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# Fuzzy Controller for Heating Oven

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***Abstract:*** *Heating oven is a popular model in control automation. It is not only often used in laboratory but also in industry. Many linear methods is tried with this model. However, under the development of society, intelligent control is focus day by day. In this paper, we propose a fuzzy structure for controlling a heating oven. This intelligent controller is proved to work well on Matlab/Simulink simulation.*
***Keywords:*** *Heating oven, intelligent control, fuzzy algorithm.*

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## I. INTRODUCTION

Heating oven is a popular model for both laboratory and industry [1]. It can described by a linear model with delay part [2]. Thence, it presents a class of model that includes delay characteristic. Some linear methods have been tried with this model such as PID [5], [6]- a popular control method in industry [3]. However, the requirement of creating an intelligent controller is assured. The intelligent controller can develop the ability of make controller more flexible when working with a models which change usually by changing of the working environment [4]. Fuzzy algorithm is a kind of intellignet control. Fuzzy controller is designed due to knowledge of experts. Experts do not need to know dynamic equations of system byt they can still control system through experiments. Thence, these experiment is collected and combined into a fuzzy controller.

## II. DYNAMIC EQUATIONS

From [2], Transfer function describing the characteristic of heating oven can be generalized as

$$G(s) = \frac{K}{T_2 s + 1} e^{-T_1 s} \tag{1}$$

K, $T_1$, $T_2$ are positive constant. They are found by the response of heating oven when suppling 100% of wattage as in Figure 2. Response in Figure 2 is equivalent to response in Figure 1 if we regard $e^{-T_1 s} \approx \frac{1}{T_1 s + 1}$

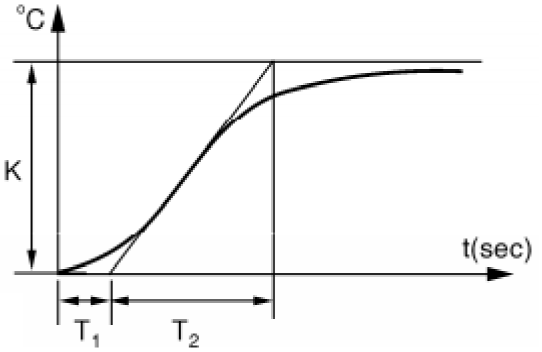

**Figure 1.** Response of heating oven when suppling 100% of wattage

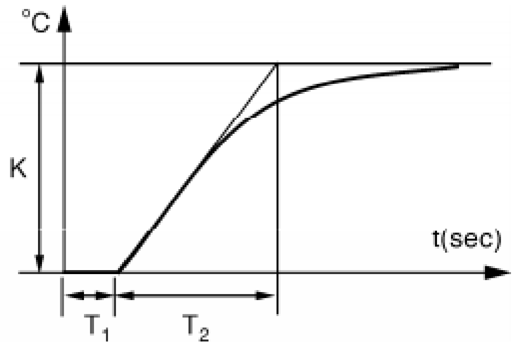

**Figure 2.** Approximately response of heating oven when suppling 100% of wattage

## III. FUZZY CONTROLLER

The inputs of fuzzy block are:

+ error between setpoint and real response (sympollized as E)
+ The derivative of this error (sympolized as DE)

The otput of fuzzy block is the wattage to supply the heating oven (sympolized as u). Value of wattage is from 0 to 1.

Menbership functions of inputs and outputs are shown in Figure 3, Figure 4 and Figure 5. Fuzzy rules are shown in Table 1.

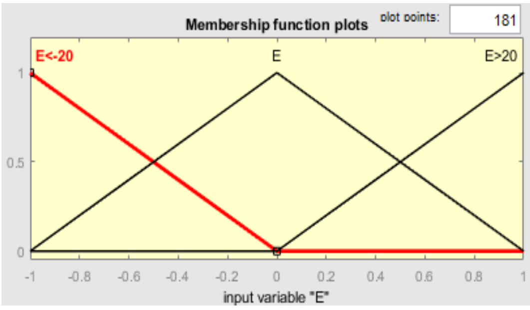


**Figure 3.** Membership functions of E

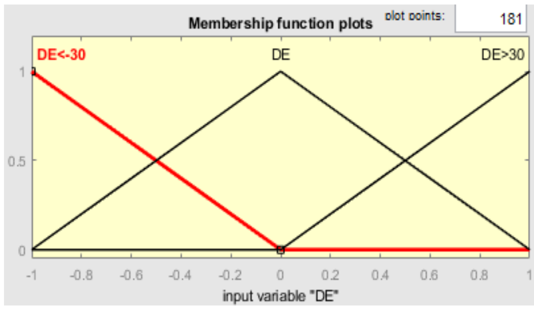


**Figure 4.** Membership functions of DE

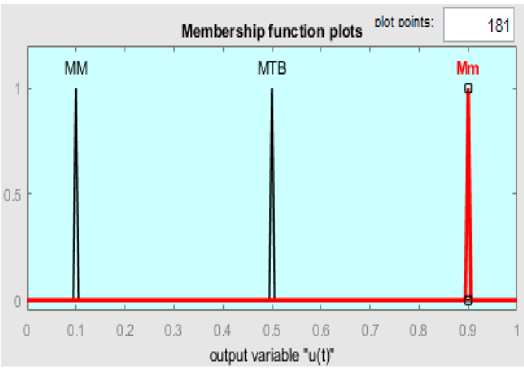


**Figure 5.** Membership functions of u

**Table 1.** Fuzzy rules of fuzzy block

| | | DE | | |
|---|---|---|---|---|
| | | DE<(-30) | DE | DE>(30) |
| E | E<-20 | Mm | Mm | MTB |
| | E | Mm | MTB | MM |
| | E>20 | MTB | MM | MM |

From the information of designing fuzzy block of figures and table above, the control block for heating oven are designed as in Figure 6 below.

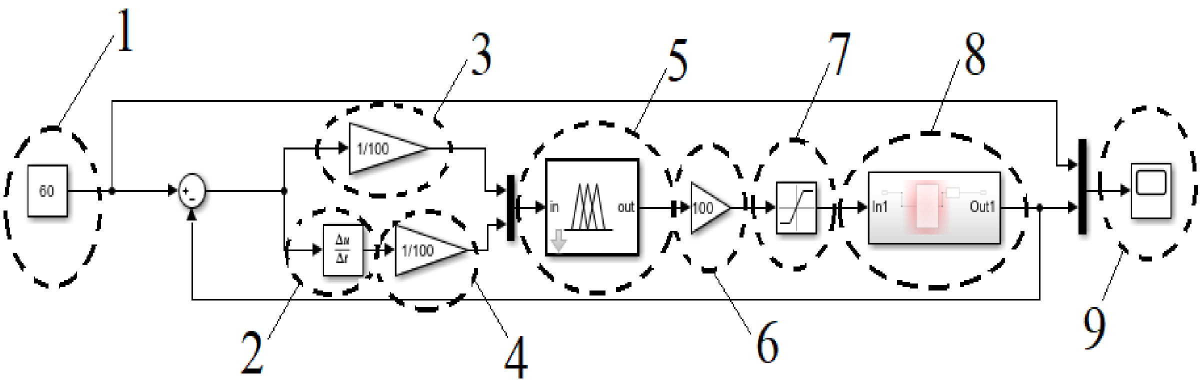


**Figure 6.** Control structurefor heating oven by fuzzy algorithm

Description of blocks:

(1)-Setpoint or expected temperature
(2)-Derivative
(3),(4),(6)-Positive constants that have to be selected through experience
(5)-fuzzy block
(7)-Saturation block to limits the value from 0 to 1
(8)- Transfer function described in (1)
(9)-Scope to show the comparation between valus of real response and set point

## IV. SIMULATION

We choose system parameters as: K=60, $T_1$=50, $T_2$=20. Set point is $60^0$C. Parameters in block (3), (4), (6) are chosen as 1/100, 1/100, 100. Thence, we obtain the simulation result as in Figure 7 below.

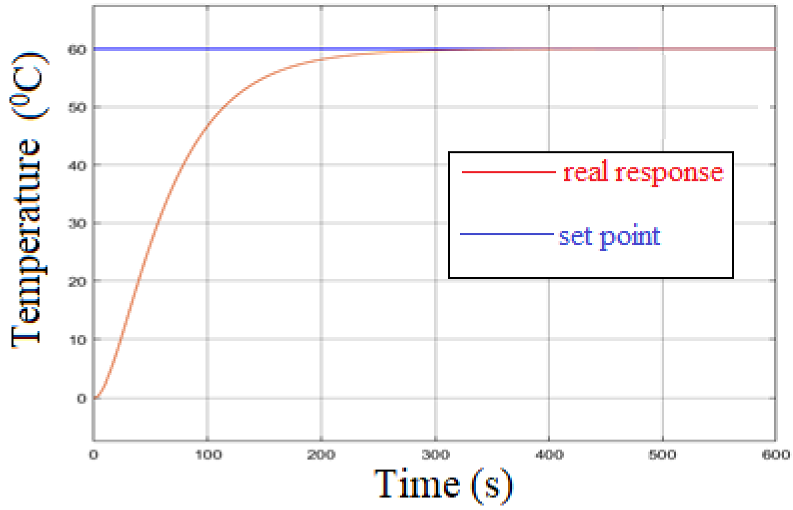


**Figure 7.** Comparation between real response and the setpoint

In this figure, under fuzzy controller, settling time is 300s, POT(%)=0, settling error is zero. Thence, fuzzy controller is sucessful in keeping the temprature of system tracking the expected value. The quality of system can be improved by putting more rules in Table 1, setting more membership functions of inputs /outputs, choosing suitable values of block (3), (4), (6) in Figure 6.

## V. CONCLUSION

In this paper, we propose a fuzzy controller to keep temperature of a heating oven to expected value. The control parameters are presented to be calibrate for better response for future calibration. The controllers are proved to work well in Matlab/Simulink simulation. Based on a linear model of heating oven, this intelligent controller can be improved for real model for later research.

**Conflict of interest**
There is no conflict to disclose.

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