International Journal of Engineering Research and Development
e-ISSN: 2278-067X, **p**-ISSN: 2278-800X, www.ijerd.com
Volume 7, Issue 9 (July 2013), PP. 78-84

Implementation of Fuzzy Pid Controller And Performance Comparision With Pid For Position Control Of Dc Motor

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Abstract:- This paper gives the demonstration about the position control of DC motor using a Fuzzy PID controller to meet the desired position in presence of set point changes the most commonly used controller in the industry field is the proportional-integral-derivative (PID) controller. The PID controllers mostly used in industries due to their robust performance in a wide range of operating conditions & their simple tuning methods. This paper presents design of PID controller with Ziegler-Nichols (ZN) technique for controlling the position of the DC motors. Fuzzy logic controller (FLC) provides an alternate to PID controller, especially when the available system models are inexact or unavailable. Fuzzy logic is one of the most successful applications of fuzzy set in which the variables are linguistic rather than numeric. The design of intelligent control systems has become an area of intense research interest. The development of an effective methodology for the design of such control systems undoubtedly requires the synthesis of many concepts from artificial intelligence. The scopes includes the simulation results of the PID controller, implementation of fuzzy PID controller to position of DC motor In this paper fuzzy PID and proportional-integral-derivative (PID) controllers are compared for controlling the position of direct motors(DC) motors. Simulation results are demonstrated using MATLAB. Performance analysis results are carried out to analyze the effectiveness of the designed Fuzzy PID controller as compared to the ZN tuned PID controller.

Keywords:- Position Control DC motor, PID, Fuzzy controller, rule base, Fuzzy ID, MATLAB/SIMULINK.

I. INTRODUCTION

Industrial process control systems have many features such as non-linear, inertial lag, time delay and time varying so on. Due to this, precise mathematical modeling is not possible. Traditional PID algorithm does not hold well for such systems which has disturbances. Fuzzy PID has more advantages as compared to PID. It has fast response, small overshoot and good anti-interference ability. In this paper a novel method for such system is introduced, named FuzzyPID. This method has the merits of both Fuzzy and PID. The Fuzzy ID control of these papers was simulated in simulation platform MATLAB. Consider the field controlled DC motor (fixed armature) for controlling the position of motor using conventional PID and Fuzzy PID controllers. Performance analysis is also carried out by comparing the time domain parameters. Furthermore, dealing the systems with uncertainties in real applications, is the another subject which must be noticed. In this way, the role of the adaptive and intelligent controllers, by the capability of the overcoming the above mentioned points are of the importance.

II. FUZZY LOGIC CONTROLLER

The design of intelligent control systems has become an area of intense research interest. The development of an effective methodology for the design of such control systems undoubtedly requires the synthesis of many concepts from artificial intelligence Fuzzy logic controller (FLC), especially when the available system models are inexact or unavailable. Fuzzy Logic (FL) is an approach to control engineering problems, which mimics how a person would make decisions, only much faster. FL incorporates a simple rule-based " IF X AND Y THEN Z" approach to a solving control problem rather than attempting to model a system mathematically [7,8]. The FL model is empirically-based, relying on an operator's experience rather than his technical understanding of the system. In other words fuzzy logic is used in system control and analysis design, because it shortens the time for engineering development and sometimes, in the case of highly complex systems, is the only way to solve the problem[9,10]. Every Fuzzy system is composed of four principal blocks as shown in Fig:1.

1. Knowledge base: Rules and parameters for membership functions.

2. Decision making unit: Inference operations on the rules.
3. Defuzzification interface: Transformation of the crisp inputs into degrees of match with linguistic variables.
4. Defuzzification interface: Transformation of the Fuzzy result of the inference into a crisp output.

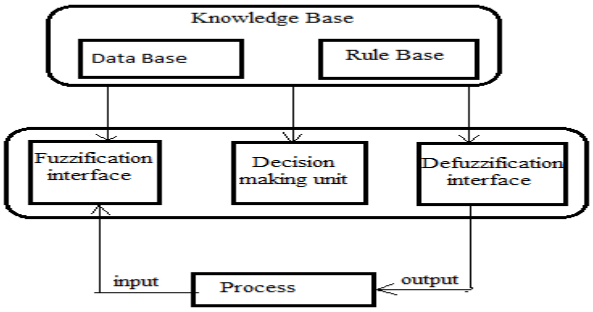

Fig.1: General structure of fuzzy Inference System

1. Fuzzification

The Fuzzy set of the Error input which contains 7 Triangular memberships is shown in figure-5. Figure-6 illustrates the Fuzzy set of the Change Error input which contains 7 Triangular memberships. Figure-7 illustrates the Fuzzy set of the output which contains 7 Triangular memberships. The data base provides necessary definitions, which are used to define linguistic control rules and fuzzy data manipulation in an FLC. The rule base characteristics the control goals and Control policy of the domains experts by means of a set of linguistic control rules. Decision making logic is the kernel of an FLC. It has the capability of simulating human decision making based on fuzzy concepts and of interring fuzzy control actions employing fuzzy implication and the rules of inference in fuzzy logic.

2. Defuzzification

The center of gravity "centroid" method was used in this paper. The controller has been tested using Simulink in MATLAB.

3. Control Base Rules

Table-2 presents the knowledge base defining the rules for the desired relationship between the input and output. The knowledge base comprises knowledge of the application domain and the attendant control goals. It consists of a data "base" and a linguistic (fuzzy) control rule base.

III. MODELLING OF POSITION CONTROL DC MOTOR

The transfer function of the field control DC motor is obtained from the "Performance comparison of PID and Fuzzy logic controller using different defuzzification techniques for positioning control of DC motors [1]".

The transfer function is given by

$$G(s) = \frac{10}{S(S+1)(S+10)} \qquad (1)$$

Set point

IV. CONTROL METHODS

1. PID CONTROLLER:

When the characteristics of a plant are not suitable, they can be changed by adding a compensator [3] in the control system. One of the simple and useful compensators feedback control design is described in this section. In this paper, the control method is designed based on the time-dimension performance specifications of the system, such as settling time, rise time, peak overshoot, and steady state error and so on.

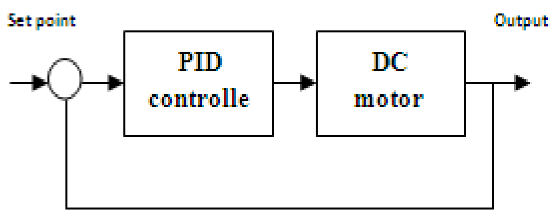

Fig. 2 Block diagram of closed loop system

A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs.

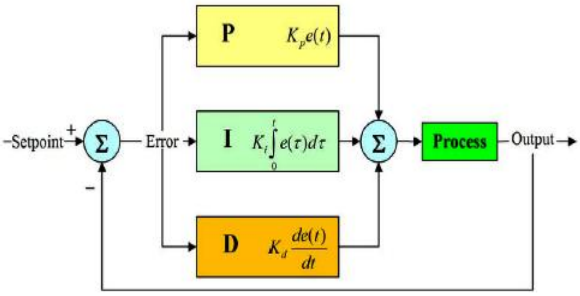

Fig. 3 Block diagram of PID controller

Three parameters K_d , K_p and K_I must be adjusted in the PID controller. In guaranteeing stability and performance and shaping the closed-loop response, it is important to select a suitable compensator.

2. *RELAY FEEDBACK TEST:*

The Astrom and Hagglund relay feedback test is based on the observation that, when the output lags behind the input by π radians, the closed-loop system can oscillate with a period of *P*u. The block diagram of relay feedback test is shown in figure (4). The output response of relay feedback test is shown in fig (5). From the response we can find the parameters are ultimate gain and ultimate period by using equations (12) & (13).

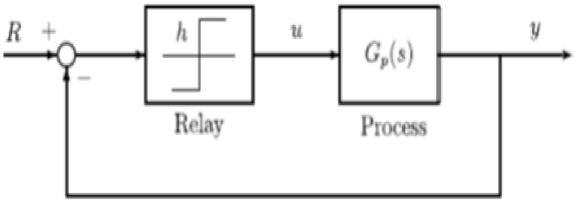

Fig. 4 Block diagram of Relay feedback test.

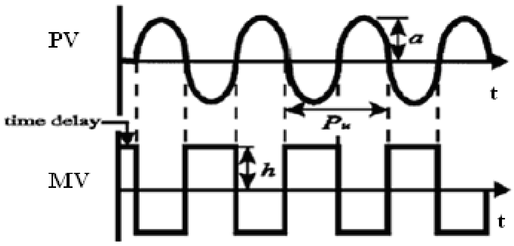

Fig. 5 Output response of relay feedback test.

A relay of magnitude *h* is inserted in the feedback loop. Initially, the input *u*(*t*) is increased by *h*. Once the output *y*(*t*) starts increasing after a time delay (*D*), the relay switches to the opposite direction, *u*(*t*) -*h*. Because there is a phase lag of -π , a limit cycle of amplitude *a* is generated, as shown in Figure 4. The period of the limit cycle is the ultimate period, *P*u. The approximate ultimate gain, *K*u, and the ultimate frequency, w_u are

$$K_u = \frac{4h}{\pi a} \quad (1)$$

$$W_u = \frac{2\pi}{P_u} \quad (2)$$

IV. FUZZY PID CONTROL ALGORITHM

The structure of fuzzy PID is shown in fig:6. It consists of two parts, one is the conventional PID controller and the other is fuzzy controller.

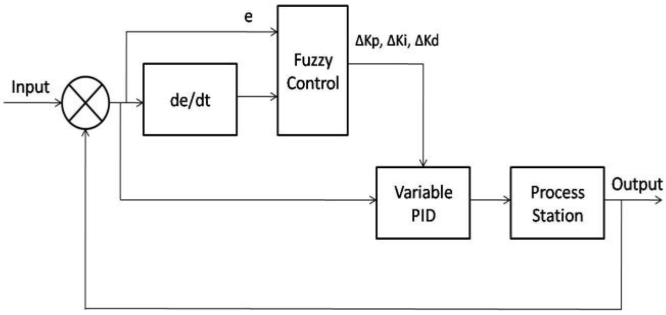

Fig.6 Block diagram of Fuzzy PID controller.

A. Design of Fuzzy PID

Fuzzy controller is the hardcore of the system. It includes the fuzzification, knowledge base, inference engine and de- fuzzification. Fuzzy controller makes the input accurate quantity to fuzzy quantity. It maps the input to the corresponding discourse. The knowledge base contains the experienced knowledge of the flow process station. Data base contains the membership function of every linguistic variable. Control rules are described by the data base. De- fuzzification again transforms the fuzzy quantity into accurate quantity.

B. Membership Function

The membership function used by fuzzy controller is triangular membership function and Gaussian function. The input ranges from -7 to +7 and the fuzzy subset are Negative Big, Negative middle, Negative small, Zero, Positive small, Positive middle and Positive Big respectively termed as NB, NM, NS, ZO, PS, PM, PB. The quantization factor and the scaling factor play an important role in the performance of the fuzzy controller.

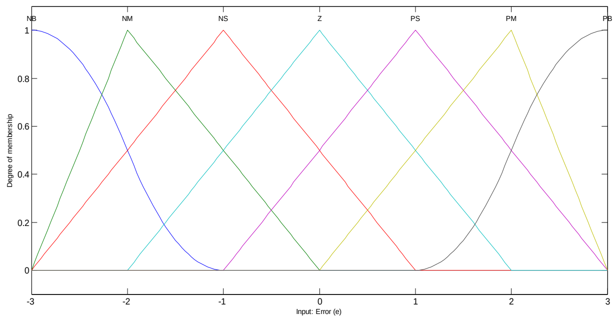

Fig.7 Membership Functions of Error Input in Fuzzy Set

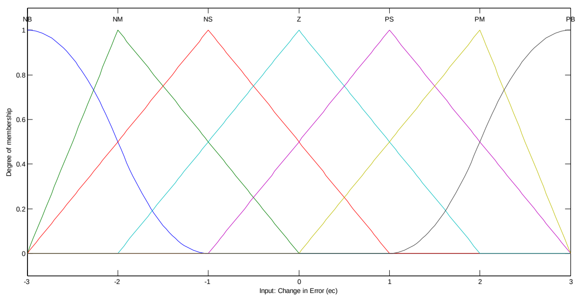

Fig.8 Membership Functions of change in Error Input in Fuzzy Set

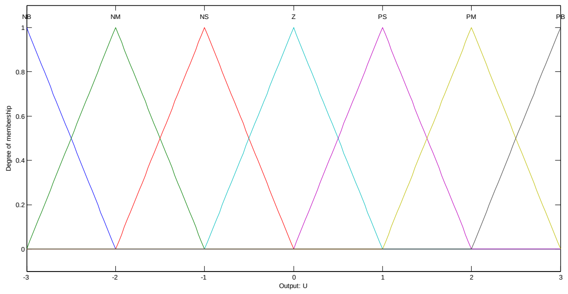

Fig.9 Membership Functions of output in Fuzzy Set

Control Rules of the Fuzzy Controller

The control rules are framed to achieve the best performance of the fuzzy controller. In this paper 49 control rules are adopted to control the position of DC motor.

Table 1: Rule base for Kp in FLC

E / CE	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PM	PS	NB	NB	NB	NB
NM	PM	PS	Z	PS	NB	NS	Z
NS	PB	PM	PS	PM	PS	PM	PB
ZE	PB	PM	PS	ZE	PS	PM	PB
PS	PB	PM	PS	NS	PS	PM	PB
PM	Z	NS	NM	NS	Z	PS	PM
PB	NB	NB	NB	NS	PS	PM	PB

Table 2: Rule base for Ki in FLC

E / CE	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PB	PB	PB	PM	PS	Z
NM	PB	PB	PB	PM	PS	Z	Z
NS	PB	PM	PS	PS	Z	NS	NM
ZE	NM	NS	Z	Z	Z	NS	NM
PS	NM	NS	Z	PS	PS	PM	PB
PM	Z	Z	PS	PM	PM	PB	PB
PB	Z	PS	PB	PB	PB	PB	PB

Table3: Rule base for Kd in FLC

E / CE	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PB	PB	PB	PM	PS	Z
NM	PM	PM	PS	PS	PS	Z	Z
NS	PM	PS	Z	Z	Z	NS	NM
NZ	PS	PS	Z	Z	Z	NM	NB
PZ	NB	NM	Z	Z	Z	PS	PM
PS	NM	NS	Z	Z	Z	PS	PM
PM	Z	Z	PS	PM	PB	PB	PB
PB	Z	PS	PB	PB	PB	PB	PB

Using this control rules FuzzyPID.fis is created. This control rules are framed in MATLAB Simulink. The above said membership function with the mentioned fuzzy subsets and the control rules form the fuzzy controller. This .fis file is implemented using Simulink and the connection is established between Process Transfer function and FuzzyPID. The inference engine used here is the Mamdani Inference engine

V. SIMULATION RESULTS

A. *Simulation Method:*

The Transfer function of DC motor to control the position is obtained from reference paper [1], and simulation results are carried out to analyses the performance of DC motor. The simulation results are carried out in MATLAB/SIMULINK as shown in the figure(10).

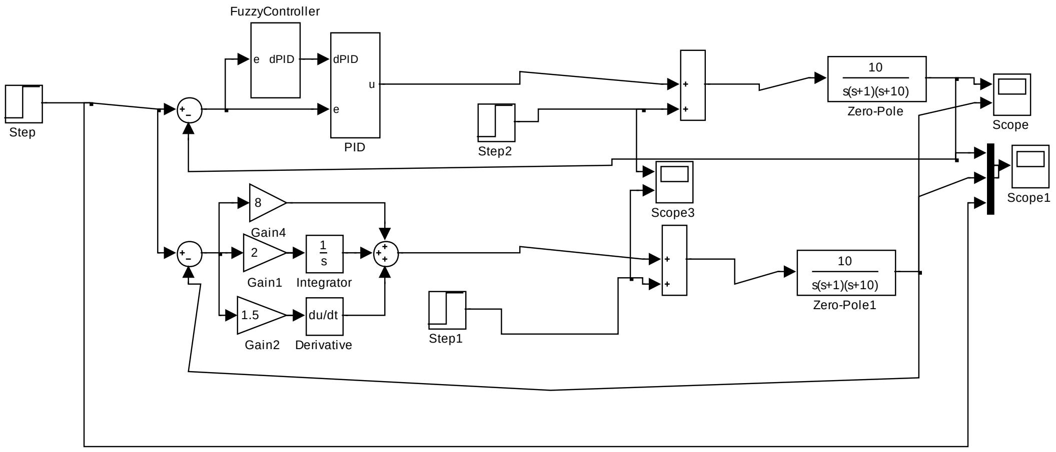

Fig.10 Simulink model of implementation FuzzyPID for position control DC motor.

B. ***SIMULATION RESULTS:***

The relay feedback test is conducted to find the parameters of ultimate gain and ultimate period. The response of Relay test is shown in Fig (11). From the fig (12) we analyse that the Z-N open loop tuned PID can able to track the set point changes with peak overshoots. From the parameters of Ultimate gain and ultimate period , calculate the tuning parameters of Z-N closed loop tuning rules. From the Fig(13) we analyse that over shoots are reduced as compared to the Z-N open loop method. The implementation of FuzzyPID controller for controlling the position of DC motor is shown in figure (10). The Fuzzy PID controller is implemented using error and change in error and considers a membership function as a triangular. The response for tracking the change occurred in position of DC motor is achieved by using fuzzy PID controller is shown in figure (14). The response of error and change in error in fuzzy sets is also shown in figure below. The response of Manipulated Variable of fuzzy controller is also shown in figure (14). From this response we analyse that fuzzy PID tracking the set point with less overshoot as compared to the Z-N closed loop tuned PID controller

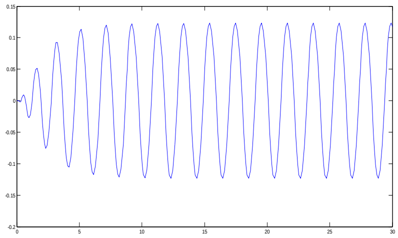

Fig.11 Response of Relay Feedback Test.

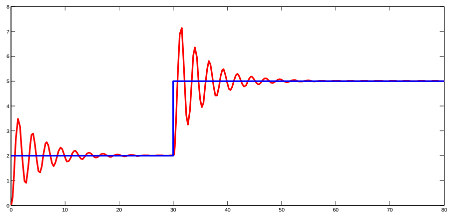

Fig.12 Servo response of Position control DC motor using Z-N open loop methods.

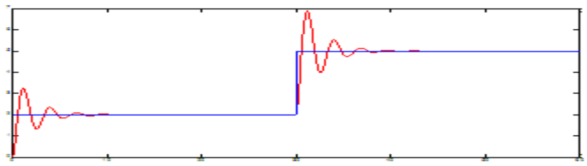

Fig.13 Servo Response Tracking by Using Z-N closed loop methods.

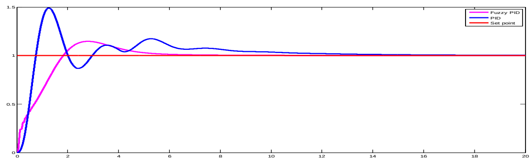

Fig.14 Servo Response Tracking by Using Fuzzy PID Controller for DC motor.

VI. CONCLUSION

The Controllers are implemented to track the changes occurred in position of DC motor (Servo Response). The Z-N open loop tuning rules are considered to design the PID controller for tracking the set point. The parameters of the Z-N Closed loop tuning rules are obtained by conducting the Relay Feedback Test. The results are validated by considering the time domain parameters. The fuzzyPID controller is implemented to track the change in position of DC motor by using MATLAB/Simulink. The simulation results proven that the fuzzyPID control method is more effective way to enhance stability of time domain performance of the DC motor. The fuzzy PID controller based adjustable closed-loop for DC motor system has been developed.

FUTURE WORK

The position of DC motor can be controlled by using adaptive controllers like Neuro fuzzy, MPC, self-tuning regulator etc. The performance analysis also carried out to analyse the qualitative comparison of DC motor.

ACKNOWLEDGEMENT

I express my truthful obligations to my guide, Mr**. S. SRINIVASULU RAJU**, M.Tech, Assistant Professor in E.CON.E Dept for his clever guidance and useful suggestions, which helped me in the project work.

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