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Design and Control of Nonlinear Hybrid Tank Process using Conventional Controllers in Petrochemical Industries

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***Abstract:** In this paper the plan of customary controllers, which can be utilized for the control of non-straight frameworks to give an ideal degree of a nonlinear tank. The non linear process takes up for the examination is Hybrid tanks due to its utilization in the field of Pharmaceutical, petro chemical ect., Its non-linearity is because of the cross sectional conduct of the procedure because of the departure of items without wastage is conceivable. The shut circle execution are resolved to get the ideal level control utilizing customary P , PI, PID controllers for different systems like Ziegler Nicholas and Cohen coon technique. The real preferred position of this strategy is straightforwardness. Reproduction results utilizing MATLAB programming to decide the outperformance of controller strategies.*

***Keywords:** Hybrid Tank, Level Control, P, PI and PID controller, Petrochemical Industries, MATLAB software.*

I. INTRODUCTION

In numerous method organizations like Parma industries, Petro-chemical ventures, Paper production industry, water treatment Industries, the essential problem is to direct the system variables and to achieve perfect reference point. It has been imperative to direct the process variables like level of liquid, stream, fail to do thus several lead to real shutdown of process. So it has been imperative to keep up the variables of the hybrid process tank at explicit reference point [5]. Most by far of the undertakings oversee non-direct methodology tank, for instance, cone molded, round, Hybrid tanks. The control of non-direct condition of the hybrid tank gives a troublesome endeavour in organizations. It is relied upon to nonlinearity & constantly varying cross section. The essential purpose of this work is to direct the liquid level in a non-linear system. The nonlinear structure taken-up for the examination is a Hybrid process tank. Due to shape of Hybrid process tank the unrefined possessions can be masterminded successfully and rapidly. It can prepare to stock up colossal measure of system parameters due to round and hollow shape [5] at the top, which can be extended reliant on the needs. It gives a snappy and sterile maintenance. The unrefined substance may join solvents, slurries, gooey solids and liquids. To desert the rusting and keep up the movement of system impartially should be conceivable with a cone like part open at the base of the structure. A large portion of the sullying happening as a result of spillage, overloading of process tank, decreased exercise and meagre behaviour workplaces should be avoided. The benchmark errand of controller setup is to achieve ideal operational situation and to configuration the controller to realize it's largely incredible implementation [5].

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II. MODELLING OF HYBRID TANK

The modelling of Hybrid tank process is the grouping of cylindrical and conical Region[1]. The tank model of the conical portion can be obtained, by considering with assumption. Those assumptions are,

- Control variable (liquid level)
- The manipulated parameter (tank flow)
- Controlling inlet flow rate of the tank.

The schematic structure of Hybrid process tank is shown in figure 1.

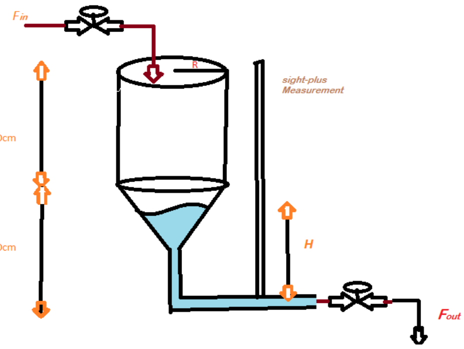

Figure 1. Hybrid Process tank setup

As it is a Hybrid tank Process two regions are considered. The storage portion is a cylindrical tank and the disposal region as the conical tank

Modelling of cylindrical region

The Outlet flow rate of hybrid tank is proportional to square root of liquid level of the tank and hence its transfer function [5] is given as

$$G(s) = \frac{h1(s)}{Fin(s)} = \frac{K}{\tau s + 1}$$

Where, Area of tank is constant in cylinder portion. It is not changing with respect to height h_1[5].

Modelling of conical portion of hybrid tank

The Non-Linear model using mass balance equation is

$$Fin - Fout = A.\frac{dh1}{dt}$$

$$Fin - Bo\sqrt{h1} = A.\frac{dh1}{dt}$$

After applying Linearization by partial discrimination, transfer model of conical portion is approximated to a first order transfer model [8] which varies with respect to the liquid height of process tank.

$$G(s) = \frac{h1(s)}{Fin(s)} = \frac{Kp}{\tau s + 1}$$

Where;

$K_p=2\sqrt{h_1}/B_o$; $B_o=a_1\sqrt{2g}$; $T=2A\sqrt{h_1}/B_o$
Kp- System Process Gain;
τ-Time Constant of process;
a_1- Conical Bottom Outlet Area;
h_1-Nominal liquid level;
A-Area at liquid height h_1;
B_o- Discharge constant.

2.1 Design Specifications

Based on the design necessity in a Petrochemical industry for the storage space purpose
H- Height of the conical section =60cm;
R- Cylindrical section Radius = 15cm;
r- Conical exit portion radius =1.25cm;
h_1- Nominal liquid level of tank=40cm;
Transfer function [5] model at the nominal liquid level 60cm,

$$G(s) = \frac{0.07126}{50.38s + 1} e^{-11.12s}$$

III. CONTROLLER TUNING TECHNIQUES

3.1 Ziegler Nicholas Method

The ZN tuning technique is a heuristic technique [5, 6] of fine-tuning a conventional controller. It is performed by setting I and D addition to zero. The relative gain P, K_p is then expanded until it arrives at a critical gain Ko, at which the yield of the control circle has steady and reliable oscillations. Ku and the critical time period Po are utilized to set the P, I and D additions relying upon the kind of controller utilized[3].

Table 1. Ziegler Nicholas Tuning Formulas [8]

Controller	Kc	τi	τd
P	0.5 Ko	----	----
P I	0.45Ko	Po/1.2	----
P I D	0.6Ko	Po/2	Po/8

Table 2. Ziegler Nicholas Tuning Values

Controller	Kc	τi	τd
P	68.25	--	--
PI	61.43	2.296	
PID	81.19	1.3776	0.3444

3.2 Cohen Coon Tuning Technique

The Cohen coon tuning [11] set of laws are suitable to a wider range of process. The tuning formulas applying in this technique works fine just on processes which is having delay time is less than 2 times the length of the time period constant. CC tuning method gives one of merely a handful couple of sets of tuning rules that has regulates for PID controllers.

Table 3. Cohen Coon Tuning Formulas

Controller	Kc	τi	τd
P	Kc= (1.03)/gp[τ/Td+0.34]	----	----
PI	Kc= (0.9)/gp[τ/Td+0.092]	Ti=3.33Td*[(τ+0.0092td)/(τ+2.22td)]	----
PID	Kc= (1.35)/gp[τ/Td+0.185]	Ti=2.5Td*[(τ+0.185td)/(τ+0.611td)]	Td=0.37Td*[τ/(τ+0.185td)]

Table 4. Cohen Coon Tuning Values

Controller	Kc	τi	τd
P	70.3993	--	--
PI	1.7020	0.067	--
PID	8.66	0.35	0.2

IV. RESULTS AND ANALYSIS

The controller tuning techniques [12] are employed for required transfer model is to achieve an ideal reference point. The desired reference point measured at 50cm. The reaction acquired from the ZN strategy and the CC techniques were analyzed and its yield is appeared in figure 2 and figure 3.

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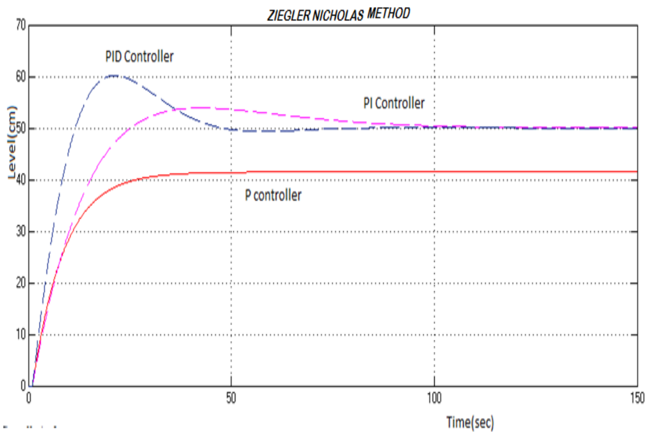

Figure 2. Controller Response with ZN Tuning method

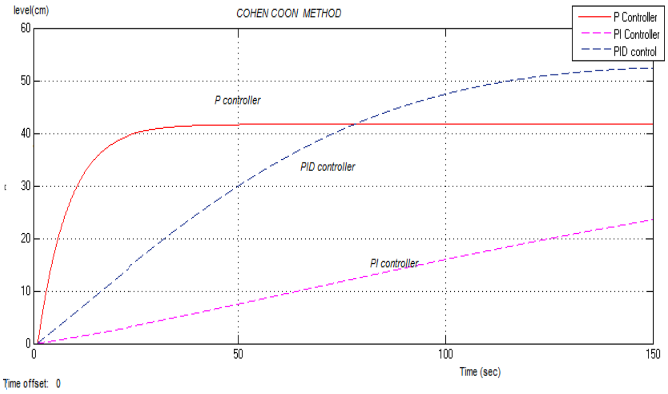

Figure 3. Controller Response with CC method

The performance of these tuning strategies are looked at dependent on the Time domain Analysis to keep up a quicker setting time and the error is diminished utilizing Time Integral performance investigation

Table 4. Comparison Time Domain Analysis ZN & CC Method

Controllers	Time Domain Parameters	Ziegler Nicholas Method	Cohen Coon Method
P	Rise Time	17.7559	122.6811
	Settling Time	129.8610	154.6142
	Overshoot	33.6931	0
	Peak	1.1340	0.0515
	Peaktime	55	161
PI	Rise Time	46.0519	142.2956
	Settling Time	116.1862	157.9859
	Overshoot	2.8216	0
	Peak	1.0484	0.2553
	Peaktime	90	161
PID	Rise Time	46.0519	25.606
	Settling Time	116.1866	160.8158
	Overshoot	2.8216	0
	Peak	1.0484	2..3939e+07
	Peak Time	90	161

Table 5. Time Integral Values Obtained with ZN & CC Tuning Method

Controllers	Time Integral Parameters	Cohen Coon Methods	Ziegler Nicholas Method
P	ISE	6.885e+04	7.082e+04
	IAE	400	400
	ITAE	2.033e+04	2.033e+04
PI	ISE	1.954e+05	1.766e+04
	IAE	400	400
	ITAE	2.033e+04	2.033e+04
PID	ISE	5.766e+04	5.212e+168
	IAE	400	400
	ITAE	2.033e+04	2.033e+04

The Level control in a Petrochemical industry is a significant issue without the wastage of Petroleum by Products. It is accomplished by utilizing tuning controller procedures like Ziegler Nicholas technique and Cohen Coon strategy. Different controller techniques like P, PI, PID were finished. Examination is set aside a few minutes' space parameters and time fundamental execution criteria. It was broke down from the outcomes that Ziegler Nicholas PID technique gives better execution with least settling time.

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