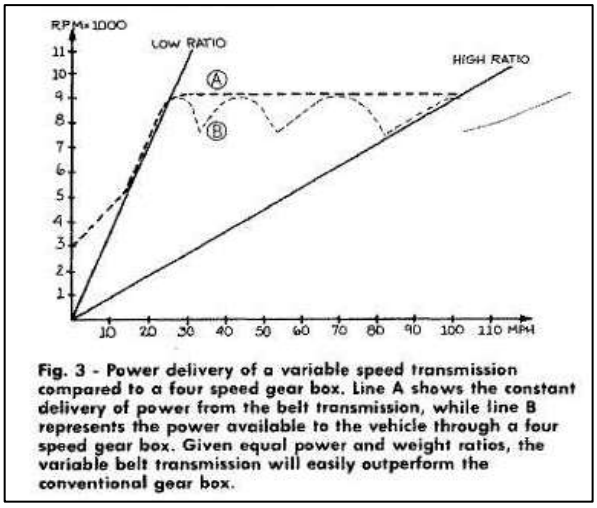

Fig- 10: Comparison between conventional & CVT transmission speed diag.

5. CONCLUSION

Thus we studied the working principle of C.V.T; saw all the basic components with their functions & role in the Vehicle Performance. Simplicity of operation and high efficiency of this system makes it very desirable in many forms of automotive applications.

LITERATURE VIEW

Olav Aaen is widely considered to be the leading expert in the field of CVT design and tuning. He has published nine editions of the **Clutch Tuning Handbook**. This Paper Reviews the basics of CVT like its construction, working. It helps to get an idea of role of components in CVT and their effects on vehicle performance. All the information is taken from the references given below.

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[5] Aprilia Forum hosted by AF1 racing.