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MICRO850 AB SYNCHRONOUS CONTROL SYSTEM OF DOUBLE MOTORS BASED ON INTEGRAL SEPARATED PID ALGORITHM

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Abstract

Summary: *Dual motor synchronization control is widely used. In this paper, the principle of variable frequency speed regulation of three-phase asynchronous motor isanalyzed. And the control algorithm based on integral separation is established. By analyzing the vector control algorithm and acceleration curve, to establish the variable frequency control strategy. In order to analyze the motion curve of double motor and the ideal dynamic and static performance of the system, the construction of dual motor synchronization control system with Power Flex 525 frequency converter and AB Micro850 PLC is needed, and thus we can achieve the goal of high efficiency and good performance of dual motor synchronization control system.*

Keywords: *dual motor; integral separation PID control algorithm; variable frequency speed control; synchronous control*

1 INTRODUCTION

The synchronous control of double motors is widely used in mechanical drive control, which is used to solve the problem of small driving efficacy or to complete a specific control task. Because of Single axis control of traditional single motor, the output torque of the motor has a certain limit. When the drive system needs a large driving power, it must be specially designed to match the driving motor and drive, which makes the cost of the system increased[1]. Multi machine and multi axis control, such as in Rewinder Control, dual motor coordinated motion, with two axis radius changes to keep the line speed to complete the paper, film rewinding task. In view of the above problems, it is needed to use a double motor or a plurality of motors to control it. Because the synchronization between multiple motors has a direct impact on the production efficiency and product quality, the research of multi motor synchronous control has very important practical significance. In this paper, we mainly discuss using Micro850 (AB) PLC Power and Flex Allen-Bradley 525 inverter to realize the synchronous frequency conversion control of dual motor, analyze the quality of synchronous movement, and verify the effectiveness of the system.

2 Speed governing principle of three phase asynchronous motor

2.1 The mathematical model of three phase asynchronous motor

The mathematical model of asynchronous motor is based on the ABC coordinate system of the three-phase static and the a-b-c coordinate system. If it is transformed to the phase of the two phase direct intersection and the stationary alpha-beta coordinate system, we can use the 3/2 transform and the rotational transformation model to obtain the following mathematical equations.

Voltage equation:

$$\begin{aligned} u_{s\alpha\beta} &= R_s i_{s\alpha\beta} + p\varphi_{s\alpha\beta} \\ u_{r\alpha\beta} &= R_r i_{r\alpha\beta} + p\varphi_{r\alpha\beta} - \omega_r J\varphi_{r\alpha\beta} \end{aligned} \quad (1)$$

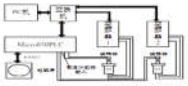
Flux linkage equation:

$$\begin{bmatrix} \varphi_{s\alpha\beta} \\ \varphi_{r\alpha\beta} \end{bmatrix} = \begin{bmatrix} L_s I & L_m I \\ L_m I & L_r I \end{bmatrix} \begin{bmatrix} i_{s\alpha\beta} \\ i_{r\alpha\beta} \end{bmatrix} \quad (2)$$

Torque equation:

$$T_e = n_p L_m (i_{s\beta} i_{r\alpha} - i_{s\alpha} i_{r\beta}) \quad (3)$$

Equations of motion which are not related to coordinate transformation:



(4)

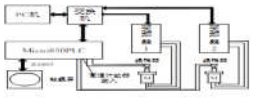
In the formula, $u_{S\alpha\beta}$ And $u_{r\alpha\beta}$ are the voltage of alpha and beta axes respectively, $i_{s\alpha\beta}$ *and* $i_{r\alpha\beta}$ are the current of alpha and beta axes $\varphi_{s\alpha\beta}$ and $\varphi_{r\alpha\beta}$ are the magnetic flux of alpha and beta axis respectively is the motor electromotive force of the rotor, *Te* is the electromagnetic torque , n_p is the rotor pole pairs , T_L is the load torque, ω_r is rotor angular velocity[12].

2.2 Principle of variable frequency speed regulation

The speed equation of the induction motor:

(5)

When there are little slip changes,n basically proportional tof1. Using the speed regulating method for changing power supply frequency f1to get a lot of speed regulation range, very good speed regulation smooth and have enough hardness of mechanical properties.



(6)

When using the variable frequency speed regulation, U_ϕ with different rules can

achieve constant torque or constant power speed and also meet the requirements of different load. When using the constant speed regulation, when U_ϕ /f1= a fixed value, for the same torque T, is approximate invariant. Asynchronous motor is under the condition of , U_ϕ /f1=constant value, Small slip s. The artificial mechanical properties of the inverter are basically a family of parallel lines[3]. As shown in Figure 1.

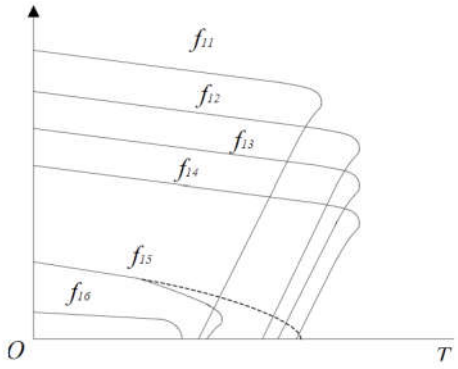


Fig.1. characteristic picture of variable frequency speed regulation of asynchronous motor

（f11>f12>f13>f14>f15>f16）

3 Integral separation PID control algorithm

PID control algorithm and its improved algorithm is widely used in the field of motor speed control [4]. The integral separation PID algorithm used in this paper overcomes the shortcomings of the traditional PID algorithm. The basic idea of the algorithm is: when the amount of control and setting is larger, the role of the cancellation of the integral, so as to avoid the integral function is to reduce the stability of the system, overshoot increased, so as to improve the dynamic characteristics of the system; When the control value is close to the given value, the integral control is introduced to eliminate the static error and improve the control precision of the system.
Its specific implementation steps are as follows [5]:

(1) According to the actual situation of the system artificially set threshold β>0;
(2) When $|e(k)|<\beta$,that is, the deviation value is relatively small, use PID control

(3) When $|e(k)|>\beta$,that is, the deviation value is relatively large, use PID control The integral separation control algorithm can be expressed as:

$$u(k)=K_p\{e(k)+K_f\frac{T}{T_i}\sum_{j=0}^{k}e(j)+\frac{T_d}{T}[e(k)-e(k-1)]\} \quad (7)$$

Logical coefficient *Kf is*:

$$K_f=\begin{cases}1 & |e(k)|\le\beta\\ 0 & |e(k)|>\beta\end{cases} \quad (8)$$

Integral separation PID control algorithm flow chart as shown in Figure 2, integral separation PID control algorithm control effect as shown in Figure 3.

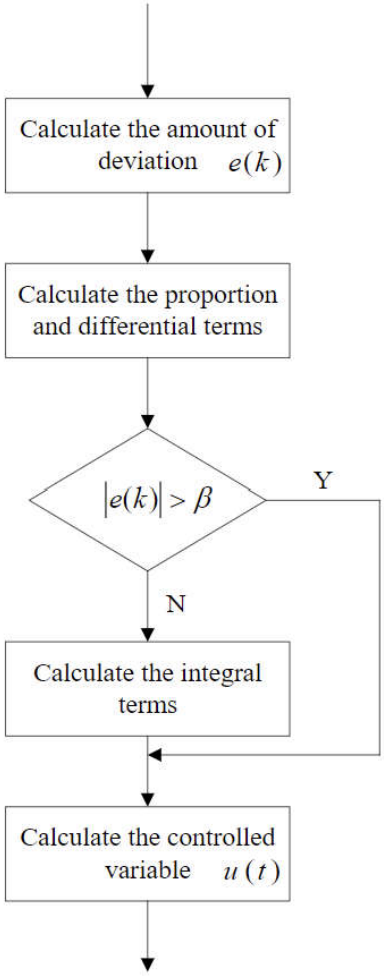
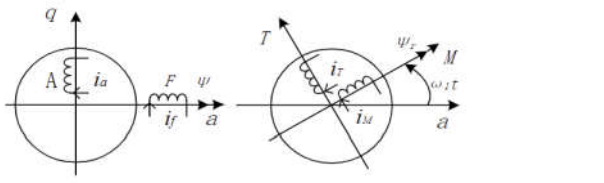


Fig.2 Integrated PID control algorithm flow

4 Variable frequency control strategy

4.1 Vector control method

Power Flex AB inverter can use vector variable frequency control method. The dynamic mathematical model of induction motor is a high order, nonlinear and strong coupling multivariable system. Though coordinate transformation, the model can be reduced and simplified, but it does not change the nature of the nonlinear and multi variable. Vector control (MMF) current space vector coordinate transformation, so as to simplify the model, and imitate DC motor torque control. Fig. 3 is the comparison of the torque of DC motor and induction motor.



(a) Component of DC motor current and its torque

(b) Torque structure of induction motor in MT coordinate

Fig. 3 Comparison of DC motor and induction motor

The model of squirrel cage induction motor under the condition of rotor fluxorientation [6], and the model in MT coordinate system is shown in Figure 4

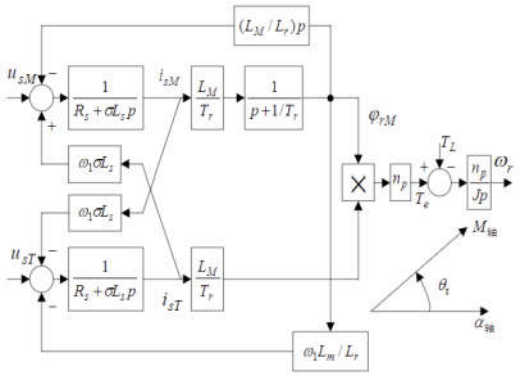


Fig. 4 Model of squirrel cage induction motor in MT coordinate system

By Figure 4, the rotor flux φ_r is produced only by the excitation component of the stator circuit i_{sm}. And the torque component i_{sT} independent, that is, the stator current excitation component and torque component is decoupled. The transferring function between φ_{rM} and i_{sM} is a first order inertial link. Its time constant T_r is the roto time constant. When the excitation current component i_{sM} abrupt, The change of φ_r by inertia block excitation, This is consistent with the inertia of the DC motor field winding. Electromagnetic torque is the point product of variable i_{sT} and φ_{rM}. Due to the influence of both i_{sT} and, it is still coupled

4.2 Acceleration and deceleration curve

The traditional motor speed control is commonly used in two ways of the acceleration and deceleration has a linear acceleration and deceleration and exponential acceleration and deceleration. These two methods of acceleration and deceleration in the start and acceleration and deceleration is the existence of the acceleration and deceleration of the mutation, resulting in shock. Type of S acceleration and deceleration, through the acceleration and deceleration of the start stage to ensure that the motor performance and reduce the full play to reduce the impact [7]. Figure 5shows the 5 section type of S plus deceleration

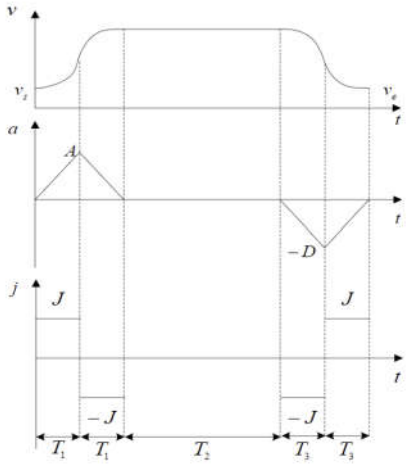


Fig.5 5 section type S plus deceleration

Five section type S acceleration and deceleration, is divided into acceleration, deceleration section, uniform section, add and subtract speed segment and deceleration section [8]. According to the diagram of velocity and acceleration, jerk and time t, we can get the following mathematical relationship.

$$\begin{aligned} S(t) &= S(t_i) + \int_{t_i}^{t} v(\tau)d\tau \\ v(t) &= v(t_i) + \int_{t_i}^{t} a(\tau)d\tau \\ a(t) &= a(t_i) + \int_{t_i}^{t} J(\tau)d\tau \end{aligned} \qquad (9)$$

5 Structure of control system

The entire system is divided into five parts: the controller, the Micro850 ABseries of PLC, 6 number of 100kHz high-speed counter, Support RS232/485 serial communication and EtherNet/IP,TCP Modbus Ethernet communication, the Driver, which is using the PowerFlex 525 converter,the inverter is very suitable for networked machines and simple system integration.Its standard features include embedded EtherNet/IPTM, security and performance of up to 22 Hp kW/30, the maximum output power is 100kW, the maximum output current is 9.6A, the maximum output voltage is 1000V, the maximum output frequency is 500Hz;Double motor with three phase induction motor, rated voltage 220V, rated frequency 50Hz, rated speed 1450rpm;Photoelectric encoder, the use is incremental encoder rotates 360 pulse, DC output; display, selection of weinview through TK6070ip types of touch screen.As shown in Figure 6, PLC, PC and inverter through the network cable connected to the switch to achieve interconnection, inverter three-phase output and motor connected, touch screen with RS-485 cable and PLC interconnection, photoelectric encoder A, B two output to the PLC high-speed counter input.

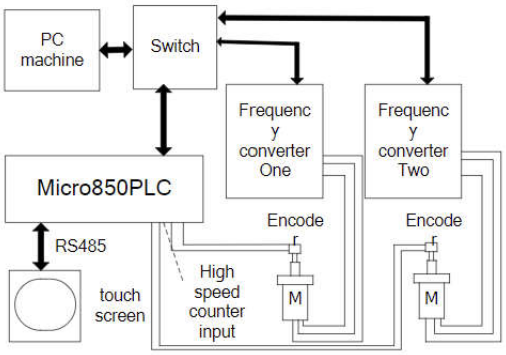


Fig.6.frequency control system of double motor

Fig.7.frequency control system of double motor

System communication mode is realized through ethernet. PLC company's AB and frequency converter have Ethernet/IP communication interface, Ethernet / Industrial Protocol (Ethernet/IP) is based on Ethernet in a real-time communication model, the purpose is to integrate the huge underlying field bus [9]

Through the network cable, PC, PLC, frequency converter and switch are connected,Need to allocation PLC, PC machine, inverter configuration IP address, make the address in the same segment.PC machine in the local connection modify the IP protocol in the Internet address and the use of Rockwell's Server BOOTP-DHCP software on the PLC, frequency converter unified configuration IP address.For example: the IP address of the PC machine is configured as "192.168.0.1", then PLC and two inverters can be configured as "192.168.0.2", "192.168.0.3" and "192.168.0.4".

6 Experimental result

The speed curve can be acquired through the weinview touch screen editing software EB8000.Experimental data shown in Figure 8, the blue curve in the figure indicates the given speed constant, the black line indicates the actual speed of the motor. Can beobtained from the figure 8, in the case of a certain overshoot, speed can be quickly followed up in the 0.5s, the curve smooth, less volatile, and the given speed curve is basically the same.

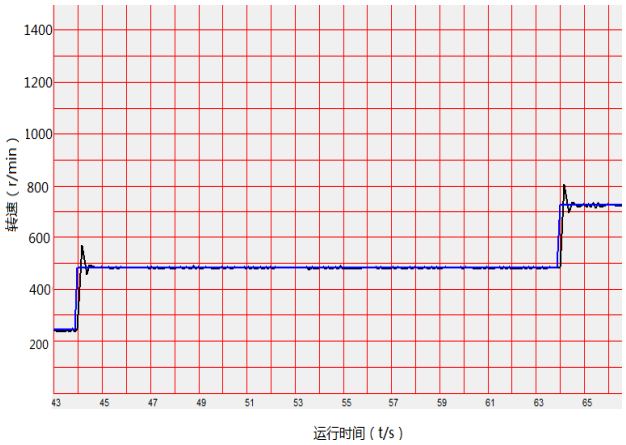


Fig. 8 experimental curve of given speed tracking

The data of experiment two is shown in Figure 9 and figure 10. The red curve indicates the speed of motor 1. The green curve indicates the speed of motor 2. The motor speed is 1 and the motor is given. The motor is 2 to track. From the graph we can see that although there is a fluctuation in the 2 curve of the motor, it is almost coincident with the 1 of the motor, and there is no obvious overshoot and hysteresis.

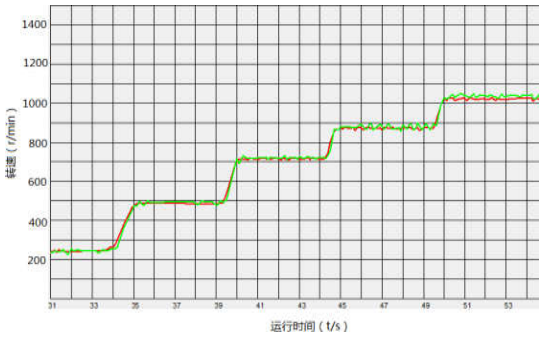


Figure 9 dual motor synchronous experiments (multi band acceleration) curve

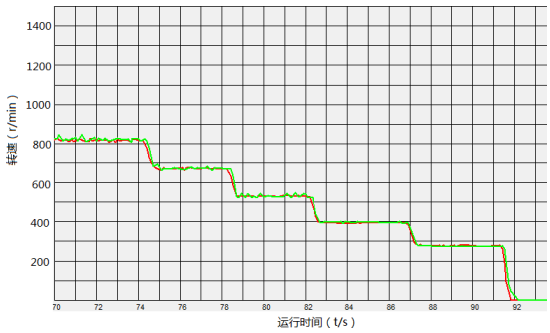


Figure 10 dual motor synchronization experiment (multi band deceleration) curve

7 Conclusion

In this paper, Micro850PLC AB and PowerFlex525 inverter is applied to the dual motor synchronous control system, the principle of variable frequency control is analyzed, and the integral separation PID algorithm is introduced. Compared with the traditional PID algorithm, the algorithm can make the system's static and dynamic performance index more ideal, and achieve the goal of high efficiency and reliable operation of the dual motor synchronization control system.

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