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CONTROLLER OF PRESSURE TANK USING DEADBEAT AND KALMAN S ALGORITHM

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ABSTRACT-***The control of process parameters is an important aspect in any process industry. This Paper deals with the design method for determining the optimal proportional integral derivative (PID) controller parameters of linear system is implemented in split range controller process station system for controlling pressure using the Deadbeat and Kalmans algorithm. The proposed approach had superior features, including easy implementation, stable convergence characteristic, and good computational efficiency. Fast tuning of optimum PID controller parameters yields high-quality solution by iterative checking of the optimum time response features. In order to produce constrained iteration, we have modeled the system using MATLAB. So that, accurate values of the controller tuning parameters and optimum steady state output are obtained. The iteration process is updated based on minimum value of settling time which is obtained from MATLAB simulation. When compared with the PID, Deadbeat and Kalmans algorithm method, the proposed method is indeed more efficient and robust in improving the step response of the pressure tank system.***

Keywords: PID, linear system, MATLAB, deadbeat and kalman s algorithm.

I.INTRODUCTION

Measurement of pressure, temperature, level and flow parameters are very vital in all Process Industries. Real time systems provide many challenging control problems due to their dynamic behavior, uncertainty and time varying parameters, constraints on manipulated variables, dead time on input and measurements, interaction between manipulated and controlled variables and unmeasured frequent disturbances. Because of the inherent nonlinearity, most of the chemical process industries are in need of modern control techniques. Nonlinear systems like pressure tanks find wide applications in gas plants and petrochemical industries. Control of pressure in split range controller process station is a complex issue, because the change in shape gives rise to the nonlinearity. The nonlinearities may also due to the saturation-type introduced by maximum or minimum allowed pressure in tanks and pneumatic valves.

The most basic and pervasive control algorithm used in the feedback control is the Proportional Integral and Derivative (PID) control algorithm. PID control is a widely used control strategy to control most of the industrial automation processes because of its remarkable efficiency, simplicity of implementation and broad applicability. Long history of its practical use and proficient working dynamics are some of the pivotal reasons behind the large acceptance of the PID control. A PID controller attempts to correct the error between a measured process variable and a desired set point by calculating and then providing a corrective action that can adjust the process accordingly.

Deadbeat algorithm is to designed to drive a plant output from an arbitrary initial state to a desired final state in the minimum number of sampling times and in such way that after the output matches the input for the first time ,the output becomes identical to the input at all sampling instants, exhibiting little or no ripple between them and the design of the deadbeat algorithm depends on knowing the model of the plant, and it is normally carried out for a specific type of input ,such as a step or a ramp function.

Kalman filtering, also known as linear quadratic estimation is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone. The filter is named after Rudolf E. Kalman one of the primary developers of its theory.

In this paper, the modeling of the system, calibration of various transmitters associated with the pressure tank system, tuning of PID parameters for the pressure control of a split range controller power station is considered. The closed loop test is performed to obtain Process Reaction Curve and mathematical model of the process. Based on the mathematical model gain tuning of the PID controller is done using Ziegler Nichols tuning method which is implemented in the real time system to get optimum settling time and minimum steady state error.

II. PROPOSEDWORK

In this paper real time is designed for controlling the split range controller process station. This model is experimentally analyzed for tunings the PID using the MATLAB software.

A. Closed loop test

Split range controller process is obtained in a PID control using closed loop system. In the process Z N method is used for tuning the PID controller. Closed loop system .LABVIEW block diagram and front panel for closed loop system in split range controller process as been shown in the figure with the output response of the system.

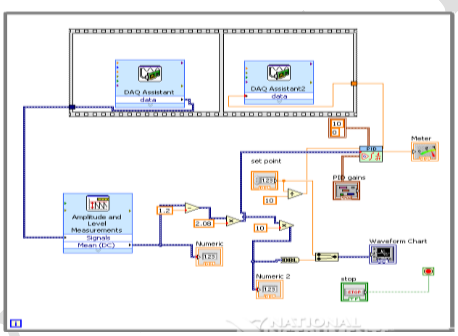

Figure 1 LabVIEW Block Diagram for split range controller process.

The figure 2.1 depicts that the data is acquired through the input pins of DAQ and the signals are generated through output pins of DAQ. The error is subtracted from the analog signal. In order to convert it into voltage of optimum range it is then multiplied with a constant value after which it is fed to the PID controller. The controller takes the control action according to the set point given. The output of the controller is given to a waveform chart for better understanding

When a new VI is opened, the front panel window of the VI appears and functions as the graphical user interface or GUI of VI. The front panel window contains a toolbar across the top and a control palette that is accessed by right-clicking anywhere on the front panel. Proportional gain is the amount the error signal is multiplied by directly. Integral gain is the inverse of the time constant applied to the error signal. The derivative control does not respond to steady state error signal, since with a steady error the rate of change of error with time is zero. Because of this, derivative control is always combined with proportional control.

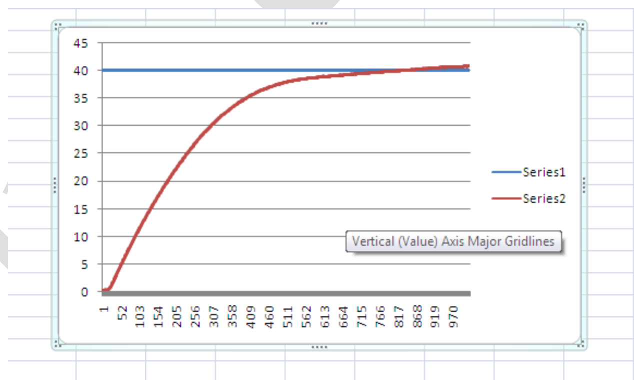

Figure 2 Output response of process in LABVIEW

B. Pid controller

PID stands for Proportional-Integral-Derivative controller. The individual P, I, D terms compose the standard three-term controller. The Three-term PID controllers are widely used in various process industries. Even complex industrial control systems make the use of a control network whose main control building block is a PID controller. It was the primary controller to be produced as a mass for the high market volume that existed in the process industries. PID controller is as type of feedback controller whose output, a control variable (CV), is generally based on the error (e) between some user defined set-point (SP) and some measured process variable (PV). Each element of the PID controller refers to a particular action to be taken on the error. Hence a PID controller comprises of following controller and its actions.

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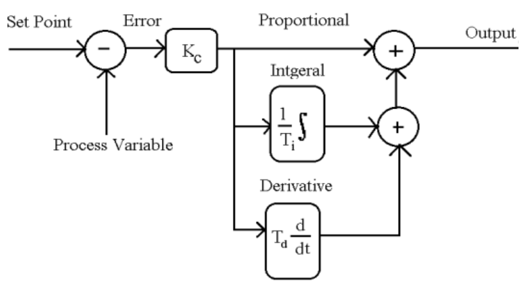

Figure 3 PID controller diagram

1) Proportional Controller

In this controller error value is multiplied by a gain Kp. This is also called as adjustable amplifier. In most of the systems Kp is responsible for process stability. If the process stability is very low then PV can drift away and if it is very high then PV starts to oscillate.

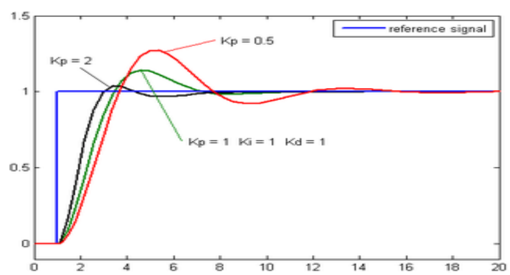

Figure 4 Plot of PV vs Time, for three values of Kp (Ki and Kd held constant)

2) Integral Controller

The integral error is multiplied by a gain Ki. In many systems Ki is responsible for driving error to zero, but went Ki is very high is to invite oscillation or instability or integrator windup or actuator saturation.

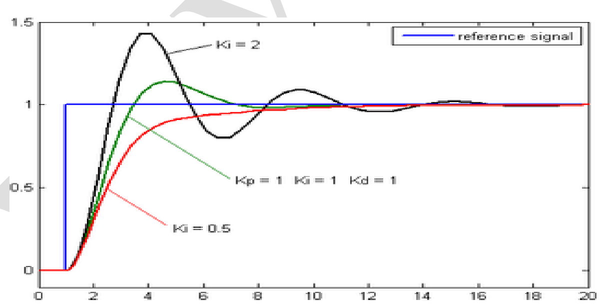

Figure 5 Plot of PV vs time, for three values of Ki (Kp and Kd held constant)

3) Derivative Controller

The rate of change of error multiplied by a gain, Kd . In many systems Kd is responsible for system response: too high and the PV will oscillate; too low the PV will respond sluggishly. The designer should also note that derivative action amplifies any noise in the error signal.

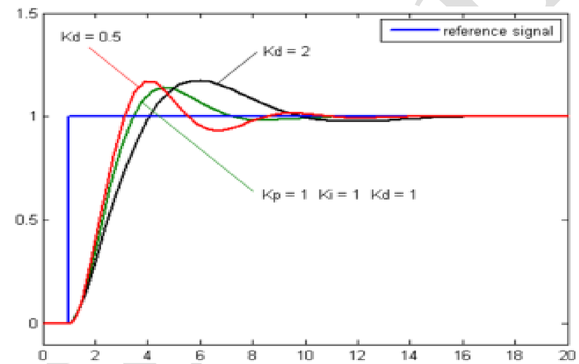

Figure 6 Plot of PV vs time, for three values of Kd (Kp and Ki held constant)

Hence a PID controller will have a transfer function as represented in below equation.

$$G(s) = K_p + \frac{K_i}{s} + K_d s$$

$$G(s) = K_p\left(1 + \frac{1}{\tau_i s} + \tau_d s\right)$$

It is also one of the most powerful but complex controller mode operations combines the proportional, integral, and derivative modes with a control loop feedback mechanism widely used in industrial control system. A PID controller corrects the error between a measured process variable and a desired set point. It calculates the difference between the two and then outputs a corrective action thorough the feedback. A proportional-integral-derivative controller is generic control loop feedback mechanism widely used in industrial control systems. The controller attempts to minimize the error by adjusting the control inputs. The controller can provide control action designed for specific process requirements. The parameters of the PID controller have to be tuned instantaneously in order to make the controller work efficiently due to the changes in the load and other process parameter. A group of parameters of the PID controller that minimize the

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evaluation function is calculated rapidly by searching in the given controller parameters area. The analytical equation is:

$$u(t) = K_p e(t) + \frac{1}{K_i}\int e(t)dt + K_d \frac{de(t)}{dt}$$

Where, K_p = proportional gain

K_d = derivative gain

e(t) = error in % of full scale range

K_i = integral gain

C. Deadbeat algorithm

The algorithm that requires the closed loop response to have finite setting time, minimum rise time and zero steady state error is referred to as a deadbeat algorithm specification that satisfies these criteria is

$$\frac{C(z)}{R(z)}=Z^{-1}$$

this specification requires that the controlled variable shall reach the set point at t=1T i.e. after a delay of one sampling period. Substituting for C/R from above equation into equation

$$G(Z)=Z\{Gho(s).Gp(s)\}$$

gives

$$D(Z)=\frac{1}{G(z)}.\frac{z^{-1}}{1-z^{-1}}$$

This is as for we can proceed with development of the algorithm without knowing the process transfer function Gp(s).In discrete-time control theory, the dead-beat control problem consists of finding what input signal must be applied to a system in order to bring the output to the steady state in the smallest number of time steps.

For an *N*th-order linear system it can be shown that this minimum number of steps will be at most *N* depending on the initial condition, provided that the system is null controllable that it can be brought to state zero by *some* input. The solution is to apply feedback such that all poles of the closed-loop transfer function are at the origin of the *z*-plane. Therefore the linear case is easy to solve. By extension, a closed loop transfer function which has all poles of the transfer function at the origin is sometimes called a dead beat transfer function.

Deadbeat controllers are often used in process control due to their good dynamic properties. They are a classical feedback controller where the control gains are set using a table based on the plant system order and normalized natural frequency.

The deadbeat response has the following characteristics: Zero steady-state error, minimum rise time, minimum settling time, less than 2% overshoot/undershoot and very high control signal output.

D. Kalman's algorithm

Kalman filtering is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone.

Kalman's filter used in the state and parameter estimation to design a digital control algorithm by Kalman algorithm approach one places restriction on c and m, instead of the usual c/r. thus suppose we assume the following expressions based on our knowledge of the process.

$C(Z)=C_1z^{-1}+z^{-2}+z^{-3}+..........+..........$

And

$M(Z)=M_0+M_1z^{-1}+M_fz^{-2}+M_fz^{-3}+.......$

Where no restriction need be placed on the value of C_1 and M_f equals the reciprocal of the process steady state gain. In this illusion M is assumed to have two intermediate values. It turns out that the number of intermediate values of M equals the order of the process.

The Kalman filter uses a system's dynamics model known control inputs to that system, and multiple sequential measurements (such as from sensors) to form an estimate of the system's varying quantities that is better than the estimate obtained by using any one measurement alone.

1) Design procedure

The control algorithm is to be designed for a unit step change in set point, then

$R(z)= \frac{z}{z-1}$ (or)= $\frac{1}{1-z^{-1}}$

and

$C(z)=(1-z^{-1})(C_1z^{-1}+z^{-2}+z^{-3}+\ldots\ldots)$

$=C_1z^{-1}+(1-C_1)z^{-2}=p_1z^{-1}+p_2z^{-2}=p(z)$

And

$M(z)/R(z)=(1-z^{-1})(M_0+M_1z^{-1}+M_fz^{-2}+M_fz^{-3}+\ldots\ldots.)$

$=M_0+(M_1-M_0)z^{-1}+(M_f-M_1)z^{-2}=q_0+q_1z^{-1}+q_2z^{-2}$

$=Q(z)$

Now $G(z)=\frac{C(z)}{M(z)}=\frac{P(z)}{Q(z)}$

Thus, the coefficient in G(z) must equal those is P(z) and Q(z). note that

$$\sum_{i=1}^{2} pi = p1 + p2 = 1$$

and

$$\sum_{i=0}^{2} qi = q0 + q1 + q2 + \frac{1}{kp}$$

These relationships do not generally hold for the pulse transfer function, but dividing by the sum of numerator coefficient will ensure that both equation

$$D(z)= \frac{1}{G(z)}\left(\frac{\frac{C(z)}{R(z)}}{1-\frac{C(z)}{R(z)}}\right)$$

$=Q(z)/P(z)[P(z)/1-P(z)]$

$D(z)= \frac{Q(z)}{1-P(z)}$

The Kalman filter has numerous applications in technology. A common application is for guidance, navigation and control of vehicles, particularly aircraft and spacecraft. Furthermore, the Kalman filter is a widely applied concept in time series analysis used in fields such as signal processing and econometrics.

E. Experimental results

The transfer function obtained for this process

$G_P(S)= \frac{0.4e^{-2s}}{24s+1}$

For the deadbeat algorithm

$G(z)= \frac{0.001224z^{-2}}{z-0.9592}$

$D(z)= \frac{1-0.9592}{0.001224z^{-2}-0.001224z^{-3}}$

For the Kalman s algorithm

$G(z)= \frac{z^{-2}}{816.9z-783.6}$

$D(z)=\frac{816.9z-783.6}{1-z^{-3}}$

Simulation has done using these values for PID controller, deadbeat algorithm and Kalman algorithm has shown below. The output response of this process figured out below

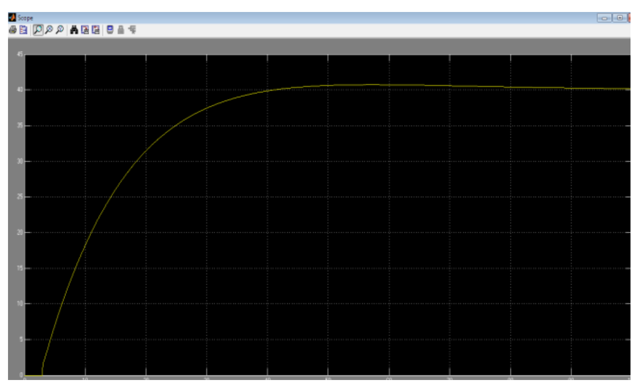

Figure 7 output response of PID simulation

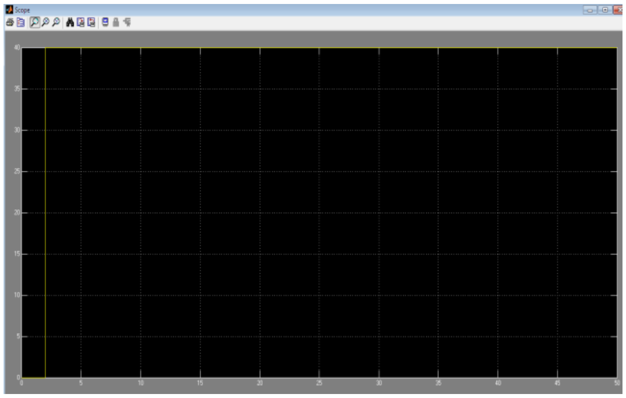

Figure 8 Output response of Deadbeat Algorithm

Figure 9 Output response of Kalman' s Algorithm

III. CONCLUSION

In this paper work, the experimental setup of the split range controller tank system was studied. Tuning is done by using PID, Deadbeat and Kalman's algorithm. The characteristic of control valve and the transmitter were obtained and the graph is plotted. The process reaction curve of the pressure tank system was obtained through closed loop test. Comparing the different methods of tuning Deadbeat and Kalman's performs better than the PID controller.

FUTURE SCOPE

The future work is to develop and implement the deadbeat and Kalman's algorithm for the pressure tank using LabVIEW software. Compare the response of the proposed algorithm with existing method.

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