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Control Design for Water Level Control in a Thermal Power Plant

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ABSTRACT: The control structure of steam boiler system is one of the most complex systems where required with many control loops and multiple parameters. It is necessary for the controller used for this system to ensure the efficiency of the steam. A control system including two control loops, where an inner flow control loop (with fast response) and an outer level control loop (with slower response) for water level of a Thermal Power Plant. In industrial production systems, different technological processes require the appearance of steam to generate torque as turbines for thermal power plants. The steam boilers of the thermal power plant are demanded to maintain a continuous water level for producing high-temperature steam and at high pressure. The paper introduces the level control algorithm for the steam boilers of the thermal power plant.
KEYWORDS: Steam boiler, Level control**,** Thermal Power Plant, Cascade control

I. INTRODUCTION

The study concentrates on a control problem in the combustion chamber and the steam boiler. The combustion chamber is a multiple outputs and inputs system, in which fuel, wind and water supply are its inputs, and the output consists of saturate steam released from the steam tank, an amount of redundant water, smoke and slag from the combustion process. In this case, water is heated in a boiler until it becomes high-temperature steam [1-8]. This steam is then channeled through a turbine, which has many fan-blades attached to a shaft. As the steam moves over the blades, it causes the shaft to spin. This spinning shaft is connected to the rotor of a generator, and the generator produces electricity[9-19]. The steam boiler collects steam then delivers it to the turbine.

II. LEVEL CONTROL SYSTEM

The process control system of the thermal power plant including objects such as temperature sensors, pressure sensors, level sensors, flow sensors, motors, etc. This process is a multi-input and multi-output system, in which the inputs and outputs are closely related to each other.

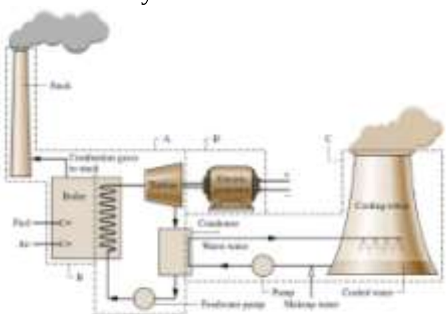

Fig.1 Steam turbine power plant

The schematic diagram of water level controller is formed as Fig .2.

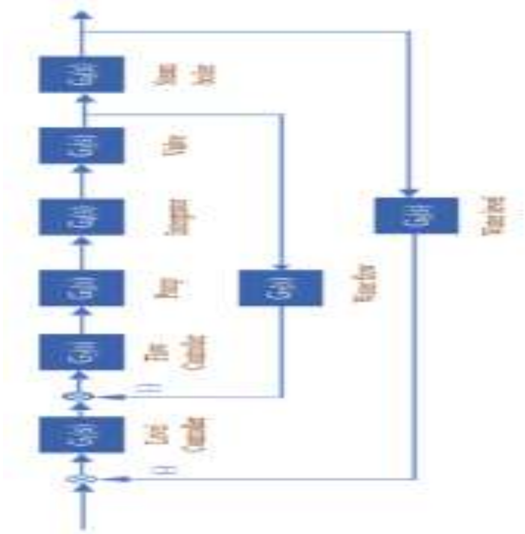

Fig .2 The schematic diagram of level controller

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The transfer functions of elements in the block diagram are written as follows:
G_3 denotes the transfer function of water supply system.

$$G_3(s) = \frac{k_3}{T_1T_2s^2 + T_2s + 1} \quad (1)$$

Because the input signal of the valve is the angular velocity, while the output signal of the power transmission is the speed, an integration block is added with the transfer function G_4:

$$G_4(s) = \frac{k_4}{s} \quad (2)$$

Next, in the valve, the input signal is the angular velocity, whereas water flow plays output role. And, the relationship between the output signal and the input signal of the valve is a first-order inertial equation has the form of G_5:

$$G_5(s) = \frac{k_5}{T_5s + 1} \quad (3)$$

In the steam boiler, the water flow is the input element. The water is transferred into steam. The output signal is the steam flow. The relationship between the output signal and the input signal is a first-order inertial equation with delay is determined by G_6

$$G_6(s) = \frac{k_6}{T_6s + 1}e^{-\tau s} \quad (4)$$

The input signal of the G_7 sensor is the water flow, while the its output signal is the DC current, so the transfer function of the G_7 flow sensor is:

$$G_7(s) = k_7 = \frac{\Delta I_{max}}{\Delta Q_{max}} \quad (5)$$

Similarly, the input signal of the G_8 level sensor:

$$G_8(s) = k_8 = \frac{\Delta I_{max}}{\Delta H_{max}} \quad (6)$$

The aim of the level and flow control system in the steam boiler is to preserve water level and the water supply flow to the boiler. are shown in Fig .3.

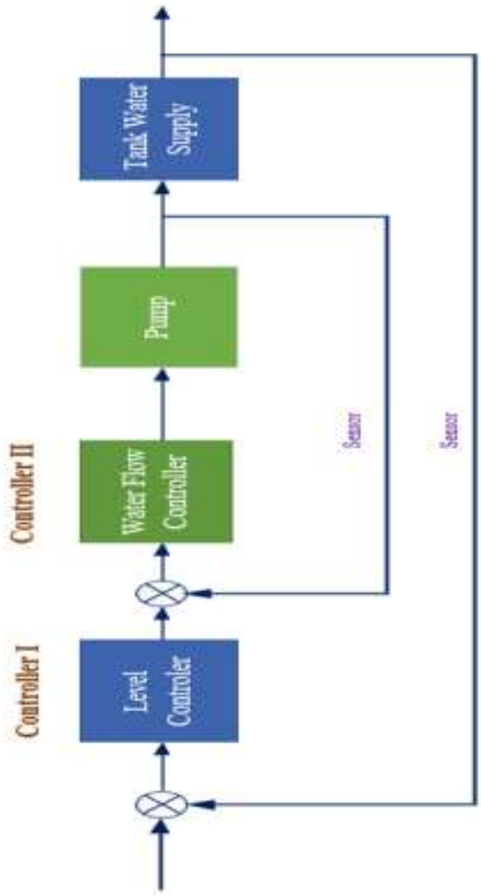

Fig .3 The cascade control structure diagram

In order to meet the heating requirement of the steam boiler, the flow of water supply must be kept stable to ensure sufficient water to the heater. To stabilize the water flow, the pump speed named Pumb in Fig -3 need to be controlled according to the reference flow.

III. DESIGN THE CONTROLLER

The Fuzzy Logic Controller (FLC controller) used in this research consists of two inputs and a output defined as Fig .4. The input variables are the control signals of the fuzzy controller, which is the control voltage error (ET) and the derivative of the error (DET); and output variable is the control voltage U.

Firstly, the number of fuzzy sets for each language variable is selected as 7 sets with the 7 language variables in each term named as follows: AL, AV, AN, K, DN, DV and DL attached to membership functions as Fig. 5.

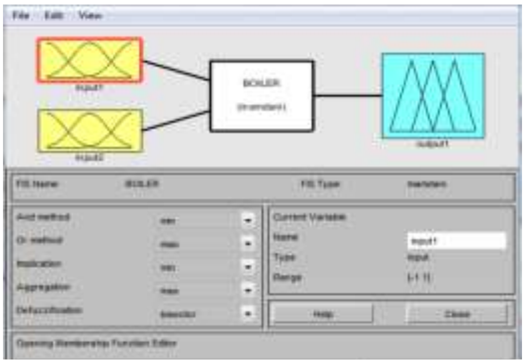

Fig.4 The input and output variables

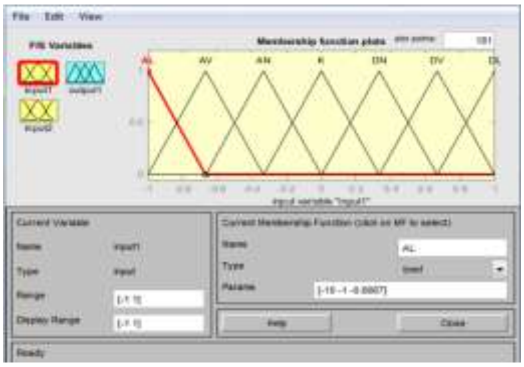

Fig .5 The fuzzy sets of language variables

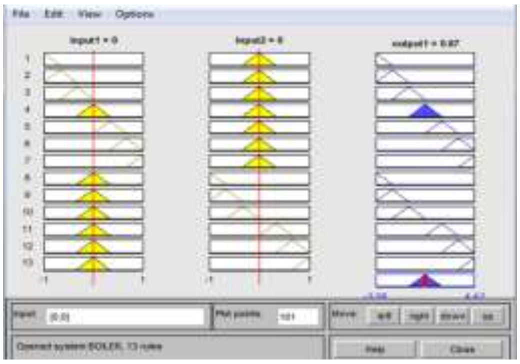

Fig.6 The input-output relationship

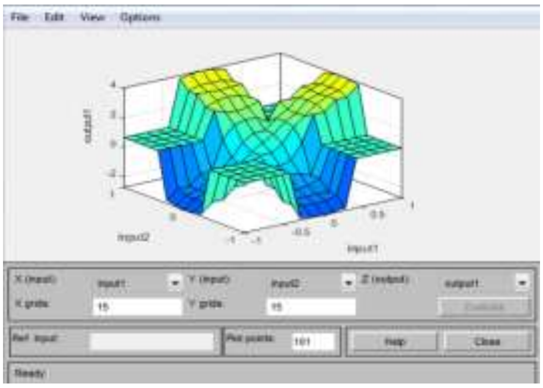

Fig .7 The equivalent input-output

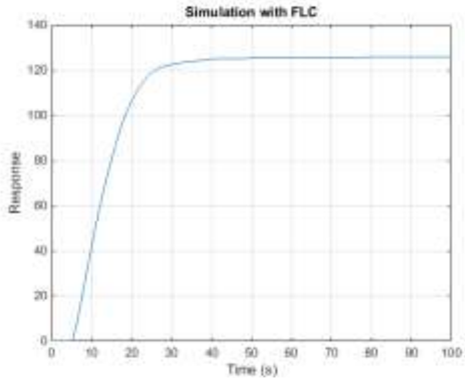

Fig .8 The response of system

The system response shows that the Controller designed for the steam boiler offers a high performance with low overshoot and short settling time.

IV. CONCLUSION

The primary purpose of this paper is to develop a two-loop control structure to keep the water level steam boiler in a thermal power plant stable. The level control algorithm for the steam boiler in the thermal power plant has been developed and designed. The design sequence is done through the simulation steps on MATLAB/Simulink to verify the theory and demonstrate the effectiveness of the control algorithm. The simulation results show that the controller meet well the control requirements.

ACKNOWLEDGMENT

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REFERENCES

[1]. Madejski, P., & Żymełka, P. (2020). Calculation methods of steam boiler operation factors under varying operating conditions with the use of computational thermodynamic modeling. Energy, 197, 117221

[2]. Taler, J., Zima, W., Ocłoń, P., Grądziel, S., Taler, D., Cebula, A., ... & Majewski, K. (2019). Mathematical model of a supercritical power boiler for simulating rapid changes in boiler thermal loading. Energy, 175, 580-592.

[3]. Taler, D., Trojan, M., Dzierwa, P., Kaczmarski, K., & Taler, J. (2018). Numerical simulation of convective superheaters in steam boilers. International Journal of Thermal Sciences, 129, 320-333.

[4]. Muhaisen, N., & Hokoma, R. (2012). Calculating the Efficiency of Steam Boilers Based on Its Most Effecting Factors: A Case Study. WorldAcademy of Science, Engeneering and Technology, 6.
[5]. Bryers, R. W. (1996). Fireside slagging, fouling, and high-temperature corrosion of heat-transfer surface due to impurities in steam-raising fuels. Progress in energy and combustion science, 22(1), 29-120.
[6]. Moghari, M., Hosseini, S., Shokouhmand, H., Sharifi, H., & Izadpanah, S. (2012). A numerical study on thermal behavior of a D-type water-cooled steam boiler. Applied Thermal Engineering, 37, 360-372.
[7]. Somerscales, E. F. C. (1990). Fouling of heat transfer surfaces: an historical review. Heat transfer engineering, 11(1), 19-36.
[8]. Popov, I. A., Gortyshov, Y. F., & Olimpiev, V. V. (2012). Industrial applications of heat transfer enhancement: The modern state of the problem (a Review). Thermal Engineering, 59(1), 1-12.
[9]. Wu, H., Beni, M. H., Moradi, I., Karimipour, A., Kalbasi, R., & Rostami, S. (2020). Heat transfer analysis of energy and exergy improvement in water-tube boiler in steam generation process. Journal of Thermal Analysis and Calorimetry, 139(4), 2791-2799.
[10]. Sarkar, D. (2015). Thermal power plant: design and operation. Elsevier.
[11]. Turbine blade failure in a thermal power plant. Engineering failure analysis, 10(1), 85-91.
[12]. Vardar, N., & Ekerim, A. (2007). Failure analysis of gas turbine blades in a thermal power plant. Engineering Failure Analysis, 14(4), 743-749
[13]. Gupta, S., & Tewari, P. C. (2009). Simulation modeling and analysis of a complex system of a thermal power plant. Journal of Industrial Engineering and Management (JIEM), 2(2), 387-406.
[14]. Reference De Souza, G. F. M. (2012). Thermal power plant performance analysis. London: Springer.
[15]. Kumar, A., & Shukla, S. K. (2015). A review on thermal energy storage unit for solar thermal power plant application. Energy Procedia, 74, 462-469.
[16]. Das, G., Chowdhury, S. G., Ray, A. K., Das, S. K., & Bhattacharya, D. K. (2003). Turbine blade failure in a thermal power plant. Engineering failure analysis, 10(1), 85-91.
[17]. Dewangan, D. N., Jha, M. K., & Banjare, Y. P. (2014). Reliability investigation of steam turbine used in thermal power plant. International Journal of Innovative Research in Science, Engineering and Technology, 3(7), 14915-14923.
[18]. Ibrahim, T. K., Basrawi, F., Awad, O. I., Abdullah, A. N., Najafi, G., Mamat, R., & Hagos, F. Y. (2017). Thermal performance of gas turbine power plant based on exergy analysis. Applied thermal engineering, 115, 977-985.
[19]. Ibrahim, T. K., Rahman, M. M., & Abdalla, A. N. (2011). Gas turbine configuration for improving the performance of combined cycle power plant. Procedia Engineering, 15, 4216-4223.