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Development of Dual Clutch Transmission System by Considering Various Working Parameters

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ABSTRACT

The paper presents the main features of a control-oriented model of a Dual Clutch Transmission (DCT) system that has been designed to support model-based development of the DCT controller. The model represents an innovative attempt to reproduce the fast dynamics of the hydraulic circuit while maintaining a simulation step size large enough for real time application. The model includes a detailed physical description of clutches, synchronizers and gears, and a simplified model of the vehicle and of the internal combustion engine, in order to simulate the behaviour of the entire system. As the oil circulating in the system has a large bulk modulus, the pressure dynamics are very fast, possibly causing instability in a real time simulation; the same challenge involves the servo valves dynamics, due to the very small masses of the moving elements. Therefore, the hydraulic circuit model has been modified and simplified without losing physical validity, in order to adapt it to the real time simulation requirements.

Keywords: Model, real-time, control, heat dissipation, Dual clutch transmission, power losses, adaptive control etc.

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1. Introduction

In recent years the need for increased fuel efficiency, driving performance and comfort has driven the development of engine and transmission technology in the automotive industry and several types of transmissions are currently available in the market trying to meet these needs. The conventional Automatic Transmission with torgue converter and planetary gears, was leading the market of non-manual transmissions, but in recent years it is losing its predominant position, because of low efficiency of torgue converter and overall structure complexity, in favor of other technologies; Continuously Variable transmission permit avoiding the problem of gear shifting, but are limited in torgue capacity and have a disadvantage of a low transmission efficiency due to high pump losses caused by large oil flows and pressure values needed. Automated manual transmission systems, with dry clutches are most efficient systems but they don't meet customer specification due to torgue interruptions during gear shift. If compared to other transmissions, the Dual Clutch transmission technology has an advantage of being suitable both low revving and high torque diesel engines and for revving engines for sport cars, maintaining a high transmission efficiency, as well as high gear shift performance and comfort. A dual clutch transmission system can be considered as an evolution of Automated Transmission system. An automated transmission system is similar to the dual clutch transmission system but only difference is that in Dual Clutch Transmission system the gear shifting and clutch actuation is smoother and easier.

Different models have been developed to control the power transfer in the drive chain of an automotive vehicle equipped with an automatic dual-clutch-transmission. Most of these methods require a more or less accurate knowledge of the clutch characteristic. In general clutch characteristics represent the relationship between the actuating variable and torque delivered through the clutch.

Pure Electric Vehicle being currently widely used in the market are mainly equipped with single speed transmission, with trade-off between dynamic and economic performance. Now-a-days multiple speed transmissions instead of traditional single speed transmissions, expecting to improve the electric vehicle performance. The usage of multi speed transmissions for electric vehicles is likely to improve average motor efficiency and range capacity or even can reduce the require size of motor car.

2. Background

This transmission was invented by Frenchman AdolpheKégressejust before World War II, although he never developed a working model. The first development of the twin-clutch or dual-clutch transmission started in the early part of 1980 under the guidance of Harry Webster at Automotive Products (AP), with prototypes built into the Ford Fiesta. Initially, the control systems were based on purely analogue/discrete digital circuitry with patents filed in July 1981.All of these early AP twin-clutch installations featured a single dry clutch and multiplate wet clutch. DCT work continued from Porsche in-house development, for Audi and

Porsche racing cars later in the 1980s, when computers to control the transmission became compact enough. The first series production road car with a DCT was the 2003 Volkswagen Golf Mk4 R32. As of 2009, the largest sales of DCTs in Western Europe are by various marques of the German Volkswagen Group, though this is anticipated to change as other transmission makers and vehicle manufacturers make DCTs available in series production automobiles. In 2010, on BMW Canada's website for the 3 Series Coupe, it is described both as a seven-speed double-clutch transmission and as a seven-speed automatic transmission.

3. LITERATURE REVIEW

In DCTs where the two clutches are arranged concentrically, the larger outer clutch drives the odd-numbered gears,while the smaller inner clutch drives the even-numbered gears.Shifts accomplished without interrupting torque distribution to the driven road wheels,by applying the engine's torque to one clutch at the same time as it is being disconnected from the other clutch.Since alternate gear ratios can preselect' an odd gear on one gear shaft while the vehicle is being driven in an even gear,(and vice versa). DCTs are the fastest-shifting road car transmission available and are even able to shift faster than a professional race car driver using a manual transmission. DCTs can even shift more quickly than cars equipped with single-clutch automated-manual transmissions (AMTs), also called single-clutch semiautomatics. Also, with a DCT, shifts can be made more smoothly than with a single-clutch AMT, making a DCT more suitable for conventional road cars.

4. METHODOLOGY

The ways to determine the clutch characteristics during operation by using of the methods of system identification were analyzed in a study. The prediction model of a system in this study was based on torque balance at the input shaft of the dual clutch transmission. This paper addresses the movement of clutch piston in the prediction model. It evaluates of the clutch characteristics providing additional and more advantageous information about the system state in comparison of the model. Furthermore the advantages and disadvantages of such detailed system model, related to the additional implementation and computation costs, will be analyzed. In order to address the points above mentioned a system model is presented, which considers the main physical interactions of the torque delivery by an automated friction clutch.

5. RESULT

DEVLOPEMENT OF DUAL CLUTCH TRANSMISSION SYSTEM FOR REAL TIME APPLICATIONS –BY N.CAVINO, D.OLIVI, E.CORTI

To develop a model suitable for real time applications, the calculations of the flow from high pressure circuit to low pressure circuit is provided by a dynamic model. Inputs to such map are current supplied to servo valves and the pressure level in the high pressure circuit. Furthermore, the input flux is provided by pump is calculated via an considering leakage flows, which depends on engine speed and clutch pressure.

Clutch characteristics which are important while designing the clutch model are:-

System Pressure: - The pressure level acting on clutches and gear actuators is controlled by proportional pressure control valves which are designed to act as closed loop system. The proportionality between actuation chambers which generates a feedback force against the valve opening, whose proportionality factor is the feedback chamber area of the spool.

Clutch Hysteresis: - The pressure variation between preload and kiss point pressure is called as clutch hysteresis characteristic. This is due to the stick-slip characteristics of the clutch, simulated in the model using two different levels of preload pressure level.

Clutch Torque: - For torque analysis we need to study the slip characteristic which the difference between the engines speed and clutch output speed. The total torque generated by the friction between the clutch discs will be the sum of basic torque and total difference in temperature. Different oil temperatures were taken into account and during simulation such maps were interpolated called as basic torque. However it is not possible to use these models into practical applications because both the pressure dynamics and mass damper system is very fast while results of the models are quite slower. So to avoid this problem simulation of clutch model with a fast current ampere from 0 to 700mA is taken.

Clutch Pressure: - When clutch is not moving pressure directly proportional to input current and during closed i.e. spool is moving condition the oil flows from port P to actuator port A.

Gear Selection: - During the gear selection on the odd shaft of the transmission, all this process the engine is transmitting torque through even gear when odd clutch is completely open therefore the engine speed and the even shaft speed are coincident. The pre-selection of gears is controlled by the TCU, which previews the future gear according to engine speed and torque request.

SIMULATION OF THERMAL BEHAVIOR OF TWO SPEED DUAL CLUTCH TRANSMISSION SYSTEM- BY XINGXING ZHOU, PAUL WALKER, NONG ZHANG

By using Newton's law of cooling for convection power losses and the total heat dissipation capacity can be found. There are no synchronizers in this two dual clutch transmission system thus the transmission can be looked as two half manual transmissions and in this case shifting is realized through the simultaneous shifting between these two half transmissions so why vehicle equipped with Dual clutch transmission can change speed smoothly with nearly no power. As the predicted temperature increases the dual clutch transmission power losses also increases. Also that the maximum power loss for dual clutch transmission is approximate 2.04KW.The power loss decreased sharply is caused by wet clutch. It is because that the effective wet clutch radius will decrease which is caused by increased centrifugal force during high speed. The wet clutch drag torque loss domain the main power losses in two speed dual clutch transmission system.

MODEL BASED ESTIMATION OF THE TORQUE CHARACTERISTICS OF AN AUTOMATED DUAL CLUTCH TRANSMISSION IN WET TECHNOLOGY –BY A.TARASOW, C.BOHN, M.VINASKE, R.SERWAY

The ways to determine the clutch characteristic during operation by using of the methods of the system identification were analysed by Tarasow in 2010 which was based on the torque balance at the input shaft of dual clutch transmission in which unknown parameters of the clutch characteristics can be accurately estimated based on the model using the prediction error method. The estimation results were verified in simulation studies and with the use of measured vehicle data. However the movement of clutch piston is not considered so the model was only applicable when friction plates come in contact with each other i.e. the piston movement has covered the complete displacement. The importance of considering the movement of clutch piston in prediction model will improve the clutch characteristics and also gives the additional information about the system state whether advantageous or not by using the unknown parameters finding considering unknown state of the system where the main physical interactions of the torque delivery by an automated friction clutch and the unknown parameters will be found by Kalman Filter method combination with the Prediction Error Method. By using the model the clutch displacement and velocity can be seen as additional information about the system state. This information based can be used e.g. in the clutch control for determination of time required for the closing of the clutch and beginning of torque delivery. The implementation and computation costs are about four times higher for next model so choice is only for desired purposes is only the drawback of the system.

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