Key technology of GLCC control system design

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Keywords: Water level control, VxWorks, Gas-Liquid Cylindrical Cycloner, fuzzy PID control

Abstract. Aiming at the key problem of GLCC multiphase flowmeter control system design, this thesis proposes a kind of gas-liquid separation task handed to the VxWorks, and adoptes liquid level fuzzy control by using of the theory of fuzzy mathematics to ensure the full separation of the gas-liquid. The technology applied the level fuzzy control method at the basis of VxWorks to design control procedure, it can change gently the control and enhance the robustness, so it has a practical value in the complex and nonlinear variable control system.

1. Introduction

The accurate measurement of the crude oil is an important link in production of the oil and natural gas. At present, GLCC has been widely used in the oil and gas separating metering,owing to low production cost, light quality, high accuracy, high automation, stable performance and other advantages.but the measurement performance of GLCC depends on the gas-liquid the separation effect, when oil and gas multiphase flow is unstable, gas-liquid compared rate is usually changed greatly in the flow pattern[1] (slug flow, stratified flow, bubble flow or blocking flow, annular flow) or wells switch case especially, separator pressure and liquid level fluctuation cause leakage phenomenon in GLCC, it may seriously affect the separation efficiency of the separator, and may lead to frequent blockage and damage of flowmeter, which ultimately affect the effective operation of GLCC. Therefore, the effective separation of GLCC,it can better meet the needs of petroleum on the high performance GLCC device. Because of the gas-liquid flow pattern is different, and the geological structure and formation pressure, temperature and other factors, they will adapt to different flow patterns to achieve good gas-liquid separation effect, on the one hand, a multi task real-time and stable separation control system is needed to solve the question,on the other hand, the liquid level is judged accurately is very important. The thesis proposes GLCC control system based on the VxWorks by analysis and comparison of the existing research results,according to the actual need, the control task(crude oil two-phase separation) gives the VxWorks[2] operating system, it can simplified program design of the gas-liquid separation; in addition using the theory of fuzzy mathematics to ensure the full separation of GLCC liquid.

2. The principle of GLCC Gas liquid separation

Gas-Liquid Cylindrical Cyclone Multiphase flow separation metering is a highly efficient separation and measurement system developed by Tulsa University in the United States, as shown in Figure 1.

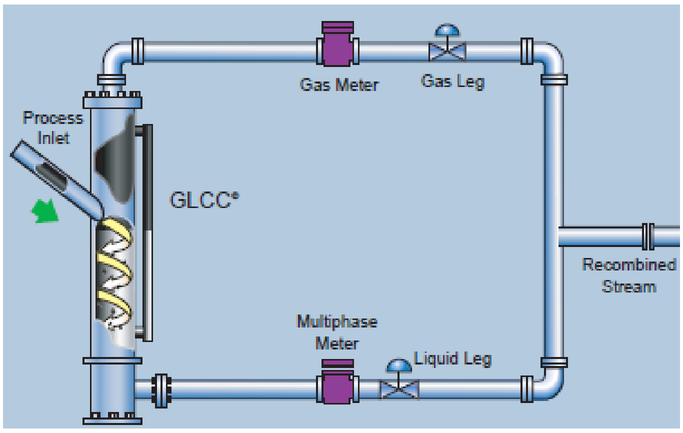

Fig.1 Block diagram of GLCC

The principle of GLCC is as follows:the import is connected the dip down pipes along the tangential direction and the vertical pipe ,the gas-liquid mixture enter the GLCC by the tangential entrance and generate swirling flow, the fluid form an inverted conical surface in centrifugal force, gravity and buoyancy. The high density liquid phase flow to the bottom of the separator along tube wall of vertical pipe, low density gas phase rose to the top of the separator along the central vortex, separated gas phase and liquid phase were metered by the gas flowmeter and liquid flow measurement, final, the gas and liquid is discharged respectively from the top and bottom separator; pneumatic valves and hydraulic valve is used to adjust the water level and pressure in Fig.1. GLCC is the role of the high efficient gas-liquid separation, but in some operating conditions, liquid droplet and gas flow with gas path, this phenomenon is called gas liquid; in addition, the gas may also be blended into the liquid and they is discharged from the bottom of the GLCC together, Coupled with the flow pattern changes real-time and is very complicated in GLCC. the flow patterns have the bubble flow, slug flow, impact flow , mist flow,and so on,the liquid cyclone with air is main part at following the entrance.Therefore, in order to carring out a good separation of gas-liquid two-phase flow, firstly,one question must be solved ,that is ,how to control the liquid level in the GLCC system. The project takes advantage of the VxWorks's real-time multi task, VxWorks controls the liquid level in GLCC system, ant it can realize the efficient separation of gas-liquid.

3. The key technology of GLCC control system

3.1 GLCC control system based on VxWorks[3]

The system uses the MSM586SL PC104 motherboard producted by the digital logic production company in Swiss, PC104 is Intel x86 series processor, it holds the system application peripherals and standard interface and a wide operating temperature and good industrial parameters,So it is widely used in industrial control field, which is suitable for oil mining field in hostile environmental. PC104 connects the network card and A/D conversion board through ISA buses, that establishs the channel between the well monitoring point and industrial network. Network card interface can communicate between the External and upper PC through RJ45, it can remotely transmiss the collected and processed oil well gets information. In addition, PC104 comes with RAM, ROM,FLASH memory and serial port ,etc, that is convenient to use.Therefore, the GLCC oil and gas separation control system is built using embedded processor PC104 based on VxWorks, VxWorks will give full play to the real-time multi task and facility tailoring, PC104 have characteristics of the shorter development cycle,lower power consumption, high reliability, it can work normally in the oil field environment relatively bad. The advantage of this system is adaptive, and it adopts liquid level fuzzy control algorithm to adjust the water level and pressure according to the different flow patterns in the range of GLCC, it can achieve better effect of separation and liquid equilibrium, the gas phase and liquid phase separated are measured respectively by measuring instrument.

3.2 The liquid level fuzzy control[4]

In the production process of crude oil, the measurement of the oil and gas separated often appear serious error because of wrong judgment level. controlled object has nonlinear characteristics and serious lag because of the different flow of crude oil, gas liquid, liquid leakage and other problems, so it is difficult to use a mathematical model to show. if we use the method of the local linear approximation ,it cannot reflect the actual situation, so the control accuracy and system immediate response cannot guarantee ,and the response characteristic is deteriorated.

the input and output signals will be quantified to achieve liquid level control By combining the fuzzy mathematics and PID method, so that the liquid level fluctuate within the set range to ensure the output crude oil smooth change,when the liquid level is beyond high limit or below the lower limit, we can adjust the opening degree of the liquid level of the liquid or gas valve ,it can make the liquid level back to normal range. when the variation of liquid level exceeds threshold value given ,the valve only is changed,the control process is shown in Figure 2.

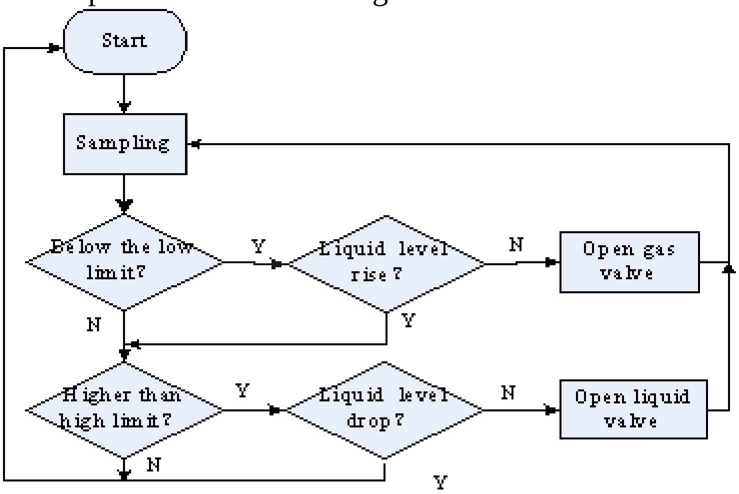

Fig.2 Block diagram of the Liquid level control

Digital PID position control equation is discretized using the Formula 1, wherein, $u(k)$ is said the output variables,it is used to control valve opening to maintain the stability of the liquid level. $e(k)$ expresses the kth level deviation, k_{p} is used to adjust the deviation and to control precision, k_i is used to eliminate the deviation that a single k_{p} can not eliminate, k_d is used to reflect the tendency of the error,it can be restrain to shorten the response time of the system and make the system as soon as possible to enter a state of equilibrium.

$$u(k) = k_{\text{p}}e(k) + k_i \sum_{j=0}^{k} e(j) + k_d[e(k) - e(k-1)] \quad (1)$$

The control scheme only considers the change of liquid level without considering the change rate of the liquid level difference and the Delay characteristics in Figure 2 ,that can not reduce the control error, so the liquid level change rate as a dimension is introduced into the fuzzy control algorithm. Thus, it can build a two-dimensional fuzzy controller,its input are the level error and error change rate, its output is actual liquid level. Incremental PID position control formula as shown in Formula 2.

$$\Delta u(k) = \text{q}_0 e(k) + q_1 e(k-1) + q_2 e(k-2) \quad (2)$$

wherein, $u(k)$ is said output variable ,it can be used to control the valve opening, $\Delta u(k)$ expresses the valve opening increment,We can calculate the output increment only need to know the three values of the discrete points, which will greatly reduce the amount of calculation, reduce the transmission effect of calculation errors and malfunction of the control valve. So fuzzy controller consider the level error and error rate as the input signal[5-6], they need quantization, therefore, the two factors need to introduce,that are $\text{P}e_{\text{h}}$ (the level error quantification factor)and $\text{P}e_{\text{vh}}$ (the level deviation change rate), and the fuzzy values and fuzzy control rules will calculate,then it operates the Fuzzy decision.In order the fuzzy output result obtained can be directly applied to the valve, we need to introduce the valve adjust quantization factor into the model. The working principle of fuzzy controller is shown in Figure 3.

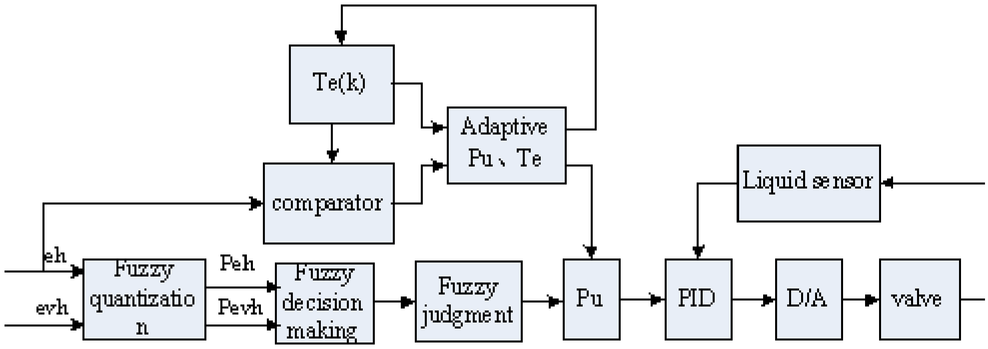

Fig.3 Adaptive fuzzy controller

In order to ensure good dynamic performance,the thesis introduced the error threshold value T_e ,when liquid level deviate from level error value e_h the reference value of the upper or lower limit was detected ,and it is large, That was to say,when $e_h > Te$,that showed the system was in a dynamic process, so it needed to increase value P_u , which can rapidly change the valve to speed up the system response; on the contrary, the system entered stable state, it needed to reduced value P_u .Adjust the value T_e followed the following principles:when setting the error threshold T_e is larger than the measured level error e_h , namely $T_e < e_h$,it indicated that the error threshold was small, it will lead to a wrong judgment,so that the output value P_u is too large, it will reduce the robustness of the system, therefore,it was necessary to increase value T_e ,on the other hand, decrease the threshold value T_e .

PID control algorithm showes that the integral characteristics can improve the steady-state error,but easily lead to overshoot.differential characteristics can reduce the overshoot, but can also reduce the system response time, it can reduce the dynamic characteristics.Therefore,it is necessary to a fuzzy control rule adaptive adjusting the PID parameters, namely, it not only prevents overshoot, but also possesses adequate response time.so,we use the following adjustment rules in this paper:

(1)when the liquid level is located in foul territory and is higher than the high limit, then liquid phase valve opening is increased to lower level, the more high limit is, the greater the valve opening is. Accordingly if the level error e_h is large, the strong control should be implemented to change the variation tendency of the error, and to reduce the error absolute value rapidly ,it will set a medium value of K_i and K_d , superior value of K_p ; if the level error e_h is small, the general control should be implemented to reduce the error absolute value rapidly, it will set a medium value of K_i and K_d , minor K_p , thus can improve the steady performance of the system.

(2) when the liquid level is located in foul territory and below the lower limit,the gas phase valve opening is increased to elevate the liquid level, the lower lequid level is, the greater valve opening is. Accordingly if the liquid level’s deviation e_h is large, the output should be maintain a rapid response so that the change rate of the error is rapidly reduced,so,it will set a superior value of K_i and K_d , take a minor K_p ;

3) when the liquid level in a stable zone and the change amount of the liquid level deviates the given value,if it is a positive deviation, we will increase liquid phase valve. Otherwise,we will increase the gas phase valve, it will set a minor K_p ,superior value of K_i and K_d .

Parameters of the PID should be adjusted according to the above rules,then,the corresponding fuzzy rules are established,finally,the values adjusted of PID are obtained through the synthesis rules.

4. Conclusion

On the one hand GLCC system needs to cope with harsh environment and varied streaming,On the other hand, the liquid level is very difficult to accurately judge on account of system dynamic characteristic and lag characteristics, so the thesis solved the key technical problems of the GLCC with the help of VxWorks and liquid level fuzzy control algorithm, which makes the system achieve better control effect ,fast response speed and small overshoot volume, the system can also be applied to other complex industrial process control.

Acknowledgements

Foundation: Project is supported by the Scientific research project of Gansu Province (No.2014B-102 and No.2013B-096), P.R.China.

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