A SCADA SYSTEM OF WATER AND STEAM CHEMISTRY PROCESS IN POWER PLANTS

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Abstract - *In this paper, a SCADA system of chemistry in the power-plant is brought forward with the functions of intelligent instrument, cybernation and information sharing, which is an effective solution to preventing for filthy, erosion and burst of the pipes in the critical and sub-critical boiler system. More over, it is one of the critical ways of increasing the efficiency of the turbine and decreasing the consumption of coal.*

Keywords - SCADA, human-simulating intelligent control chemistry process monitoring, medicament feeding.

1. STRUCTURE AND FUNCTIONS OF THE SYSTEM

The controlled object is various of solute in the system of water and steam including several kinds of ions and three kinds of medicaments, mainly consisting of oxygen dissolved, pH, ammonia, silicon dioxide, natrium ion, phosphate anion, hydrazine and etc. The controlled object distributed in different units, the bus topology is adopted in the SCADA system and the ADAM5510/485 is selected as sub-node integrating with various of software resource and hardware resource, which are connected with RS-485 protocol. AS a result, a distributed data acquisition and control network is built up. Accounting of the requirement of high real-time, high stable, friendly interface and various of functions in the industrial control system, the WindowsNT4.0 is selected as OS, the configuration software of Intellution FIX, Visual Basic 6.0 and Turbo C 2.0 are selected as main tools in the SCADA system.

As for functions of the control module, both manual and auto styles of are designed .In scheme of auto-control, three control-loops of ammonia, phosphate and hydrazine are designed and the arithmetic of PID intelligent control is adopted. Therefore, the fluctuation of medicament feeding due to the lag of feedback can be restrained.

The main monitoring functions include: the displaying of the real-time data; the enrolling of history event; the querying of history data, history trend pictures, history events and history alarms; the forming and printing of reports the security of the SCADA system and etc.

2. THE MODULE OF MEDICAMENT FEEDING AUTOMATICALLY

In this module, three control-loops of ammonia, phosphate and hydrazine are designed and their principles are similar to each other, so we describe the control-loops of phosphate as an example.
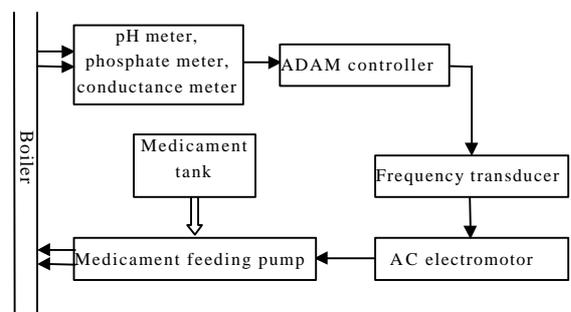

Fig.1 – The structure of medicament feeding automatically

In this control loop, three input variables are the pH value of boiler water, the conductance of it and content of phosphate dissolved in it. They are input into the ADAM 5510 controller, then the result of the arithmetic of PID intelligent control is output into frequency transducer to perform the doing control. As a result, the frequency of the feeding medicine electromotor varies, so does the content of phosphate dissolved in boiler water.

2.1 the arithmetic of Human-simulating intelligent control

The theory of human-simulating intelligent controller is based on Characteristic Model, Characteristic Identification, and Characteristic Memory. According to the deviation and the changing of the deviation of the controlled variable, the special control pattern is adopted. While the system deviation increasing, namely, the signs of $E(t) and \dot{E}(t)$ is same as each other, or the system deviation is constant ($\dot{E}(t) = 0, and E(t) \neq 0$), the pattern of PID control is adopted. Then the strong close-loop control effect is brought out; In the other hand, when the system deviation decreasing, namely, the signs of $E(t) and \dot{E}(t)$ is different, or the system deviation is zero, the pattern of holding control is adopted. The idea can be described as follow:

$$IF\ (E\dot{E} > 0)OR(\dot{E} = 0, E \neq 0)$$

$$THRN\ : U(t) = u_0(n-1) + A_{PID}$$

$$IF\ (E\dot{E} < 0)OR(E = 0)$$

$$THEN\ : U(t) = KK_p \sum_{i=1}^{n} E_{mj}(t)$$

In the control-loop of phosphate, which has three input variables and single output one control system, an algorithm combining the idea of human-simulating intelligent control with the algorithm of classic PID control is adopted. It is an improved PID arithmetic.

$$u(t) = \begin{cases} u_0(n-1) + K_p[E(t) + T_d\dot{E}(t) + \frac{1}{T_i}\int_{t_1}^{t_2} E(t)dt] \\ u_0(n) = KK_p \sum_{i=1}^{n} E_{mj}(t) \end{cases}$$

$u_0(n-1)$: the controller output value on n-1 time slicing

$u_0(n)$: the value of u(t) on n time slicing;

$E(t)$: syetem deviation;

$\dot{E}(t)$: the changing rate of system deiation;

$E_{mj}(t)$: the extrmum value on i time slicing;

In this control system, At the begin of the control pattern, the system deviation ($E(t)$) is small relatively, the effect of proportion control is weak; however, the value of $\dot{E}(t)$ is big relatively, the control effect of differential coefficient is strong. So the controlled variables can increase or decrease sharply. At the end of the control pattern, the control effect of differential becomes weaker, however, the control effect of integral grow stronger, so the overshoot can be restrained.
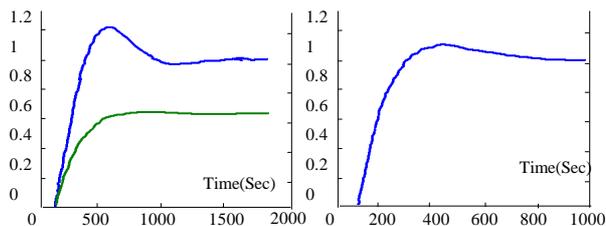

Fig.2 –the step impulse response of classic PID and human-simulating PID intelligent control.

2.2.controller and the realization of the arithmetic

The ADAM 5510 is applied in the system as controller, it fulfills data acquired and program control independently, which supplies with itself c library and abundant hardware resource. This control program is design with the Turbo C IDE supported by ADAM 5510.
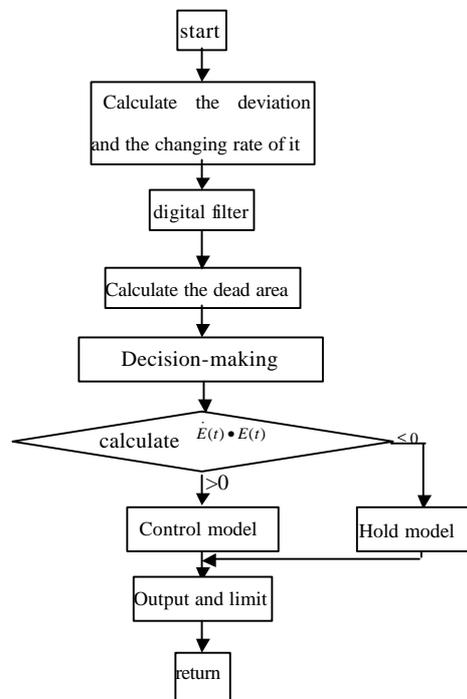

Fig.3 – the flow chart of PID intelligent control

In the control system, there is two control models: PID control model and holding control model. After making decision by the decision-making database, different control model is adopted. All parameter is gained at power plant. Namely, if $\dot{E} \bullet E > 0$, the PID control model is adopted and a set of parameters are applied, if $\dot{E} \bullet E \leq 0$, then another set of parameters is applied in the PID control model.

The practice shows that the system is stable and reliable. The change of phosphate is confined in the range of $0.5mg/L \sim 3.0mg/L$.
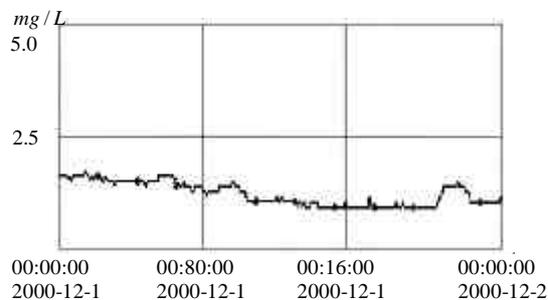

Fig.4 – the history trend of content of phosphate

3. THE SECOND EXPLOITATION OF REPORT MODULE OF FIX

To meet some other practical needs, a method of second exploitation of FIX report module by programming Visual Basic Server/Client application is brought forward in this paper. Not only does this method qualify us to query history data, put through the limitation that the history data files can been not directly opened by user, but also provide us with a standard interface between FIX and Access, Excel and network. In detail, analysis the structure of the datum in the FIX history database, then program the DDE Client application and obtain the data in the FIX history database and save as standard type of database such as Access and Excel. Then we can share this database with other node on-line by the application module of winsocket.
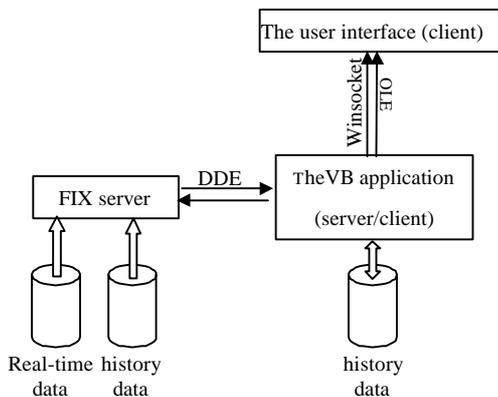

Fig.5-data communication between FIX and the VB application

4. THE IDEA OF VIRTUAL INSTRUMENT

The idea of Virtual Instrument is absorbed in this SCADA system. The modification and setting for transducers and instruments are realized by adjusting slope rectification coefficient, intercept and range, output limits and other parameters of the on-line instruments.

5.CONCLUSION

The practice shows that the SCADA system is stable and reliable in power plant, which is effective solution to preventing for filthy, erosion and burst of the pipes and increasing the efficiency of the turbine and decreasing the consumption of coal in the critical and sub-critical boiler system in power plant.

REFERENCES

[1] Shiyong Li, "Fuzzy Control, Neuron control and Intelligent Cybernetics", *Press of Harbin Iindustrial University* .1998.
[2] Yunsheng Zhang, Principle And Application for Real-time Control System Software Design, *National Defence Press*, Beijing, 1998.
[3] Zuoshan Xiao "The water & steam physical chemistry process of thermodynamics equipment", *Hydraulic and Electric press*, 1987
[4] YANHUA, "User's Manual ADAM5000", unpublished