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DYNAMIC MODELING OF BRAKE IN POWER-SPLIT DHT AND PRESSURE TRACKING CONTROL WITH SLIDING MODE VARIABLE STRUCTURE METHOD

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ABSTRACT−Since the mode transition performance of power-split DHT (Dedicated Hybrid Transmission) are directly influenced by torque dynamic characteristic of the brake, the brake pressure should be controlled accurately. In this paper, a dynamic model of brake and its pressure regulating system are established by considering system nonlinear characteristics and input disturbances, and a sliding mode variable structure controller is developed to track the brake pressure. First, the operation principle of DHT's pressure regulating system is introduced. Second, the dynamic models of solenoid proportional pressure valve, electromagnetic direction switching valve and brake are established with AMESim parametric plant model. Furthermore, a sliding mode variable structure controller for tracking pressure is designed based on MATLAB/Simulink. Finally, the AMESim parametric plant model is validated by measurements, and the proposed controller are verified by AMESim and Simulink co-simulation. The results show that the system dynamics can be well characterized by the AMESim parametric plant model. The target pressure can be tracked rapidly and accurately by using sliding mode variable structure controller and the controller has better robustness.

KEY WORDS : Dedicated Hybrid Transmission (DHT), Hydraulic system, Dynamic modeling, Sliding mode variable structure

NOMENCLATURE

A_{ex3} : flow area of exhaust port
A_{in3} : flow area of supply port
A_{fb3o} : flow area of the orifice in feedback chamber
A_{fb} : effective action area of feedback chamber
A_p : effective piston action area
A_{po} : orifice area
C_d : flow coefficient
c_m, c_s : constant coefficients
c_p : piston equivalent damping coefficient
c_{s3} : equivalent damp coefficient of valve spool
d_{fb3o} : diameter of orifice in feedback chamber
d_{po} : diameter of orifice
d_p : diameters of piston chamber
d_{s3l}, d_{s3r}: diameter of left and right side of valve spool in feedback chamber
d_r : diameter of piston rod
F_{s3} : solenoid force
F_{drag} : resistance force of seal rings
k_m, k_s : constant coefficients
m_p : piston mass
m_{s3} : mass of valve spool
P_{sup3} : supply port pressure
P_{out3} : output port pressure
P_{fb3} : feedback chamber pressure
P_p : oil pressure in brake chamber
Q_{in3} : supply port flow
Q_{out3} : output port flow
Q_{fb3} : feedback chamber flow
Q_{ex3} : exhaust port flow
Q_{inp} : flow of the supply port of brake chamber
Q_{exp} : flow of the exhaust port of brake chamber
V_3 : volume of the main chamber
V_{fb3} : volume of the feedback chamber
V_p : initial volume of clutch chamber
x_{s3} : displacement of valve spool
x_{s30} : initial displacement of valve spool
x_p : piston displacement
x_{p0} : initial piston displacement
α : damping coefficient of seal rings in piston chamber
β : volume modulus
ρ : oil density

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1. INTRODUCTION

As one of the typical full and plug-in hybrid systems, power-split DHT utilizes planetary gear train to integrate or