

The Design of Engine Starting Program Control System Based on PLC

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Abstract: The traditional engine starting program control system based on electromechanical combination has many disadvantages, the application of PLC in the engine starting program control system can improve the performance of the system. This paper mainly introduces the working principle, hardware design and software design of the control system based on PLC.

1. Introduction

The traditional engine starting program control system of military and civil aircraft generally adopts the combination of mechanical and electrical methods, because of adopting electromechanical timing mechanism to control relevant relay and contactor to realize engine starting program control, the volume of control system is magnifying, the weight is weighted, the consume of electric energy is much, the reliability is bad, and the system isn't in common use by adopting the hardware design of fixed connecting wire, the prominent problem of the system is control precision gradually reduces due to mechanical wear. Because PLC combines the advantages of flexible programing, complete functions and wide application of the computer with the advantages of simple control, convenient use and strong anti-interference ability of the relay system, and has the advantages of small size, light weight and power saving, so replacing the timing mechanism with PLC to complete the engine starting program control will vastly improve the performance of engine starting program control system.

2. The principle of engine starting program control

The engine acceleration from the static state to the lowest speed state which can work independently is called engine starting. In order to make the engine rotor rotate gently and without impact from the static state, the timing mechanism must adjust the starting torque of the starter step by step, make the torque of the starter increase step by step, and timely control the fuel supply and ignition of the engine combustion chamber. The principle of starting program control for an aircraft engine is shown in Fig.1.

The program control of timing mechanism divides the working process of starter into the following stages:

The first stage: within 1s~3.6s after pressing start button, make the starter work in the state of compound excitation and the armature in series with step-down resistance, and starting torque is limited in a very small range. Therefore, the starter can drive the engine rotor to rotate gently through the transmission device.

The second stage: within 3.6s~9s after pressing start button, short-circuit the start voltage reducing resistance, the voltage at both ends of the starter increases, the start torque increases rapidly, and then the turbine speed increases rapidly.

The third stage: within 9s~15s after pressing the start button, the two groups of batteries in the starting power car change from parallel to series, the voltage at both ends of the starter increases from 28v to 56v, and the starting torque increases sharply, so that the turbine speed rises sharply.

The fourth stage: within 15s~22s after pressing the start button, the series voltage reduction resistance of the parallel excitation coil of the starter reduces the excitation flux, the back EMF, and increases the armature current and the torque of the starter, so as to further accelerate the turbine.

3. PLC control system

3.1 System Hardware Design and I/O Address Distribution

In the engine starting program control system, the PLC adopts FX2N-48MR-001 type of Mitsubishi FX2 series, which has high reliability, strong anti-interference ability, is suitable for use in military and civil aircraft, and has flexible configuration and high cost performance[1]. It can be seen from Fig. 1 that in order to realize the four stage control of the starter, since the start button is pressed, the pull in time of contactors KM1 and KM2 is 9s-21s, KM3 is 3.6s-22s, KM4 is 1s-3.6s, KM5 is 1s-15s, and KM6 is 15s-22s. In addition, according to the control requirements of the system, PLC control system needs to introduce two input relays corresponding to stop button and start button respectively, six output relays corresponding to four contactors and relays respectively, as well as four power on delay time relays and two power off delay time relays controlling the four contactors and two relays working in different time periods. The electrical control circuit diagram of engine starting program and I/O address coding table of PLC are shown in Fig. 2 and Table I, respectively.

3.2 Software Design

The most widely used PLC trapezoidal diagram programming language is used in the software design. Trapezoidal diagram which very resembles the circuit diagram of relay control system is intuitive and ease to understand, especially suitable for switch logic control, and easy to be mastered by electrical personnel familiar with electrical. The trapezoidal diagram of the control system is shown in Fig. 3.

In Fig. 3, X0 and X1 are input relays; Y1~Y6 are output relays; T1~T4 are energizing time delay relays; T5 and T6 are outage time delay relays; M0~M4 are intermediate relays.

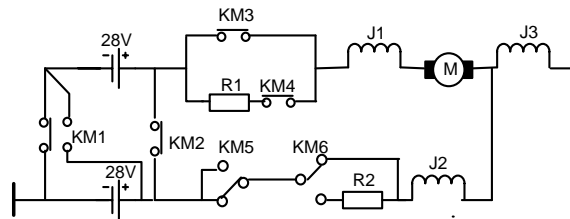


Fig. 1 the principle circuits of engine starting program control.

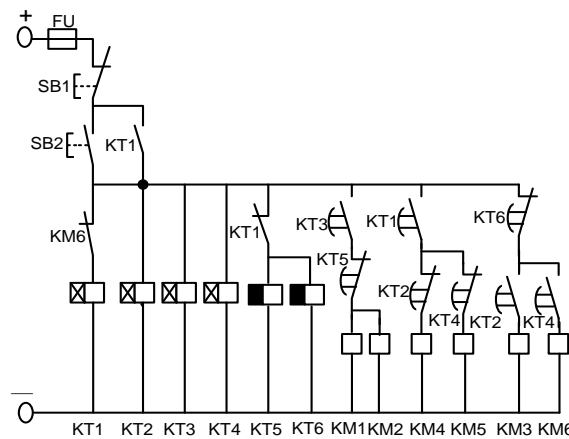


Fig. 2 the electrical control circuit diagram of engine starting program.

Table 1 I/O address coding table.

SB ₁	X ₀	SB ₂	X ₁	KM ₁	Y ₁	KM ₂	Y ₂
KM ₃	Y ₃	KM ₄	Y ₄	KM ₅	Y ₅	KM ₆	Y ₆
KT ₁	T ₁	K ₁₀	M ₀	KT ₂	T ₂	K ₃₆	
KT ₃	T ₃	K ₉₀		KT ₄	T ₄	K ₁₅₀	
KT ₅	T ₅	K ₂₁₀	M ₁	M ₂	KT ₆	T ₆	K ₂₂₀ M ₃ M ₄

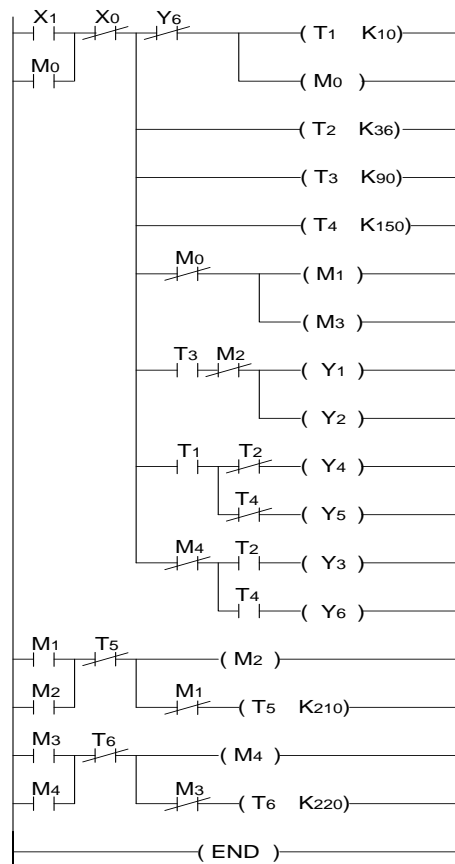


Fig. 3 The trapezoidal diagram of control system.

4. Conclusions

The application of PLC in the engine starting program control system can greatly improve the performance of the control system, which not only makes the control accuracy of the system high, anti-interference ability strong, but also makes the system has the advantages of small volume, light weight, power saving, versatility and so on.

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