Application Research on Quality Stability Control of a Spray Drying Tower for Naphthalene Superplasticizer based on Siemens PLC

Yonghui Xie[1], Ruchun Liu[1], Xiaojun Wang[1], Xujie Hou[1], Qinghai Shi[2]

1. College of Mechanical and Electrical Engineering of Weifang Vocational College, Weifang Shandong 262737
2. Zibo Gemu Control&Measure System Corporation LTD., Zibo Shandong 255000

(Xyh1212@126.com, 1028328150@qq.com, 1016060817@qq.com, 1546302318@qq.com)

Abstract: This article introduced a control scheme based on Siemens PLC to handle the quality stability issue in operation of the spray drying tower for Naphthalene Superplasticizer. A series feed-forward control scheme is proposed to solve the problems of water content fluctuation of naphthalene series water reducer slurry and solid content fluctuation caused by frequent and wide range fluctuation of gas pressure as fuel. The practical application shows that the control scheme can handle the fluctuation of water content well.

1. Introduction

Spray drying tower has been widely concerned because of its high thermal efficiency and simplicity of operator. Now many research achievements and application cases have been published in succession.

In the theoretical research, Chuanhua Liao has studied the heat transfer process of spray drying tower which establishes the theoretical foundation for mathematical model of the spray drying tower[1-2]. Liangcheng Sun and Yang Zheng has studied the simulation of the spray drying tower which provides a new idea for theoretical analysis of the spray drying tower[3-4]. Bao Wang has studied two kinds of heat balance methods of the spray drying tower[5-6]. Jinglin Ma has studied the simulation of the spray drying tower based on honey production process which has a profound guiding significance for honey production[7-8]. Lixia Zhao has probed and summarized the process of the spray drying tower, the spray drying equipments and the application of the spray drying technology. Jinxin Tang has summarized the research and application progress of the spray drying engineering. Yurun Zhang has studied the modeling and optimization of the spray drying tower.

In the industry application, Wang Xizhong[9] introduced the current status of white carbon black spray drying, including the process and parameters of the atomizer, and introduced related energy saving measures, which provided a reference for the improvement of white carbon black spray drying process. Lei Han[10] has analyzed the principle of wall sticking of sugary material spray drying and put forward six coping approaches; Yunfeng Kang has studied the process conditions of producing tomatoes and carrots compound powder in his master’s thesis and acquired that technical parameters influenced the products quality. Providing a guiding for industrial production; Jirong Xing has introduced the application of centrifugal spray drying equipment and pressure spray drying equipment in large white carbon black...
production line and at the same time he also studied that process and hot air distributor and operating parameters have influenced on the product.

Research examples about spray drying are too numerous to mention one by one. From the summary of the literature, the majority of people have made huge progress when studying the technology and operating parameters. In the aspect of control, there are also many people doing meaningful work from all aspects. Heyun Zhu have designed automatic control strategy for washing powder spray drying tower; Tongjun Liu studied IMC control and MPC control for spray drying process and compared these two control strategies; Quan Li has analyzed the relationship between the spray drying tower powder moisture content and the temperature of the wind in and out of the tower, and designed control scheme and control variables, and designed adjuster parameters based on step response curve; Xiaoyang Wang has designed automatic control system for hard metal drying based on S7-400; Yingchun Pan has designed unmanned monitoring system for the ceramic drying tower which including the temperature control subsystem, the pulp control subsystem, the combustion control subsystem, the negative pressure control subsystem and the platform system; Guoshu Li has controlled the water content of the ceramic spray drying tower with upper computer computing and lower computer collecting parameters, showing and controlling. I think control is the key to the practice, hence, this paper proceed from the production actually of the water reducer spray drying tower and aimed at operating problem and proposed technical solutions to make water reducer content stable.

Chapter 2 introduced a control scheme to handle the water reducer quality stability issue in operation of the spray drying tower. Chapter 3 offered the field conduct effect on a technical solution based on PLC and WinCC. Chapter 4 is a brief summary of the control strategy.

2. Quality stability control strategy

2.1. Field technological process and problem description

The brief production flow is shown as Figure 1, the production flow mainly includes gas-fired air heater, spray drying tower, cyclone separator and finished product warehouse. Slurry enters the spray drying tower from the top then contacts the hot air coming from the combustible gas hot stove, and after that, the water in the slurry gradually evaporates in the process of decline because of its own gravity and becoming qualified finished product. At last, it will become final finished product after going through cyclone separator and finished product warehouse.

Figure 1 Naphthalene super plasticizer spray drying tower flow digram

In the actual production, due to the gas comes from the coking production process in upstream and the types of coal and production scheduling factors in coking process, there is a frequent and violent fluctuation of gas pressure(as in shown in Figure 2), which makes the temperature of the top of the drying tower unstable. Naphthalene-series water reducer slurry comes from the sulphonation reaction in
upstream, the water content of the slurry exists as a large disturbance, and in the case of the unstable temperature in the top tower the solid content of the finished water reducer has a large fluctuation (as is shown in Figure 2), and under the condition of guaranteeing the quality of products qualified, the solid content in the finished water reducer is always in a high level. Hence it is a waste of gas and greatly making profit lost.

2.2. Control solution of cascade feed forward

In allusion to the actual control difficulties mentioned above, a control solution of cascade feed forward is put forward. The PID control process is shown in Figure 3.

When the wave of flurry water content influence the solid content of the finished water reducer, we can conquer by adjusting the temperature of the top of the drying tower. The adjustment of the temperature can be guaranteed by controlling the gas valve. With regard to the measurable disturbance form the gas pressure. By analyzing the field test data, we can know it needs a long time for the disturbance to influence the solid content and it is hard to make the disturbance stable down with normal feedback control. So we manage it as feed forward.

Whether the control effect is good or not is not only up to the quality of the control system but also to the measurement precision. It is found that in the process of field conduct, there exists a large measurement instability in the gas pressure measurement. In consideration of that the instrument
accuracy is not high, the measurement is not stable and there exists interference, the data processing
based on Kalman filter theory is proposed.

3. Technological realization based on PLC and WinCC and field application effects
After using controller, control effect is shown in Figure 4. Before using controller, both gas pressure
and water reducer content change greatly. After using controller, the water reducer content stables down
to a large degree. The controller plays a great role in stable operation and the stability of water reducer
content. The solid content parameter are shown in table 1.

![Figure 4 The effect comparison of the controller used before and after](image)

Table 1: The operation statistical parameter comparison of before and after the operation

| Project | maximum | minimum | average | variance |
|---------|---------|---------|---------|----------|
| Before  | 92      | 83      | 87.3452 | 3.638    |
| After   | 88      | 87      | 87.3    | 0.054    |

4. Conclusion
After analyzing practical problem, we put forward a overall solution based on cascade feed forward
control. And pre-processing unstable field measurement data based on kalman filtering method. On this
basis, based on the technological realization with PLC and WinCC, field application effect shows the
method successfully solve the practical problem. It improves the operation stability of the spray drying
tower and the indicators stability of the water reducer content. It further saved energy and reduced
consumption and improved productivity.

References
[1] Kang Yunfeng. Take tomato carrot composite powder spray drying method research [D]. Hebei
agricultural university, 2006.
[2] Xing Jirong Xing Fengmin. Spray drying technology in the application of white carbon black
production [J]. Journal of drying technology and equipment. 2010 (4) : 174-180.
[3] Zhu Heyun, Zhang Yurun, etc. Washing powder spray drying process of automatic control [J].
Journal of daily chemical industry. 1983 (3) : 1-6.
[4] Han Peiyao Liang Weiming, Zhou Qin. Pellet detergent tower spray drying process of the
microcomputer control system [J]. Journal of guilin institute of electronics industry, 1988
(2) :7-14.
[5] Zhu Heyun, Zhang Yurun. The design and operation of spray drying automatic control
improvement scheme [J]. Journal of information and control. 1985 (2) : 58-59.
[6] Liu Tongjun, Wang Kuanquan. Large spray drying tower control strategy study [J]. Industrial control computer. 2005 (5) : 19 to 20.

[7] Li Quan. Spray drying tower powder wet content analysis, design and debugging of the control system [J]. Journal of wuyi university (natural science edition), 1994 (1) : 19-24.

[8] Wang Xiaoyang. Automatic control system for analysis of spray drying tower [Z]. Chengdu, China: 2005:3-5.

[9] Pan Yingchun. Automatic control system design of spray drying tower [Z]. China guangdong foshan: 2004:72-75.

[10] Li Shuguo. Automatic control of powder spray drying tower water [J]. Journal of basic automation. 1999 (6) : 16-18.