

Acceleration Performance Analysis for Rubber V-Belt CVT with Belt Tension Clutching

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ABSTRACT

The power train system for Utility Vehicles (UVs) or All-Terrain Vehicles (ATVs) mainly consists of a rubber V-belt CVT. The adjustment of the CVT specification requires many steps to realize the shifting operations of the CVT so as to satisfy the acceleration feeling of the driver.

In this paper, we report on the simulation technology that predicts the transient behavior during an acceleration of the vehicle equipped with a belt tension clutching CVT, which has both functions of the shift operation and the clutch action. By using the developed simulation technique, it has become possible to adjust the CVT specifications efficiently.

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INTRODUCTION

The power train system for UVs or ATVs mainly consists of a rubber V-belt CVT. Generally, a dedicated clutch mechanism is needed in order to transfer the engine power gradually for the power train system. There are several clutching methods, e.g. friction, centrifugal, and hydraulic, for the mechanism.

On the other hand, the constant-speed belt transmission for agricultural machines or civil engineering machinery often has a clutching function by itself. This type of the belt transmission doubles as a clutch function by loosening the belt tension intentionally during starting to transfer the engine power. One of the methods is a clutch method providing another pulley between the two sheaves in order to adjust the tension. This method that adjusts the belt tension is partly called 'belt tension clutching'. Since the power train of the belt tension clutching system is not necessary to provide a dedicated clutch separately, it is possible to reduce the size and cost of power train system.

Then, it is considered to add a belt tension clutching function to the rubber V-belt CVT to get the above-mentioned advantages, smart size and low cost, to UVs & ATVs. In order to achieve a compact powertrain system, the CVT without intermediate pulley is referred in this paper. For the clutch action, this type of the CVT loose the belt tension intentionally by changing the sheave thrust on the belt. However it is difficult to adjust the CVT specifications and predict the vehicle acceleration, because the slip condition of the belt varies significantly by sheave thrust. So there is a number of adjustment work at the design stage of the CVT specifications in order to design the acceleration feel of the vehicle satisfies the ride drivers. Thus, it

has been demanded to develop the technology that predicts the transient behavior of the belt tension clutching type CVT for designing both sifting and clutching optimally and efficiently.

In previous studies, it has been proposed that the simulation technology enables to adjust the CVT specifications effectively for a vehicle with a rubber belt type CVT, which is not a belt tension clutching CVT[1] [2]. In those studies predicts the behavior when the actual vehicle is accelerated by taking into account the dynamics sheave during shifting. However it does not take into account the actual characteristics of the tension generated against slipping condition of the belt in calculating the tension of the rubber belt. In those studies, it is difficult to predict the transient behavior of the belt tension clutching CVT accurately.

In this report, we show a prediction technology about the transient behavior of the belt tension clutching CVT, by calculating the tension in consideration of the characteristics of the slip state and tension of the belt.

OUTLINE OF RUBBER V-BELT CVT WITH BELT TENSION CLUTCHING

The configuration of a rubber V-belt CVT with belt tension clutching dealing in this paper is shown in [Figure 1](#), [Figure 2](#). The drive (DR) side sheave has a spring and a cam, so centrifugal force is generated in the cam in accordance with the rotational speed on the sheave. The sheave spacing is varied due to the change of the force balance. Similarly, the driven (DN) side sheave is equipped with a spring and a grooved cam-shaft, so the sheave spacing is varied by the influence of load force acting on the cam shaft. Thus,

sheave intervals of both the DR side and the DN side are changed, the reduction ratio of the CVT varies continuously in consequence of variations with two pitch radii.

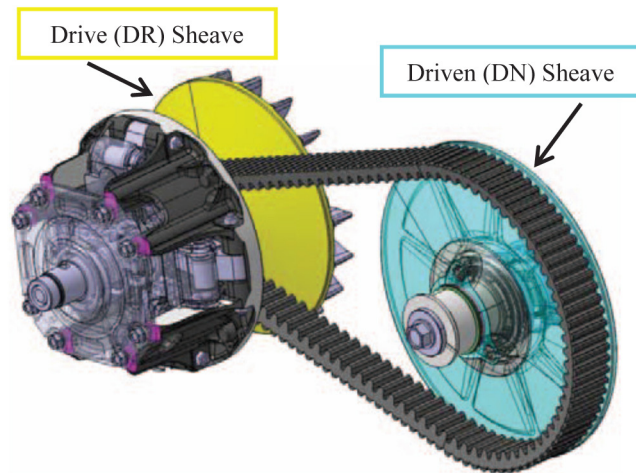


Figure 1. Rubber V-belt CVT system

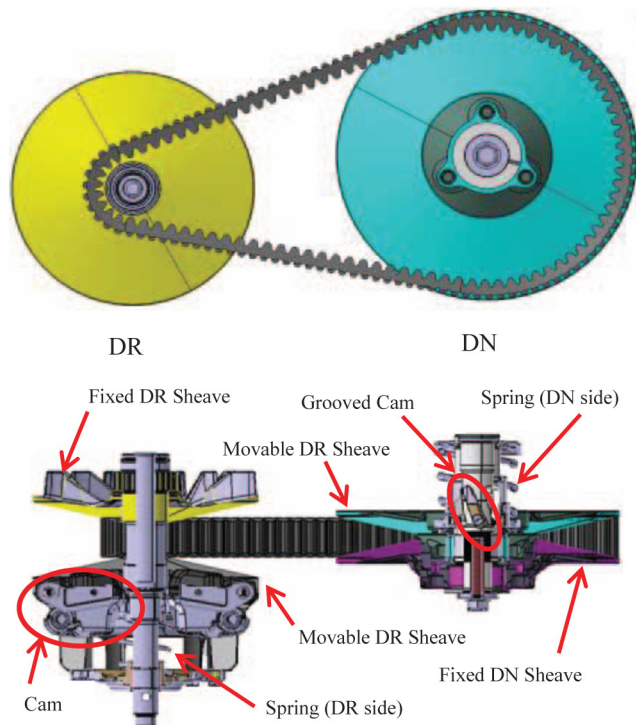


Figure 2. Components of CVT

The process of the belt tension clutching CVT that makes a clutching operation and shift operation is shown in Figure 3. A belt tension clutching CVT has intentional spacing set in the DR-side sheave, so a movable sheave of the DR-side is not in contact with the belt aspect in the initial state. For this reason, since the engine is the centrifugal force acting on the DR side cam is small in an idling state, belt tension does not occur. As increasing the engine speed from the idle speed, DR sheave starts to grasp the belt. Gradually increasing the belt tension during reducing the belt slip rate, clutching operation is performed. After completion of the belt

tension clutch, the reduction ratio of the CVT varies continuously like a normal CVT depending on the input engine speed and the vehicle load torque on the output side.

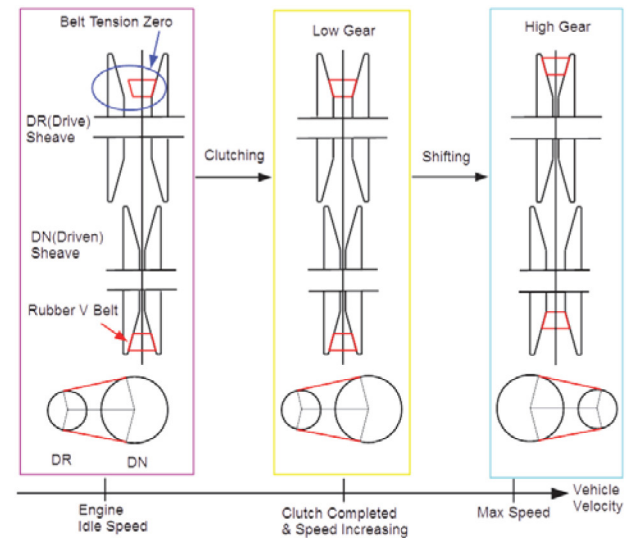


Figure 3. Schematic diagram of the belt tension clutching CVT during clutch action and shift operation.

SIMULATION MODEL

For predicting the transient behavior of the CVT speed change with the belt clutch function, we have created an analysis model shown below. As shown in Fig.4, this model consists of the following elements, engine model, DR side sheave model, DN sheave model, calculation model of belt tension and sheave thrust, vehicle model. This simulation is a one-dimensional model that the input is engine throttle and the output is the vehicle speed.

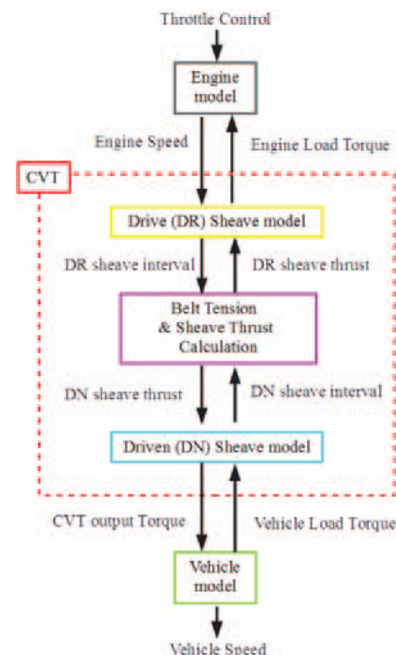


Figure 4. Calculation flow of the simulation model