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STARTING SLIDING MODE VARIABLE STRUCTURE THAT COORDINATES THE CONTROL AND REAL-TIME OPTIMIZATION OF DRY DUAL CLUTCH TRANSMISSIONS

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ABSTRACT–This paper researches the coordination of control between an engine and clutch at the system level to adequately reflect a driver's intention and improve the starting performance of a vehicle equipped with a dry dual clutch transmission (DCT). Four-degree-of-freedom (DOF) starting dynamic equations are established for a dry DCT with a single intermediate shaft, and a two-DOF model of the sliding friction process and a single-DOF in-gear model of stable operation are obtained after simplifying these equations. Taking advantage of predictive control and a genetic algorithm, target tracing curves of the engine's speed and the vehicle's velocity are optimally specified online, and the starting sliding mode variable structure (SMVS) coordinating control strategy is designed to track these curves. The starting performance of a prototype car equipped with a dry DCT is simulated under different starting cases on the MATLAB/Simulink software platform. The simulation results show that the designed SMVS coordinating controller not only embodies driver intention and effectively improves the dry DCT car's starting performance but is also highly robust when subjected to variations in the vehicle parameters.

KEY WORDS : Dry dual clutch transmission, Starting sliding mode variable structure control, Real-time optimization, Simulation

1. INTRODUCTION

A dry dual clutch transmission (DCT) can be created from an automated mechanical transmission (AMT) if the AMT's transmission mechanism (including the input shaft, positions of gear pairs, and the intermediate shaft) is remodeled and a dry friction clutch and actuators are added. The problem of power interruption while shifting can be resolved effectively by the coordinating control between a dual clutch and engine. At the same time, the quality of shifting and the vehicle's acceleration performance can also be improved.

To create the starting process of a vehicle equipped with a dry DCT, a single clutch can be selected to perform the process individually or a dual clutch can be selected to perform the process jointly. To balance the sliding friction work of the two clutches and to lengthen their service lives when dual clutches were both involved in the starting process, Qin *et al*. (2010) developed and simulated a control strategy. To obtain minimum sliding friction work, Qin and Chen (2011) made use of a linear quadratic form optimal control method to realize the uniform clutch optimal starting control of an AMT and DCT through the state variable's selection and constraint modification. However, dual clutch simultaneous participation can easily lead to power cycling, so its feasibility requires further investigation. By contrast, the starting dynamics model and control logic of a DCT are the same as an AMT's when a single clutch is involved. The modeling and control of starting a vehicle equipped with an AMT have been studied widely and in depth in the literature. Sun and Zhang (2004) and Chen *et al*. (2010) set up a starting dynamics model for a two degree-of-freedom (DOF) car and developed a clutch optimal engaging control law using the minimum value principle. Garofalo *et al*. (2002) and Amir *et al*. (2005) took the equivalent damping of a transmission system into account and designed a quadratic optimal starting controller. Lucente *et al*. (2007) established a clutch hydraulic actuator model and a starting dynamics model for a six-DOF car, obtaining corresponding model parameters through experimentation. Serrarens *et al*. (2004) established a five-DOF starting clutch engaging model and simplified it, proposing an engine speed decoupling control strategy for a double-input and double-output system. Chen *et al*. (2011) designed the model referenced adaptive controller (MRAC) to compensate for the discontinuity of the transition of a friction clutch. An experience-based fuzzy logic starting control method was also researched in various ways. Fuzzy

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