WATER LEVEL CONTROL IN A THERMAL POWER PLANT BASED-ON THE HA METHOD

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ABSTRACT

Hedge Algebra (HA) algorithm is a soft-computing tool developed from fuzzy logic that can be applied and calculated effectively with high accuracy in the control aspect. The paper presents an application of the controller based on hedge algebra in the control of the water level for the thermal power plant. The system's response is shown through simulation on Matlab/Simulink.

Keyword:, *HA, HAC, steam boiler, level control.*

1. INTRODUCTION

Hedge Algebra (HA) is a new approach to the fuzzy logic calculations. HA takes benefits of the reasoning ability of the human to deal with uncertainties and inaccurate information of controlled objects. Although HA is based on fuzzy logic, it builds on an algebraic structure and is a tool for ensuring semantic ordering, supporting fuzzy logic in the reasoning and control problems. Besides developing the benefits of the fuzzy system, the HA controllers also promote the advantages of natural language processing and intuitive thinking, and avoid identification problems with complex modeling [1-5]. The study concentrates on a control problem in the combustion chamber and the steam boiler, Fig -1.

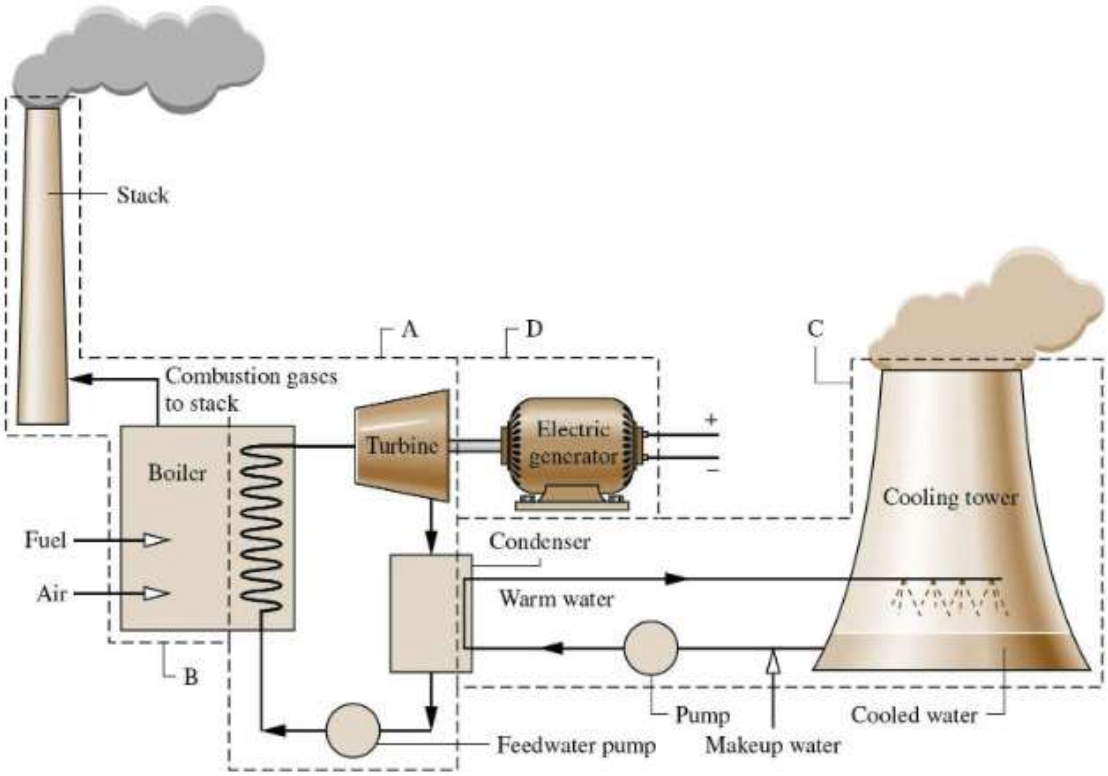

Fig -1 Steam turbine power plant

2. CONTROL DESIGN

HA is the development basing on the logic perception of linguistics [6-8]. The input/output relationship in fuzzy logic must define membership functions discontinuously, whereas HA creates an algebraic structure in terms of functions of linguistic input/output variables.

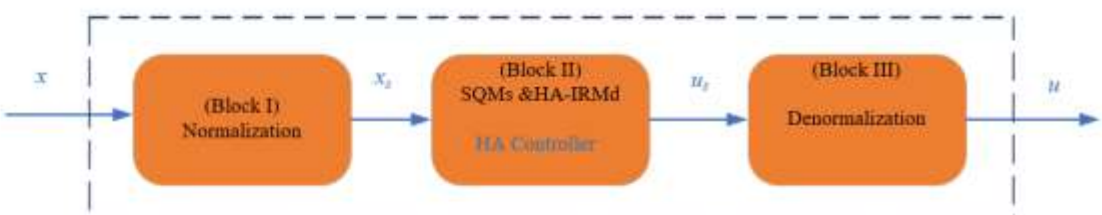

Fig -2 The diagram of HAC controller

Where:
x is the input value, x_s is the input semantic value.
u is the control value, u_s is the control semantic value.
HAC includes the following blocks:

Block I – Normalization (linear transformation from x to x_s): determining the input variable, state variable, control variables (output variables), and the working range of variables. Identifying calculated conditions (choosing the calculated parameters of HA). Calculating the values of semantic quantifying of input variable, state variable, and control variable (apply hedges on the working range of the variables).

Block II - Semantically quantifying mappings &Hedge Algebra-based Interpolative Reasoning Method (performs semantic interpolation from x_s to us basing on the semantic quantifying mapping and rules): changing fuzzy control rules to control rules with semantic quantifying parameters of HA. Solving the approximated problems based on HA to determine the semantic quantifying of control states. Combining the semantic quantifying values of controls and building semantic quantifying curve.

Block III – Denormalization (linear transformation from u_s into u): basing on the initial conditions of the control problem to solve semantic quantifying curve interpolation and determine the real control value.

The HAC controller used in this research consists of two inputs and an output. The input variables are the control signals of the HAC, which is the control voltage error (ET) and the derivative of the error (DET), and output variable is the control voltage U.

Choosing a set of calculation parameters with:

$$G = \{0,\ \text{Small},\ W,\ \text{Large},\ 1\} \tag{1}$$

$$H^{-} = \{\text{Little}\} = \{h_{-1}\};\ q = 1 \tag{2}$$

$$H^{+} = \{\text{Very}\} = \{h_{1}\};\ p = 1 \tag{3}$$

$$f_m(\text{ Small }) = \theta \tag{4}$$

$$\mu(\text{ Very }) = \mu(h_1) \tag{5}$$

$$\mu(\text{ Little }) = \mu(h_{-1}) \tag{6}$$

The result is as follows :

$$\alpha = \beta \tag{7}$$

$$f_m(\text{ Large }) = 1 - f_m(\text{ Small }) \tag{8}$$

Calculations of sematic quantifying values for ET, DET

$$U = \{\text{ Small, Little Small, Very Small, W, Large, Little Large, Very large }\} \tag{9}$$

$$v(\text{ Small }) = \theta - \alpha f_m(\text{ Small }) \tag{10}$$

$$v(\text{ Very Small }) = v(\text{ Small }) + \text{ Sign (Very Small)} \times \left\{ \sum_{i=1}^{1} f_m(h_i \text{ Small }) - 0.5 f_m(h_1 \text{ Small }) \right\} \tag{11}$$

$$v(\text{ Little Small }) = v(\text{ Small }) + \text{ Sign (Little Small) } \times \left\{ \sum_{i=-1}^{-1} f_m(h_i \text{ Small }) - 0.5 f_m(h_{-1} \text{ Small }) \right\} \tag{12}$$

$$v(\text{ Large }) = \theta + \alpha f_m(\text{ Large }) \tag{13}$$

$$v(\text{ Very Large }) = v(\text{ Large }) + \text{ Sign (Very Large) } \times \left\{ \sum_{i=1}^{1} f_m(h_i \text{ Large }) - 0.5 f_m(h_1 \text{ Large }) \right\} \tag{14}$$

$$v(\text{ Little Large }) = v(\text{ Large }) + \text{Sign(Little Large)} \times \left\{ \sum_{i=-1}^{-1} f_m(h_i \text{ Large }) - 0.5 f_m(h_{-1} \text{ Large }) \right\} \tag{15}$$

With the mathematical model of the system in [9], response results of the control system using HA are shown in Fig -4.

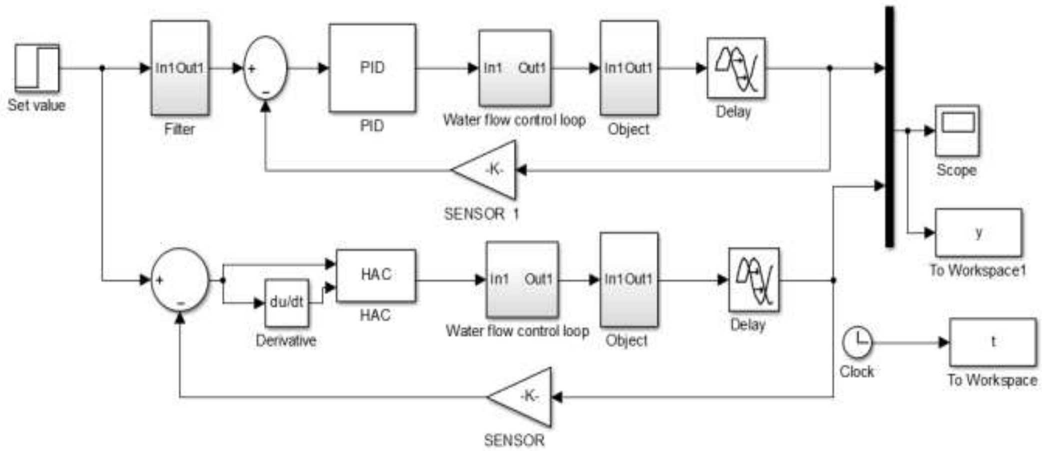

Fig -3 The simulation diagram on Matlab/Simulink

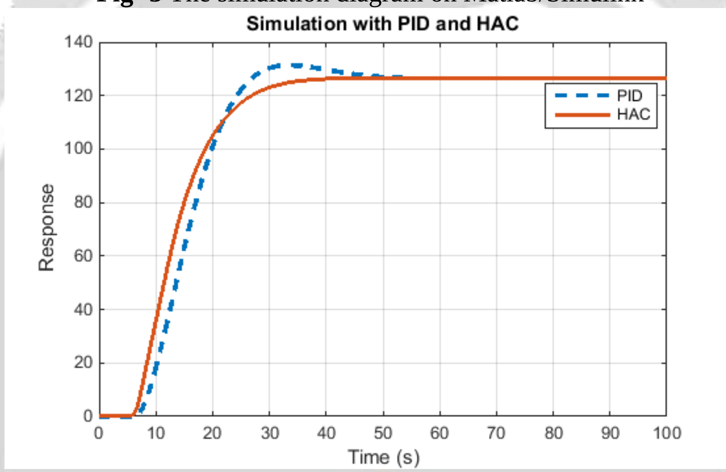

Fig -4 HAC simulation results

The simulations result in MATLAB/Simulink are shown in Fig -3, Fig -4.

3. CONCLUSIONS

This paper has proposed an approach to design HAC based-on controllers for the level control problem in the thermal power plant. Simulation results show the stability and accurate tracking of the system. After a certain period of time, the error converges to zero. It can be seen that HAC performance meets the requirements of the level control problem in the steam boiler.

4. ACKNOWLEDGEMENT

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