Adaptive Fuzzy Controller to Regulate Anode Covering Material Recipe

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Abstract

An adaptive controller for keeping the Anode Covering Material (ACM) recipe feeding stably and efficiently is proposed in this paper. The controller is based on fuzzy logic control strategy by developing a method of adjusting the quantification and proportion factors. The selection of these factors makes a big influence on the static and dynamic performances of the controller. This new control strategy is implemented in Albras ACM Plants. The controller program was developed with ladder language and runs on Programmable Logical Controllers (PLCs) from Allen Bradley. ACM plants are operating with flowmeters which are being controlled by fuzzy controllers, and the feed rate, which is the control variable, works around the established operation point. The results demonstrate the effectiveness and viability of the system that hereafter will be implanted for other processes at Albras.

Keywords: Fuzzy control, self-optimization, flowmeter, anode covering material.

1. Introduction

One of the most important routine in the potroom operation is anode covering. Over the last decade dramatic developments have taken place in the preparation and optimization of anode cover material (ACM). Basically, the ACM is removed from the top of spent anodes or butts in the rodding shop, reclaimed and processed. It is normally composed of a hard, sintered portion from the lower part of the anode cover and a loose, dusty portion from its upper part. The main functions to be fulfilled by ACM consist in the protection of anode carbon against air oxidation and also thermal insulation against heat losses from the top surface of the anodes [1]. At Albras, the blending stations for preparation of the ACM recipe are located at the rodding shops. The blending is processed using separate silos for the ACM components (crust/alumina ratio) and individual proportioning flowmeters. Precise proportioning of ACM components is required to minimize the variability of physical properties and chemical composition. In accordance with the characteristics of the ACM blending process, a control strategy with a double-deck structure of self-optimizing and fuzzy control is developed and presented in this paper. This control strategy uses only input and output signals [2]. The organization of this paper is as follows. In the first section, is discussed in detail the proposed fuzzy logic controller. In the second section, an improvement is introduced to the fuzzy logic controller. Real time application results are given in the last section, which demonstrate that the proposed control strategy is practical and efficient.

2. Fuzzy Logic Control for Flowmeter

The structure of a fuzzy controller in the control loop are shown in Figure 1, where F (Fuzzification), KB (Knowledge Base), IM (Inference Machine) and D (Defuzzification). For this SISO (single input, single output) system, a fuzzy controller with two dimensions is suitable, and its input variables are error E and the change of error Ec and the output variable U of the controller is the frequency increment to control the speed of the screw conveyor [3].

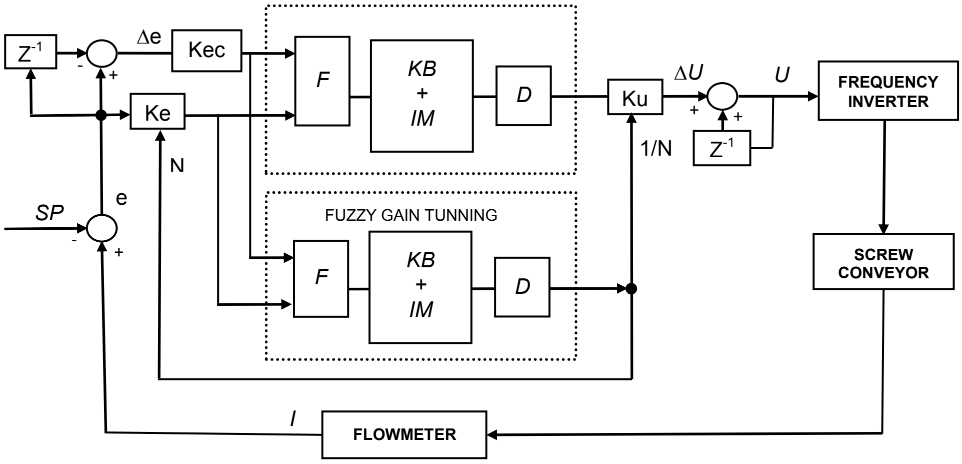

Figure 1. Structure of the fuzzy controller.

The Equations (1 – 3) describe the input and output variables respectively.

Input variables:

$$e(k) = I(k) - SP(k) \tag{1}$$

$$\Delta e(k) = e(k) - e(k-1) \tag{2}$$

Output variable:

$$U(k) = U(k-1) + \Delta U(k) \tag{3}$$

where:

e	Feed rate error
Δe	Change of the error
I	Feed rate
SP	Set Point
U	Frequency Increment

In the fuzzy controller presented above, the inputs are the error E, the change of error Ec and the output is the change of control U. The rules base is represented by 7 linguistic values, NB: Negative Big; NM: Negative Medium; NS: Negative Small; ZR: Zero PS: Positive Small; PM: Positive Medium; PB: Positive Big. Next, the membership functions and the domains of the fuzzy sets. The feed rate of the flowmeter is proportional to the screw conveyor speed signal (0 – 100 %, modulated by the frequency inverter). So, the basic domain of the error (possible normalized value) is: E ϵ [-0.2, 0.2], while the basic domain of the change of error is Ec ϵ [-0.04, 0.04]. Let Ke = 5, Kec = 2.5, where Ke is the quantification factor of error, Kec is the quantification factor of the change of error. Thus, the domain of error is: E ϵ [-1.0, 1.0]; the domain of the change of error is Ec ϵ [-0.1, 0.1]. The basic domain of the output variable (0 – 10V) is: U ϵ [0, 10]; therefore, the basic domain of change of the control variable is: U ϵ [-10, 10]. Let Ku = 10, where Ku is the proportion factor. The fuzzy domain of the change of control is: ΔU ϵ [-1.0, 1.0]. The membership function in the controller is triangular [4], as shown in Figures 2 - 4.

With the Adaptive Fuzzy Controller, the ACM Plants get to produce within the client specifications.

6. References

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