ISSN 2354-0575

DESIGN AND SIMULATE A FUZZY CONTROL SYSTEM FOR CONTROLLING OF RESISTANCE OVEN TEMPERATURE

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Received: 02/03/2017
Revised: 20/04/2017
Accepted for publication: 15/05/2017

Abstract:

Fuzzy control plays an important role in the modern engineering cybernetics. It is considered as an outstanding control method because of its flexible characteristic. Many studies on fuzzy control are carried out, and there studies showed that fuzzy control archived good results in application of the Fuzzy Set Theory, Fuzzy Logic and Fuzzy Deduction. This paper will briefly introduce the general structure of a fuzzy control system, design and simulation the automatic temperature control system of resistance oven using Matlab & Simulink. The result showed that the system archives ver quick response on the variation of set-point.

Keywords: *Fuzzy control, fuzzy set theory, fuzzy logic, fuzzy deduction, designing controllers.*

1. Introduction

Fuzzy logic was first developed by Zadeh in the mid-1960s for representing some types of "approximate" knowledge that can not be represented by conventional, crisp methods. Fuzzy logic uses fuzzy set theory, in which a fuzzy set is represented by a membership function. Existing fuzzy logic controllers commonly employ fuzzy reasoning that is based on the compositional rule of inference of Zadeh. Fuzzy logic control (FLC) has been used in many real applications where conventional model based controller is fail to applied. Tzuu-Hseng S. Li, et al. designed of an EP-based fuzzy sliding-mode control for a magnetic ball suspension system [1]. Yung-Chiang Chung, et al. proposed an optimal fuzzy sliding mode control for bio-micro fluidic manipulation [2].

Comparing to the traditional methods used to design control systems, fuzzy system design method has some prominent advantages as follows:

Easier to design controllers because there is no need to use mathematical model of the plants to synthesize systems.

Fuzzy controller is easier to understand than others (includes technical aspect) and can be changed easily.

With the complex design problems, the solution of using fuzzy controllers can reduce the complexity of computation and also reduce product costs.

In many cases, fuzzy controllers work more stable; more robust to the external disturbances and with higher performance.

Based on the requirement of applications of high technology in industrial automation systems, the author deeply studies on the set of fuzzy control and applies it to control temperature of resistance oven. This is a popular system in production, especially in heavy industry such as steel manufacturing.

This paper will briefly introduce the general structure of a fuzzy control system, design and simulation the automatic temperature control system of resistance oven using Matlab & Simulink. The model was tested and reality operated thoroughly by computer control.

2. Structure of a fuzzy controller

There are four blocks in a structure of fuzzy controller: They are presented in Figure 1.

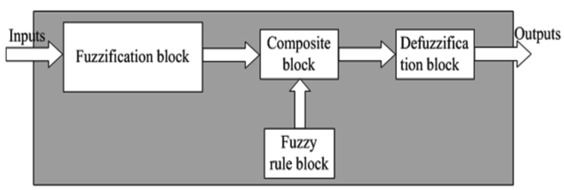

Figure 1. *Block chart of fuzzy control unit*

Fuzzification and composite blocks are the core of the fuzzy controller because they could simulate thinking of human to realize the human's ideas.

The composite block is the block where the inputs of fuzzy set (in the basic fuzzy set U) and the fuzzy rule sets which is introduced by designer are collected together to produce the outputs of fuzzy set (in the basic fuzzy set V). In another word, the role of composite block is to reflect the inputs of fuzzy set (in set U) to the outputs of fuzzy set (in set V) following the fuzzy rules.

The basic fuzzy rules are the IF-THEN rules which are established on the language variables, these rules represent the relationship among inputs.

The above fuzzy rules are the official ones; from them there exist some other extra rules driven from official rules [3].

The de-fuzzification block is defined as a device to assign a fuzzy set B' which belong to $V \subset R$ to a real value $y^* \in V$. It means that de-fuzzification approach is to realize a point in V; this point can express exactly the fuzzy set B'. Fuzzy set B', however, can be established in many different ways.

There are some criteria to get the suitable de-fuzzification approach, such as:

Confidence: y* must intuitionally represent for fuzzy set B', for instance, y* may be nearly in the range of fuzzy set B' or y* can be defined by the highest dependent function in B.

Simple Computation: This is the important criteria; since the computation in fuzzy control requires real-time response.

Continuity: it means that the small change in B' results in no significant change in y*.

The basic fuzzy controller which has only ability to solve the current inputs belongs to group of static fuzzy controllers. To spread the application range of the basic fuzzy controller to the dynamic problems, suitable dynamic systems should be added to the basic fuzzy controllers. These dynamic systems will provide the derivative values and integrate values of the signals for the basic fuzzy controller. Therefore, the basic fuzzy controller with the added suitable dynamic systems is called fuzzy controllers.

In principal operation, there are no differences between fuzzy control system and other conventional control systems. The difference here is the fuzzy controller seems to operate actively with its own artificial intelligent [4].

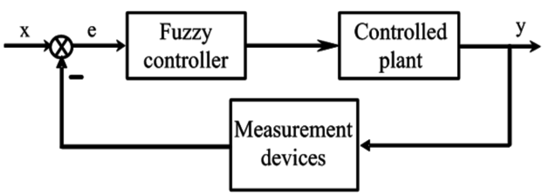

Figure 2. *Fuzzy control system*

Fuzzy control systems are designed based on: Inputs include by fuzzification and extra blocks to solve the active problems such as integrate, derivative, etc.

Composite device: it is the operation of combination of rules R that is built base on the control rules.

Outputs include defuzzification and direct interfacing blocks which connect directly to the controlled plant.

3. Design and simulate a fuzzy control system for controlling of resistance oven temperature

Step 1: Establishing rules for parameters of fuzzy PID controller

Table 1. *The rules for* k_R

de/dt \ e(t)	NB	NM	NS	ZE	PS	PM	PB
NB	B	B	B	B	B	B	B
NM	S	B	B	B	B	B	S
NS	S	S	B	B	B	S	S
ZE	S	S	S	B	S	S	S
PS	S	S	B	B	B	S	S
PM	S	B	B	B	B	B	S
PB	B	B	B	B	B	B	B

Table 2. *The rules for* k_D

de/dt \ e(t)	NB	NM	NS	ZE	PS	PM	PB
NB	S	S	S	S	S	S	S
NM	B	B	S	S	S	B	B
NS	B	B	B	S	B	B	B
ZE	B	B	B	B	B	B	B
PS	B	B	B	S	B	B	B
PM	B	B	S	S	S	B	B
PB	S	S	S	S	S	S	S

Table 3. *The rules for* α

de/dt \ e(t)	NB	NM	NS	ZE	PS	PM	PB
NB	S	S	S	S	S	S	S
NM	MS	MS	S	S	S	MS	MS
NS	M	MS	MS	S	MS	MS	M
ZE	B	M	MS	S	MS	M	B
PS	M	MS	MS	S	MS	MS	M
PM	MS	MS	S	S	S	MS	MS
PB	S	S	S	S	S	S	S

Step 2: Establishing the fuzzy set and composite rules in Matlab&Simulaink for controlled plant. This is a first order delay system described by the formula.

$$W(s) = \frac{0,82e^{-30s}}{160s+1}$$

The main signal is the setting temperature set up during the control process. In the first period, we set temperature at 40°C. And then, the temperature is changed to 50°C.

* The Input and Output Fuzzy Set

Table 4. *The composite rule T_i*

de/dt \ e(t)	NB	NM	NS	ZE	PS	PM	PB
NB	S	S	S	S	S	S	S
NM	B	B	S	S	S	B	B
NS	B	B	B	S	B	B	B
ZE	B	B	B	B	B	B	B
PS	B	B	B	S	B	B	B
PM	B	B	S	S	S	B	B
PB	S	S	S	S	S	S	S

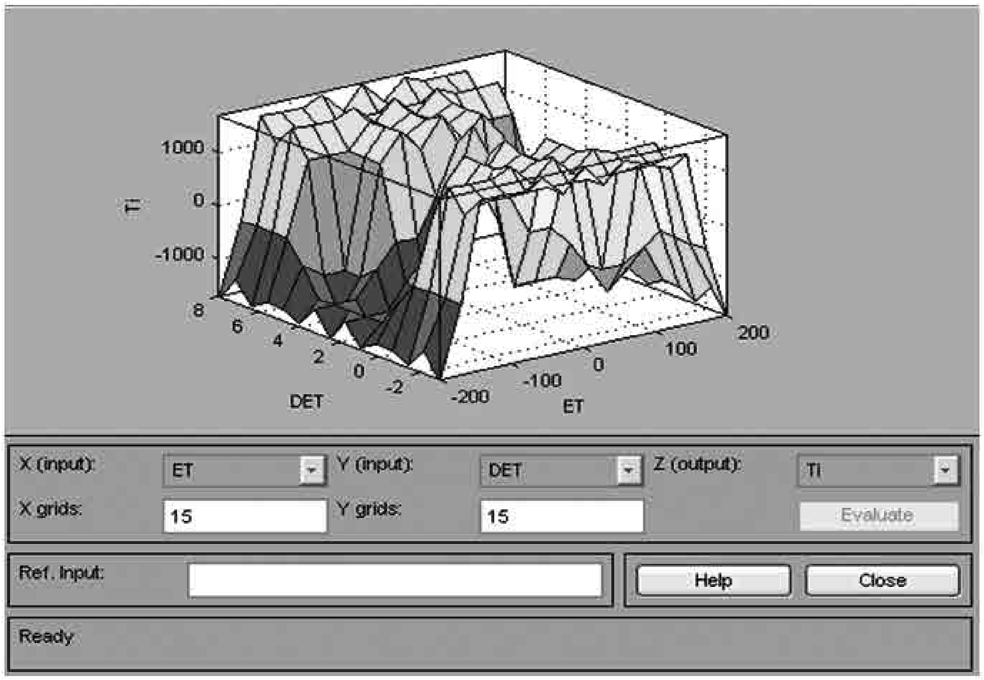

Figure 3. *The relationship between the Input and Output variables of the fuzzy PI method with the constants K_R*

Step 3: Simulate a fuzzy control system for controlling of resistance oven temperature in Simulink

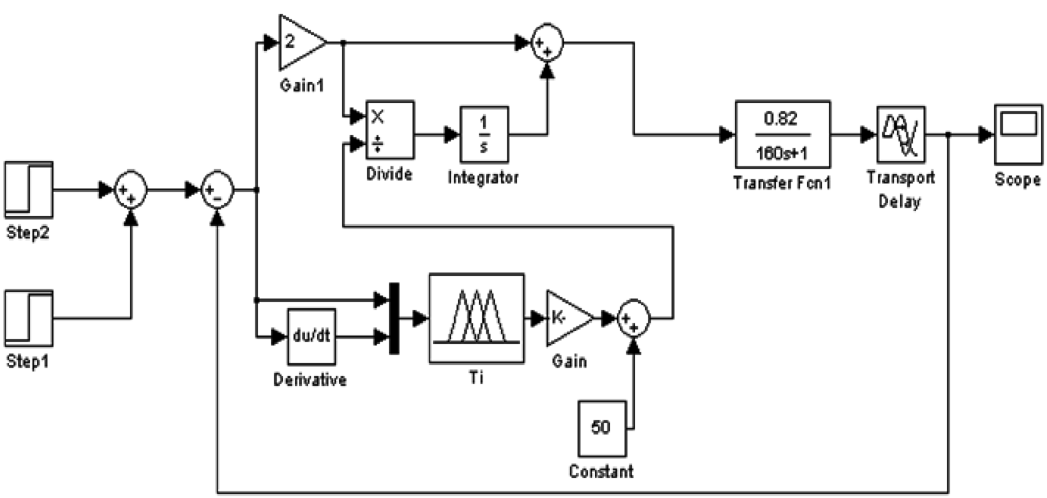

Figure 4. *Simulation block diagram of the fuzzy PI method with the constants K_R for the object- resistance oven*

ISSN 2354-0575

*** Simulation Results**

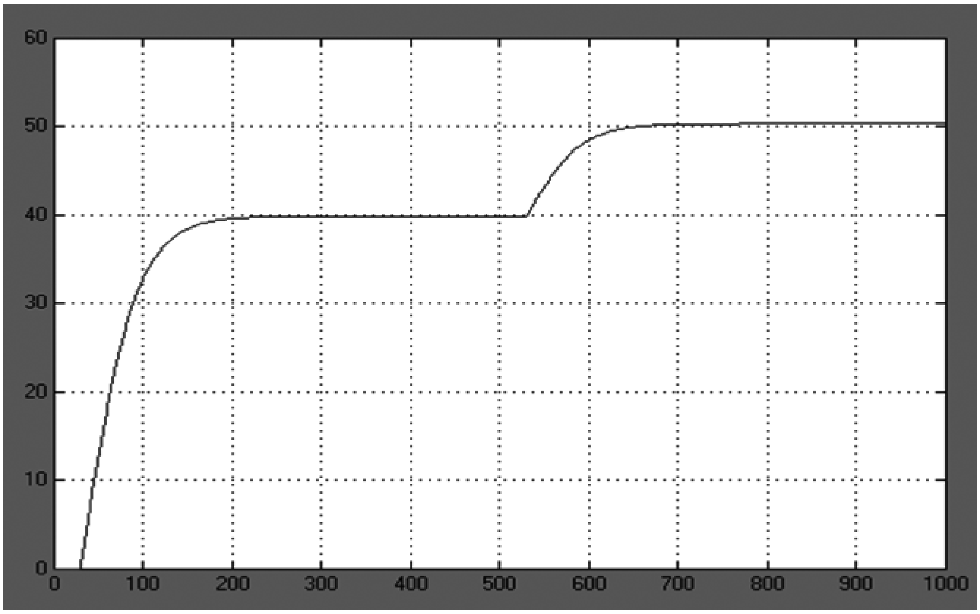

Figure 4. *Simulation result of the fuzzy PI method with the constants K_R for the resistance oven temperature*

5. Conclusion

The result showed that the system archives ver quick response on the variation of set-point. Over shoot quantitive is small $\sigma \approx 0\%$ and statistical errors equal to zero $e_\infty = 0$.

Fuzzy adapter for the parameters of PID controller and application for the resistance oven temperature increases the performance and the stable in working process (includes: the object survey, design the controller, modeling and simulation).

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THIẾT KẾ VÀ MÔ PHỎNG HỆ THỐNG ĐIỀU KHIỂN MỜ CHO ĐỐI TƯỢNG LÒ ĐIỆN TRỞ

Tóm tắt:
Điều khiển mờ chiếm một vị trí quan trọng trong điều khiển học kỹ thuật hiện đại, đến nay điều khiển mờ đã là một phương pháp điều khiển nổi bật bởi tính linh hoạt và đã thu hút được những kết quả khả quan trong nghiên cứu, ứng dụng lý thuyết tập mờ, logic mờ và suy luận mờ. Bài viết này sẽ giới thiệu ngắn gọn cấu trúc chung của một hệ thống điều khiển mờ, thiết kế và mô phỏng hệ thống điều khiển tự động nhiệt độ của lò điện trở sử dụng Matlab & Simulink. Kết quả chạy thực đều có cho đáp ứng nhanh, đáp ứng của hệ thống với sự thay đổi setpoint là rất tốt.
Từ khóa: *Điều khiển mờ, lý thuyết tập hợp, logic mờ, giải mờ, thiết kế bộ điều khiển.*