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Improve performance of Temperature Control for an Injection Mould Machine using Fuzzy Logic

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Abstract: - **This paper presents a technique for the linear fuzzy controller designing for to limit temperature in injection-mold machine. Initial, time-delay system is presented as temperature control system. A fuzzy- controller system is made up of controller (heater transfer function) & decision maker. All two decision makers & controller are outlined by utilizing fuzzy circuit, and it is simulated in MATLAB. For encouraging a usage of fuzzy-circuit, linear-equations are utilizing and its reaction is contrasted with that of fuzzy- controller. At last, fuzzy controller is then outlined / designed and its response is contrasted with fuzzy system response. We are working for temperature control of the injection-molding machine. We are balancing the system temperature by using fuzzy-logic controller.**

Keywords: PID Controller, Fuzzy Controller, Fuzzy PID, Temperature Control.

I. INTRODUCTION

Typically, Injection molding- machine, generally called plastic product device through an injection molding- process. Significantly it's comprised of two essential parts which are clamping unit and injection unit.

Generally, Injection molding- machines are better in mold fasten in both vertical and horizontal position. In fact, most machines are then recorded for aligned horizontally while vertical machines are then connected in diverse use of niche such as insert molding, majorly machine allowing for covering the gravity advantages. It has been signified that particular vertical machines needn't bother with mold to be in fastened. Really different techniques are intended to consider tools action inside platens, and frequently connected manual clasps that exist in both parts and dashed inside platens; while the application of hydraulic clamps chocks are big to hold fundamentally, single place tool and magnetic clamps are then applied. Regularly hydraulic and magnetic clamps are connected in events where quick changes of tools are exceptionally fundamental.

In reality designers of mold are used to select whether mold applies cold or hot runner system in plastic performing within injection unit to existing cavities. Significantly cold runner is viewed as simple channel which carved within mold. Regularly plastic which generally covers cold-runner cools instantly cools and this permits them to be launched out with the part significantly as spruce. The system of hot runner is profoundly confused; it utilizes cartridge predominantly of heaters, in order to keep a plastic in runners-hot as part- cools.

A. Applications

Normally the Injection molding is applied to generate different things like the wire spools, the packaging, the bottle caps, the automotive dashboards, the Game boys, the pocket combs, different musical instruments (and parts of them), the one-piece chairs and lastly the small tables, the storage containers, the mechanical parts like the gears, and some other plastic products present today. The Injection molding is the highly applied modern method in the production parts; normally it is regarded to be very suitable in the generations of the increased volumes to the similar same object.

Fuzzy logic plays such a special role in control issues that it is considered as an intelligent controlling method. In this paper the fuzzy method is used to control the temperature and as we see the response gets better in this method. Three articles are used as basic references to complete this paper. In [1], Prabha has modeled the heater of injection mould machine as a transfer function with time delay as follow:

$$G(S) = \frac{K\, e^{-\zeta S}}{TS+1} \qquad \text{.....(1)}$$

Same transfer function has been used to model the heater. In [2], Zhou has considered input/output membership functions of the fuzzy controller in terms of temperature and of triangle type.

The same method has been used to design the fuzzy controller system described in section. in [3],hanamane, has implemented a controller using microprocessor to control the injection mould machine temperature. In aforementioned paper the implementation of this controller using fuzzier and defuzzier has been argued and a flowchart algorithm with a fuzzy controller has been proposed. In this paper we have used the same algorithm to simulate the fuzzy controller.

Implementing fuzzy rules in integrated circuits has some difficulties such as complex input/output rules and computing decimal numbers. In this paper a linear time invariant equation has been estimated from fuzzy rules using regression method. This equation facilitates modeling the fuzzy system and implementation of fuzzy rules in integrated circuits [4].

B. System Transfer Function

The system transfer function in general is as follow:

$$G(S) = \frac{K\, e^{-\zeta S}}{TS+1} \qquad \text{......(2)}$$

Where, k represents the gain, τ system delay and T time constant.
Analyzing injection mould machine concludes that the transfer function possesses one degree of freedom and a time delay as follow:

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$$G(S) = \frac{0.92144\ e^{-3S}}{144\ S+1} \quad .....(3)$$

The open loop system is stable and tracks the set point after a time constant, which is about 560 seconds. To see the advantages of the fuzzy controller, the close loop system results of a PID compensator is compared with that of the fuzzy compensator. Then a fuzzy controller and a switch as a controller are designed and the results are compared to analyze now fuzzy logic act as a controller.

C.PID compensator design

The PID compensator is designed so that the setting time of close loop system is reduced.

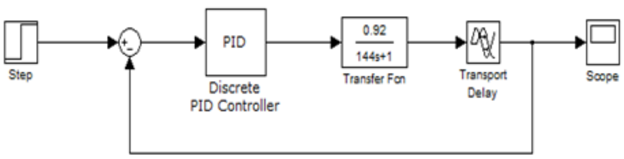

Figure 1:- . closed loop system with PID compensator

D. Fuzzy Logic Design For Injection Molding Machine

For design fuzzy logic injection molding machine, fuzzy logic is apply. Fuzzy logic is design by according to table 1.

FIS Matrix	My_fis1
Refresh Rate	2

Table 1:- Fuzzy logic Design

For design the transfer function Numerator Coefficient is 1, denominator coefficient is [144 1].For design the transport delay time delay is 1 , Initial output is 0 and initial buffer size is 1024 .

Designing of Fuzzy logic controller gives the low setting time. Fuzzy logic rules are shown in figure 2.

Figure 2:- Fuzzy Logic rule file

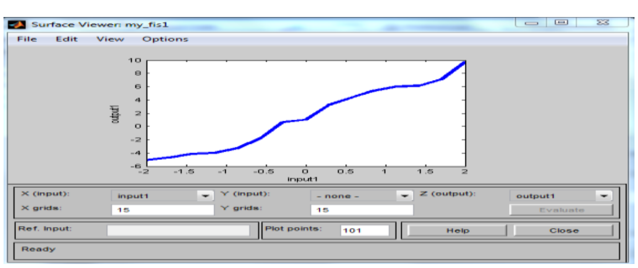

Figure 3:- Surface view graph for fuzzy logic rule file

Image 3 is showing the input output graph for the fuzzy rule file. Figure 4 is showing the model of the injection molding machine by use fuzzy logic. We use fuzzy block for design fuzzy rule file and then transfer function. Scope is helping to generate the waveform.

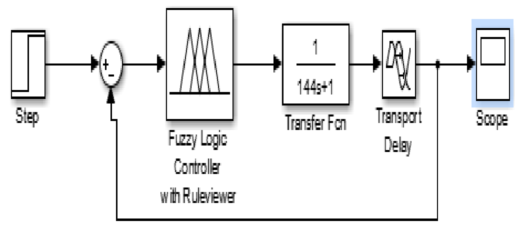

Figure 4:- Block diagram of fuzzy logic base design model

According to Fuzzy logic design file the overshoot goes up to 1.0. By the PID controller overshoot goes up to 1.5. That means at present time overshoot setting time is reduced by the 0.5. The transfer function value numerator is 1 and denominator value is [144s +1] is define in reference paper [29].

The second advantage by the fuzzy logic is, in very short time machine get stable. In the PID controller machine goes stable but it becomes after a long time. As the figure 4 is showing that machine is getting stable at 400 and before this it is unstable.

E. Fuzzy Rule Input Function

As compare from the fuzzy logic design file machine is getting stable in little time as compare to PID controller.

Very negativ	VN
Low negativ	LN
zero	Z
Low positiv	LP
Very positiv	VP

Table 2:- Inputs/Outputs membership functions

For design the fuzzy logic rule file input is taken from [-2 to 2] range .according to figure 5 Very negative is set at -2 point. Low negative is set at -1.25, while zero is set at 0. For positive the low positive is set at 1 and very positive is set at 2. The values of the fuzzy logic system is design according to reference paper [29].

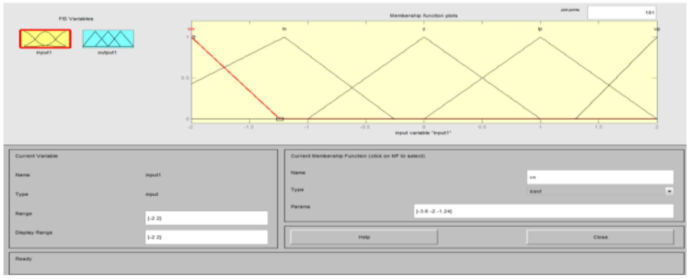

Figure 5 :-input Fuzzy logic rule file for without PID Fuzzy

F. Fuzzy Rule Output Function

For the output fuzzy rule file the range is [-9 to 11] according to figure 6. Very negative is set at -9 while low negative is set at -4. Zero is set at 1 while low positive is set at 6 and very positive is set at 11 according to figure 6. Surface view is showing a linear graph for the input and output function.

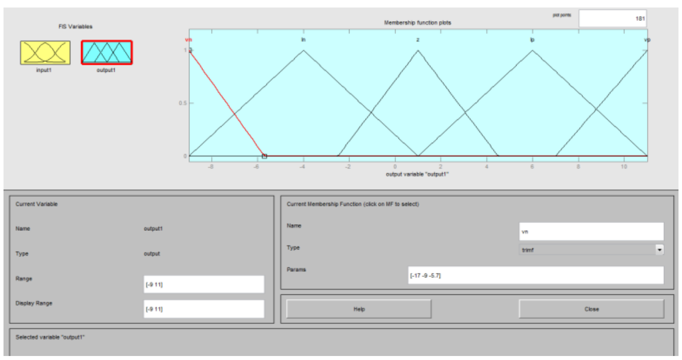

Figure 6:-Output fuzzy rule file

G. PID Based Oven Temperature Control

For control the oven temperature we have to use PID controller for controlling the accuracy of the oven temperature as shown in image 7. The oven temperature varies from 3.3 to 6.8. That means in this we have tolerance of 1.8 degree. We can reduce the temperature tolerance rate by use fuzzy logic. As the value of the oven temperature goes greater than 7 negative values generate and when the temperature goes below 4 then the value come positive.

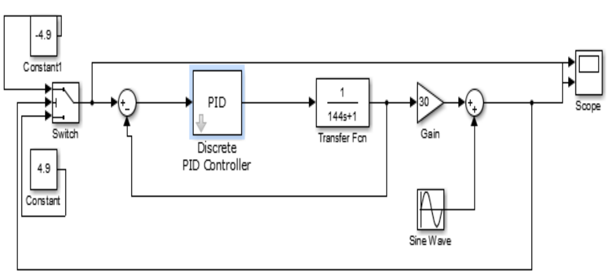

Figure 7:- Oven temperature control by PID controller

For design the constant of the value of contact is -4.9 to 4.9 and the sample rate is inf .Now we have design the switch for change the values of the switch.

Proportional gain(Kp)	3.5
Integral Gain(Ki)	0.5
Derivative Gain(Kd)	1
Time constant for Derivative (s)	1
Output limit [upper lower]	[100 100]
Output Initial value	0
Sample time	0.5

Table 3:- PID controller for design the temperature control

As we have been discuss the value of Kp, Ki, Kd is defined according to output graph. To achieve the graph we set the values of the Kp, KI, Kd. Transfer function is design by numerator Coefficient 1 , Denominator Coefficient [144 1].For design the gain we use the gain of 30 and the sample rate is -1 . For design the sine wave amplitude 5 , bias is 0 and frequency (rad/sec) is 0.1 .

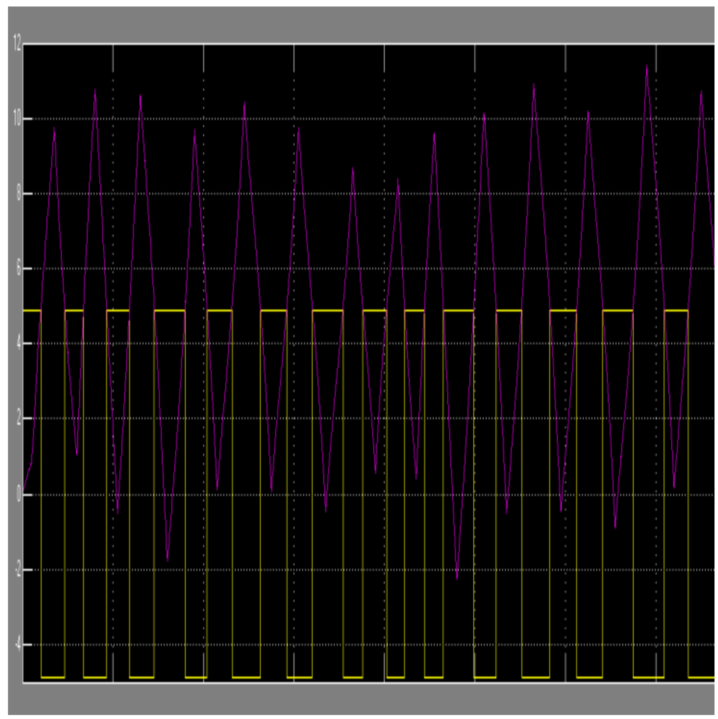

Figure 8 :- Temperature control for PID controller

II. PROPOSED METHODLOGY

We are introducing the fuzzy logic controller for improve the performance of the system .We are changing the fuzzy logic rules for the design system so that we can achieve the constant temperature and stable setting point .

A. Fuzzy Logic Controller for Setting Point Control

Fuzzy logic controller is used for control the setting point of the system . We are using seven membership functions for control the error . Range of the input function is [-1 to 1] . These function names are mf1, mf2, mf3, mf4, mf5, mf6, mf7.

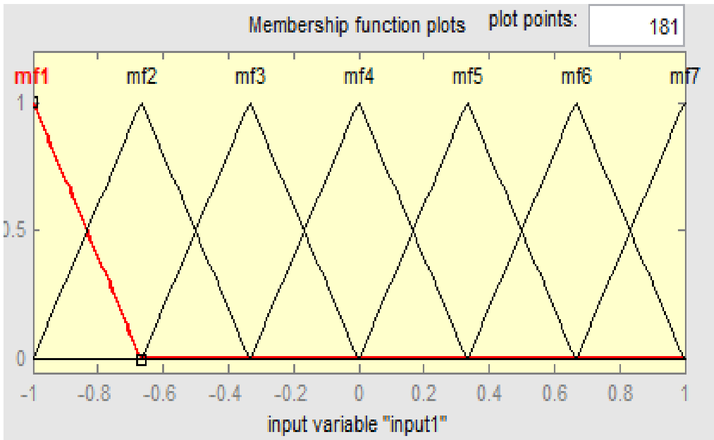

Figure 10:- Input for fuzzy logic rules

For output we have seven membership functions mf1, mf2, mf3, mf4, mf5, mf6, mf7. The range of the output is [-8 to 10].

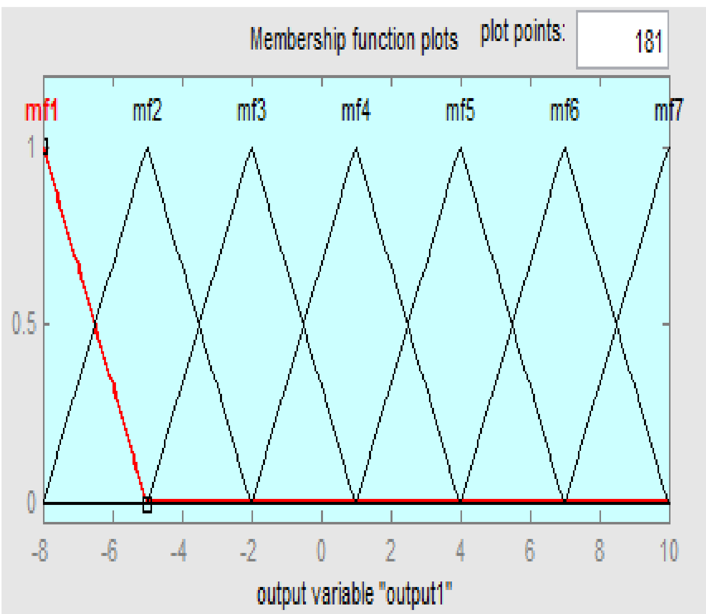

Figure 11:- Output membership functions for proposed fuzzy logic

Input	Output
Mf1	Mf1
Mf2	Mf2
Mf3	Mf3
Mf4	Mf4
Mf5	Mf5
Mf6	Mf6
Mf7	Mf7

Table 4:- proposed fuzzy logic design rules

B. Fuzzy Logic Controller for Temperature Control

Fuzzy logic controller is used for control the temperature of the system. We are using seven membership functions for control the error. Range of the input function is [0 to 10] . These function names are mf1, mf2, mf3, mf4, mf5, mf6, mf7.

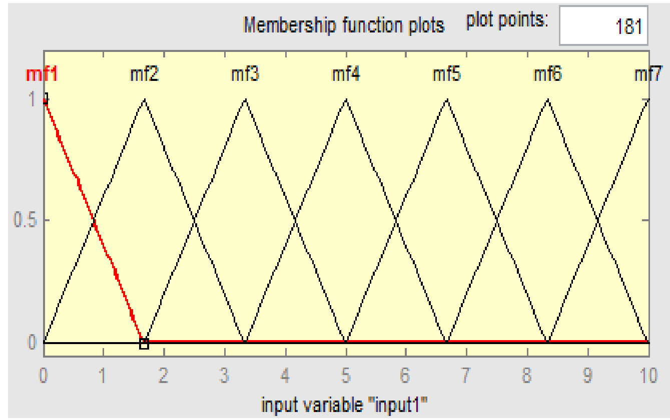

Figure 12 :- Fuzzy logic for input of temperature control

For output we have seven membership functions mf1,mf2,mf3,mf4,mf5,mf6,mf7. The range of the output is [-5 to 5].

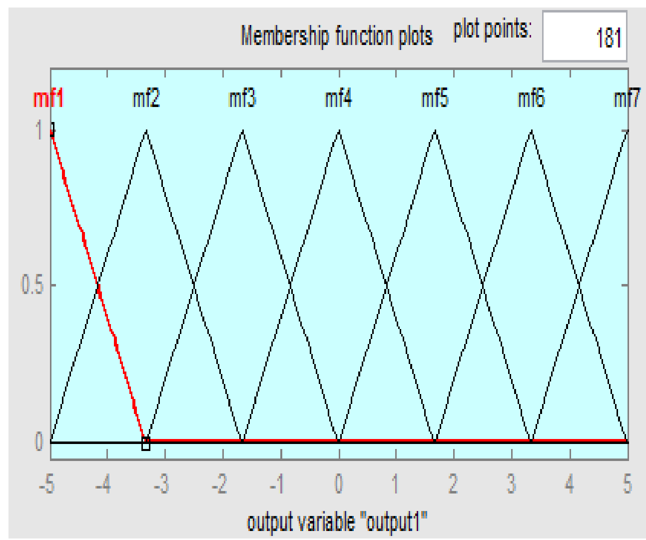

Figure 13 :- Output membership functions for proposed fuzzy logic

Input	Output
Mf1	Mf7
Mf2	Mf6
Mf3	Mf5
Mf4	Mf4
Mf5	Mf3
Mf6	Mf2
Mf7	Mf1

Table 5 :- proposed fuzzy logic design rules

III. RESULTS

A. Setting Point Controller

We are using improve fuzzy logic controller for control the setting point of the injection molding machine. As the graphs are showing the setting point for the PID controller is not stable. It is changing by the time and getting stable after 400 sec.

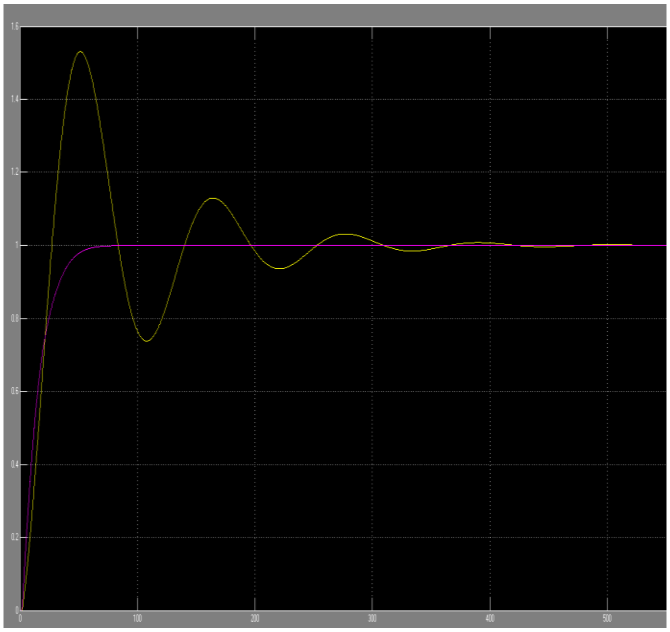

Figure 14:- PID output graph for Setting point

As the graphs is showing that the fuzzy logic is used in base paper but there one peak is left. That means system is not getting stable . It is getting stable after 60 sec.

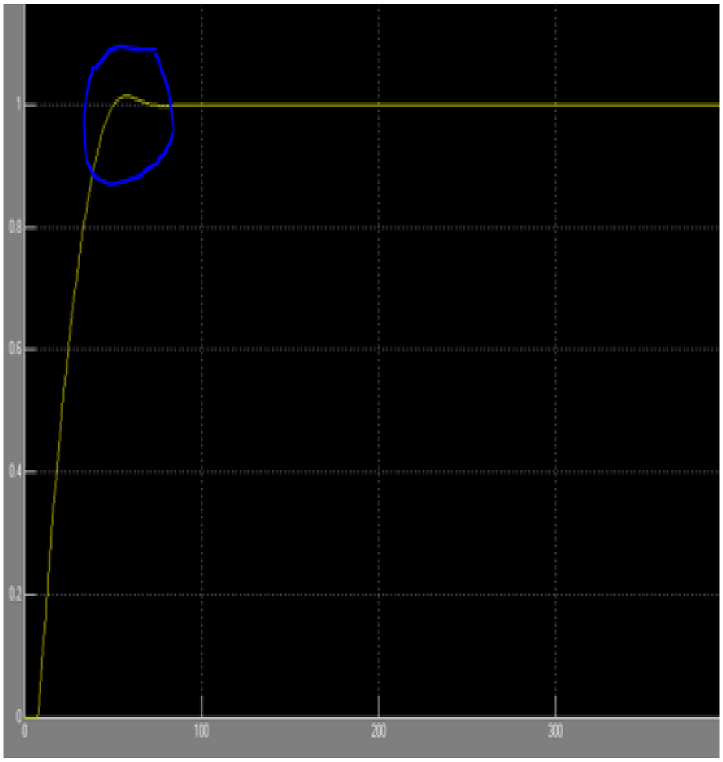

Figure 15:- fuzzy logic output for setting point

According to our design system, system is getting stable at 50 sec. it is not giving any peak for the proposed fuzzy logic controller. We reduce the 17% stability time from the existing system stability time.

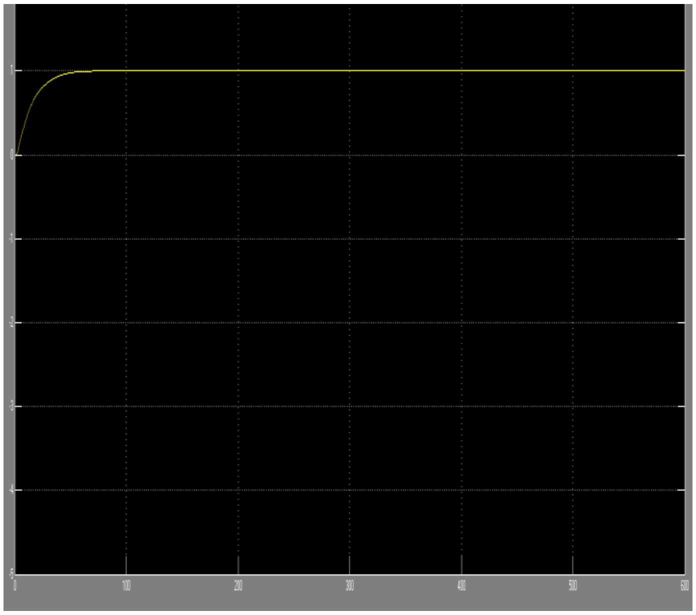

Figure 16:- Proposed fuzzy logic controller output for setting point

	PID	Fuzzy (Existing)	Fuzzy (Proposed)
Time (sec)	400	60	50

Table 6 :- comparison table for setting point

B. Temperature Control for Injection Molding Machine

In the existing design the temperature is varying 4 to 7° C. The temperature is not stable. The value of the constant is varying -5 to +5 .The temperature is controlling by PID controller. By apply fuzzy logic the temperature control is getting in stable form.

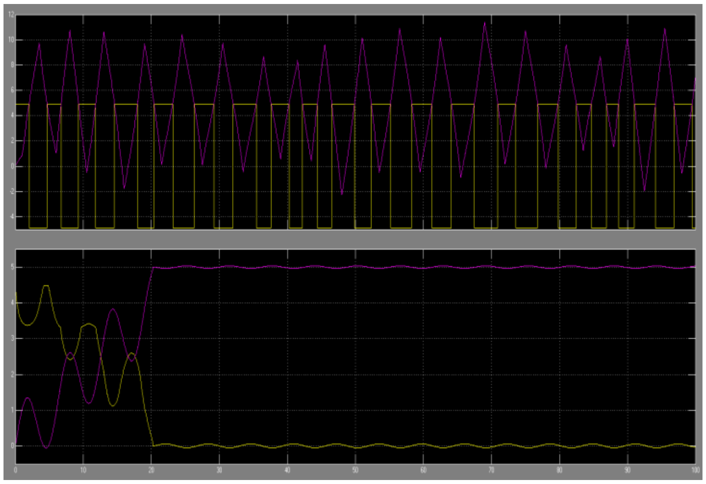

Figure 17 :- PID and Fuzzy controller for temperature control

IV. CONCLUSION

In the starting injection molding machine have very high setting point. For the PID controller setting point overshoot was 1.5.After applying fuzzy logic setting point overshoot was 1.0. The combined attribute in the molding operated machine conducted by the PMSM regulation system is generated with the Fuzzy regulator approach in relation to the Fuzzy control mechanism made in relation to the existing features within the melting and solid conversion state. Actually the relation of the Simulink limited area it is the based PID regulator placed into action with the simulated of the present Fuzzy regulator system. Normally the outcomes of the simulation shows that the present fuzzy related PID system portray good outcomes in relation to the old PID regulation system. In this thesis we have apply fuzzy logic for reduce the setting time. We have applied the Fuzzy logic it we have been reduced the setting point overshoot. It shows that setting point have been reduced after apply fuzzy logic. The results shows that fuzzy logic have low setting time and overshoot is reduced up to 1 with stable temperature of injection molding machine .

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