International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 9, September- 2014

A Novel Method of Controller Design For Desired Closed Loop Performance

Devashish
NIT Patna

Amit Kumar Suman
NIT Patna

***Abstract*— In most of the control application, which uses PID controller, tuning is very important to get desired closed loop performance. PID tuning is the name given to the adjustment of three parameter- Kp, Ki & Kd to achieve desired closed loop performance. The Ziegler Nicholas tuning is the father of the most of tuning method which are being adopted nowadays. The most tuning method has been designed on the basis of knowledge obtained from Ziegler Nicholas tuning. This paper presents a computational approach for tuning using MATLAB programming. Desired result will be obtained using 3rd order of system transfer function and result will be compared with Ziegler Nicholas and some other previous existing work.**

Keywords—PID Controller,Compuatational approach,Matlab

I. INTRODUCTION

The PID controller are the best known and widely used controller in industrial control process, because of their simple structure ,robustness and disturbance rejection capacity .The design of PID controller require proper adjustment of three parameter (proportional gain kp, derivative time constant Td and integral time constant Ti) to get desired closed loop performance. Several efforts has been made to reduce time for getting appropriate value of these three parameter. The result obtained after Ziegler Nicholas tuning is often not what is desired. So in order to get exact desired response one has to make different "Hit and trial" ,which is too time consuming. So main purpose of this work is to develop a novel controller using MATLAB to get desired response, when mathematical model of system is known.

II. MODELLING OF CONTROLLER

PID controller is a control closed loop feedback structure. It has three different parameters; the proportional gain Kp, the integral time Ti and derivative time Td.

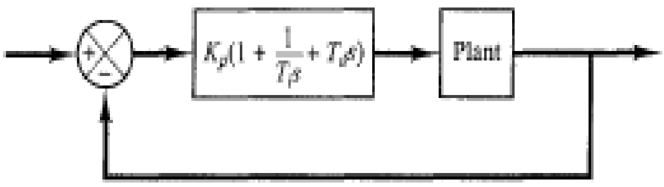

Figure 2.1 : Block diagram of PID Controller

PID controllers tuning has always been an area of vast research in any process control industry. Ziegler Nichols Method (ZN) is one of the oldest and widely used methods of tuning, on basis of which many tuning formula has been derived so far. It gives elementary knowledge for PID Tuning. "Tuning" is the name given to adjustment of the three parameters of the PID controller to obtain desired closed loop performance.

There are two basic rules of Ziegler Nicholas for tuning of PID controller. We will discuss second rule for modelling of our controller. In the second method two parameter ki and Kd of PID controller is set to be zer o. Using proportional gain only, Kp is increased from 0 to a critical value Ks at which response exhibit sustained oscillation first. If it (sustained oscillation) doesn't occur, then this method cannot be applied. Thus in this way critical gain Ks and corresponding period Pcr is calculated.

$$Gc(s)= \quad Kp(1+\frac{1}{Tis} + Tds)$$

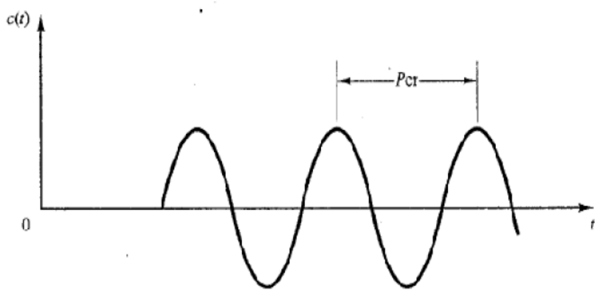

Fig 2.2-Sustained oscillation

Type of controller	Kp	Ti	Td
PID	0.6Kcr	0.5Pcr	0.125Pcr

Table-2.1

Putting these values in the standard equation of PID controller. We will get

$$\mathbf{Gc(s)=0.075}\, \boldsymbol{Ks\ Pcr}\, \frac{(s+4/Pcr)^{2}}{s}$$

Now we can redefined this equation in two different parameter and t.where l=0.075Ks Pcr and t=4/Pcr. Rewriting the above equation .

$$\mathbf{Gc(s)=k}\frac{(s+a)^{2}}{s}$$

It can be seen from above equation that the transfer function of a PID controller can be written also in this way.Where instead of three unknown ,Kp.Ti,Td ,we have to find only two, l and t.

III. SYSTEM DESIGN :A CHEMICAL REACTOR

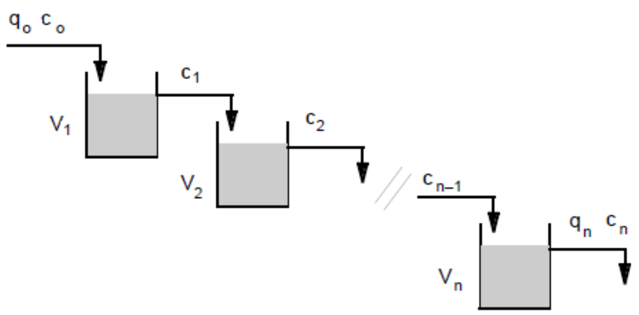

Figure 3.1:-“n” number of vessel in series

A third order system chemical reactor system has been taken in .same transfer function has been used here. which is of third order.[5]

$$\mathbf{G(s)} = \frac{1}{(S+1)(S+3)(S+5)}$$

IV. DESIGN OF CONTROLLER USING COMPUTATIONAL APPROACH.

In this section the set of all parameter value that will give required transient specification will be searched. After Mathematical calculation or MATLAB simulation we get value of ,k=19 and a=3.05.We will search all possible value of k and a around these values. This educated guess of K and a we get from Ziegler Nicholas tuning itself.

MATLAB PROGRAM

```
“t=0:0.01:10;% Time Range
l=0;
for k=5:0.1:50;%Range for 'k'
 for a=0.5:0.1:20;%Range for 'a'
num= [k 2*k*a k*a^2];%Numerator
coeficient
den= [1 9 23+k 15+2*a*k
k*a^2];%Denominator coefficient
y=step(num,den,t);%Step response
s=1001;%Initialization
 while y(s)>0.99 & y(s)<1.01;%Range for
overshoot
s=s-1;
end;
ts=(s-1)*.01;%settling time
m=max(y);
if m<1.01;
if ts<3.0;
l=l+1;
solution(l,:) = [k a m ts];%solution for
'K','a','m','ts'.
end
end
end
end% End for all loop”
```

RESULT

The result obtained after running the above program is tabulated below .where Mp is peak overshoot and Ts is the settling time of the transient response.

K	a	Mp	Ts
20.6000	1.3000	1.0005	2.4600
20.6000	1.4000	1.0023	1.9000
20.6000	**1.5000**	**1.0090**	**0.7600**
20.7000	1.3000	1.0005	2.4600
20.7000	1.4000	1.0023	1.9000
20.7000	1.5000	1.0098	0.7600
20.8000	1.3000	1.0005	2.4500
20.8000	1.4000	1.0023	1.8900
20.9000	1.3000	1.0005	2.4400
20.9000	1.4000	1.0023	1.8900
21.0000	1.3000	1.0005	2.4300
21.0000	1.4000	1.0023	1.8900
21.1000	1.3000	1.0005	2.4200

Selection of Parameter

These are the some list of set of value for controller parameter "k" and "a" and corresponding performance specification, peak overshoot,Mp and settling time Ts. We will select those parameter which we need as per our requirement. Our system is chemical reactor so there should be minimal settling time and least overshoot. So we will select the value which is marked in bold, as it gives minimum settling time of all.

V. RESULT

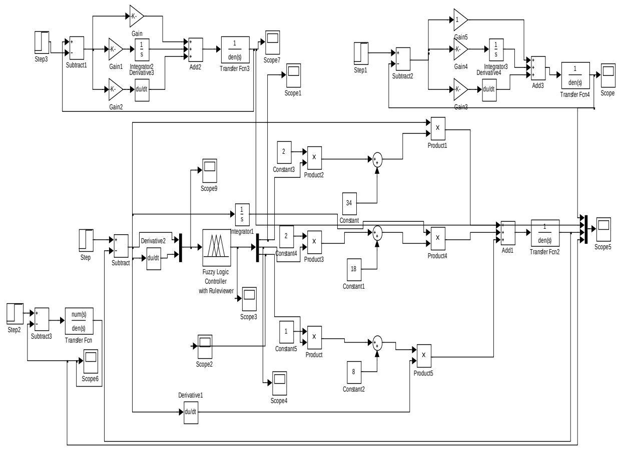

Fig 5.1: Simulink Model

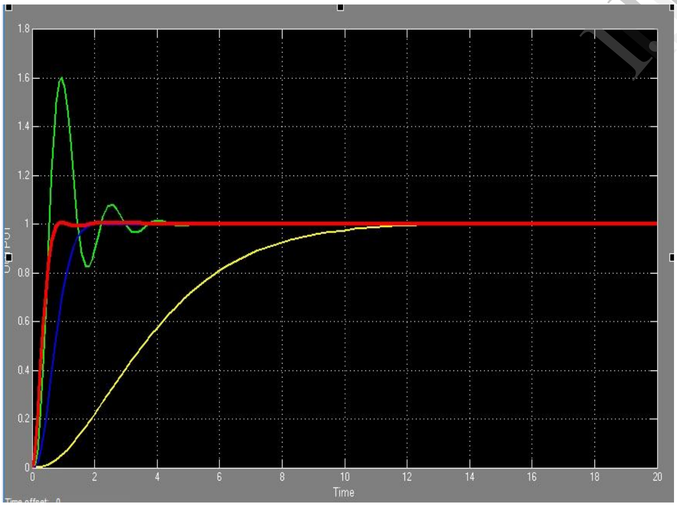

Fig 5.2: output Response

VI. DISCUSSION OF RESULT

For comparison purpose we have put result of some of the previous work with same system and input. The response marked in green is the result obtained by Ziegler Nicholas Tuning, which has largest overshoot. The response marked in yellow is the tuning by Salem [1], which has though no overshoot but has largest rise time. The response marked in blue[8] has smooth response having no overshoot but larger rise time than that of proposed method. The response shown in Red is due to computational approach .It can be seen easily that it has best performance in terms of settling time, rise time and peak overshoot.

Tuning Method	Rise Time (Sec)	Maximum Overshoot	Settling Time(Sec)
Ziegler Nicholas	<1	60%	5
Salem	12	No	13
Fuzzy Tuned	2	NO	2
Computational Approach	<1	<1%	1.8

Table-6.1

Vii. CONCLUSION

In this paper, PID controller design method using a novel computational method has been discussed. The main advantage of this method lie in the fact that it saves much of time, that is being used in heat and trial after Ziegler and Nicholas Tuning to get desired result. It works on the basis of data obtained by Ziegler and Nicholas Tuning. In other word it can be said Ziegler Nicholas Tuning provides an educated guess of parameter selection for the proposed computational approach .Performance obtained with this controller is very much as per requirement.

VIII. FUTURE SCOPE

In future, some code will be introduced to check whether controller designed by this proposed method will be stable or not. Gain and phase margin concept will be used in the program for this purpose.

REFERENCES

1. New efficient model-based PID design method Farhan A. Salem, PhD, European Scientific Journal May 2013 edition vol.9, No.15 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431
2. Study on PID parameters tuning method based on Matlab/simulink Supping Li, Quansheng Jian Chaohu University Chaohu 238000, China e-mail:lsp20061002@126.com. 978-1-61284-486-2/11/$26.00 ©2011 IEEE
3. Design and Simulation on PID Variable Damping Ratio Controller of Second-order System 978-1-4244-7941-2/10/$26.00 ©2010 IEEE
4. K.H. Ang, G. Chong and Y. Li, "PID control system analysis, design and technology," IEEE transaction on Control System Technology, Vol.13, No.4, 2005
5. Chemical Process Control: A First Course with MATLAB Pao C. Chau University of California, San Diego
6. IG.Ziegler and N.B.Nichols, "Optimum settings for automatic controllers," Trans.ASME, vol.64, pp. 759-768, 1942.
7. Katsuhiko Ogata, modern control engineering, third edition, prentice hall -2001
8. "PID controller tuning for optimal closed loop performance" by Devashish in International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181Vol. 3 Issue 6, June - 2014