CHEMICAL ENGINEERING TRANSACTIONS

VOL. 62, 2017

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Fei Song, Haibo Wang, Fang He

ISBN 978-88-95608- 60-0; **ISSN** 2283-9216

DOI: 10.3303/CET1762147

Design of Transformer Oil Temperature Intelligent Monitoring and Alarm System Based on PLC

Kun Zhang

Chongqing Vocational Institute of Engineering, Chongqing 402260, China
Zhangkun@126.com

According to the requirements of the transformer oil product management system, the overall plan is designed, PLC is used as the next machine, and the distributed I/O system is built, based on the system software design transformer electrical schematic diagram. Using the flow meter metering transformer oil, high-speed pulse output signal stability and temperature control realize the purifier with MATLAB software simulation, PID control, and small brain model combining CMAC (Cerebellar Model Articulation Controller) control mode to control PLC transformer oil temperature. PC USES MCGS development, oil and grease, and net oil link of the control implementation monitor each process, reducing the loss of transformer oil to meet the needs of modern enterprise intelligence, energy conservation and environmental protection.

1. Introduction

Transformer working conditions are relatively poor. In the high temperature environment only the transformer oil cooling can guarantee the transformer works well and reliable, otherwise it may cause serious electrical or mechanical failures. The transformer oil is also an insulating medium that plays an important role in the transformer. It is not conductive without lubricating. Because of the transformer oil cooling, lubrication, cleaning, and other important roles, in order to maintain the normal operation of the transformer and the traditional transformer manufacturer production, preparing quite amount of transformer oils is needed to satisfy the use requirements. The transformer manufacturer stores a large amount of oils used in transformer oils and finished products test to take up the enterprise more liquidity in the process of storage (Li and Qi, 2014; Chen et al., 2010; Yu, 2006). Usages and experiments are need to sampling the observation of transformer oil, if the detected index is not in conformity with the standard values. The transformer oil purification processing is needed before using. At present, the usage, supervision and management of the transformer oil are semi-automatization. The accurate quantification of exercises is needed when production. Reducing the loss of superior products, improving oil purifier control temperature effect, and the efficiency of oil purifier, ensure the net oil process control using PID control method compared with the traditional way, but the precision is still inadequate. The overshoot is serious, and is not easy to set parameters, only using the PID control method because of the net oil efficiency is low. Based on the above requirements, the design scheme of the intelligent monitoring and alarm system for PLC transformer oil temperature is put forward in this paper, so as to realize the intelligent control of PLC transformer oil temperature. Using flow meter metering transformer oil, high-speed pulse output signal stability and temperature control realize the purifier with MATLAB software simulation, PID control, and small brain model combining CMAC (Cerebellar Model Articulation Controller) control mode to control PLC transformer oil temperature. These algorithms can be implemented by a computer quickly and the algorithm is more precise and advanced. The net oil gained by the process of transformer oil temperature output error is smaller. The overshoot can even be 0, and reduce the energy consumption in four layers. The purification efficiency improves significantly (Xie and Ning, 2016; Ding and Yang, 2003).
The transformer oil is important to the power transformer internal insulation medium. A large number of transformer oils need to be stored in order to maintain the normal production in traditional transformer manufacturers. At present, our country's most transformer manufacturers used the transformer oil and oil management are still semi-automatization. The production of oils, the oil injection, and the net oil operations

Please cite this article as: Kun Zhang , 2017, Design of transformer oil temperature intelligent monitoring and alarm system based on plc, Chemical Engineering Transactions, 62, 877-882 DOI:10.3303/CET1762147

cannot be accurately quantified. The oil loss causes a big loss to the enterprise. The oil purifier temperature control effect performs not well. The filter oil pipeline design is not rational with a series of problems (Liu et al., 2015).

2. Process improvement and control system of the design

Due to the transformer manufacturer's product storage areas are limited, it may be relatively concentrated or scattered. Each region has a certain distance, in order to guarantee the control ability. For the Siemens S7-300 PLC system platform, the bus control network is Profibus-DP. The input or output control system into distributed I/O setting is made up of three ET200s. The computer CPU is in some extension modules on the basis of the main module, including the oil inlet system and the test system to control the static pressure of the transformer. PC USES MCGS development, the implementation of oil as well as grease, and oil cleaning of the control implementation are used to monitor each procedure. The oil temperature sensor collected from the transformer oil temperature signal, by the DP bus to PC will be the CMAC and PID control strategy of parallel calculation. The output execution control signal controls three-phase voltage regulator module, electrical heating actuator driven, and the transformer oil temperature of the oil purifier by PLC. In the second part, other stations control the oil pump start-stop device and the test fixed speed filling system. In the third part, the liquid level information in each tank is also collected and the solenoid valve actuator is controlled, which mainly control the pneumatic valve and the pneumatic control valve.

2.1 Design of siemens PLC control system

According to the control demands, manufacturers consider the transformer oil management system overall scheme design, select Siemens 57-300 series PLC as slave computers, and use the bus connection ET200M from stations to distribute I/O control system. Manufacturers design the electrical schematic diagram and the system software, and analyze the realization of the high-speed pulse output flow meter. The MATLAB software simulates the temperature control in the process of oil purifier in the net, the conventional PID control, fuzzy parameter self-tuning PID control and small neural Model CMAC and PID parallel control. To analyze the simulation results, finally the CMAC and PID parallel control strategies are chosen to control the oil temperature.
The upper and lower computers, the software, the acquisition equipment, the detection device and the actuator constitute the whole Siemens PLC control system.
For the CPU325-2DP main controller, the maximum input or output I/O points are 65536, and the maximum analog output points are 4096. Equipped with a 2 MB memory card to store data, the liquid level acquisition information USES SM331 module collects the simulation quantity. The frequency converter analog volume is output by SM332, and the 8-channel fm 350-2 is used for counting and the frequency can reach 20 KHz. The station chooses im150-1 to mount distributed input or output I/O interface modules. The hardware configuration of the Siemens PLC is shown in Figure 1.

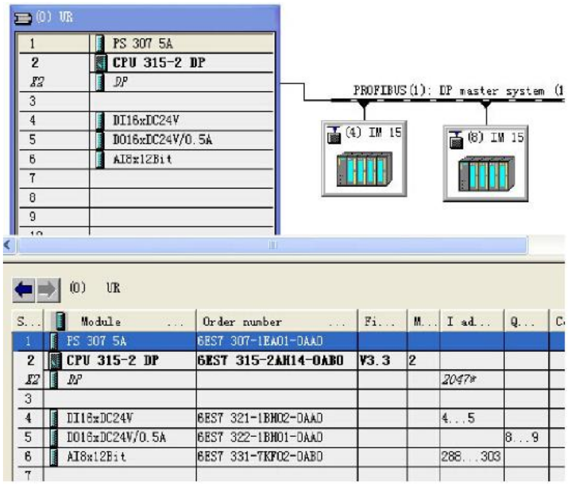

Figure 1: The Hardware Configuration

The digital input module adopts SM321 (including connector) and the hardware configuration is 16-channel 24V direct current digital input, and 3-piece SM321. While the digital output module adopts 16-point SM322 (including connector) and the hardware configuration is 6ES73222BHOl0AA0, 16-channel 24V direct current

digital input, and 4 blocks. The analog input module adopts 8-channel SM331 (including connector) and the hardware configuration is 6es7311-7k02-oabo, 4-20ma current and four-wire system. While the analog output module adopts the 4-channel SM332 (including connector) and the hardware configuration is 6ES7322-SHDOI-OABO, 4-20ma, and two clean oil machines to control the input end. The high speed pulse input module adopts the 8-channel fm350-2.
The transformer oil monitoring system is the Siemens PLC programming software STEP-V5.5. According to the requirements of transformer manufacturers, the transformer oil is with the automatic function implementation and the basic manual control function, so as to facilitate the normal production of the whole production system.

2.2 Design of tests and actuators

The design of tests and actuators includes the following parts: oil tonnage testing devices, flow monitoring devices, actuators, oil temperature detecting devices, etc. Oil tonnage detection devices are mainly based on the principle of ultrasonic liquid level gauge testing. The ultrasonic transmission in the transmission medium will be checked when the liquid level forms reflected waves from the surface of the medium and then backs to the propagation by a sensor again after receiving. Wave signals will be into electrical signals according to the transmitting and receiving ultrasonic time. The ultrasonic driving distance is judged, and then the level is calculated and determined. The calculation formula of the oil quantity is the ellipse area times the height of the liquid surface. The elliptic area of the tank is calculated by the equation of the oval cross section. After the volume of oil tank is obtained, the oil quality of the transformer can be achieved when the density of the transformer oil is also known.
Using the MCGS development PC interface can monitor the real-time amount of oil in the tank, the oil cleaning process, the filling operation, and the static pressure test. Thus, enterprises can get the data query production storage, make the oil management, use all achieved automation, record every use links accurately, and avoid the risk of product loss . Transformer manufacturing enterprises will be satisfied.
Instantaneous and cumulative flows can be gained through the flow monitoring device, and be measured by the flow meter, mainly the float-type flow meter, the worm wheel flow meter, the electromagnetic flow meter, etc., that is selected according to the different using occasions. In this paper, the lwgy-40al2bt1 turbine flow meter, produced by Beijing Global Technology Co., LTD, is used to calculate the flow rate according to the turbine speed calculation. The fluid through the turbine will drive the blades rotating and the corresponding sensor installation will deal with the transmission circuit according to the turbine speed and the direct ratio relation of fluid, convert the actual flow rate, and process the flow and the flow velocity. The high speed pulse signal is one of the output signals, which is simpler than the 4-20ma signal. The error easy to be obtained is small, and the programming implementation is simple. The Siemens 300 PLC is relatively expensive, but it is more suitable for the accuracy of high-speed pulse signal collection and output. The hardware wiring diagram of the flow meter is shown in Figure 2.

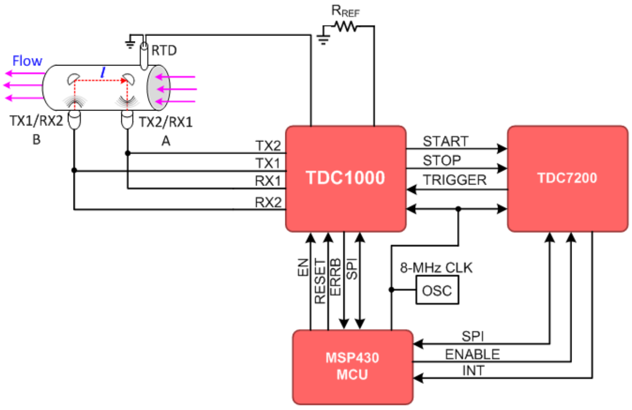

Figure 2: Flow Meter Hardware Wiring Diagram

The actuator on the transformer is mostly valves and electric heaters. As mentioned above, the three-phase regulating module receives PLC signals for power control of the electric heater. The pneumatic valve controls the cylinder movement by the flow of the gas path, and input 24V dc, 200 Ma, indirect valve switch. The fast oil pump is 50 kW, 2380 V alternating current low power density tube electric heating original heating.
For most transmission manufacturer process maintenance manuals, the oil purifier net works well at 55 degrees Celsius, based on the thermal resistance one-piece pt100 temperature collector to collect oil purifier

inlet temperature. In accordance with the principle of the linear relationship between the resistance and the temperature of platinum, the sensor can calculate the temperature.

2.3 Net oil temperature and oil injection speed control

During the test process of the transformer net oil machine, the oil at the entrance and the oil speed are moderate, and these two parameters are used as the key control parameters to monitor the transformer oil.
The transformer oil purifier inlet temperature control needs to be under the guidance of the manual gearbox manufacturer process, keeping at 55 degrees Celsius, before the transmission oil into the oil purifier installed a long pipeline for heating. The net oil purifier efficiency achieves the optimal value, but the existence of a heating pipeline makes the control system with delay and inertia.
During the test, it is usually carried out according to certain operating procedures. There are two types of oil filling: conventional oil injection and vacuum injection. The conventional oil injection mode is suitable for the transformer with power of 110 kW and below. The actuator is the gear pump, which is controlled by the inverter. The vacuum filling method is suitable for the transformer with power of 110 kW, taking the pneumatic regulating valve as an actuator. Various actuators can be selected according to the above requirements. Other performance test of the transformer can be carried out after the test of oil filling speed is qualified. According to the requirements of transformer manufacturers, the oil filling speed of the transformer is selected 6t/h.
The single CMAC network consists of the input, output and middle layers. In the computer, each state of an address's input space distribution is stored in memory. Next the memory storage unit obtains numerical. Finally, to obtain the output value, the operation of the relationship between input and output layers is as follows: developers are pre-installed in the input layer in advance in nonlinear mapping within the multidimensional space form the input layer. The intermediate layer is composed of the basis function, and the input layer only has a few action basis functions output value of 1. The basis function is generalized to obtain a middle layer parameter. Next, instructions are cooked up by the middle layer to the output layer, the input layer and the middle layer of nonlinear mapping. USES the linear function relationship between the middle layer and the output layer gets the corresponding weight. The weight is adjusted by the gradient descent method and an intermediary relationship, to carry on the numerical mapping relationship between the input and output layer.
According to the specific function of the transformer oil monitoring system, this system consists of the PC configuration interface, the software system and the lower computer PLC signal acquisition, control and detection devices. The actuator is composed of the Siemens 57-300PLC as the core controller, Profibus-DP bus connecting ET200M to build a distributed I/O control network, and the control system structure diagram of figures. The control system structure diagram, developed by the MCGS PC monitor interface, includes the on-line monitoring, data process, display and output of real-time and historical data report for the operator to print. The complex control algorithm MATLAB and exchange data through OPC and MCGS achieve the control of oil temperature oil. The lower machine PLC to the Siemens 300 series 315-2DP controller uses Profibus-DP bus to build a station, 2 I/O from the station by ET200M distributed control system. Data acquisition and output are based on each functional module of the mount, and the CPU will exchange data through the MPI interface and the PC to its own.

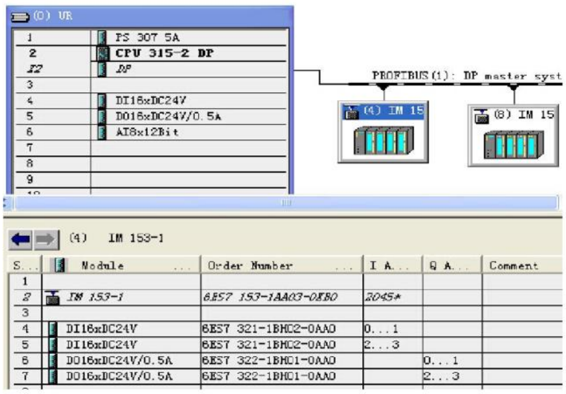

Figure 3: 1# Slave Hardware Configuration

This paper adopts PID and CMAC network to control the feed forward and feedback. The numerical simulation software MATLAB is with the input function of fuzzy reasoning. Click enter, and pop-up editor of fuzzy reasoning. It is edited, modified, and saved under the editor. Click on the file, and select a new "Mamdani"

model. Open the rule editor, and select the appropriate type. The selected value of parameters is 100, the middle layer parameters for 5, and PID and parallel control of CMAC parameters KP = 1.2, KD = 0.14, on the basis of the cash M file and the simulation.
The simulation results show that, in the network with delay and inertia, the conventional control effect is poor, the overdose deviation is larger, and the adjustment time is long. Compared with the conventional control effect, the fuzzy logic control effect is better, the overshoot is smaller, the condition time is shorter, and the result is satisfactory. These two parallel control overshoot volumes are almost negligible, and the separate PID and CMAC controls are more precise and combine the advantages of both from the output curve. These two parallel control strategies well fulfill the gearbox manufacturers' needs in the inlet temperature of the oil purifier control.

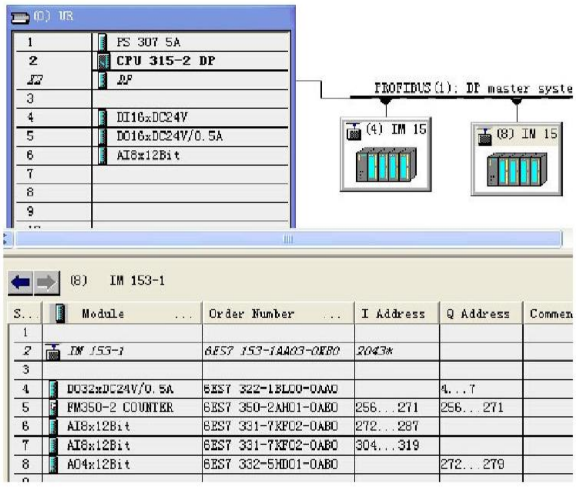

Figure 4: 2# Slave Hardware Configuration

Operators can operate the whole transformer oil test according to the upper machine and the process flow interface and measure the amount of actual oil in each tank. The oil injection, net oil, parameter setting, test process and specification, control valve, etc. all can click and select in the human-computer interaction interface. The touch screen sensitivity can also save the data and historical data. The PC has a huge database, in which stores the test staff basic information, transformer models, as well a control and system parameters. The standard curve can be compared with the experimental simulation diagram, finding out the experimental simulation figure deviations, faults, diagnoses, etc. When the test fails or the oil quantity is insufficient, the alarm makes the beep sound, reminding the test personnel to check the system failures and generate the system fault records. Finally, various reports are exported for access and printing. This system can also make the PID control and the CMAC network simulation module simple. Added to the system, each test only brings up the module. Inputting parameters can repeat the experiment conveniently: add the finished product oil monitoring, oil monitoring "test", "user management", "the finished product oil", "experimental oil" interface, etc. in a new window. Set the password, and then log in the registered user name to test the PC in the online and real-time databases. The real-time database updates the data in the memory and connects to the devices. The implementation of the upper machine parameters and the parameters of Siemens PLC in the database link forms the link among channels. The simulation and practical approach conform to the real quantity which reflects the actual situation. PC variables are consistent with those in the Siemens PLC.
Here, the upper machine operator permissions can be set according to the situation, including the user operation permissions, administrator permissions, operation system with conventional options in the menu, modifying and perfecting the personal information, such as forgetting password operation process, etc. In the main interface, selecting the corresponding module can implement the corresponding operation, such as selecting "refined oil monitoring" that the finished product oil monitors "test" and other corresponding operations, including the implementation of transformer oil, refined oil filling quantity detection and data printing, oil tank, the net transformer oil calibrate gold control, cycle test, a variety of interface and operation for the operator to select, friendly interface, simple and easy panel Settings humanized, and test data real-time display .

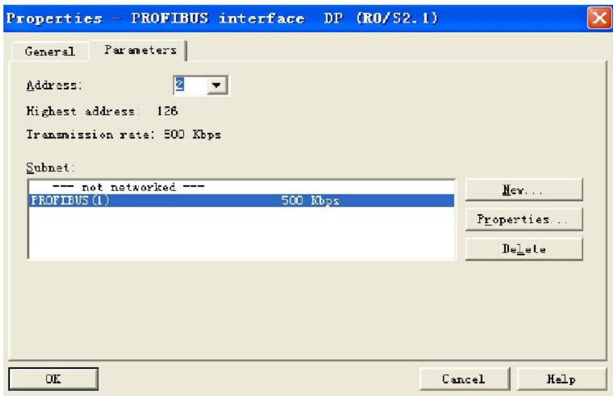

Figure 5: Communication Rate Setting

3. Conclusion

In this article, through the transformer manufacturers' transformer oil management system requirements, the overall scheme design, selection of PLC as a lower machine, and building a distributed I/O system are all based on the system software design of the transformer electrical schematic diagram. Using the flow meter metering the transformer oil, high-speed pulse output signal stability, and temperature control realize the oil purifier with CMAC and PID control, and small brain model combining the transformer oil temperature control PLC. The upper machine adopts MCGS to develop, implement the operation of oil quantity, oil filling and net oil, and monitor each process to reduce the loss of transformer oil. The numerical simulation software MATLAB is with the input function of fuzzy reasoning. Click enter, and pop-up editor of fuzzy reasoning. Click enter, and pop-up editor of fuzzy reasoning. It is edited, modified, and saved under the editor. Click on the file, and select a new "Mamdani" model. Open the rule editor, and select the appropriate type. The selected value of parameters is 100, the middle layer parameters for 5, and PID and parallel control of CMAC parameters KP = 1.2, KD = 0.14, on the basis of the cash M file and the simulation. The simulation results show that, in the network with delay and inertia, the conventional control effect is poor, the overdose deviation is larger, and the adjustment time is long. Compared with the conventional control effect, the fuzzy logic control effect is better, the overshoot is smaller, the condition time is shorter, and the result is satisfactory. These two parallel control overshoot volumes are almost negligible, and the separate PID and CMAC controls are more precise and combine the advantages of both from the output curve. These two parallel control strategies well fulfill the gearbox manufacturers' needs in the inlet temperature of the oil purifier control.

Reference

Based on Siemens PLC transformer oil monitoring system design and implementation, Master's thesis of northern national university, 2016.

Chen Y.G., Xia S.Y., Wang Y.Y., 2010, Design of transformer air-cooled intelligent control system based on PLC, Electrical industry, (7), 44-48.

Ding F., Yang S.Y., 2003, Design conception of intelligent measurement and control system of transformer oil temperature, Xinjiang power, (2), 43-44.

Li C.H., Qi X.D., 2014, Intelligent control and monitoring system design of power transformer oil temperature, Journal of Taiyuan university of science and technology, 35(1), 8-14.

Liu G.L., Hu E.D., Yang Z., Zhao W.X., Zhou P., 2015, Monitoring system of transformer oil design based on PLC. Computer Measurement & Control, Computer measurement and control, 23(11), 3668-3670.

Xie A.P., Ning N., 2016, Research on a large transformer intelligent air cooled control cabinet based on PLC, Journal of Tangshan normal university, 38(5), 65-67.

Yu X.C., 2006, Design of intelligent temperature controller for dry transformer based on CAN bus, Microcomputer information, 22(34), 67-69.