Experimental Investigation To Study Effect of 6mm Sleeve Fix Pitch on Power Transmission & Vibration in Floating Bar Timer Belt Drive

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Abstract— **The solid cone arrangement in A+CVT is replace by hollow cone with floating bars. The metal chain is replaced by timer belt making system cost effective and standardized. The floating bar are fixed at one end and provided with damper sleeves at other end , in our project we have tested the system with 6mm sleeve , this changes the pitch distance at the floating end which will affect the vibrations produced by drive during transmission . The object of project is to study the variation in vibration parameter of displacement and acceleration due to change in sleeve dimensions. The effect of change in sleeve dimensions on drive torque, power and efficiency will also be studied.**

Keywords: ***A+CVT, acceleration, displacement, floating bars, floating end, timer belt.***

I. INTRODUCTION

The primary function of a transmission is to transmit mechanical power from a power source to some form of useful output device. Since the invention of the internal combustion engine, it has been the goal of transmission designers to develop more efficient methods of coupling the output of an engine to a load while allowing the engine to operate in its most efficient or highest power range. Conventional transmissions allow for the selection of discrete gear ratios, thus limiting the engine to providing maximum power or efficiency for limited ranges of output speed. Because the engine is forced to modulate its speed to provide continuously variable output from the transmission to the load, it operates much of the time in low power and low efficiency regimes. A continuously variable transmission (CVT) is a type of transmission, however, that allows an infinitely variable ratio change within a finite range, thereby allowing the engine to continuously operate in its most efficient or highest performance range, while the transmission provides a continuously variable output to the load. The development of modern CVTs has generally focused on friction driven devices, such as those commonly used in off-road recreational vehicles, and recently in some automobiles. While these devices allow for the selection of a continuous range of transmission ratios, they are inherently inefficient. The reliance on friction to transmit power from the power source to the load is a source of power loss because some slipping is possible. This slipping is also a major contributor to wear, which occurs in these devices. To overcome the limitations inherent in the current CVT embodiments employing friction, a conceptual, continuously variable, positive engagement embodiment has been proposed for investigation at Brigham Young University. This concept proposes utilizing constantly engaged gears which transmit power without relying on friction. Because the proposed embodiment is new, no engineering analysis has yet been performed to determine its kinematic and meshing characteristics, an understanding of which are necessary to validate the proposed concept as a viable embodiment. This research will investigate both the kinematic and meshing characteristics of this and related concepts.

The objective of this research is also to analyze the family of positive engagement CVTs. Although the CVT embodiment that has been proposed for investigation is new, other embodiments belonging to this family have been developed and published. The embodiments in this family do not rely on friction based power transmission. All embodiments in this family, however, have been based on overcoming a distinct problem which manifests itself seemingly regardless of the embodiment and will hereafter be referred to as the non-integer tooth problem. This research describes the nature of the non-integer tooth problem and details the occurrence of the problem in the proposed concept, as well as three published embodiments, and details solutions to the non-integer tooth problem as embodied in the three published embodiments. The presentation of some published solutions to the non-integer tooth problem clarifies the nature of the noninteger tooth problem, as well as aids in the development of characteristics of a general solution to the non-integer tooth problem applying to all members of the positive engagement CVT family [8].

II. LITERATURE SURVEY

1.Beachley et al, (1979)[1] described Hydrostatic transmissions which are commonly used in off-road vehicles and agricultural machinery. Many commercial riding lawn mowers commonly employ hydrostatic transmissions in their drive trains.

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2. Kumm et al (1985)[8] analysed the Flat belt CVT .Developed originally by Kumm Industries, the flat belt CVT is composed of a flat elastomer belt and two pulleys. The two pulleys are composed of two guideway discs on each side. These guideway discs have logarithmic spiral guideway slots which support the ends of the belt drive elements. The set of guideways in one disc have clockwise curvature and the slots in the opposing disc have counterclockwise curvature.
3. Singh and Nair et al (1992)[2] described the Traction drive and V-belt drive CVT.Traction drives were one of the earliest forms of CVT concepts ever developed.
4. Kluger and Fussner,et al (1997)[3] analysed the Friction CVT.The friction CVT is one of the most common forms of CVTs in use today. These CVTs are characterized by the use of friction to transmit power.
5. Srinath N July (2015)[10]. This paper describes the design and development of power transmission through manual Anderson CVT. This design simplifies the transmission of power from rotary motion and also over comes the complexity of changing the speed ratios of pulleys and gears.

III. Research Background

There are many machines and mechanical units that under varying circumstances make it desirable to be able to drive at an barely perceptible speed , an intermediate speed or a high speed. Thus an infinitely variable (stepless) speed variation in which it is possible to get any desirable speed. Some mechanical, hydraulic, drives serve as such step less drives. However the torque Vs speed characteristic of these drives do not match torque at low speeds. The need of a step less or infinitely variable speed drive with following characteristic: -

1)Step less or infinitely varying speed.
2)Wide range of speed variation i.e. (Nmax - Nmin).
3)Shifting from one speed to another should be shock less.
4)Minimum number of controls for speed changing.
5)Ease of operation

In case of automobiles it is found that the conventional belt cvt offers following disadvantages[9]:

a) Velocity ratio is not constant , i.e ;the percentage slip is very high thereby leading to lower transmission efficiency and in accuracy of drive
b) But these drives offer following disadvantages:
c) Limited number of steps available so limited range of spindle speeds.
d) Non constant velocity ratio drives hence precise speeds are not available.
e) Occurrence of slip leads to low transmission efficiency (< 60%)
f) Machine needs to be stopped for each speed change .
g) Other form of stepped drives are the Pick-off gears, All geared headstocks , Norton gear boxes , etc..all these drives show the same problems explained above with varying intensity , hence the step-less mechanical were invented.

Continuously Variable Transmission (CVT) or variable speed drive is a type of automatic transmission that can change the "gear ratio" (gears are not generally involved) to any arbitrary setting within the limits. The CVT is not constrained to a small number of gear ratios, such as the 4 to 6 forward ratios in typical automotive transmissions. CVT control computers often emulate the traditional abrupt gear changes, especially at low speeds, because most drivers expect the sudden jerks and will reject a perfectly smooth transmission as lacking in apparent power. An extension to CVT design, sometimes known as the Infinitely Variable Transmission (IVT), allows the transmission to drive a vehicle backwards as well as forwards. Transmission input is connected to the engine, then it is split into 2 shafts with one connected to an epicyclic gear set. The output from the CVT shaft is connected to another shaft that connects to a different set of gears in the epicyclic. The gear that does not draw power from engine or CVT transfers torque to the transmission output. The gear set acts as a mechanical adding machine to subtract one speed from the other, allowing the car to go forwards, backwards, or neutral[5].

IV. Problem Statement

It is a technology invented by Larry Anderson, under US patents 6,575,856[1] and 6,955,620[3]. Two parallel cones have "floating sprocket bars" mounted in longitudinal grooves around the circumference of each cone. A specially-designed chain meshes with the floating sprocket bars, and is free to slide along the length of cones, changing the gear ratio at each point. The floating sprocket bars(Fig.1) make the A+CVT positive-drive, non-friction-dependent. Another advantage of the A+CVT is the simplicity of its design, as it consists of far fewer components than other transmissions. The technology is also adaptable to a variable diameter pulley-type CVT, by mounting the floating sprocket bars on the inner face of the pulley sheaves[7].

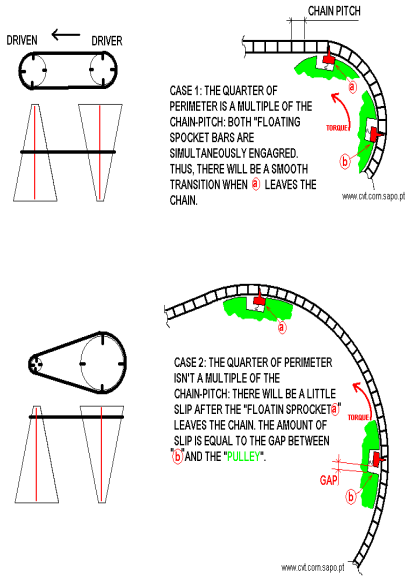

Fig.1(Floating Sprocket Bar[8])

Fig.1(Anderson CVT[7])

The above design(Fig.2) uses conventional spring loaded rubber sprocket bars, which are subjected to heavy wear and tear, hence may have to be replaced frequently, so also the manufacturing cost of the above device is slightly on the higher side hence a alternative fixed pitch CVT is proposed in the following literature.

V. SOLUTION TO PROBLEM

Alternative fixed pitch CVT (Fig.3) is a modification over the A+CVT , in the following parameters;

a.The cone are made hollow instead of solid as in A+CVT , alloy steel bars are used instead of rubber sprocket bars., this strengthens the generators of the cone and provides for a more stable power transmission and better load carrying capacity. So also the net weight of the cone comes down by more than 70% , this leads to reduced material cost.

b. The second change is in the belt , a timer belt of L-section is selected as the transmission element , this makes the selection easy and commercial viability more possible as the timer belt is an standard available part and can be selected from manufacturer catalogue. As the belt is an standard element hence it comes cheap, thereby further reducing the manufacturing cost. Belt on the other hand helps keep noise at low level making the drive silent to perform.

The use of alternative materials for cone and belt completely changes the complexion of the drive making it commercially viable and popular , as the spares will be all standard parts.

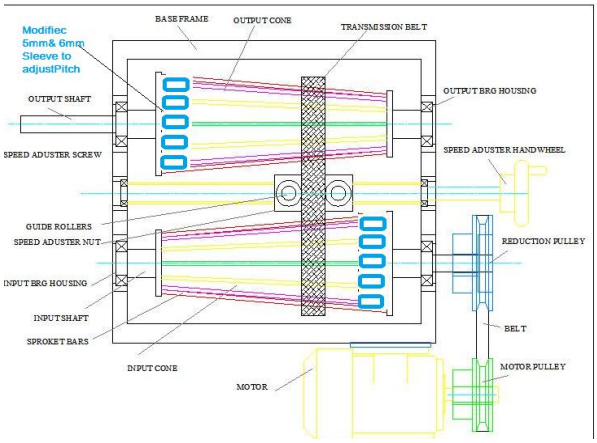

Fig.3(Line Diagram of Proposed Drive)

VI. EXPERIMENTATION

Experimental setup consists of following components.

1. Two Hollow Cones with floating bars.
2. Timer belt
3. Input Shaft
4. Output Shaft
5. Electric Motor
6. Dyno brake pulley
7. V-belt

The Experimental setup is as shown in Fig.4. It consist of single phase (230 volt, 0.5 Amp, 185watt, 50Hz,1440 rpm)TEAC capacitor motor for driving the system. The motor shaft transfers its revolutions to input shaft through pulley and V belt. The two cones are then rotated by means of timer belt. Arrangement is made to attach different loads on output shaft by dynobrake pulley.

Fig.4(Photograph of Experimental Setup)

VII. EXPERIMENTAL PROCEDURE

Start the motor by turning on the electronic speed variator knob. Let the mechanism to run and stabilize at certain speed say 660 rpm. Place the pulley cord on dyno brake pulley and add 500gm weight into the pan. Now take the output speed reading by means of tachometer. Simultaneously note the displacement and acceleration by means of vibrometer. Add another 500gm weight and take similar readings. Repeat the procedure by adding each time 500gm weight upto six readings.Tabulate the readings in observation table.Plot the Torque Vs Speed,Power Vs Speed,Load Vs Speed, Displacement Vs Speed and Acceleration Vs Speed Characteristics.

OBSERVATION TABLE I

Sr.No	Loading		Displacement(mm)	Acceleration(mm/s^2)
	Weight(kg)	Speed(rpm)		
1	0.5	650	0.215	180
2	1.0	641	0.241	190
3	1.5	630	0.257	192
4	2.0	620	0.289	196
5	2.5	614	0.291	210
6	3.0	610	0.314	217

Sample calculations:

For 0.5 kg load

Torque= 0.5x9.81x0.0325=0.159413Nm

Power= 2πx650x0.159413/60=10.85227 watt

Efficiency=10.85227/70=15.50325%

RESULT TABLE II

Sr.No.	Load (kg)	Speed (rpm)	Torque (Nm)	Power (Watt)	Efficiency	Displacement (mm)	Acceleration (mm/s^2)
1	0.5	650	0.159413	10.85227	15.50325	0.215	180
2	1.0	641	0.318825	21.40402	30.57717	0.241	190
3	1.5	630	0.478238	31.55507	45.07867	0.257	192
4	2.0	620	0.63765	41.40559	59.15084	0.289	196
5	2.5	614	0.797063	51.25611	73.22302	0.291	210
6	3.5	610	0.956475	61.10664	87.2952	0.314	217

OBSERVATIONS FROM RESULT TABLE

1.Power Vs Speed Characteristics

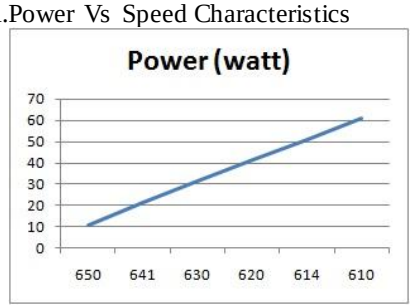

Fig.5(Power Vs Speed Characteristics)

The output speed reduces with increase in power.

2.Torque Vs Speed Characteristics

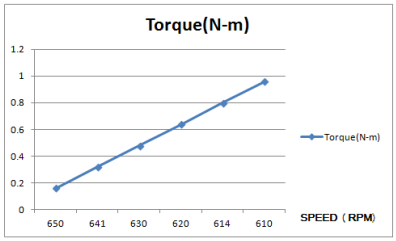

Fig.6(Torque Vs Speed Characteristics)

The output torque increases with decrease in output speed.

3. Efficiency Vs Speed Characteristics

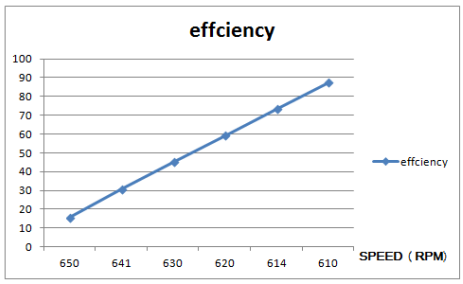

Fig.7(Efficiency Vs Speed Characteristics)

The efficiency increases with reduction in output speed.

4. Displacement Vs Speed Characteristics

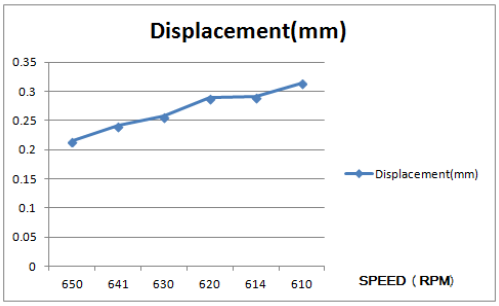

Fig.8(Displacement Vs Speed Characteristics)

Vibrational displacement increases with increase in load on dyno brake pulley as result drive is subjected to slight vibration.

5. Acceleration Vs Speed Characteristics

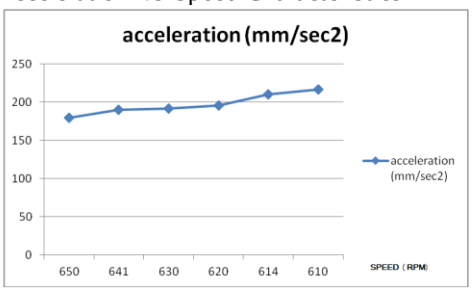

Fig.9 (Acceleration Vs Speed Characteristics)

Vibrational acceleration increases with increase in load on dyno brake pulley as result drive is subjected to slight vibration.

VIII. CONCLUSION

Conventional transmissions allow for the selection of discrete gear ratios, thus limiting the engine to providing maximum power or efficiency for limited ranges of output speed. Because the engine is forced to modulate its speed to provide continuously variable output from the transmission to the load, it operates much of the time in low power and low efficiency regimes. A continuously variable transmission (CVT) is a type of transmission, however, that allows an infinitely variable ratio change within a finite range, thereby allowing the engine to continuously operate in its most efficient or highest performance range, while the transmission provides a continuously variable output to the load. In this research work the proposed CVT gives maximum transmission efficiency upto 87% at much lower vibration level.

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