Development and control strategy research for subsea all-electric actuators

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Abstract

The development of subsea all-electric Christmas trees is an area of focus in the offshore oil industry worldwide. The main difficulties are associated with the development and control strategies for subsea all-electric actuators, which are the most critical components of subsea Christmas trees. In this paper, a single-motor level fuzzy PID control with an integrated working condition detection module and a 3-motor redundant-level deviation strategy with coupled joint synchronous control were proposed to realize the real-time determination of algorithm parameters according to the working conditions, accelerate convergence to solve the problem of rapid redistribution, maintain the fast speed of the servo motor of the subsea all-electric tree valve actuator, conduct simulation analyses of the synchronous control model, build the synchronous control electrical system and test this system. With the simulation analysis, a synchronous control electrical system was built, tested and verified. The simulation results of the control strategy show that the proposed single-motor fuzzy PID-deviation coupled control strategy in this paper tends to be stable approximately 0.2 s after the system is started; additionally, with this approach, the convergence speed is faster than that of the traditional PID method, tracking errors are highly reduced, and robustness to load shocks is decreased. The test results show that when the inlet pressures are 1.0 MPa, 1.5 MPa and 2.0 MPa and the three servo motors simultaneously work, the control effect is good, the synchronization effect is good. When one servo motor fails, the two redundant servo motors can still control the all-electric valve actuator and provide good synchronization control capabilities. When the inlet pressure is 1.0 MPa, 1.5 MPa and 2.0 MPa, whether the system is in normal operation or a servo motor fails, the vertical and horizontal vibration values of the system are within reasonable ranges. This result verifies that the proposed control strategy yields superior performance in power distribution compared to traditional systems and strong robustness. The synchronous control strategy can be applied to the synchronous control problem of subsea all-electric production systems, which is of great significance for the development of subsea all-electric production systems.

Full Text

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