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The Uniform Stream Fuzzy Optimization of Straight-heating Boiler in Petroleum Pipeline

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Abstract: On the basis of bias-flow analysis of burning system about power-plant straight-heating boiler and its countermeasures, a control scheme is given for the three Fuzzy controller to be built by three pipes export absolute temperature-difference as the input in Petroleum Pipeline, the openness valve as the controlled object. After realizing this control scheme, the problem of coked heat-pipes in burning process has be resolved perfectly. It makes the heat-pipe's life increase more than three times. The result of in real running shows the new design scheme is in reason and in effect in Petroleum Pipeline.

Keywords Straight-heating Boiler; Petroleum Pipeline; Stream Fuzzy Control

INTRODUCTION

The task of power-plant straight-heating boiler is to heat the base oil in the one pipe, which comes from oil extraction plant and converges from 3 different pipes, and provide oil in stable temperature for the later process (e.g. the oil steady device). Because the temperature of the exit influent affect directly the quantity and quality of the oil steady device; The bias-flow of the 3 pipes will coke heat-pipes, and make the deflection-flow be more to stop the production at last. The normal manual control depends on fiercely the estimation, experience and responsibility of personnel, this makes production very unsteady.

The main target of automatic control system for straight-heating boiler heat process is to control the temperature of the exit pipes and the uniform stream of the three pipes. The temperature control of the exit pipes can get satisfied result by normal PID control. But the stream control adopted manual control in the past. Nowadays, there's no research report about uniform stream control. Research on uniform control is only limited within the uniform liquid level control by Chu Yunfei etc. Because the Fuzzy controller can format and modelize one's experience by Fuzzy logic and Fuzzy discursion, and build up acceptable control model for computer, in recent years, Fuzzy controller have progressed a lot in the theories and applications, and applied broadly in industry. Therefore, this paper try to apply the Fuzzy control in the straight-heating boiler uniform stream control in the oilfield power plant, and provide technique support for stream auto-control.

BUILD UP THE SCHEME

Scheme

Select the temperature of the three exit pipes as measure variables, the open value as control variables, the controlling diagram is shown in fig.1. Arrange the temperature measure values of the three pipes in the system state identification as three state, maximal, middle and minimal, E.g. $T_{\max} = T_1$, $T_{mid} = T_2$, $T_{\min} = T_3$ Now set the state identification as the inputs of three Fuzzy controllers:

$$e_1 = [T_1 - T_{\max}] = 0$$
$$e_2 = [T_2 - T_{\text{mid}}] = 0$$
$$e_3 = [T_3 - T_{\min}] = 0$$

Set the outputs as the control ports $c_1 = 1(T_1 = T_{\max})$ of select switch. The outputs of the switches are all-open, this means that the valves (relative to)of the pipe whose temperature is highest will open, increase the oil flow, and reduces the temperature, but $c_2 = c_3 = 0(T_2, T_3 \neq T_{\max})$ here the outputs of the switches are the outputs u_2, u_3 of the Fuzzy controllers. The outputs of another states can also get in some way. According to the analysis above, the state identification part of system is easy to do, and the key of control scheme is to design the Fuzzy controllers.

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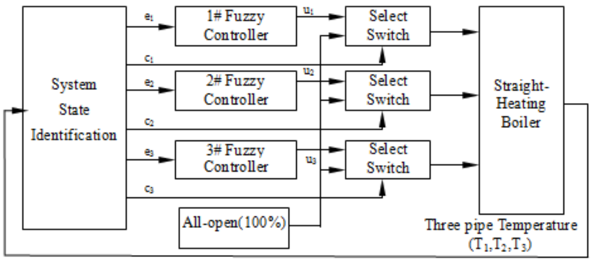


Figure1. Straight-heating Boiler Control Scheme

Select the subset of Fuzzy

According to the operation experience of the straight-heating boiler, select the absolute value of the difference between the temperature of single pipe and the highest temperature of three pipes as the input of the Fuzzy controller, the open value of the valve as the control variables. The input and the output of the Fuzzy subset:

Input: {E_1 minimal bias-flow, E_2 middle bias-flow, E_3 maximal bias-flow}.

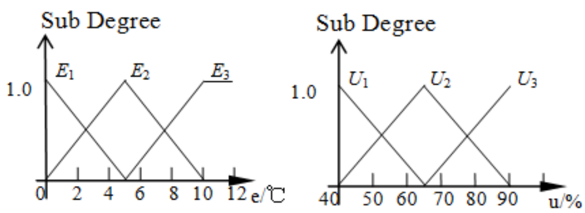
Output: {U_1 all-open, U_2 mid-open, U_3 min-open}.

The domain of control variables and controlled variables $e \in [0,11]$, $u \in [0,100]$.

FUZZY CONTROLLER

Fuzzy Method

The input variables dispersed as six levels: [1,3,5,7,9,11], the output variables dispersed as six levels: [40,50,60,70,80,90]. The sub degree function of Fuzzy set's input and output is triangle (that's got after many modifications in the practice), show in fig.2.



(a)Sub Degree Function of e (b) Sub Degree Function of u

Figure2. Sub Degree Function

From the set above, we know the domain of Fuzzy subset *e* and *u*, show in tab.1. For a accurate input, at first numeralize it, then get its sub degree from tables, and that's the Fuzzy method of the input.

Table1. Fuzzy Subset Evaluation

e	E_1	E_2	E_3	u	U_3	U_2	U_1
1	0.8	0.2	0.0	40	1.0	0.0	0.0
3	0.5	0.5	0.0	50	0.6	0.2	0.0
5	0.0	1.0	0.0	60	0.2	0.8	0.0
7	0.0	0.5	0.5	70	0.0	0.8	0.2
9	0.0	0.2	0.8	80	0.0	0.2	0.6
11	0.0	0.0	1.0	90	0.0	0.0	1.0

Fuzzy Ratiocination

Control rate consists of three control rules:

$$R = \bigcup_{i=1}^{3} R_i \quad (1)$$

R_i: if $e = E_i$ then $u = U_i$ $i = 1,2,3$.

Calculate the sub degree function of the sigleness rule .According to max-min ratiocination [LI Ming *et al*., 2002], take $R_1$for example.

$$R_1 = E_1 \times U_1 = \begin{bmatrix} 0.8 \\ 0.5 \\ 0.0 \\ 0.0 \\ 0.0 \\ 0.0 \end{bmatrix} \begin{bmatrix} 0.0 & 0.0 & 0.0 & 0.2 & 0.6 & 1.0 \end{bmatrix}$$
$$= \begin{bmatrix} 0.0 & 0.0 & 0.0 & 0.2 & 0.6 & 0.8 \\ 0.0 & 0.0 & 0.0 & 0.2 & 0.5 & 0.5 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \end{bmatrix}$$

(2)

When the input of Fuzzy set is a single point function (adopt single value Fuzzy device), the Fuzzy matrix above is Fuzzy output in rule R1, show in tab.2.

Table2. Rule R1 Fuzzy Output Relation Matrix

e	u					
	40	50	60	70	80	90
1	0.0	0.0	0.0	0.2	0.6	0.8
3	0.0	0.0	0.0	0.2	0.5	0.5
5	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0

Follow the same method, we can calculate the Fuzzy output matrix in rule R2 and R3, show in tab.3 and tab.4. Rule R1, R2, R3 are related by or operator, so that the total Fuzzy output is the collection of output in the three rules, such as tab.5.

Table3. Rule R2 Fuzzy Output Relation Matrix

e	u					
	40	50	60	70	80	90
1	0.0	0.0	0.0	0.2	0.6	0.8
3	0.0	0.2	0.5	0.5	0.5	0.5
5	0.0	0.2	0.8	0.8	0.2	0.0
7	0.5	0.5	0.5	0.5	0.2	0.0
9	0.8	0.6	0.2	0.2	0.2	0.0
11	1.0	0.6	0.2	0.0	0.0	0.0

Table4. Rule R3 Fuzzy Output Relation Matrix

e	u					
	40	50	60	70	80	90
1	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
7	0.5	0.5	0.2	0.0	0.0	0.0
9	0.8	0.6	0.2	0.0	0.0	0.0
11	1.0	0.6	0.2	0.0	0.0	0.0

Table5. Fuzzy Output Matrix

e	u					
	40	50	60	70	80	90
1	0.0	0.0	0.0	0.2	0.6	0.8
3	0.0	0.2	0.5	0.5	0.5	0.5
5	0.0	0.2	0.8	0.8	0.2	0.0
7	0.5	0.5	0.5	0.5	0.2	0.0
9	0.8	0.6	0.2	0.2	0.2	0.0
11	1.0	0.6	0.2	0.0	0.0	0.0

Remove Fuzzy

According to area barycenter method to remove Fuzzy .

$$u^* = \sum_{j=1}^{n} u_j \mu_U(u_j) / \sum_{j=1}^{n} \mu_U(u_j) \qquad (3)$$

which n is the level of the output disperse. When e=1, non-fuzzy value of the Fuzzy controller output:

$$u^* = \frac{0\times40+0\times50+0\times60+0.2\times70+0.6\times80+0.8\times90}{0+0+0+0.2+0.6+0.8} = 83.8$$

(4)

Calculate all the input and get the query table, such as tab.6. In tab.6, I is the input current signal of the valve (which is a pneumatic valve with input signal from 4 to 20 mA).

Table6. Fuzzy Output Query

e QS.	e QSd	U	I(mA)	e QS.	e QSd.	U	I(mA)
(1,2)	1	83.8	6.6	[6,8)	7	57.3	10.8
[2,4)	3	72.8	8.4	[8,10)	9	52	11.7
[4,6)	5	65	9.6	[10,∞)	11	45.6	12.7

System Realization

This system is realized based on industrial computer (IPC), and design the software in Visual C++, the control period is 90 s; For each variable the average of 20 samples in one second set as it's swatch, the data in the 90 s set as the measure variable after filter. According to the sample information, the state of the straight-heating boiler is show on the screen. The system structure schematic is shown in fig.3.

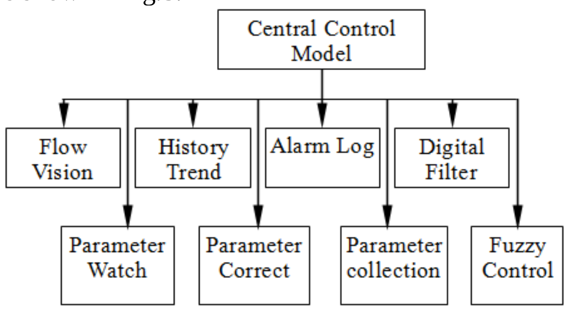


Figure3. System Structure Schematic

Conclusions

This system has been working in one power plant of DaQing Petroleum Administer Office. In the last three years, taking the temperature difference of the three pipes for input, taking the open value of the valve for control variable, and based on the computer control technique, there were not coked pipes, and didn't replace the heat pipes. Therefore it cut down a lot repair charge, at the same time, improve the quality of supply and reduce the consume. It proved that the reasonability and validity of the uniform stream Fuzzy optimization control scheme. It is obvious that, the problem about bias-flow in the running of other stream control system can be solved by the Fuzzy control method in this paper

References

Dou Chunxia，Zhang Xinzhong, The Design of Adaptive Fuzzy Controller for Boiler Burning System Based on FCGA[J] . Transactions of China Electrotechnical Society,17(2)，2012：88－91.

JIANGYongcheng, XIEYong sheng, SHI Fu shan, Intelligent Strategy for Boiler Combustion System and

Method to realize it in MCGS. Control and Instruments in Chemical Industry,2011,32(2):57-60

Junxiong Liu, Limei Yan, Yubo Duan, et.al. The research on brittleness source identification of electric machine system[J]. Energy Education Science and Technology Part A: Energy Science and Research. 2013 Volume (issues) 31(4): 1911-1918

Xie Kemi, Hou Honglun, 2002, An Adaptive Hierarchical Fuzzy PID Parameters Control for Superheated Steam[J]． Transactions of Systems Engineering China,17(4)，336－339.

Xu, A., Xu, J., & Yuan, Y. (2014). Analysis of the Coupling Degree in Supervision Control Systems Based on Improved DEPSO. Journal of applied science and engineering innovation, Vol.1(5)., pp.301-306

Xu Jianjun, Yan Limei, Liu Xiaobin, 2005, the Application of Fuzzy Analytic Hierarchy Process to Analyze the Brittleness for Transformer [J]．Transactions of China Electrotechnical Society，Vol.20(2)：94~98

Xu Jian-Jun, Liu Chao, Wang Shu-Da. Research of small pipeline leak detection applied SPRT algorithm [J]. Electric Machines and Control, May 2009:448-451 +457. (In Chinese)