IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 3, March 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.122

9940 572 462 | 6381 907 438 | ijareeie@gmail.com | www.ijareeie.com

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

Design, Simulation and Performance Analysis of Manual Tuning Versus Fuzzy Logic Tuning of PID Controller for Flow Control Process

Thirumurugan P[1], Surya S[2], Lingtan N[3], Arjun M[4], Karthik K[5]

Assistant Professor, Dept. of ICE, Saranathan College of Engineering, Trichy, Tamilnadu, India[1]

UG Student, Dept. of ICE, Saranathan College of Engineering, Trichy, Tamilnadu, India[2-5]

ABSTRACT:The OPC (Open Process Control)-based fuzzy adaptive PID control algorithm is designed for flow process stations to boost control efficiency over traditional PID controllers. Only if the mathematical model of the device can be computed does the PID controller function well. As a consequence, PID control for variable and complicated systems is difficult to implement. However, fuzzy logic control does not require a precise mathematical model and is suitable for both simple and complex applications, a flow input of range 0 to 100 is given as input and corresponding control signal is produced in the PID controller. This paper aims at analysing the performance of both the control techniques at ideal conditions.

KEYWORDS:PID, Flow Control, Process Control, MATLAB, Fuzzy Logic Controller, Fuzzy-PID.

I. INTRODUCTION

Many industrial applications, such as chemical reactors, heat exchangers, and distillation columns, require flow control. Nonlinearities and dead time are inherent in most industrial processes, restricting the efficiency of typical PID controllers. The design and implementation of a Fuzzy Logic Controller (FLC) for flow control applications is the focus of this project. The goal is to solve problems associated with traditional PID control schemes, such as dealing with unpredictable disturbances and non-measurable noise, as well as to enhance transient state and steady state response efficiency. Nonlinear, inertial lag, time delay, and time varying are only a few of the characteristics of industrial process control systems. As a result, accurate mathematical modelling is difficult. the customary. For such systems, the PID algorithm does not work well. There are disruptions A new algorithm that can deal with these problems has been created. Limitations must be taken into account. There are more benefits of fuzzy PIDin addition to PID It has a quick response time, minimal overshoot, andAnti-interference capacity is fine. The fuzzy controller is a nonlinear control system. The fuzzy control algorithm is based on the controllerintuition and familiarity with the regulated plant.Many industrial applications, such as chemical reactors, heat exchangers, and distillation columns, require flow control. Nonlinearities and dead time are inherent in most industrial processes, restricting the efficiency of typical PID controllers. The design and implementation of a Fuzzy Logic Controller (FLC) for flow control applications is the focus of this project.Simulation and implementation results showed that the developed controller has less overshoot, good control performance, better disturbance handling ability, great robustness and is more flexible and intuitive to tune. It is expected that this advanced controller improves efficiency and productivity of industrial processes through proper handling of any disturbance or noise and increase the robustness of controller actions.

II. LITERATURE REVIEW

[1] System with feedback control contains drawback which is related to the instability of the system. In order to resolve this problem an appropriate controller should be chosen and also it must be ideal for the monitoring system. [2] The major problem faced by the worker is maintaining the required pressure and flow till the extreme ends. In this paper, the parameters such as pressure and flow are maintained constantly by implementing control valves depends on the different pressure and flow rate of the transmitting pipe and these parameters are monitored. [3] The mathematical model of the controlled object is established by the step response curve method. With the development of modern industry, the accuracy of the pump flow control system is more and more high. [4] Fuzzy Logic is a mathematical system that can deal with uncertain and ambiguous information which is complex to calculate by means of conventional mathematics. Fuzzy Logic uses Fuzzy sets in continuous interval [0, 1] rather than two-valued logic (0, 1) or crisp set. [5] The System variables can be divided into two categories. The first one is the input variables which are measured from the system

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

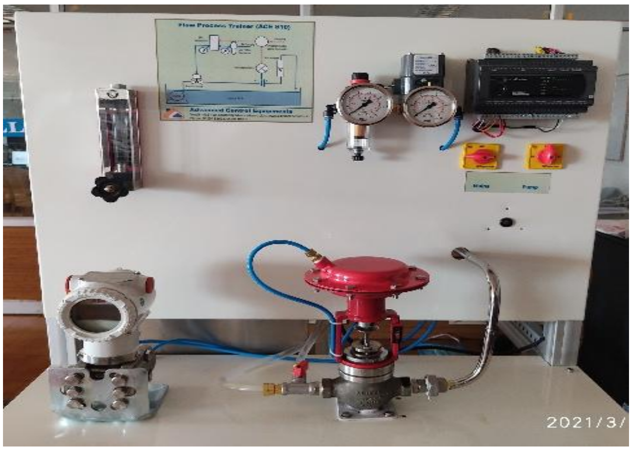
||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

and second one is the output variables which are used by fuzzy logic controller for the system control. The fuzzification unit converts data from measured values to appropriate linguistic data. Decision making unit is the most important part of a fuzzy logic controller and is capable of achieving the desired control strategy. [6] Fuzzy Logic Controller (FLC) enhances the closed loop performance of a PID controller in terms of handling change in an operating point for nonlinear processes by online updating the controller parameters. FLC works with a set of control rules, derived from expert's knowledge. Various fuzzy logic controller structures which are analogous to the conventional PID controllers are analysed using single or multiple input conditions (viz. error, change of error and rate of change of error). The fuzzy tuning parameters may be the choice of inputs, scaling factors, membership functions (number or type or both), rule base, fuzzification–defuzzification and inferencing techniques.

III. EXPERIMENTAL SETUP

The PLC-based flow method is intended to help you understand the components of a flow process and how to manage them. It consists of a pipeline with an orifice as a flow system and a flow-calibrated differential pressure transmitter. A pump and rotameter are attached to one end of the pipeline. The flow of the pipeline is controlled by a control valve that responds to a pressure signal of 3 to 15 psi. The signal pressure is converted from the controller's output (4-20mA) using a current to pressure (I/P) converter. A digital indicating controller controls the process parameter. The support frame houses these units, as well as the requisite piping. The set-up is intended for use on a tabletop. The set-up is intended for use on a tabletop. WPLSoft ladder logic software can be used to monitor the set-up. For monitoring and controlling the operation, the controller is connected to a computer through USB. To conduct various tests, user-friendly applications will be provided in conjunction with the hardware.



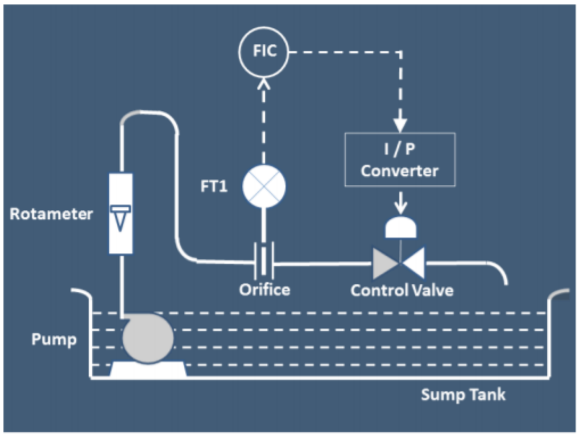


Fig 1: Experimental setup for flow monitoring and control system

IV. EXPERIMENTAL ANALYSIS

A PLC-based PID controller controls the level of opening control valves based on pressure signal monitoring to achieve the optimal constant flow rate. The optimised pressure signal is fed to the PLC controller from the pressure signal obtained for the control valve opening levels in order to make the decision.A Fuzzy controller is employed for this flow process along with a PID controller to determine the parameters required for the PID controller to produce a best response for the flow system, Thusthis paper aim in comparing and analysing the response obtained from the system with a PID controller where the gain values are tuned with different tuning methods and a system with a PID controller where the gain values for the PID controller are obtained using Fuzzy logic.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

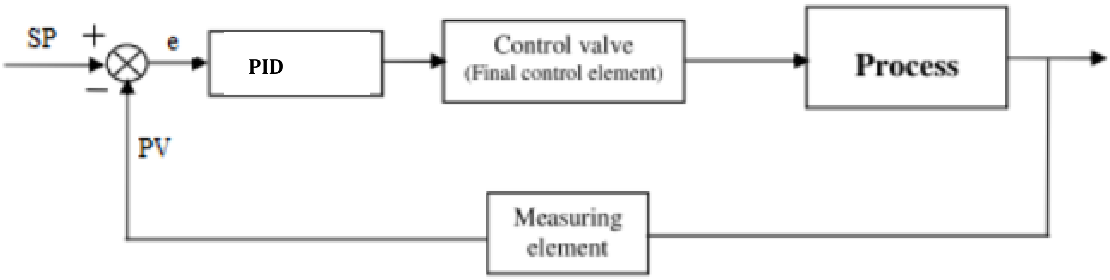


Fig 2: Experimental setup with PID controller for manual tuning

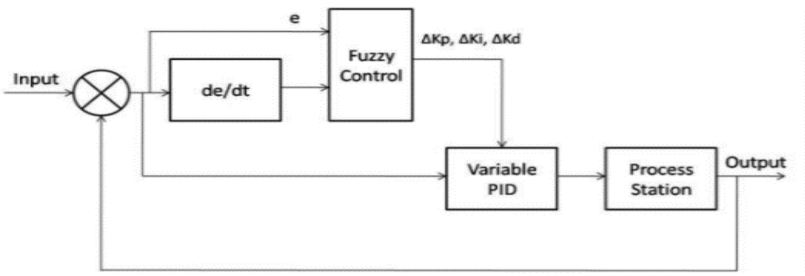


Fig 3: Experimental setup with Fuzzy logic controller for tuning with fuzzy

V. MANUAL TUNING OF PID CONTROLLER

A Proportional–Integral–Derivative controller is a control loop mechanism employing feedback that is widely used in industrial control systems and a variety of other applications requiring continuously modulated control. A PID controller continuously calculates an error value e(t) as the difference between a desired set-point (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively). In practical terms it automatically applies an accurate and responsive correction to a control function

A. *OPEN LOOP:*

An open-loop system, also known as a non-feedback system, is a continuous control system in which the output signal has no influence or effect on the input signal's control operation. In other words, the performance of an open-loop control device isn't evaluated or "fed back" for comparison with the input. As a result, regardless of the final result, an open-loop device is required to faithfully execute its input order or set point. Furthermore, since an open-loop system has no knowledge of the output state, it is unable to self-correct any errors it can create when the pre-set value drifts, even though major deviations from the pre-set value occur.

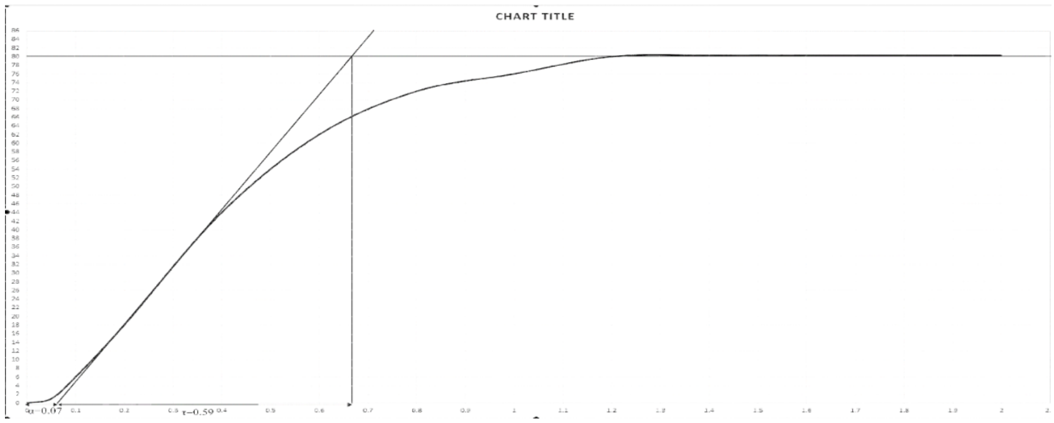
The experiment is carried out on a lab scale experimental device to determine the effect of pressure on the flow rate of liquid across transmission lines. In the open loop scheme, a transient response curve is recorded for model creation by controlling the pressure to obtain the corresponding liquid flow. In terms of nonlinearity, the curve depicts the effect of pressure on the flow rate and degree of complexity. The flow is regulated by opening the control valve based on the pressure sensor's three pressure signals.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021



T

Fig. 4 Process Reaction Curve obtained from the flow process (Open Loop)

$$G(s) = \frac{K\, e^{-t_d s}}{\tau s + 1}$$

K=80 is the final value of the system (at steady state)

$\boldsymbol{\tau}$**=0.465** sec, which is time taken to reach 63.2% of the final value(**K**)

$$G(s) = \frac{80\, e^{-0.05s}}{0.465s + 1}$$

$\boldsymbol{t_d}$= **0.05** sec, which is a dead time

The most common feedback controller used in industrial control is the three-mode controller (PID). Loop tuning is a tool for determining the best mode gains depending on the design and complexity of the operation. The three parameters should be chosen to achieve a set of predetermined objectives. These objectives usually call for a plant response with minimal steady-state error, load insensitivity, and a transient response to set point changes and disturbances.

B. *COHEN-COON*:

The Cohen-Coon method is known as a 'offline' tuning method, which means that once the input has reached steady-state, a phase change can be introduced. The performance can then be calculated using the time constant and time delay, and the response used to determine the initial control parameters. There are a number of pre-determined settings for the Cohen-Coon method to get a minimum offset and a normal decay ratio of 1/4(QDR). An answer with a 1/4(QDR) decay ratio has decreasing oscillations, with the second oscillation having 1/4 the amplitude of the first.

PID Parameters	Formula	For, k=80, α=0.07, τ=0.465
K_p Proportional gain	$\frac{1}{K}\frac{\tau}{\alpha}\left[\frac{4}{3}+\frac{1}{4}\left(\frac{\alpha}{\tau}\right)\right]$	0.118364
τ_i Integral Time	$\alpha\left[\frac{32+6\left(\frac{\alpha}{\tau}\right)}{13+8\left(\frac{\alpha}{\tau}\right)}\right]$	0.162150
τ_d Derivative Time	$\alpha\left[\frac{4}{11+2\left(\frac{\alpha}{\tau}\right)}\right]$	0.024776
K_i Integral Gain	$\frac{K_p}{\tau_i}$	0.729966
K_d Derivative Gain	$K_p\tau_d$	0.002933

Table1 PIDParameters obtained from Cohen-Coon tuning

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

C.*ZIEGLER-NICHOLS*:

This method is still commonly used to fine-tune proportional, integral, and derivative behaviour in controllers. The Ziegler-Nichols open-loop method is also known as a process reaction method because it measures the process's open-loop response to a shift in the control variable output. This basic test necessitates the recording of the system's response, which is best done with a plotter or device. Using various multiplier constants, those process response values can be plugged into the Ziegler-Nichols equation for the gains of a controller with P, PI, or PID behaviour.

PID Parameters	Formula	For $K = 80; \alpha = 0.07; \tau = 0.465$
K_p ProportionalGain	$\frac{1.2}{K}\frac{\tau}{\alpha}$	0.099643
τ_i Integral Time	2α	0.14
τ_d Derivative Time	0.5α	0.035
K_i IntegralGain	$\frac{K_p}{\tau_i}$	0.711736
K_d DerivativeGain	$K_p\tau_d$	0.003488

Table2PID Parameters obtained from Ziegler-Nichols First Method

VI. TUNING OF PID FUZZY LOGIC

Fuzzy Logic is a mathematical system that can deal with vague and unclear data that is difficult to measure using standard mathematics. Instead of two-valued logic (0, 1) or crisp sets, Fuzzy Logic uses Fuzzy sets in the continuous interval [0, 1]. The general configuration of the Fuzzy Logic system is shown in Figure 2. The Fuzzification interface uses membership functions to translate crisp input into a linguistic variable, while the Defuzzification interface uses membership functions to convert fuzzy output into crisp numbers. Centroid of Area, Mean of Maximum, and Largest of Maximum are common defuzzification methods. The rule base is a compilation of IF-THEN statements that reflect an expert's linguistic expertise, while the decision-making unit uses the Rule Base to translate Fuzzy inputs to Fuzzy outputs and decides how rules are enabled and combined using operators like AND, OR, and NOT. The most popular Fuzzy Inference Systems (FIS) are Mamdani and Takagi and Sugenofuzzy inference systems, which combine rule base and decision-making unit.Figure 2 portrays a general FLC block diagram. The error (e) and change of error (ce) are the most common FLC inputs; the outputs are scaled before being fed to the final element (e.g. Control Valve).

dkp dki dkd	**dERROR**				
	NB	**NS**	**ZE**	**PS**	**PB**
NB	S B B	B S ZE	B S ZE	B S ZE	B ZE B
NS	S B ZE	B S ZE	B S ZE	B ZE B	B S B
ZE	S S ZE	B B ZE	ZE ZE ZE	B B ZE	B S ZE
PS	S S B	B ZE ZE	ZE S ZE	B S B	B B ZE
PB	S ZE B	B S ZE	ZE S B	B S ZE	B B ZE

LEGENDS:

NB-Negative Big

NS-Negative Small

ZE-Zero Error

PS-Positive Small

PB-Positive Big

S- Small

B- Big

Table 3 Membership function for the fuzzy logic to tune the PID

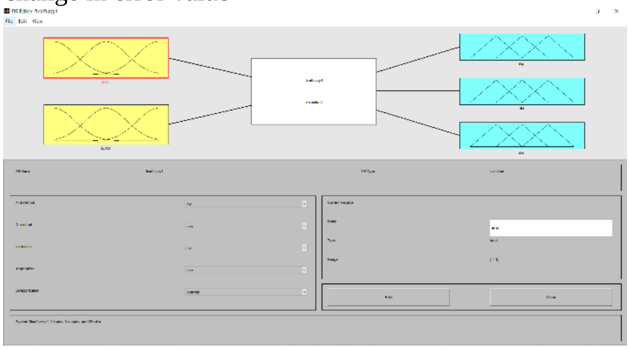
| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

A. *IMPLEMENTATION OF THE MEMBERSHIP FUNCTION IN FUZZY LOGIC USING MATLAB:*

The membership function created for thetuning of PID controller is mentioned in table 3 This function is implemented into the fuzzy logic controller via MATLAB and a corresponding rule base is created with two input variable error and derivative of the error and 3 output variable which gives output of dKp, dKi, dKd corresponding to the input error and change in error value



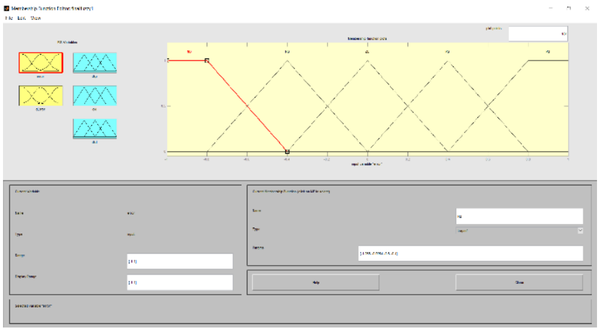
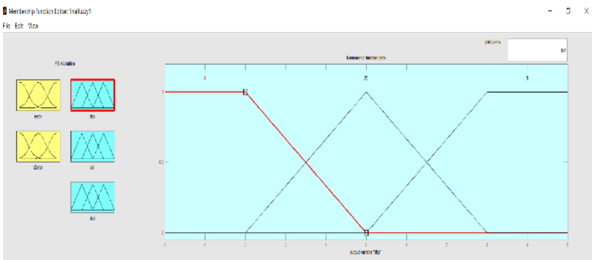
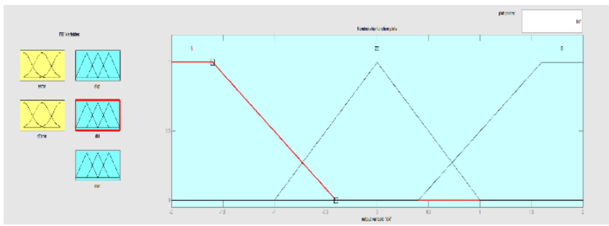


Fig 5. Fuzzy logic with 2 inputs and 3 outputs with a rule base

Fig 6. Membership function for error and change in error





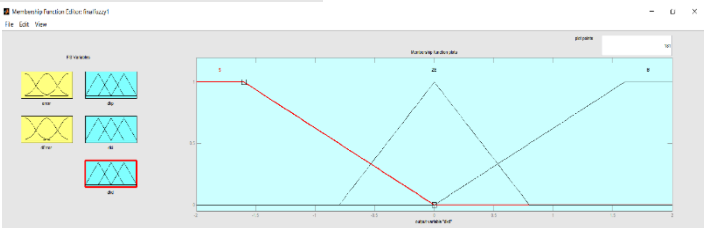


Fig 7. Membership function of the outputs dKp, dKi, dKd

Fig 8. Rules framed in fuzzy controller for PID tuning

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

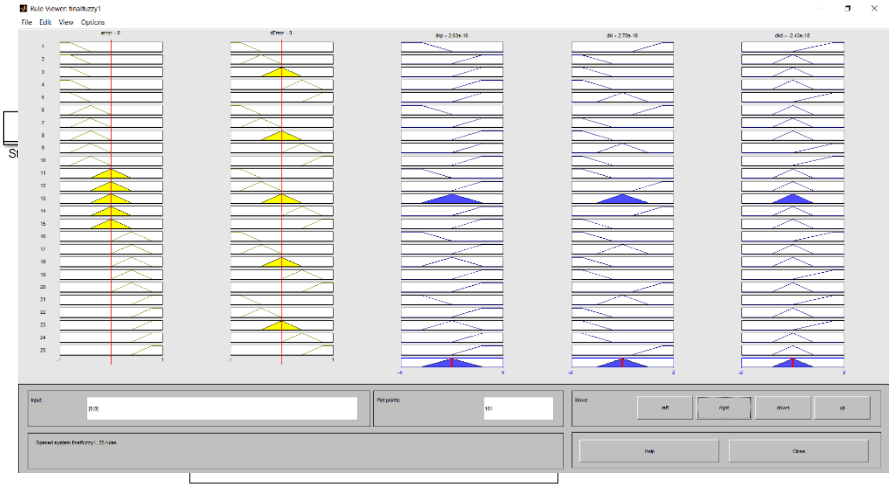


Fig 9. Implementation of Fuzzy-PID and conventional PID in flow process (Simulink model)

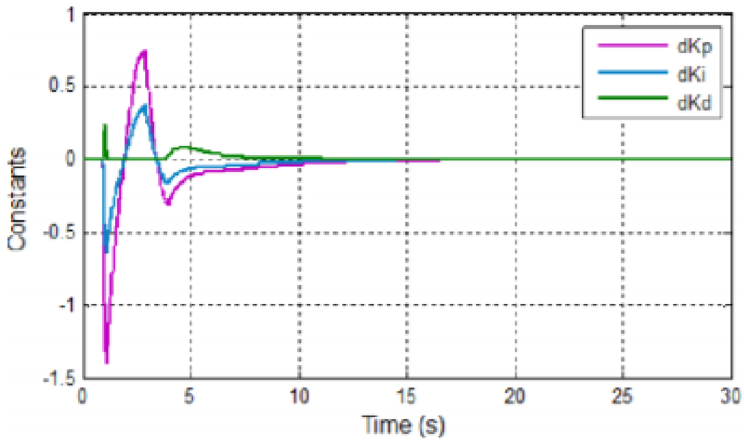


Fig 10. Response obtained from fuzzy logic controller

VII. RESULTS

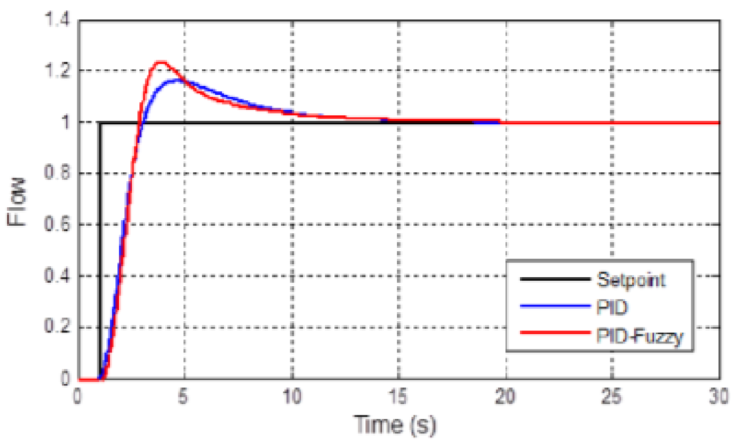


Fig 11. Response obtained from Conventional PID and PID-Fuzzy logic controller

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.122|

||Volume 10, Issue 3, March 2021||

DOI:10.15662/IJAREEIE.2021.1003021

Fig 11 shows the control characteristics that were obtained based on the simulation performance. The simulation results show that the PID-Fuzzy controller generates a better response in the linear condition than the PID controller, despite having more overshoot. For these two types of controllers, the control signal produced exceeds the maximum limit. With a value of about 0.6, the largest addition to the PID constant occurred at Kp.When comparing the results, it can be seen that the fuzzy logic controller takes a little longer to boost than the PID controller, but the system reaches its steady-state condition faster. When the system attempts to achieve its target location, the fluid flow fluctuates less, according to these experimental findings, if the fuzzy logic control algorithm is used as the system's controller. Fig 9 shows the output responses of Fuzzy logic controller that is dKp, dKi and dKd which are further fed to the PID controller block for controlling the system as gains (Kp, Ki, Kd)

VIII. CONCLUSION

The design of a self-tuning PID-Fuzzy controller for liquid flow control in a tank system has been completed successfully. When compared to the conventional PID controller, the simulation results show that the PID-Fuzzy controller can provide the best control response. The answer is generated by the fuzzy controller with a rise time of less than 1 second, a settling time of less than 6 seconds, and overshoots of less than 14%. The developed control signal does not exceed the maximum limit.More research is required to develop a more robust optimization process, especially to reduce the still-high overshoot. As a future development of this paper we can further add an anti-windup block after PID controller that eliminates the integral windup which will eventually yields better system response (faster than the proposed system)

REFERENCES

[1] SINA RAZVARZ, CRISTÓBAL VARGAS-JARILLO, RAHELEH JAFARI, AND ALEXANDER GEGOV, “Flow Control of Fluid in Pipelines Using PID Controller” IEEE Access, Digital Object Identifier 10.1109/ACCESS.2019.2897992, Feb.19

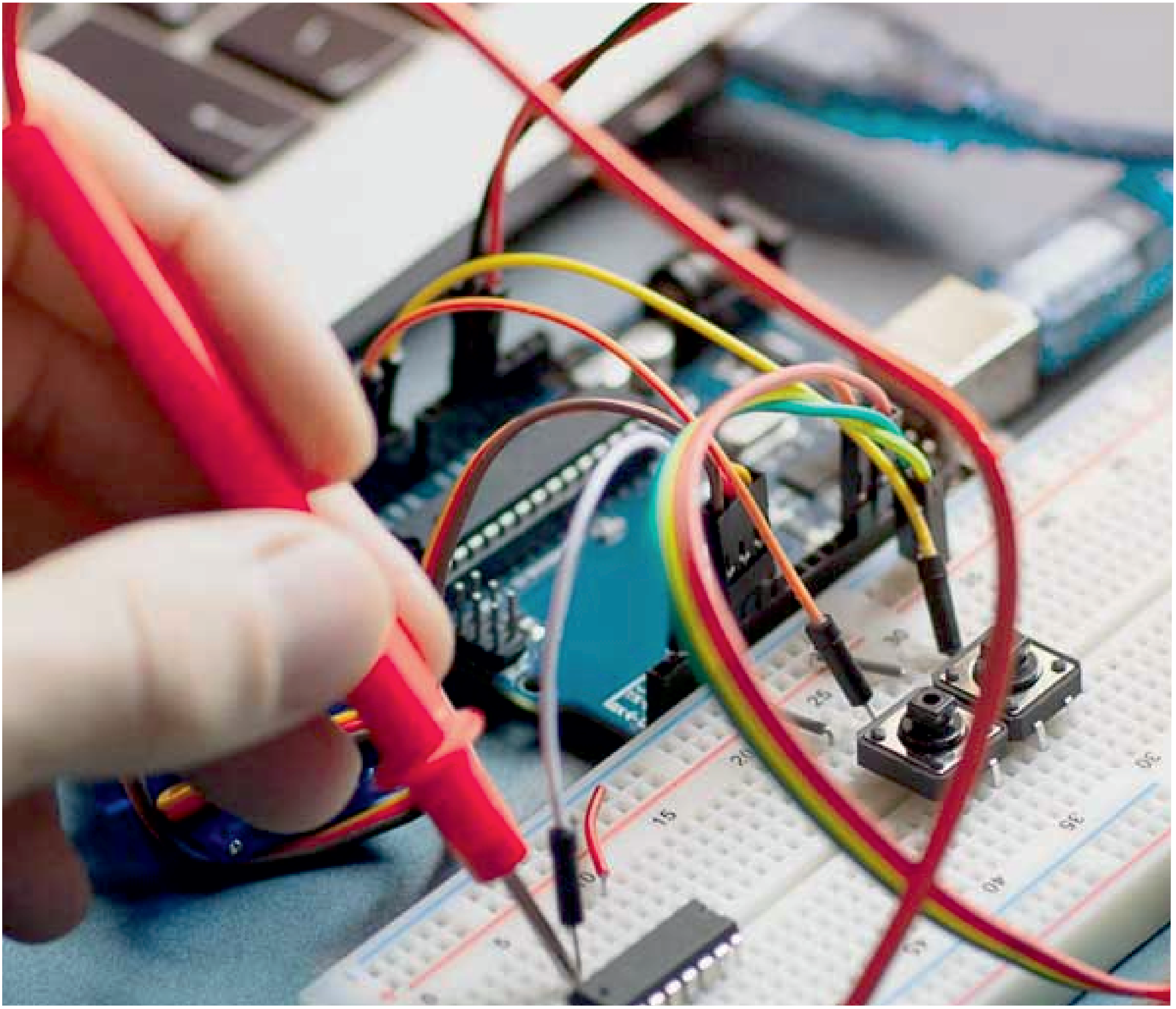
[2] E.B.Priyanka (PG Scholar), “REMOTE MONITORING AND CONTROL OF PRESSURE AND FLOW IN OIL PIPELINES TRANSPORT SYSTEM USING PLC BASED CONTROLLER” 2016 Online International Conference on Green Engineering and Technologies (IC-GET).

[3] Qi Xing Liu1, “Design of flow control system based on expert PID,” 2016 International Symposium on Computer, Consumer and Control.

[4] Tareq Aziz Hasan AL-Qutami, Rosdiazli Ibrahim., “Design of a Fuzzy Logic Process Controller for Flow Applications and Implementation in Series Tanks Pilot Plant,” 2015 International Conference on Industrial Instrumentation and Control (ICIC) College of Engineering Pune, India. May 28-30, 2015.

[5] Abdurrahman Unsal,Ahmetkabul, “MATLAB based Fluid Level Control using PID and FUZZY Logic Controllers”International Review on Modelling and Simulations Vol.4 N.6 Dec 2011.

[6] E.B. Priyanka⁎ , C. Maheswari, S. Thangavel., “Online Monitoring and Control of Flow rate in Oil Pipelines Transportation System by using PLC based Fuzzy-PID Controller” ELSEVIER, Flow Measurement and Instrumentation 62 (2018) 144–151.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 7.122

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

www.ijareeie.com

Scan to save the contact details