Continuously Variable Transmission For Indian Bicycles

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Abstract : A bicycle with a continuously variable transmission elminates the use of derailleur and gear shifters drivetrain components. The continuously variable transmission is driven by a pinion which is inturn provided with input torque by the unser pedal input. The gear ratio is controlled by the torque required at the wheels. The CVT delivers power to a pinion which inturn rotates another gear which is coaxially fitted to a gear which terminates to a static hub wheel. The user neednot control anything as everything is done automatically as per the change in the torque requirement. This proves to be the least rider dependent as the rider has to control only the front and rear brakes which are available at the handle bar. Overall this paper provides a sleek, modern upgrade to the traditional bicycle devices and incorporates several new features which make ride a pleasure comfort.

1 Introduction

The present paper related to the bicycle transmission and drive train assembly. More specifically, this work relates to a bicycle with a continuously variable transmission for transmistting the user power to a static hub wheel through a drive train assemby fitted to the chassis of the bicycle. A CVT effectively provides a continuum of gear ratios within the minimal and maximal range. It provides the efficient and safe output of the human input provided. By automatically changing the ratio to low, the CVT makes it easy for the cyclist to climb the hill. When it comes to plane roads it automatically shifts to the higher ratio thereby making the cyclist to move faster. The cyclist needn't change the power or the rate of pedaling in line with the change in the road conditions. This mechanism does so by varying the speed according to the change in required torque. A CVT mechanism thus makes it feel same for the rider while climbing hills or even moving on plain roads. The CVT automatically adjusts the ratio contingent on the requirement of torque

The particular ransmission, which serves as a front gear system mounted to a pedal crank arm, or as freewheels at a rear hub so as to be meshed with a drive chain for transmitting the drive force from pedaling to the rear wheel of the bicycle.[1] The invention provides an automatic transmission for bicycle, which changes its speed in response to the speed of its turning wheels without extra manipulation. Also, an incorrect gear engagement between the bicycle chain and the chain sprocket causes loud noise, abnormal wear and tear between gear sets, etc. [2] This invention also comprises an automatic transmission for a multi-speed bicycle employing a multi-stage rear sprocket assembly having different-diameter sprockets and having a derailleur for selectively derailing the drive chain from one sprocket to an adjacent sprocket by means of centrifugal force imparted to the derailleur in response to increased speed of the bicycle. [3] This invention provides a drive transmission

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for a bicycle or automatically adjusts the transmission ratio be-tween the rear wheel and the pedal sprocket without the use of levers or other complicated mechanisms. It also provides such a drive transmission, which has a relatively infinite number of ratios between the rear wheel and the pedal sprocket. [4] Provides a vehicle drive apparatus, which includes a wheel rotatable supported on the vehicle, and a shift member supported for rotation coaxially with the wheel and supported for movement axially with respect to the wheel between first and second positions [5] These bicycles provide means for varying the transmission ratio between the pedaled sprocket and the rear wheel of the bicycle, the ratio being adjusted in discrete increments by the rider in accordance with speed and/or grade of terrain. The conventional transmission changing mechanism of speed bicycles is the so-called "derailleur" mechanism. [6] The drive ratio of a bicycle transmission is automatically varied through a radially contractible drive chain sprocket wheel assembly that is drivingly coupled to a pedal driven, drive ratio control disk. A force transmitting spring couples the control disk to the sprocket wheel assembly. A fluid-dash-pot device dampens angular oscillation of the control disk relative to the wheel assembly and reduces cyclic fluctuations in the drive ratio. [7] An electronic/electromechanical transmission shifter has a velocity detector, which generates an electrical signal representing the vehicle velocity. A microcomputer is connected to the velocity detector, to a plurality of manually controlled switches and to a digitally controlled linear actuator, which is linked to the shift member of the vehicle. [8] To provide a multi-speed inline shaft-driven transmission for a bicycle that is compact, durable, and efficient. Which utilizes two sets of bevel gears for efficiently transferring power between angled shafts. It provides a bicycle transmission, which provides multiple gear ratios without using any clutches. It utilizes straight cut gears to provide variable transmission ratios. [9] A freewheel gear cluster provided on the rear of a bicycle of the type using a derailleur to shift its drive chain and having gear-up assistant hooking members provided on the rim of the large-diameter sprocket on the side facing the small-diameter sprocket wheel, wherein the improvement comprising: a gap provided between the bottom of the gear-up assistant member and the sprocket wheel capable of imbedding the links of the drive chain.[10] Multi-stage sprocket assembly for a bicycle, including two or more sprockets, in which at least one of axially outermost sprockets is provided at the laterally outer surface of a body thereof with a plurality of projections extending axially outwardly of the sprocket, the projections being positioned circumferentially of the sprocket body and radially inwardly of the dedendum circle of the sprocket, so that a driving chain may, when riding over and coming off the sprocket, be stopped by the projections to thereby be reliably prevented from being jammed between the sprocket and a spoke, hub flange or crank arm at the bicycle.[11]

In the present scenario, the heavy traffic congestions, excessive pollution and progressive depletion of fuel have lead to an incomprehensible situation. Day by day new innovations are coming up in the field of automobiles with greater ease, pleasure and comfort riding. There have always been opportunities for development in the human abled movement, the most common being the improvement in the bicycle riding experience. Even today’s bicycles are not comfortable requiring variable power input, whenever there is a change in terrain.

At present we find bicycles fitter with two sprockets, which delivers a constant fixed gear ratio. We also find bicycles fitter with many side-by-side coaxial sprockets having, from the smallest to the largest, an increasing number of teeth according to the following sequence 12,13,14,15,16,17,19,21,23,25 [12] and a sprocket connected to the pedal with 32 teeth.

2 Continuously Variable Transmission

The most common type of CVT operates on an ingenious pulley system that allows an infinite variability between highest and lowest gears with no discrete steps or shifts. A continuously variable transmission (CVT) is a transmission which can change steplessly through an infinite number of effective gear ratios between maximum and minimum values. This contrasts with other mechanical transmissions that only allow a few different distinct gear ratios to be selected. The flexibilty of CVT allows the rider to maintain a constant pedalling speed over a range of output velocities. This can provide better riding comfort and pleasure and make no difference moving at levelled lands or elevated lands. Thus keeping the input constant it delivers varied speeds as per the change in the torque requirement on to the rear wheel.

2.1 Mechanism of CVT

In a CVT system, when the rider rotates the peddal, the rollers in driving pulley create the displacement of the drive pulley and change the CVT ratio by centrifugal force depending on the speed of the peddal. That roller will push the drive pulley to increase their diameter. The distance between the centers of the pulleys to where the belt makes contact in the groove is known as the pitch radius. When the pulleys are far apart, the belt rides lower and the pitch radius decreases. When the pulleys are closes together, the belt rides higher and the pitch radius increases. The ratio of the pitch radius on the driving pulley to the pitch radius on the driven pulley determines the transmission gear ratio. V belt is connected between drive pulleys to driven pulley to transmit the energy from the peddal.

2.2 Calculations of Force requirement at the rear wheel

2.2.1 When the bi-cycle moves uphill along an inclination of θ

$$F= mg \sin\theta + Cr\, mg \cos\theta + \tfrac{1}{2}\, Cd\, \rho\, Av^2 \quad (1)$$

$$P= mg \sin\theta\, v + Cr\, mg \cos\theta\, v + \tfrac{1}{2}\, Cd\, \rho\, Av^3 \quad (2)$$

2.2.2 When the bi-cycle moves on a flat land

$$F= Cr\, mg + \tfrac{1}{2}\, Cd\, \rho\, Av^2 \quad (3)$$

$$P= Cr\, mg\, v + \tfrac{1}{2}\, Cd\, \rho\, Av^3 \quad (4)$$

The Continuously Variable Transmission (CVT) system consists of two parts: the variator (drive pulley), and the clutch (driven pulley). These are connected by the CVT belt. The CVT system works through the changing of the distance between the plates on the two pulleys. The clutch pulley plate width increases, and vice versa. This creates an infinite number of possible gear ratios, as the transmission is altering itself on the fly to adapt to the current torque requirement condition.

The CVT transmission system must be able to tranfer this amount of load from the peddal onto the wheels as per the rider input.

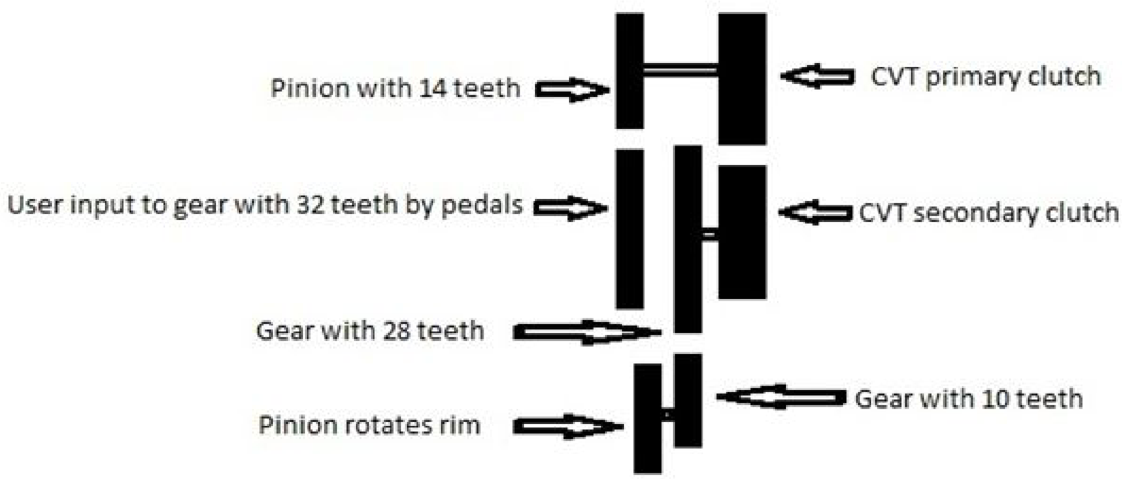

Fig. 1 Representation of the gear and CVT arrangement.

Fig. 2 Left side view of the bicycle.

From Fig. 2, it is seen that the front wheels are comparatively smaller than the rear wheels, the reason being that the front wheels are required for steering purpose only. A wheel with smaller diameter leads to lesser traction force and weight reducton of the over all bicycle. The rear wheel of the cycle is supported with a static hub wheel. The hub and the 3 alloy spokes hold the wheel in its proper position with respect to the chessis and doesnot allow it to wobble. The alloy consists of 2 taper bearings which form a groove like structure but having a gap between the two inclinations for the geared profile to rotate.

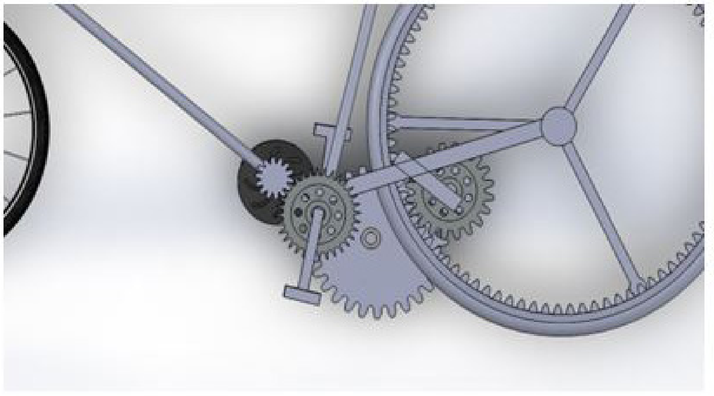

Fig. 3 Left side view of the transmission of the bicycle.

From Fig. 1 and Fig. 3, the user inputs onto the pedals are transferred to a gear with 32 teeth, which in turn rotates a pinion of 14 teeth, the reduction ratio being 2.28. This pinion is coaxially fitted to the primary clutch of the CVT. The primary clutch in turn is connected to the secondary clutch with the help of a belt, in Fig. 1 and Fig. 4. The secondary clutch is connected to a gear of 28 teeth which is meshed with another pinion with 10 teeth, the reduction ratio being 2.8. This gear is coaxially fitted to another pinion with 14 teeth and finally this terminates rotating the rim with 42 teeth, the reduction ratio being 3.

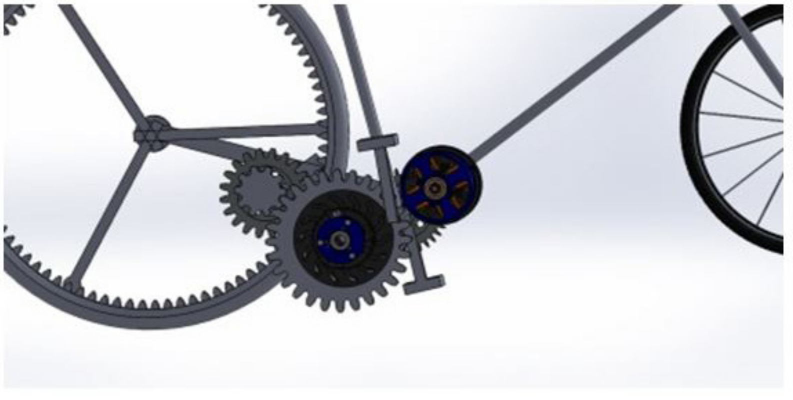

Fig. 4 Right side view of the transmission of the bicycle.

3 Results and Discussions

A bicycle with a continuously variable transmission fitted to a static hub wheel proves to be better as it provides a infinite gear ratios when compared to the derailleur which has fixed number of gear ratios. As the gear ratios change automatically depending upon the change in terrain and the change in the torque requirement to the rear wheel there by reducing the chances of fatigue, as the rider feels no difference in pedalling while moving uphill or in flat lands, only the speed changes keeping the rate of pedalling constant. As a cyclist has no idea about the exact gear ratio he should ride at any particular time, so when it is shifted to automatic, the rider gets the efficient output of the input. This is supported aerodynamically and proves to be a effective means fo transmission when compared to the present conventional technique. As this mechanism directly drives the rim, so it proves to be efficient.

Appendix

Eq. 1- Force calculations when the bicycle moves uphill along an inclination of θ
Eq. 2- Pressure calculations when the bicycle moves uphill along an inclination of θ
Eq. 3- Force calculations when the bicycle moves on a flat land
Eq. 4- Pressure calculations when the bicycle moves on a flat land

F = Force
P = Pressure
m =Mass
g = acceleration due to gravity
□ = angle of inclination
Cr = Coefficient of friction
Cd = Coefficient of drag
ρ = density of air
A = projected frontal area
v = velocity of the bicycle

References

1. Shimano, K. (1983). U.S. Patent No. 4,380,445. Washington, DC: U.S. Patent and Trademark Office.
2. Jung, Y. C. (2000). U.S. Patent No. 6,158,294. Washington, DC: U.S. Patent and Trademark Office.
3. Chattin, J. R. (1992). U.S. Patent No. 5,163,881. Washington, DC: U.S. Patent and Trademark Office.
4. David, D., & Sheldon, W. (1975). U.S. Patent No. 3,873,128. Washington, DC: U.S. Patent and Trademark Office.
5. Imhoff, D. (1987). U.S. Patent No. 4,713,042. Washington, DC: U.S. Patent and Trademark Office.
6. Dutil, R., & Gilbert, R. (1986). U.S. Patent No. 4,598,920. Washington, DC: U.S. Patent and Trademark Office.
7. Newell, H. R. (1976). U.S. Patent No. 3,995,508. Washington, DC: U.S. Patent and Trademark Office.