A REVIEW ON CONTINUOUSLY VARIABLE TRANSMISSION SLIP CONTROL

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Abstract- Automakers are continuously researching new technology in order to develop power train systems such that they reduce power losses in the vehicle. The most important key element in a passenger vehicle is comfort ride performance. The solution to achieve this is by which continuously variable transmission. Continuously Variable Transmission (CVT) uses variable adjustable drive ratios instead of discrete gears to obtain optimal engine performance. As CVT development proceeds, performance will always be going to increase and costs will be reduced timely which makes further development and application more desirable. Knowing its performance limitations will act as a guide for employment in different applications.The current paper reviews the state-of-the-art research on slip control in continuously variable transmissions. The various methods to control clamping force of the pulleys on the belt in such a way that a limited amount of slip is allowed are also discussed.

Index Terms- **CVT, Slip control, Clamping force control, continuously variable transmission.**

I.INTRODUCTON

A Continuously Variable Transmission (CVT) is an alternative type of transmission system which allows varying steplessly through nonstop & infinite no. of effective gear ratios between maximum and minimum values. This diverges with other mechanical transmission systems that only permit a few discrete gear ratios. The CVT can provide the flexibility to driving shaft to maintain a particular angular velocity over a specified range of output velocities. As compared with other transmission systems CVT allows the engine to run at its most efficient RPM for a range of vehicle speeds.

CVT keeps on emerging as a important innovation for improving the fuel efficiency of vehicles with Internal Combustion (IC) engines. CVT's use immensely flexible commute proportions rather than distinct riggings to achieve ideal motor execution. Since the motor dependably runs at the most proficient RPM for a given vehicle speed, CVT fitted vehicles achieve favored gas mileage.

As can be seen in Fig.1.1, the CVT does not require the use of bulky gear sets as in the conventional transmission. A CVT system is included of two conical pulleys and a belt. The conical shape causes the belt to rise and fall between the sheaves of each pulley when the sheaves of each pulley move closer or farther away from one another. Depending upon the state of the belt, the active gear ratio is changed. Instead of using bulky fixed gears which only give a finite number of gear ratios, the CVT pulleys create a continuous variation of gear ratios by constantly changing the state of the belt between the pulleys.

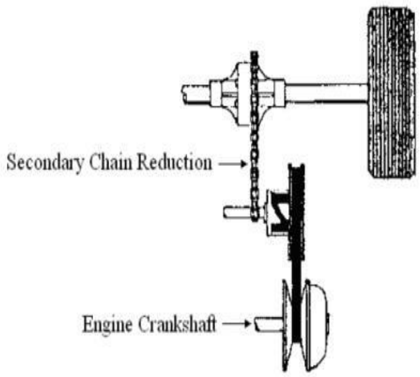

Figure 1.1: CVT system in which the 2 belt pulleys represent the CVT`s primary and secondary gear reduction.

II.SLIP CONTROL

The Continuously Variable Transmission efficiency can be reduced at high clamping force. Higher clamping forces needed to transmit the torque and to prevent the slip of the belt or the chain. The slip loss is mainly due to between pulley sheaves and the intermediate element. To avoid excessive slip between intermediate element and the pulley sheaves, this element is over-clamped. This increases friction and variator losses. However, too small clamping forces reduce friction forces and increase slip (Figure 2.1). Due to small clamping forces, adequate power cannot be transmitted and the efficiency decreases. Therefore, the slip control and clamping force control is very essential in Continuously Variable Transmission.

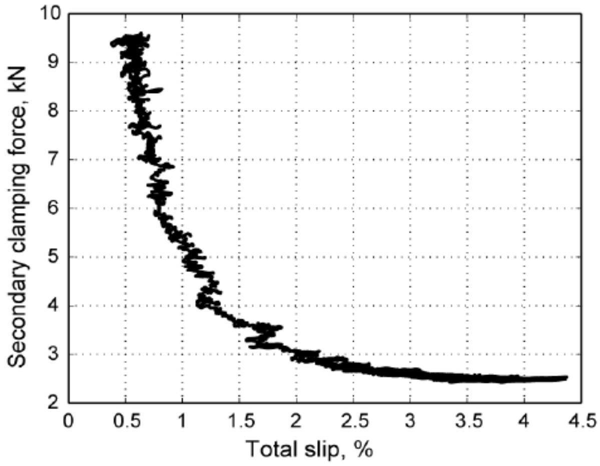

Figure 2.1: Secondary clamping force as a function of the total slip of the variator

III.LITERATURE REVIEW

Zhu Hong-bo, Zhang You-kun, Wang Yong-cong [1] . This paper stating that the modified clamping force control strategy according to the load of CVT in un-steady states. The relationship between the actual optimal slip rate and the theoretical optical slip rate is analyzed. The transmission torque of CVT in un-steady states varies repeatedly, which causes the cone clamping force to be inaccurate and increases the slip rate. The slip rate of V-belt is depends upon the traction coefficient of belt and pulley, the torque, the theoretical ratio of CVT. The clamping force control strategy controls the driven pulley cylinder pressure precisely to maintain the actual slip rate of the CVT close to the optimal slip rate curve under the current speed ratio which helps to improve the fuel economy of the powertrain. The control logic block diagram is shown as Figure 3.1.

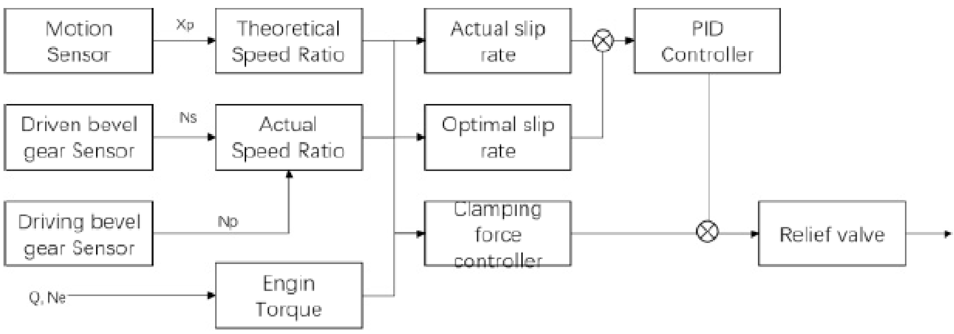

Fig.3.1. Logic block diagram of slip rate control

For un-steady state condition slip rate correction the driving state is identified, then analyze the slip rate in un-steady states. After that slip rate correction is done using correction factor which depends on the driving state of the vehicle. According to fuel consumption characteristics and torque characteristics, a 1.5L engine as a prototype is used and building the engine simulation model using Simulink software. For Co-simulation with Simulink and AMESim a control strategy model of the CVT slip rate is prepared. By simulation and analysis the possibility of the slip rate control strategy is confirmed. The theoretical optimal slip rate is modified by changing the corrected coefficient. Therefore the CVT slip rate control strategy can be more efficiently used to the un-steady state and improves the stability of the slip rate and the fuel economy of the CVT.

B. Bonsen, T.W.G.L. Klaassen, K.G.O. van de Meerakker, M. Steinbuch, P.A. Veenhuizen[2]. In this paper the push belt type variator is examined .This tvpe of variator uses two conical pulley-sets and steel push belt to vary the ratio. Power is transmitted between friction between pulley and belt. High clamping force level are applied to prevent slip from occurring, which could damage the pulley and belt. However high clamping force wear and fatigue and increase the internal friction between in the belt. Furthermore high clamping force cause more actuation losses due to hydraulic leakage. Lower clamping force, the efficiency of variator increases, but also increase the risk of damage. A model of CVT is derived and method is presented to control the slip in the variator. This enables the variator to operate at its maximum efficiency and at the same time prevent damage by preventing high amount of slip. The behavior of variator is highly non-linear. Slip in the system is control using the clamping force level. The purpose of the slip controller is to operate the variator in the optimal operating point. Which is a slip level depending on the ratio the variator is in the range is in between 1% to 3%.

Florian Verbelen, Michiel Haemers, Jasper De Viaene, Stijn derammelaere, Kurt Stockman, Peter Sergeant[3]. In this paper it gives the use of adaptive PI controller for slip control in belt continuously variable transmission. The controller parameters are updates in function of the operating point by the use of linearized equations of the slip dynamics. Therefore the highly nonlinear system is reduced to a first order transfer function which is easily controlled with a PI controller. The results are obtained based on a detailed model by considering various parameters which affects torque disturbances and speed ratio variations. The simplifications which are made in the controller design show that controller is robust against torque disturbances and speed ratio variations.

Jian Ji, Jeongman Park, Oheun Kwon, Minjae Chai, Donghyeon Lee and Hyunsoo Kim[4]. This research paper gives macroslip detection method which can effectively detect macroslip with an acceptable time delay. The introduced macroslip detection method is validated by performing experiments on testing apparatus. A schematic diagram of the testing apparatus is shown in Figure 3.2.

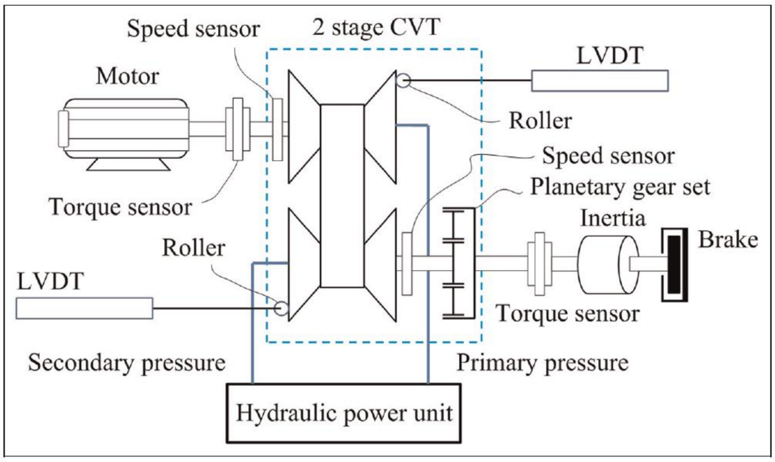

Fig.3.2- Schematic diagram of the testing apparatus.
CVT: continuously variable transmission; LVDT: linear variable-differential transformer.

Also clamping force control strategy is developed based on macroslip detection method. This control strategy helps to maintain the minimum clamping force to avoid macroslip in normal driving conditions. An additional clamping force must be applied when macroslip appeared and reset to zero after macroslip disappeared. By reducing the marginal clamping force the CVT system efficiency can be improved. The macroslip detection method helps to detect macroslip and controlled clamping force is obtained by clamping force control strategy.

IV.CONCLUSION

A Continuously variable transmission gives higher fuel economy, reduced emissions and improved vehicle performance. Certain new configurations of CVT designs focus on reducing transmission losses by controlling slip rate and clamping force. The current paper addresses the state-of-the-art research accomplished towards understanding CVT slip control methods. Measurement of slip is critical in normal automotive CVT's. There is need to develop an easier method to determine slip and its control strategy. Further research will be focused on precise clamping force control and shifting behavior of CVT.

V.REFERNCES

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