Research on Permanent Magnet Synchronous Motor Driven h-Platform Cross-Coupling Synchronous Controller

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Keywords: Permanent Magnet Synchronous Motor, h-Type Platform, Cross-Coupling, Synchronous Controller

Abstract: the Development of Information Technology, Permanent Magnet Synchronous Motor Has Also Been Rapidly Developed. However, Until Now, the Permanent Magnet Synchronous Motor Drives the h-Type Platform. Due to Various Parameter Changes and Load Disturbances, the Problem of Non-Synchronous Operation on Both Sides of the Motor Occurs. Aiming At This, Based on the Analysis of the Mathematical Model of the Permanent Magnet Synchronous Motor Driven h-Type Platform, the Simulation Design and Results Analysis of the Permanent Magnet Synchronous Motor Driven h-Type Platform Cross-Coupling Control Algorithm and System Are Carried out. the Results Show That the Permanent Magnet Synchronous Motor Drives the h-Platform Cross-Coupling Synchronous Controller to Effectively Coordinate the Systematic Error of the Motor.

1. Introduction

1.1 Literature Review

In recent years, with the development of science and technology, microelectronics technology, new power electronics technology and rare earth permanent magnet materials have also been rapidly developed, so permanent magnet synchronous motors have been rapidly promoted and applied. Based on the cross-coupling mastery algorithm, combined with the mathematical model of permanent magnet synchronous motor operation calculation, a permanent magnet synchronous motor control system based on cross-coupling algorithm is obtained. The cross-coupling algorithm is referenced in the control system, and the computer system is used for simulation checking. It is concluded that the cross-coupling system can reduce the system error of the permanent magnet synchronous motor and verify the system's executable (Guo, et al, 2013). Aiming at the problem that the permanent magnet synchronous motor generates uncertainty during operation, the problem of different frequency motions on both sides of the H-type precision motion platform is proposed. A new control method is proposed. The fuzzy PID controller is used for control, and the fuzzy PID controller is used in a single spindle to ensure the tracking accuracy of a single spindle. A cross-coupling control system is introduced between the two spindles to eliminate the running-in problem between the two motors, thereby reducing the positional synchronization difference of the two axes during operation (Wang and Zhang, 2018). In the operation of permanent magnet synchronous motor, the motor and motor speed are different due to the overload of the load, which is easy to cause differential oscillation. Combined with the synovial control algorithm and the cross-coupling control structure algorithm, the synchronous speed control of permanent magnet synchronous motor is constructed. System (Xia et al, 2017). The use of CCC can effectively eliminate the coupling phenomenon of permanent magnet synchronous motor during operation and realize the synchronous control of permanent magnet synchronous motor (Jin and Zhao, 2018). The experimental results obtained show that it has better robust performance and better tracking performance, which significantly reduces the existing errors.

  DOI: 10.25236/ISMHI.2019.108

1.2 Research Purpose

At present, there have been many studies on current decouplers for permanent magnet synchronous motors. Permanent magnet synchronous motors can be converted into dual-output systems by converting coordinates. In this case, a suitable controller is required to perform decoupling control (An et al, 2019). Matrix diagonalization decoupling, state feedback decoupling and direct compensation decoupling are several mainstream decoupling controllers. In the high-power experiment process, multiple permanent magnet synchronous motors run at the same time, and there will be problems of running different frequencies. At this time, adjacent permanent magnet synchronous motors are prepared to adopt the control strategy of synovial variable structure and cross-coupling structure. (Jiang et al, 2014). Combined with the mechanical structure characteristics of permanent magnet synchronous motor, the error and error of multiple permanent magnet synchronous motors in operation are analyzed. The operation model of permanent magnet synchronous motor is constructed by computer technology. According to the simulation results, the control system of adjacent cross-coupling structure and variable structure algorithm has strong interference ability, little influence by interference, and the error generated during operation is smaller than that of traditional deviation coupling mechanism combined with PID algorithm. system. The existing permanent magnet synchronous motor generates an error during operation, and needs to be adjusted by a PI regulator. Through a series of conversions, the amount of alternating current is converted into a direct current amount, and monitoring by a PI regulator can achieve a relatively good performance. The effect is that the robustness of the permanent magnet synchronous motor control system is significantly reduced. The H-type platform cross-coupling synchronous controller has a good control effect on the operation of the permanent magnet synchronous motor. After simulation research, the control system has excellent robustness and dynamic performance. Based on this, I hope that the research in this paper can provide reference for relevant scholars.

2. Permanent Magnet Synchronous Motor Driven h-Type Platform Mathematical Model

Permanent magnet synchronous motor drive is a nonlinear strong coupled, multivariable mathematical model. Simplifying the analysis of such mathematical models is the key to the control of permanent magnet synchronous motors (Xiao and Huang, 2011). The article decouples the permanent magnet synchronous motor driven H-platform model, and then obtains a simpler model through coordinate transformation, which is convenient for control analysis. On the basis of neglecting flux saturation, high-order harmonic effect, hysteresis loss and eddy current of the motor, it is assumed that the windings of the motor are Y-connected, and then a symmetrical three-phase sinusoidal alternating current is introduced. In this regard, the coordinate vector diagram of H-type platform driven by permanent magnet synchronous motor is obtained, as shown in Figure 1. Among them, ($\alpha-\beta$)is a two-phase fixed coordinate system, ($\mathrm{a-b-c}$) represents three-phase stator coordinate system, ($\mathrm{d-q}$)stands for two-phase rotation coordinate system. In rotating coordinate system ($\mathrm{d-q}$), the d axis represents the direction of the rotor magnetic field, Then ($\mathrm{d-q}$) the voltage equation in the rotating coordinate system is, $\begin{cases} U_{\mathrm{q}} = R_{\mathrm{a}}\mathrm{i}_{\mathrm{q}} + \dfrac{\mathrm{d}\Psi_{\mathrm{q}}}{n} + \omega_S\Psi_{\mathrm{d}} \\ U_{\mathrm{d}} = R_{\mathrm{a}}\mathrm{i}_{\mathrm{d}} + \dfrac{\mathrm{d}\Psi_{\mathrm{d}}}{n} - \omega_S\Psi_{\mathrm{d}} \end{cases}$

In the upper form, $U_{\mathrm{q}}, U_{\mathrm{d}}$ represents the armature voltage component in the rotating coordinate system ($\mathrm{d-q}$). $\mathrm{i}_{\mathrm{d}}, \mathrm{i}_{\mathrm{q}}$ represents the armature current component in the rotating coordinate system ($\mathrm{d-q}$). $\Psi_{\mathrm{d}}, \Psi_{\mathrm{q}}$ represents the stator flux component in a rotating coordinate system ($\mathrm{d-q}$). R_{a}, ω_S, Ψ_{d} indicate stator resistance, rotating angular velocity and rotor flux respectively.

Then, the electromagnetic torque equation of permanent magnet synchronous motor can be expressed as follows, $T_e = \frac{3}{2} \mathrm{p_n} \left[\Psi_d \mathrm{i_q} + \left(L_d - L_q \right) \mathrm{i_d i_q} \right]$. Among them, $\mathrm{p_n}$ represents the pole logarithm of the rotor.

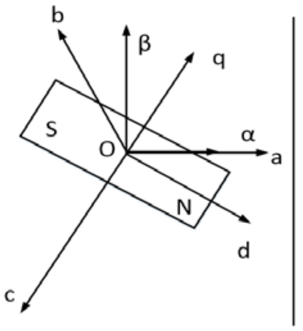

Fig.1 Coordinate Vector

3. Cross Coupling Control Algorithm and System Simulation Design of h-Type Platform Driven by Permanent Magnet Synchronous Motor

3.1 Cross-Coupled Control Algorithms

Generally speaking, there are two kinds of errors (Yang, 2018) in the control system of H-type platform driven by permanent magnet synchronous motor (PMSM). Tracking errors refer to the errors of permanent magnet synchronous motor (PMSM) in given values and actual operation. Profile error, also known as synthetic error, refers to the shortest distance between the coordinated trajectory of two motors and the given trajectory at a fixed time.

In this regard, the contour error is, $\varepsilon = \sqrt{\left(P_{xa} - P_{xo}\right)^2 + \left(P_{ya} - P_{yo}\right)^2} - \rho$. Among them, ($P_{xa}, P_{xo}$) means at a fixed time p, The curvature center coordinate corresponding to the given trajectory, ρ represents the curvature radius.

Further, the contour error formula is obtained by Taylor series, $\varepsilon = -E_x C_x + E_y C_y$

C_x and C_y are expressed as cross-coupling coefficients of tracking errors in the process of coordinated operation of dual permanent magnet synchronous motors.

3.2 Cross-Coupled Control Structure and System Simulation Design

In PMSM coordination system, tracking error of single motor will further synthesize contour error. Therefore, the reduction of contour error can be achieved by reducing the tracking error, that is, by adjusting the contour error and controlling the accuracy of the control system. This paper further combines the common PID control with cross-coupling algorithm, and designs a PMSM synchronous control coordination system. The parameters of two permanent magnet synchronous motors are different.

4. Simulation and Analysis

In this paper, the tracking simulation of H-type platform system driven by permanent magnet synchronous motor (PMSM) without cross-coupling and with cross-coupling control is carried out to verify the rationality and effectiveness of the proposed algorithm. In this regard, in the simulation system, the speed loop PID parameters are further set as follows, D = 0, I = 3, P = 1.5.

4.1 Simulation Results of h-Type Platform Driven by Permanent Magnet Synchronous Motor without Load

In the process of load-free tracking control of H-type platform driven by permanent magnet synchronous motor, the speed loop PID parameters are set as D=0, I=50, P=100. The cross-coupling coefficient is set as follows, $C_x = 2$, $C_y = 0.05$ .By comparing the single permanent magnet synchronous motor with the double permanent magnet synchronous motor without cross-coupling control, it can be seen that the maximum tracking error of the single permanent magnet synchronous motor is 0.02mm without cross-coupling control under the H-type platform driven by the permanent magnet synchronous motor without load. The maximum tracking error is 0.015 mm when the single permanent magnet synchronous motor runs steadily. The maximum tracking error of the single motor is 0.008mm when the H-type platform driven by dual permanent magnet synchronous motor is not loaded. Compared with no cross-coupling control, the tracking error with cross-coupling control is reduced by about 50%.

4.2 Simulation Results of h-Type Platform Driven by Loaded Permanent Magnet Synchronous Motor

Under the condition that the cross-coupling coefficient of H-type platform driven by permanent magnet synchronous motor and the PID of speed loop remain unchanged, the PID parameters of speed loop are raised to D=0, I=300, P=450. At the same time, when the permanent magnet synchronous motor drives H-type platform running at 0.2s, a 6 N.m step load is added to drive H-type platform system. The calculation shows that the position tracking error of H-type platform driven by PMSM without cross-coupling control is about twice that of H-type platform driven by cross-coupling control PMSM. It can be seen that the cross-coupling control of H-type platform driven by permanent magnet synchronous motor has strong load disturbance suppression ability. Through the above two simulation results, it can be seen that the cross coupling control algorithm is feasible for the coordinated control of PMSM driven h-platform.

Acknowledgement

This paper is a research fund project at school level in 2019,Self-tuning Strategy for Controller of Permanent Magnet AC Motor Drive System,NHKY-2019-15

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