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Application of Artificial Intelligence Technology in Forest Motor Control Syste

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Abstract:

In forestry operation engineering, motor is the main energy consuming equipment. The control accuracy of motor has a great impact on efficiency and energy consumption. With the rapid development of industrial production, people's demand for electric energy is increasing, so it is urgent to develop and save electric energy. As power equipment, motors are widely used in power plants and industrial and mining enterprises. Based on this, this paper studies the application of artificial intelligence technology in motor control system. This chapter first introduces a practical constant current soft start algorithm. Then the algorithm is improved by adding a fuzzy control algorithm with self-adjusting factor. After selecting the membership function of input and output, the fuzzy relation is obtained according to fuzzy reasoning and fuzzy rules. The experimental results show that the fuzzy control has better response performance and faster regulation speed, and can achieve low power consumption and energy saving of the control system on the premise of ensuring the stability of the system.

***Keywords**: Forest Motor, Artificial Intelligence, Motor Control System, Soft Start Algorithm.*

I. INTRODUCTION

Motor plays a very important role in the national economy, electrical, mechanical, metallurgical, construction, coal, petroleum, chemical, automotive, aircraft and shipbuilding industry and other modern industrial production and industrial sectors, as well as our daily life, all kinds of motors are used [1-2]. Motor is a kind of energy conversion equipment from electric energy to mechanical energy, which is the main force of power equipment. In China, the total installed capacity of motor accounts for more than 75% of the total capacity of all electrical equipment, and the power consumption accounts for more than 7096% of the total power generation [3]. However, the failure rate of motor also ranks first among all kinds of electrical equipment [4]. Among all kinds of motors, asynchronous motor is of great concern. Because of its simple structure, low cost, convenient maintenance, mechanical properties to meet the requirements of most production machinery, so the scope of application is more extensive. The Research Institute of Japan Electrical Association has investigated and analyzed the failure rate of asynchronous motor, special motor, transformer and other electrical equipment in 625 factories with power supply over 1000kW. The results show that the motor is the highest failure rate, up to 38.1% [5-6].

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Most motors are used in harsh environment, especially in thermal power plants, mines and petrochemical enterprises [7]. Under the working conditions of high temperature, high humidity and dust, it is easy for motors to have faults such as locked rotor, short circuit, open phase, leakage and long-term overload, resulting in insulation damage. If the main motor of a production line breaks down, it will cause the shutdown of the production line, and even affect the process flow of the whole large-scale production system. In addition, the indirect economic losses caused by motor failure, damage and plant shutdown are even greater.

Therefore, it is necessary to timely and accurately detect the running state of the motor, and carefully analyze the causes and characteristics of motor faults. It is very important to design and use the control and protection device with superior performance to protect the safety of the motor and ensure the normal operation of the motor.

Artificial intelligence is a new frontier discipline which is emerging and developing rapidly in the middle of 20th century. It is the law of exploring and simulating human intelligence and thinking process, and then designing some intelligent science similar to human. Or artificial intelligence studies how to simulate, extend and extend human intelligence by means of artificial methods and technologies, that is, using various automatic machines or intelligent machines.

The development of intelligent computing technology promotes the development of motor control and protection technology. The global optimization method with good convergence and strong adaptability is applied to the optimization design of motor control and protection, which makes it meet certain design requirements. It is possible to find the best economic and technical indicators. The new optimization algorithms such as genetic algorithm, immune genetic algorithm, ant colony algorithm and particle swarm optimization algorithm are introduced into the optimization design of motor control and protection. The optimization calculation of the control and protection of electric machine is carried out with the parameters and knots of motor environment factors, voltage, current, temperature, power frequency as design variables, and the results are satisfactory.

II. PREDICTION OF MOTOR LIMIT TEMPERATURE RISE TIME BASED ON NEURAL NETWORK

2.1 Principle of motor heating

The motor is an electromagnetic mechanism of energy conversion. The efficiency problem of energy conversion, that is, there is energy loss in the process of energy conversion, and the loss part finally turns into heat energy, which makes the motor heat and the temperature rise. When the temperature of the motor rises and exceeds the ambient temperature, this excess value is called temperature rise. National standard: 40 ℃ as the reference value of the ambient temperature, temperature rise is the temperature rise value of 40 ℃. The higher the temperature rise of the motor, the higher its own temperature, which accelerates the aging of the motor insulation material and reduces its service life. The relationship between the service life t of the motor and the temperature θ of the motor itself is as follows [8-10]:

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$$t = Ae^{-\alpha\theta} \quad (1)$$

In the formula, t is the service life of motor, that is, the service life of insulating materials of motor, and A and α are the coefficients of insulating materials. When different insulation materials are used, the service life of motor is related to the heat resistance grade of insulation materials at the same temperature.

Assuming that the motor is a homogeneous object, only the average temperature is calculated. According to the energy conservation theorem, the differential equation of heat balance of motor in actual operation is:

$$Pdt = K_r S\tau d\tau + cGd\tau \quad (2)$$

Where P is the heating power; Kr is the heat dissipation coefficient; S is the heat dissipation area; τ is temperature rise, c is specific heat; G is the weight of the heating body; t is time.

The solution of the differential equation is as follows:

$$\tau = \tau_m\left(1 - e^{\frac{t}{T}}\right) + \tau_0 e^{\frac{t}{T}} \quad (3)$$

The motor protector shall act when the temperature rise of the motor is less than the limit temperature rise τ_{max} to disconnect the circuit.

$$\tau_{max} = \left(\tau_m\left(1 - e^{\frac{t_r}{T}}\right)\right) + \tau_0 e^{\frac{t_r}{T}} \quad (3)$$

And the stable temperature rise of the motor is proportional to the square of the current, namely:

$$\tau_{max} = kI^2 \quad (4)$$

When the initial temperature rise of the motor is zero, the action time for obtaining the limit temperature rise of the motor is as follows:

$$t_r = -TIn\left(1 - \frac{\tau_{max}}{kI^2}\right) \quad (5)$$

It can be seen from the above formula that the greater the overload current of the motor, the shorter the time for the motor to reach the limit temperature rise. The relationship between overload current and tripping time obtained by this method fails to consider the internal structure of the motor itself and the heat exchange law between them, so the error is large.

2.2 Determination of BP network for prediction of motor limit temperature rise time

When the motor runs under long-term stable load, the voltage, frequency and power factor of the power supply can be considered to remain unchanged, and only the current, ambient temperature and rotational speed are taken as input variables. Moreover, although the environmental temperature changes with the seasons, it has little influence on the indoor situation, so the environmental temperature is approximately considered to be unchanged during network training; Considering the three factors that affect the speed, i.e. current, voltage and frequency, there are two factors that are approximately unchanged, so there is a strong correlation between the speed and current, and both of them need not be used as inputs, but only current can be selected as inputs. This paper studies the

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time when the motor reaches the limit temperature rise during cold start, so the current temperature rise of the motor can be ignored. Through the above analysis, the temperature rise prediction system can be simplified as a BP network with two inputs and one output for current and current temperature rise of the motor, and its structure diagram is shown in the following Figure 1:

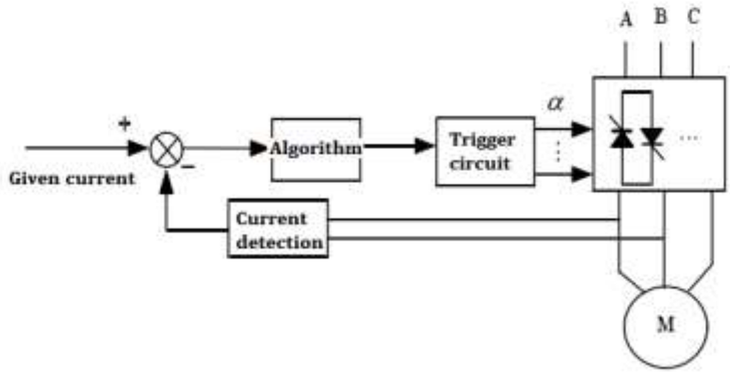

Fig 1: Prediction block diagram of motor cold start reaching limit temperature rise under long-term stable load

For the system studied in this paper, the values of the input and output layers are all between [-1,1]. Because the output of the hyperbolic tangent function is between [-1,1], it is often selected as a signal requiring input in the range of [-1,1]. Therefore, choosing this function as the activation function of each layer is beneficial to the convergence of the learning algorithm. In this paper, hyperbolic tangent function is selected as activation function of hidden layer, and linear activation function is selected as activation function of output layer. The expression of hyperbolic tangent function is:

$$f(x)=\frac{1-exp(-x)}{1+exp(-x)} \quad (6)$$

III. RESEARCH ON MOTOR CONTROL TECHNOLOGY BASED ON NEURAL NETWORK

3.1 Analysis of breaking time scheme

A large number of experiments on new AC contactors have found that the following two points affect the opening time of contactors.

(1) the action dispersion of contactor mechanism. the time from getting the instruction to completing the action machine (inherent time T_g and dispersion time T_f of mechanical action) is a range value (such as 20±2ms). But not a fixed value, and its dispersion is affected by the surrounding environment (such as vibration and temperature, etc.).

(2) mechanical action timeliness, with the increase of contactor service time, on the one hand, it changes the inherent time T_g of mechanical action, on the other hand, it also changes the dispersion time T_f of mechanical action.

The fluctuation of contact system action time often has several milliseconds, and the best action time range of zero crossing breaking is only 0.2ms ~ 0.6ms before zero crossing. On the one hand,

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from the perspective of mechanical design, we can reduce the dispersion of action time by improving the level of mechanical design. On the other hand, from the point of view of software design, it can dynamically adjust the time when the MCU sends out the breaking command, so that the breaking time of the first open phase of the contact falls in the best breaking time area. This paper focuses on the method of software dynamic adjustment.

In the literature, it is proposed to use the arithmetic average value as the best estimate of the breaking time of the intelligent contactor to adjust the breaking time of the next intelligent contactor to make it fall within the best breaking range. The experiment proves that the scheme is feasible. However, it is directly concluded in the literature that the data distribution of breaking time of intelligent contactor follows t distribution, which can be approximately expressed as normal distribution. Then, according to the characteristics of normal distribution, the expectation and standard deviation are obtained by using maximum likelihood function, and the next breaking time is dynamically adjusted according to the expectation. In the literature, the conclusion that "although the data sample is t-distribution, it is close to normal distribution" is lack of theoretical proof, as well as approximate processing error analysis and error compensation. In addition, there is a lack of theoretical proof on whether the sectional time of contactor always obeys normal distribution in the whole service life of contactor. The existing algorithm of contactor breaking time is more complex. If the distribution type of sample observation value changes during the use of contactor, it is difficult to deal with only relying on the computing power of single chip microcomputer.

Due to the strong learning ability of neural network technology, it can fully approximate any complex nonlinear relationship, and can be used in uncertain systems with adaptive ability. In this paper, with the help of artificial neural network, through a large number of experimental data training, we build a system to predict the breaking time of contactor, which provides a certain theoretical basis for the acquisition of breaking time.

3.2 Collection and processing of experimental samples

When the control voltage of the motor is lower than 85% of the rated voltage, the control voltage and current are collected, and a large number of experimental data are used as samples to train BP neural network, predict the time of arc free breaking, and send the tripping signal to cut off the control power supply to realize arc free breaking.

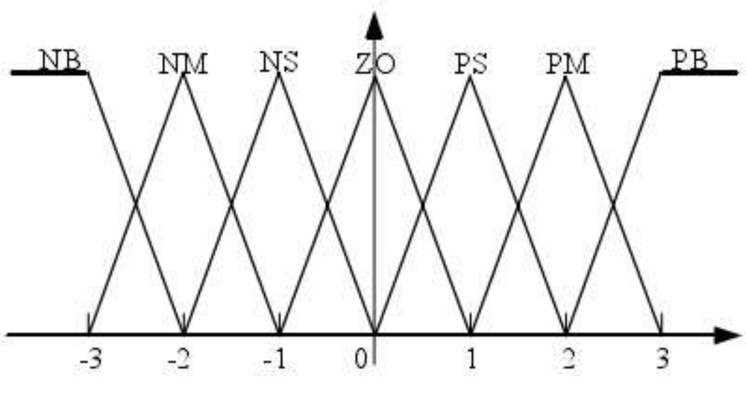

Fig 2: Block diagram of zero crossing breaking system

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Collecting training samples and necessary data processing is the key step to realize neural network prediction of intelligent contact breaking time. The experimental object of this paper is digital kbo-45c, the rated current is 45A, the experimental test bench and experimental circuit are shown in Figure 3 and Figure 4.

The test equipment in Figure 4 is independently developed by Zhejiang Zhongkai High-tech R&D Center of Tongji University. In this experiment, the test equipment provides low voltage and high current for KB0.

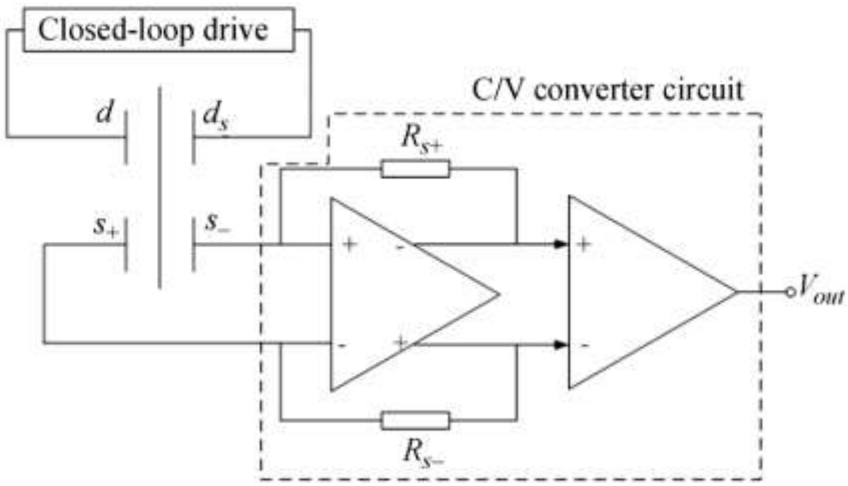

Fig 3: Experimental circuit

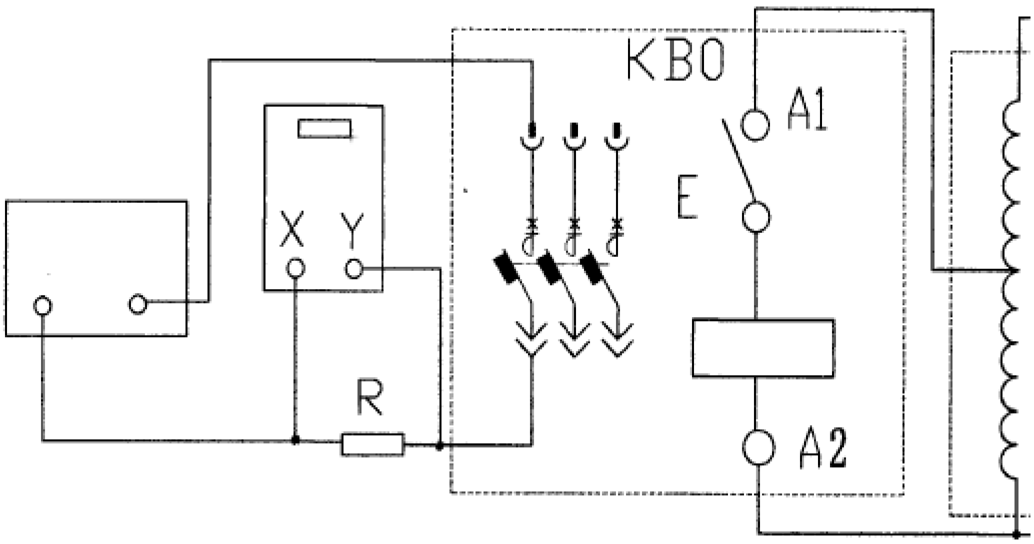

Fig 4: Experimental circuit

IV. DEVELOPMENT OF MOTOR CONTROL AND PROTECTION DEVICE SYSTEM

4.1 Hardware design scheme

Hardware is the basis and carrier of the system, and hardware circuit is the basis of the normal work of the system. The hardware design of digital KBO control and protection device integrates

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digital circuit technology and analog circuit technology, with rich functions According to the function, the hardware circuit of the digital control and protection device can be divided into the following modules: microprocessor module, power supply module, signal processing module, communication module, switch input module, switch output module, zero crossing comparison module and human-computer interaction module. The principle of the system structure is shown in Figure 5.

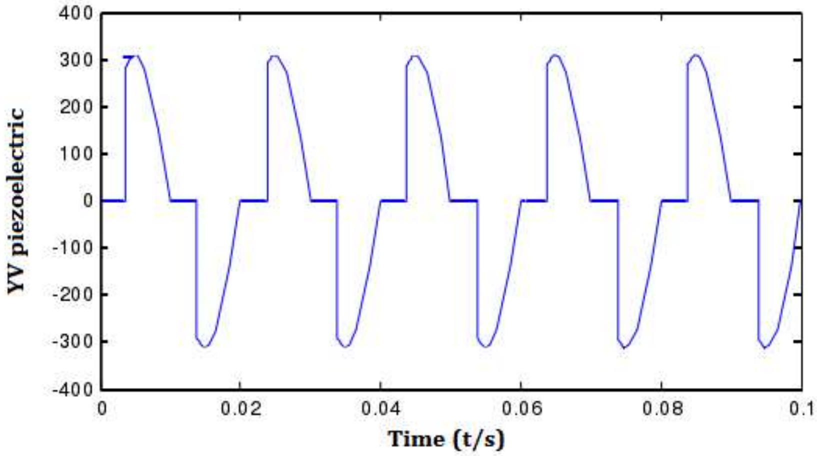

Fig 5: System structure block diagram

4.2 Soft armor design

The design of software is the key to complete the design task of digital control and protection device, and it is also its "soul". Good software design can maximize the advantages of hardware resources. Therefore, for the design of digital control and protection device, in addition to reasonable hardware resource design, there should also be a set of efficient and reliable software system as support.

The lower computer software is written in dsPIC30F series chip of microchip company. The debugging tool of the software is MPLAB ICD2 (provided by microchip company), the development environment is MPLAB ide7.6 (provided by microchip company), the program editor is MPLAB C30 (provided by microchip company), and the program language is C language. The overall architecture of the lower computer software is shown in the figure below.

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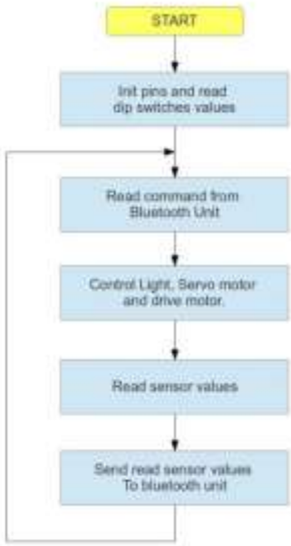

Fig 6: Software main program flow chart

4.3 Test results and conclusion

In view of the need of communication function verification, the laboratory completed the construction of communication function demonstration frame. The demonstration frame is connected to PC by 32 intelligent digital kbo-t through shielded twisted pair cascade and connected to PC via usb/485 converter. The following tests were carried out with the demonstration frame:

(1) Configuration function test: configuration of PC communication port and baud rate; Configuration of communication address and type of slave station;

(2) Configuration function test: monitoring configuration of multiple slave stations;

(3) Communication function test: real time parameter refresh, display and modification of setting parameters, remote control;

(4) Data recording function test: fault information is recorded in the database and can be viewed according to address.

The demonstration frame has been running safely and reliably for 30 days. The remote control, remote signal, telemetry and remote adjustment functions of the prototype are verified, and the design scheme of communication module is also verified.

V. CONCLUSION

After consulting a large number of domestic and foreign technical literature, this paper analyzes the application of artificial intelligence in motor control and protection technology, and divides the subject into three directions: the application of artificial neural network in motor thermal overload protection, the application of neural network in motor air control technology, and the application of expert system in motor fault diagnosis. This paper involves a relatively large system, need to complete a lot of tasks, the design is more complex. In this paper, some functions of the system are designed and implemented, and some functions are tried and explored.

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