ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

Implementation of a Fuzzy and a PID scheme in LabVIEW for a Non Linear Level Process

Rishi Raj Saikia[1], Ramesh H.R.[2]

PG Scholar (C&I), Dept. of EE, UVCE, Bangalore, Karnataka, India[1]

Associate Professor, Dept. of EE, UVCE, Bangalore, Karnataka, India[2]

ABSTRACT: This paper deals with a trapezoidal tank level control schemes. The level of the process fluid is controlled using a conventional PID scheme and a Fuzzy control scheme. Both the controllers are implemented in LabVIEW and interfaced to the process using an arduino Mega2560. The defuzzification method chosen for the Fuzzy controller is Mamdani method and tuning of the PID controller is done using Ziegler-Nichol's oscillation method. The controlling of the level is done using a feed pump as actuator. The real time data from the process set up is used to find out performance criteria like IAE,ISE, rise time, peak time and percentage overshoot.

KEYWORDS: LabVIEW, arduino mega2560, Mamdani, PID, FUZZY, IAE, ISE, rise time, peak time,percentage overshoot.

I.INTRODUCTION

Liquid level control has always been a matter of utmost importance. A linear tank generally have a uniform cross sectional area, thus usually controllable using a conventional controller. But linear tank suffers from drawbacks like lack of complete discharge which results in accumulation of sediments and thus decreasing the tank life and also leads to choking of the outlet. Due to such issues the industries are currently moving towards non linear tank models like conical, spherical or trapezoidal which facilitates a better discharge. Moreover a trapezoidal tank provides a better cleaning solution. But due to the inherent nonlinear characteristic the level control itself becomes a challenging task. A conventional feedback controller in such scenario fails due to the inability to adapt the non linear nature, which leads to a high overshoot and in worst case a highly unstable oscillatory response. To cope up such situation periodic tuning of the controllers can be employed which itself is a cumbersome and costly practice.

A fuzzy controller on the other hand uses human like intuition and model less design approach which uses the knowledge of output variation due to input variation.

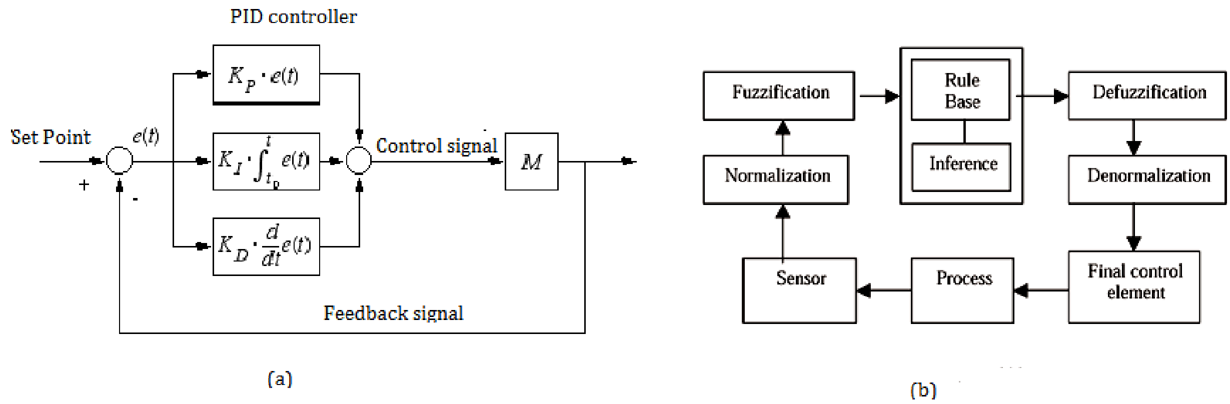


Fig.1.(a) A PID control scheme and (b) A Fuzzy control scheme

The fuzzy controller has four main components:
(1) The rule-base holds the set of rules, of how to control the system.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

(2) The inference mechanism evaluates which control rules are being on at the current time and then decides what should be the input to the plant.
(3) The fuzzification interface modifies the inputs so that they can be interpreted and compared to the rules in the rule-base.
(4) The defuzzification interface converts the conclusions reached by the inference mechanism into the crisp controller output.

II.PROCESS SETUP

The process setup used in here is consists of the following hardware:
Sump: The Sump is of dimension as length=24.5cm, breadth=19.5cm and height=34.5cm and is made up of transparent acrylic and also contains a submersible water pump as an actuator.
Process Tank: The upper process tank is of trapezoidal shape and with dimensions 21cms X 21cms at the bottom and 30cms X 21cms at the top and with a height of 22.5cms.

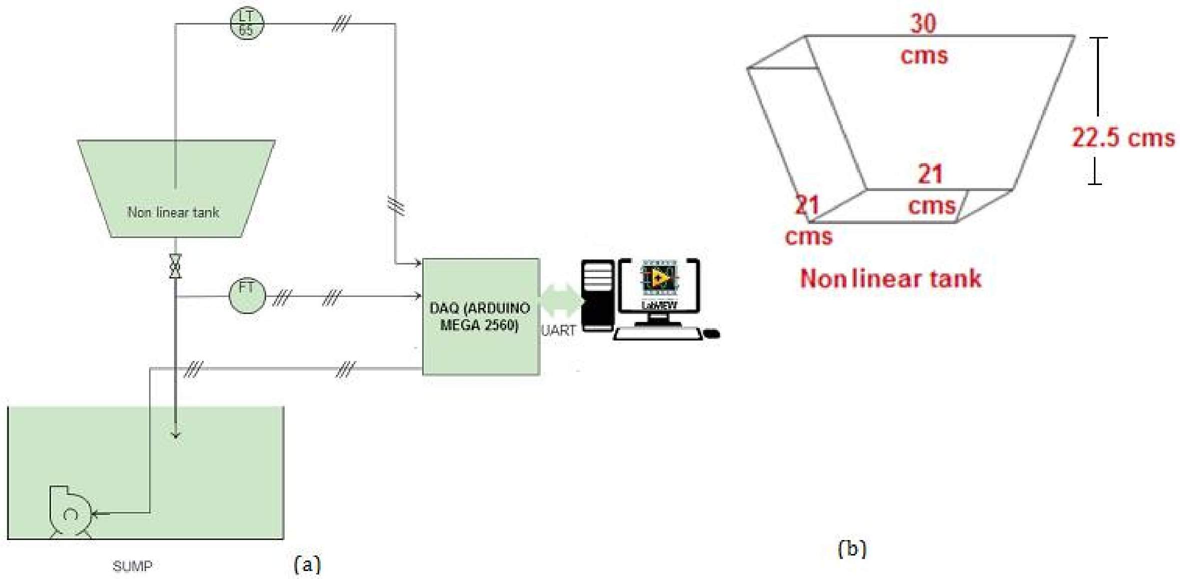


Fig.2. (a) System setup and (b) Non linear tank dimension

Level sensor (Ultrasonic): In this setup a non contact type level measurement is used. Here a HC-SR04 distance sensor is used to measure the depth. It uses +5V DC with effective Angle <15° and a ranging distance of 2cm to 400 cm
Flow Sensor (YF-S201): Hall Effect turbine type sensor with flow range: 2ltr/min to 9ltr/min with frequency range from 16 Hz to 65 Hz respectively with accuracy of ±10%.
Pump:It is a 12/24V submersible BLDC motor with a flow range of 2ltr/min to 20ltr/min for a PWM change from 5 to 100% or a control voltage 0f 0-5V.
Arduino Mega 2560: Here arduino mega 2560 is used for data acquisition.
Software toolkits: makerhub Linx, arduino ide and LabVIEW Fuzzy and PID toolkit

III.SYSTEM MODELLING

The system is modelled using mass balance principle and with assumptions that the specific gravity is constant for the liquid and also the fluid is incompressible.
The cross section area (A) of the non linear tank can be expressed in terms of height (h) as

$$A = 21^2 + 2 \times 21 \times \frac{4.5}{22.5} h \qquad (1)$$

The change in liquid volume is given by the following equation:
Rate of change of volume of liquid (v) = inflow (Qi) – outflow (Qo) (2)

$$dv/dt = Qi - Qo$$

Or

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

$$dAh\,/dt = Qi - C\sqrt{h} \quad \text{...where C = 22.6 a constant (at hs=6)} \quad (3)$$

$$dh/dt = \ (Qi - C\sqrt{h})/(441 + 18h) \quad (4)$$

Using Taylor series expansion and linearising at steady state hs=6, from equation (4) we have;

$$dh/dt = (Qi - Qis)/(441 + 18hs) - \ (h - hs)C/((2\sqrt{hs})(441 + 18hs)) \quad (5)$$

Considering $Qi - Qis = Q$ and $h - hs = H$ and taking Laplace transform of the above equation we get,

$$\frac{H(s)}{Q(s)} = \frac{(2\sqrt{hs})/C}{1 + (2\sqrt{hs})(441 + 18hs)/C} = \frac{k}{1 + Ts} \quad (6)$$

At hs=6

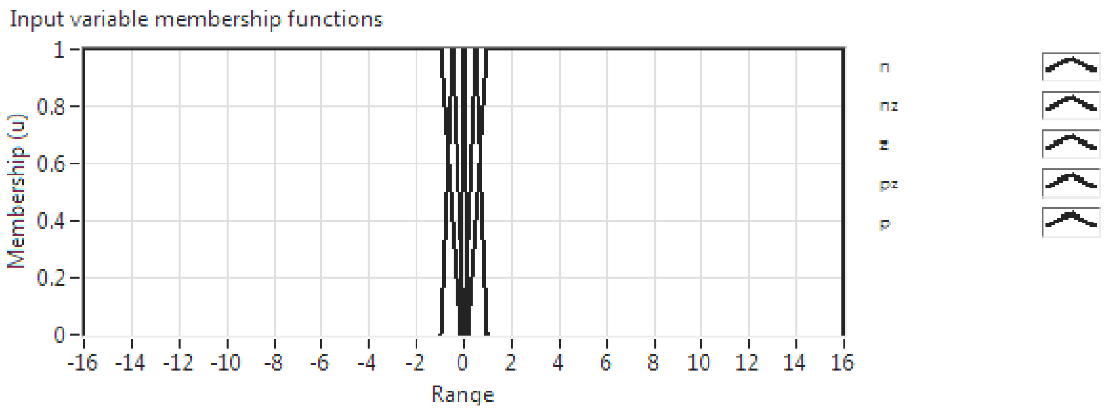
$$\frac{H(s)}{Q(s)} = \frac{0.22}{1 + 118s}$$

IV.FUZZY CONTROLLER DESIGN

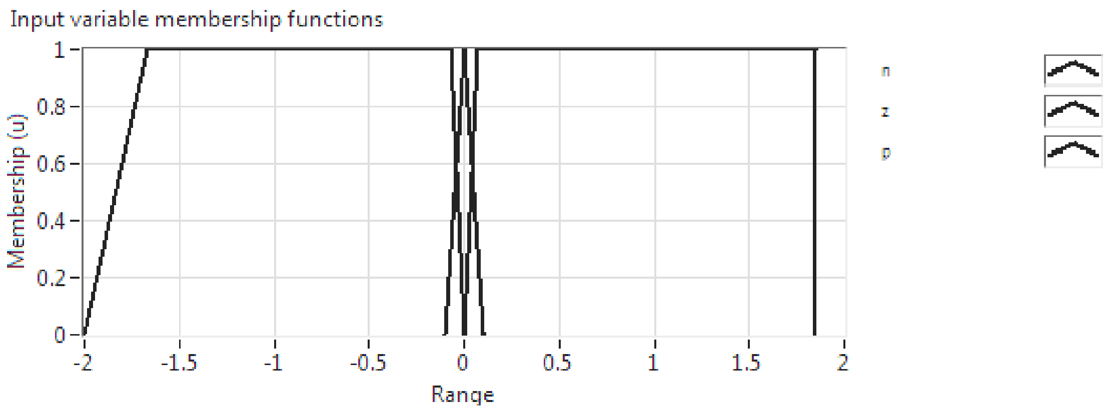
The Fuzzy system designer in LabVIEW is used to design the Fuzzy controller. The input variables to the system are being chosen as error ($e(t)$) and rate of error change ($\dot{e}(t)$). The output variable is the PWM output which is named as pwm.

Input:

$e(t)$ is divided into five subsets namely **Negative(n), Negative Zero(nz), Zero(z), Positive Zero(pz) and Positive(p)**.



(a)



(b)

Fig.3. Input membership functions for (a) $e(t)$ and (b) $\dot{e}(t)$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

$\dot{e}(t)$ is subdivided into three subsets namely **Negative(n), Zero(z) and Positive(p).**
The figure 3 shows both the inputs and their membership functions.

Output:

pwm is also divided five subsets namely **Very low(vl), Low(l), Medium(m), High(h) and Very high(vh)**.

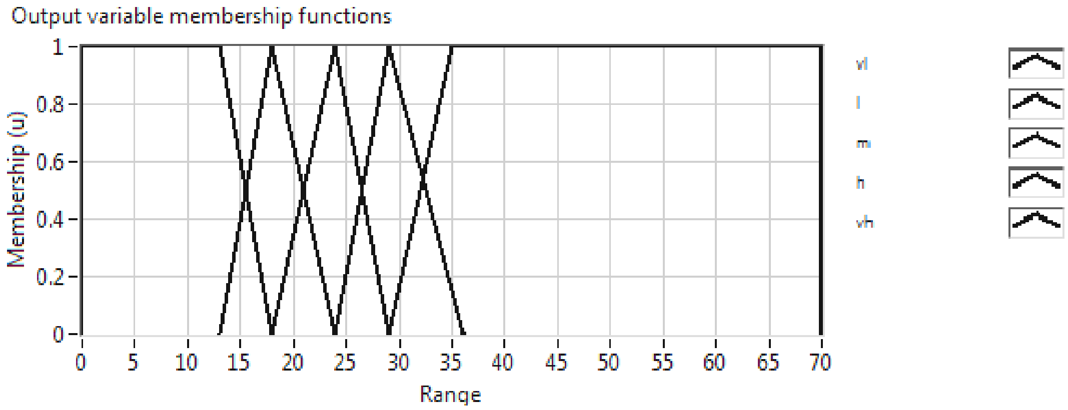


Fig.4. Output membership function

The rule-base for output is shown in a table below. The premise is determined by the minimum operator.

$\dot{e}(t)$ \ $e(t)$	n	nz	z	pz	p
n	vl	l	m	h	vh
z	vl	vl	m	h	vh
p	vl	l	m	h	vh

Table.1. Rule-base

Centre of area method is employed for defuzzification. The function output plot with the input relationship is shown below:

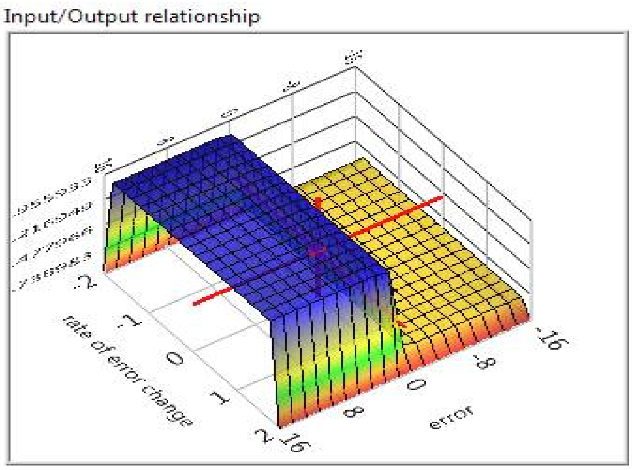


Fig.5. Antecedent and Consequent relationship surface

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

V. IMPLEMENTATION

Both the Fuzzy and the PID control scheme are implemented using the following subVIs.
Non linear sensor: This subVI takes the input from the level sensor and gives the output as level in the terms of cm.
Pump: This VI gives the PWM duty cycle for controlling of the pump.

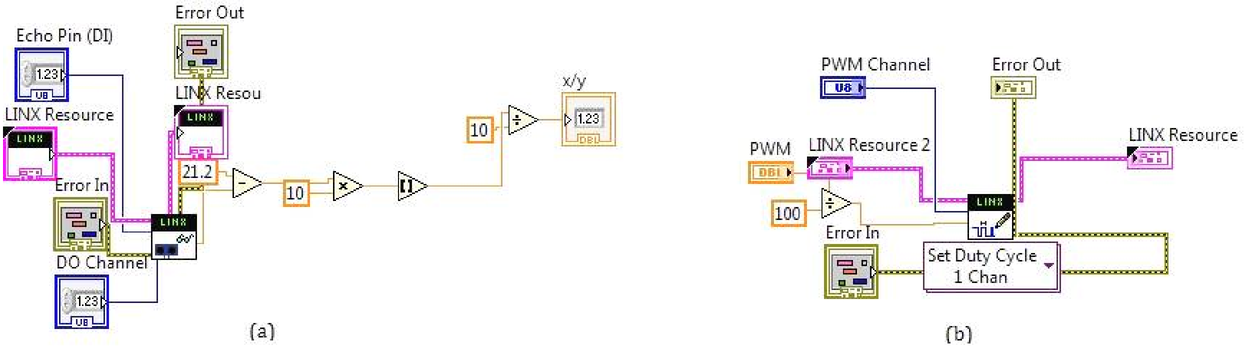


Fig.6. (a) Non linear sensor and (b) Pump VI

The block diagrams of PID control scheme and the Fuzzy control scheme is shown below.

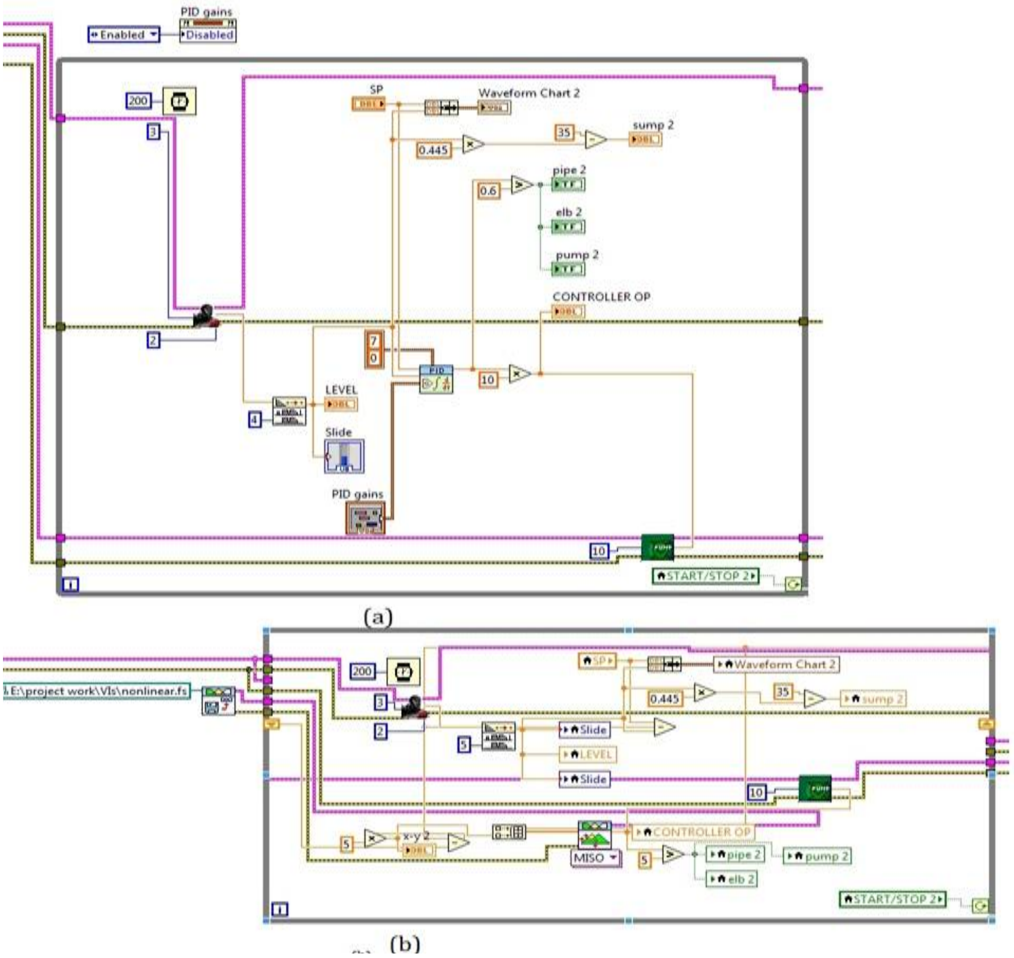


Fig.7. (a) PID control scheme and (b) Fuzzy control scheme block diagram

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

VI.RESULT AND DISCUSSION

The PID is tuned using Ziegler Nichol's closed loop tuning method. The tuned K_c, T_i and T_d values are found out to be $K_c = 2$, $T_i = 0.07$ min and $T_d = 0.005$ min.
The set point tracking is done for both the controllers and IAE, ISE is found out.

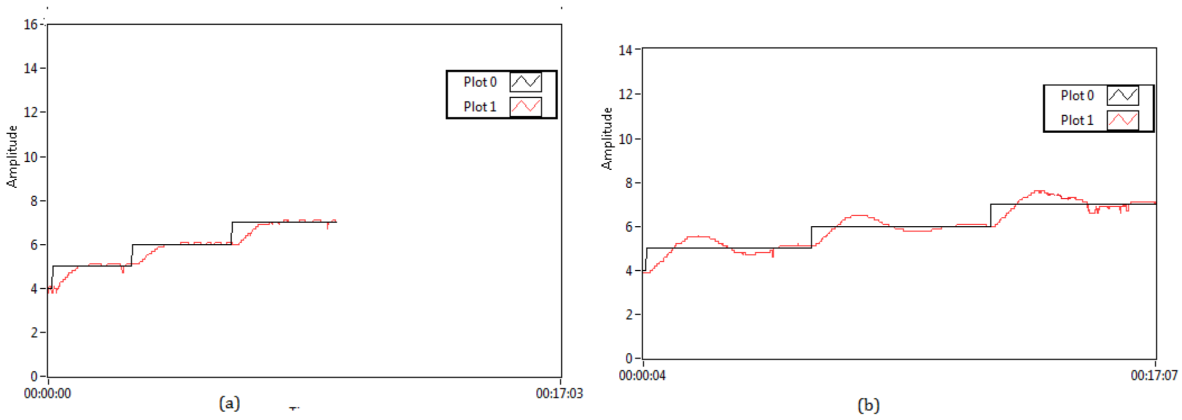


Fig.8. Real Time Set point tracking for (a) Fuzzy controller and (b) PID controller

The IAE and ISE for both the controllers are calculated for a step change from 4-5cm, 5-6cm and 6-7cm.

		PID	FUZZY
IAE	4-5 cm	50.6	37.4
	5-6 cm	75	38.9
	6-7 cm	85	43.5
ISE	4-5 cm	45.6	24.5
	5-6 cm	35.4	23.6
	6-7 cm	41.7	29.2

Table.2 PID and Fuzzy controller (IAE and ISE)

The maximum IAE for PID is found to be 85 whereas for Fuzzy its 37.4 which is twice. Similarly the maximum ISE for Fuzzy controller is found out to be 29.2 compared to 45.6 for PID scheme proving inability of PID to suppress large error.

	PID	Fuzzy
Settling time 1% error band(in sec)	230	90
Peak Time (in sec)	80	65
Rise Time (90%) (in sec)	50	54
Percentage Overshoot	40	0

Table.3 Transient response for PID and Fuzzy control scheme

The table 3 shows a better transient result in case of a Fuzzy controller in comparison to a PID controller. The PID shows a less rise time and a high settling time as compared to the Fuzzy controller. Moreover the percentage peak overshoot is zero for a Fuzzy controller.

VII.CONCLUSION

The real time data show that a Fuzzy controller is a better option in case of a non linear process in comparison to a conventional PID controller. Fuzzy controller is also better in suppressing large error which is evident from the low ISE. In situations demanding zero or very less overshoot and a low settling time Fuzzy controller is preferable.

REFERENCES

[1] Asst. Prof. Mrs. Deepa Shivshant Bhandarel and Dr. Prof. Mrs. N. R.Kulkarni " Performances Evaluation and Comparison of PID Controller and Fuzzy Logic Controller for Process Liquid Level control", 15th International Conference on Control, Automation and Systems
[2] Laith Abed Sabri, Hussein Ahmed AL-Mshat "Implementation of Fuzzy and PID Controller to Water Level System using LabView" International Journal of Computer Applications (0975 – 8887).
[3] Dharamniwas, Aziz Ahmad, Varun Redhu and Umesh Gupta "Liquid level control by using fuzzy logic controller" IJAET, ISSN: 2231-1963.
[4] "Labview PID and Fuzzy Logic Toolkit User Manual by National Instrument", 2009.
[5] Kevin M. Passino and Stephen Yurkovich "Fuzzy Control".
[6] ZHuo Wang and Qiang Wang "Application of Fuzzy Controller in Drum Water-level Control" 2011 International Conference on Mechatronic Science, Electric Engineering and Computer.
[7] Rishi Raj Saikia, Ramesh H.R. "Real Time Implementation and Performance Analysis of a PID and a Fuzzy Controller for a Linear Process using LabVIEW" 2016, IJAREEIE vol. 5 issue 5.
[8] Peter Bejoum Eyabi "Real time fuzzy logic and PID implemetation and control in LabVIEW" San Jose State University,SJSU ScholarWorks.
[9] T.Pushpaveni, S.Srinivasulu Raju, N.Archana, M.Chandana, "Modeling and Controlling of Conical tank system using adaptive controllers and performance comparison with conventional PID" International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May-2013