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ASPECTS REGARDING GENERAL CONSIDERATIONS IN THE STUDY OF CONTINUOUSLY VARIABLE TRANSMISSION – CVT

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ABSTRACT

This paper aims to study specific type involved in presenting Continuously Variable Transmission system components simplified principle, by studying, perfecting and seeking to obtain a smooth power curve without almost any peak, taking into account the general considerations, pressure control, analysis and considerations about belt slip motion, vibration and specificenergy

KEYWORDS: CVT, optimization, experiment, belt, variable transmission, power loss, pressure control , belt sleep, analytical approach

1. GENERAL CONSIDERATIONS

The engineers implicated in the study of CVT systems, are continuously pursuing technology for wind generators to explore the most different types of rotors, rotor-generator drive systems, transmissions, chassis to continuously develop performance, efficiency and stability of wind structures.

A few of the benefits of using wind turbines are: renewable fossil fuel reduction, less air pollution, less than the initial cost of many construction used in the exploitation of natural resouce and many others.

A concept well enough summarized in this paper is Continuously Variable Transmission or short CVT system, proposed in the present work which has the appearance of offering infinite number of gear ratios in well defined limits of the minimum and the maximum bouderies. Also the traction of the whole system is not interrupted when gearing, the CVT keeps all the torque transmission when shifting except for specific system slides.

This gives a much smoother motion of the transmission itself compared to the traditional transmission with gears components.

This particular type of system is created to eliminate bullying through efficiency that occurs in the automatic transmission system (robotic) existing in these wind generators.

By studying and perfecting the CVT we seek to obtain a smooth power curve without peaks, no maximum peak or mininum peak, by optimizing the kinetic energy provided by the wind in all wind conditions starting from the smallest wind up to extreme winds, with different ratios applied.

The CVT system has been studied quite a lot by the engineers in the automobile field and has been optimized to produce appreciable results even compared to those produced by manual or automatic gearboxes.

It is known that the system may have difficulty with high torque and low speed wind, but a continuous variable system is appreciated by the fact that the results given show a continuous curve generated that the system can manage and maintain in the context of the use of the energy generated.

For the effective control of the CVT belt system, the belt allows at any time through a specialized software to improve overall system performance for a particular operating conditions.

Also to get the maximum efficiency, it is recomended to perform both mechanical and electrical modifications on existing CVT systems in cars and scooters. [1]

The experiment can be done with a rotor and a generator that simulate real conditions of the effect of wind on the rotating blades, transmission of the torque from axle shaft to the generator to be made by the CVT.

The entire system can be connected to a dynamometer for power measurement and electricity resulting from a voltmeter.

The experiment has the particular impact of transmission strategy and the behavior in particular conditions, vibrations occurred and its effectiveness, results that aim obtaining generalized model.

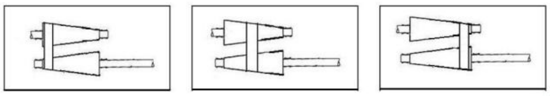

Fig 1. Simplified principle of CVT system

In Figure 1 can be seen the CVT system more streamlined, one end being attached to the engine and the other end to the generator.

Fig 2. The belt that can be used in most of the CVT system

The belt shown in Figure 2 which is present in the proposed CVT system configuration has the flexibility needed for both engine torque and speed for maximum operation. Also in the case of high wind speeds the CVT system may disconnect the generator or it can rotate at speeds of 20-25 times smaller than the wind speed to protect any component.

The best efficiency on the curve is described by optimizing the operation in terms of energy, rotation and direction of rotation as shown in Figure 3.

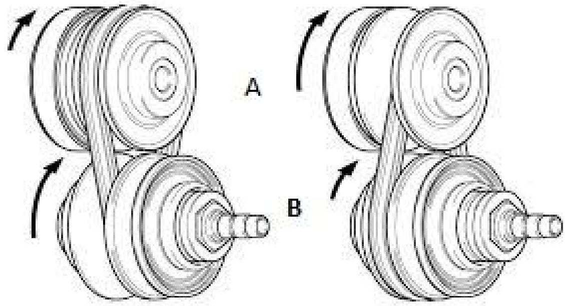

Fig 3. Sense of rotation, and the ratio type (B<A and B>A)

2. PRESSURE CONTROL OF THE DECKS AND THE BELT

Raising pressure at the base of the belt between the two decks is essential and it is the key component in this type of transmission efficiency.

Ideally, the pressure on the belt would need to be optimized to achieve efficient transmission friction that occurs with turntables and avoids the belts slip (if the pressure is too low) or to heat up too much (when pressure is too high) and exert friction that overheats and could destroy the belt. [2]

For these reasons, it is always necessary to aid algorithmic specialized software optimization in doing its adapting to the differences between short and long wind speed. This algorithm uses a variable speed rotor to apply pressure differentiated by speed for hydraulic pump by pressing in turn the belt. Hydraulic pump was instrumented to evaluate energy use. To study the input torque is generally used a sensor for torque power.

3. IMPACT CAUSED BY THE USE OF CVT SYSTEM

Using a CVT system significantly enhanced traction control by changing the ratio continuously throughout the entire operation.

Every time the speed of the engine (rotor) can be set using a potentiometer to any value allowed from minimum to maximum range possible, and because of specific software that will be studied in the future, the power transmission shaft generator must be optimal.

Engine operating points, namely instantaneous engine torque and speed can be set frequently (within certain limits) during the rotation starting from the common minimum to maximum points.

By setting these points, the system will significantly increase control of the tracks, if the power curve is around those points.

The CVT system was operated by the passage of five various values in ascending order to the existence of a system that can simulate classical shifting gears and specific ratio.[3]

To start the rotation of the wind generator at a very small wind power is necessary that the propeller shaft be lower and the generator shaft be higher so as to result in a low speed but a large torque multiplication transmitted through the system.

4. BRIEF ANALYSIS OF THE BELT SLIP

The large forces that push on the belt pressing system reduce transmission efficiency in a CVT system. But those forces are necessary to prevent and mitigate landslides between belt and pulley.

A V-shaped belt (high to low-less friction) O (same speed -less friction) or V trip (low to high-less friction) are components of the system. The belt or the chain transmit torque from a driving side to another side by movement with friction. By changing the pressure on the plates is adjusted the ratio and therefore the rotation speed of the generator, optimum power is provided.

To prevent the escape of a chain or the belt, a pressure will be applied influencing the transfer curve.

Transfer curve can be controlled for maximum efficiency, mostly depending on the CVT ratio. Efficiency of the system is high only in the range of 1-2% slip. [4]

Since torque is not the same at all times and because a torque sensor will not always be used because of the cost consideration, the pulley is generally pushed with maximum force that will act almost all the time. By acting with pressure on the belt or chain with large forces, those forces can damage or produce deformation for internal components such as belt or pulley.

Belt pulley uses friction to transmit power from the first pulley in the second. Traction curve is a dimensionless relationship between torque and slip. Maximum input transmision that can be transmitted by the first pulley to the second with the help of the chain or the belt, is dependent on the clamping force that is applied.

The coefficient of traction is a dimensionless value and is equal to :

$$\varphi = \frac{T_q \cos \varphi}{2 F_s R_s} \qquad (1)$$

Where the T_q represents torque input, R_s represents the secondary radius of the belt, F_s represents the secondary clamping force and φ is the pulley angle.

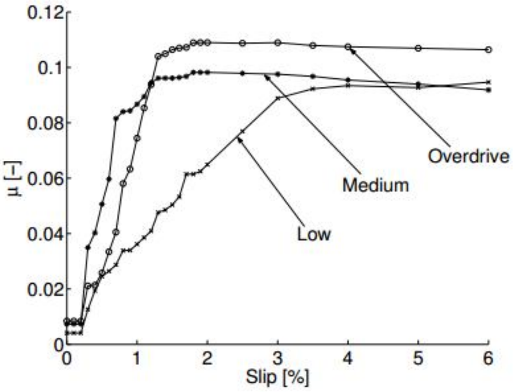

Fig 4. Traction coefficient at low ratio, medium and overdrive corresponding positions from fig 1.

The traction coefficient in overdrive shown in Figure 4 was ω_s = 150, 225,300 and the traction coefficient at ratio low was the same,but the belt sleeps within Δ.

The slipping belt or chain in the CVT system can be defined as:

$$\vartheta = \left| \frac{\omega_s}{\omega_p r_0} - 1 \right| \qquad (2)$$

where :
ϑ is the slip of the belt or chain
ω_s is the angular speed of the secondary axle
ω_p is the angular speed of the primary axle
r_0 is the geometrical ratio

And r_0 is defined as:

$$r_0 = \frac{R_s}{R_p} \qquad (3)$$

where:
R_s is the running radius on the secondary pulley
R_p is the running radius on the primary pulley

The imput speed of the first pulley and the pressure applied have a decisive influence on the final result and in optimizing the entire system.

4. SHORT ANALYTICAL APPROACH OF MOVEMENT SPEED, VIBRATION AND ENERGY

Before starting the experiments it is useful to make an estimate of analytic equations of the belt. LAGRANGE II equations are used to show the equations of motion, where T is the kinetic, V is the potential energy of the system, q is the vector of the generalized coordinates and Q^T_{NK} is the vector of the non-conservative forces.

$$\frac{d}{dt}\left(\frac{\varphi T}{\varphi \dot{q}}\right) - \left(\frac{\varphi T}{\varphi q}\right) + \left(\frac{\varphi V}{\varphi q}\right) = Q^T_{NK} \quad (4)$$

Equations of motion can also be under the form:

$$M\ddot{q} + B\dot{q} + Cq = 0 \quad (5)$$

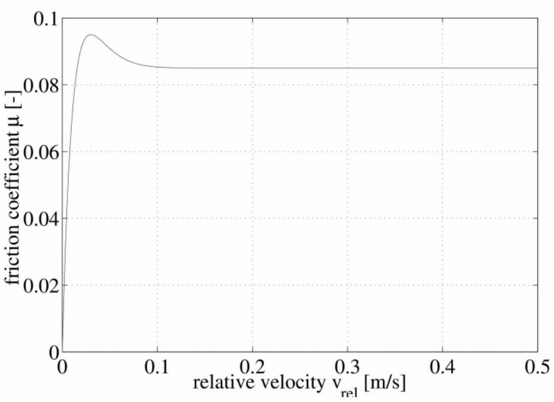

Fig. 5. Friction coefficient μ vs relative velocity (m/s)

Moreover, moving mass is assumed to be harmonic and described in the following equation using the angular frequency.

$$x = \hat{x}\cos\omega t \quad (6)$$

$$\dot{x} = -\hat{x}\omega t \quad (7)$$

The mass movement around the trajectory is assumed to be small and coefficient of friction in contact with the elements can be linearized, at constant speed.

For a specific movement of the belt speed is given the following drawing.

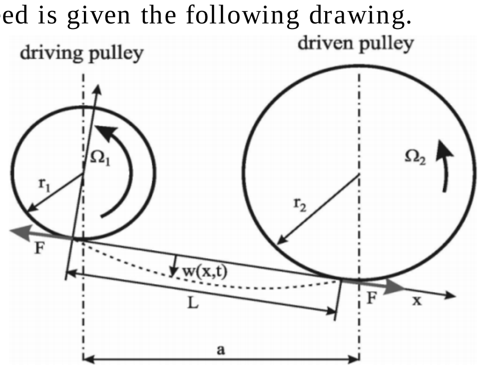

Fig 6. Geometry of a specific speed ratio

The vibrations of the belt are shown in the following graphs in two ways:

1. Under heavy load:

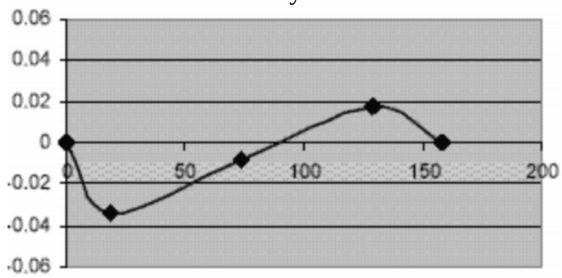

Fig 6. Vibration of the belt under heavy load

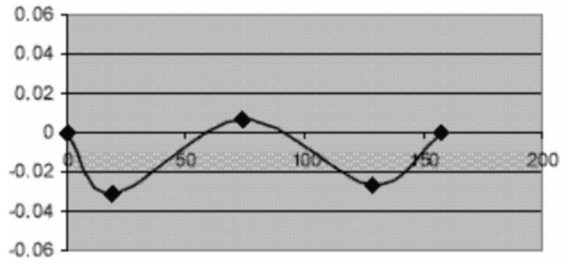

Fig 7. Vibration of the belt under no load

The kinetic and potential energies of the belt are given in the next equation.

$$T = \frac{1}{2}\int_0^L \mu\,((\omega+v\omega')^2+v^2)dx \quad (8)$$

$$V = \frac{1}{2}\int_0^L \mu\,(F\,\omega'^2+EI\,\omega''^2)dx \quad (9)$$

5. CONCLUSIONS AND FUTURE WORK

In this paper, are presented general considerations, a brief analysis of the sliding belt or chain in a CVT transmission, rotational speed, vibrations and energies involved to create the necessary traction between the axis of the blade and the shaft generator.

The object of this study was to obtain a baseline for the futured studies which are to explore and optimize the use of CVT system in wind generators.

5. REFERENCES

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