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Application of Proportional-Integral-Derivative (PID) Regulator for Regulation of Basic Parameters in Production Process

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Abstracts

Proportional-Integral-Derivative (PID) control is the most common control algorithm used in industry and has been universally accepted in industrial control. The PID controller is composed of three distinct parts called Proportional, Integral, and Derivation, each of them accept the error signal as internal signal and operates on it, and ultimately the final signal of their output is combined together. The output signal of them, which is the same signal of PID output, is sent to the system for error correction. For this reason, we need to know the correctness of their operation by checking the regular measuring equipment. An enhanced PID developed for wireless measurements has been found to inherently eliminate oscillations from a wide variety of sources including discontinuous and delayed responses in the automation system and interactions between loops when used with a threshold sensitivity setting and the dynamic reset limit. The advancements in new techniques and a greater understanding of existing capabilities enable the PID to not only improve loop performance but to individually optimize unit operations. For this reason, types of controllers that are more common in the chemical industry and which deals with the use and exploitation of operators closed loop systems, the theory of classical PID and the effects of tuning a closed loop control system are discussed in this paper. Finally, we find exact gain for controlling basic parameters; at first we control the level.

Keywords: PID, error, Parameter, controller, Equipment, proportional, Integral, Derivative

Introduction

PID control is a name commonly given to three term control the mnemonic PID refers to first letter of the name of the individual terms which makes the standard three term controller, the P refers to proportional term, I refers to integral term and D refers to derivative term in the controller (Mohammad and Michael, 2005). Processing plants have various activities such as mass and energy transfer operation, thermal and chemical conversion, filling, packaging, etc. modern factories use

automatic process control operation, hence the automatic control has main role for development of industry, nowadays there is no any small or large product factory without any automatic process control. It is necessary for a chemical engineer to understand control strategy to obtain control of desired quality and flow rate of products by maintaining process parameters such as pressure, flow rate, temperature and level in desired equipment present in plant. The cost of controlling instruments at a plant is about 40-60% of the initial investment of the plant, the accurate control strategy is important to avoid material loss, quality degradation, accidents and environmental pollution {1}.

The most common control structure in process industry is the PID structure and most often is the derivation action turned off resulting in a PI controller, it is due to introduction of disturbance sensitivity by the derivation part, additive action may increase performance significantly and joint design of PID controller and measurement filter for load rejection, when the noise sensitivity limitation may be set (Kristiansson and Lennartson, 2006, Garpinger, 2009, Larsson and Higglund, 2011).

Proportional-integral-derivation (PID) control offers the simplest and yet most efficient solution to many real world control problems¸ three term of PID controller covering treatment of transient and steady state responses. The publicity of PID control has grown tremendously, PID control invented in 1910 and the science of automatic control offers now a wide spectrum for control scheme such as fuzzy logic control (Lee 1990), neural network control (Fukuda and Shibata, 1992) and adaptive control (Astrom and Wittenmark, 1995). But now more than, 90% industrial controllers are implemented based on PID control algorithms, and no other controllers can be compare in simplicity, clear functionality, applicability and ease with PID controllers Ang, Chang and Li ,2005).

1. Importance of PID control

On based of three main reasons past record, wide availability and simplicity the PID control remain importance control tool to use widely in industries. One another reason reinforce thereby ensuring that more general framework of digital control with higher under controllers has not really able to displace PID control, it is really unique then the process situation demands more artificial controller or more complex controller solution to control a complex process that the control engineer use more advanced methods, even where the complexity of the process demands the multi loop or multi variable control solution, the network based on PID control building block is often used (Moradi, et, all, 2002)

2. PID application

PID controller are probably the most widely used industrial controller even complex industrial control system may include a complex control network whose the main control building block is a PID control module. The PID controller has long history of use and survived the change of technology from analogue era to digital computer control system age, it is the initial controller to mass produced for high volume market which existed in the process industries (Mohammad and Michael, 2005). The application of PID controller to control the main parameters of product process is the important applicable type of used controller in industry due to simplest structure, ease work, high quality and resistance. In process product industries the parameters such as temperature, flow rate, level, pressure etc, are controlled continuously and the PID controller is suitable and useful to control the mentioned parameters and these controllers are more selected in commercial deals. The PID controller related to digital signal and PID is the main part of a control loop in industrial process. This research paper is discussed to control some parameters such as temperature, pressure, level and different methods of control

In past century the controller theory were predicated to mechanical, hydraulically, pneumatically and electrically instruments which used to control the product process parameters, but now predicates the micro process and computerized system which has informing and controlling function due to process condition. the control in product processes done because of:

A. Decreasing of variable

B. Increasing of efficiency

C. Immunity and assurance

The PID controllers widely used in process product, they have set point value which given by operator and the regulator will taken specific place due to set point value, the measurement reading of parameter during process is called process variable, and the signal obtained of set point and process variable difference is out put signal which has 4-20mA value in a closed loop.

3. Three terms control

The signal framework of input and output for the three term controller is shown in bellow figure, it is used to explain the three term of PID controller.

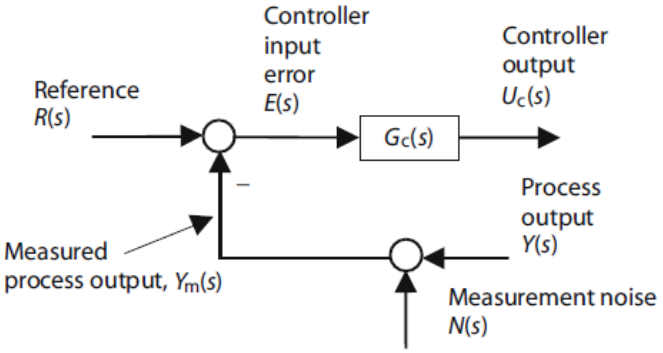


Figure 1. controller inputs and outputs.

1.4- Proportional control

Proportional control is symbolized by the P-term in PID controller. It is the simplest form of regulation in a close loop, and decreases the variable but cannot remain forever the system to given value. P-controller is preparing the output signal and responds to variable within few seconds and contain of less delay time with obtaining of remaining deviation it is used when the controller action is to be proportional to the size of process error signal (Michael A, 2005). The input and output signals of P-controller has linear relationship which named (Gain) and shown by (K_p), it can adjusted in P-controller, if (K_p) adjusted by large value that means the control loop is unstable as shown in bellow figure.

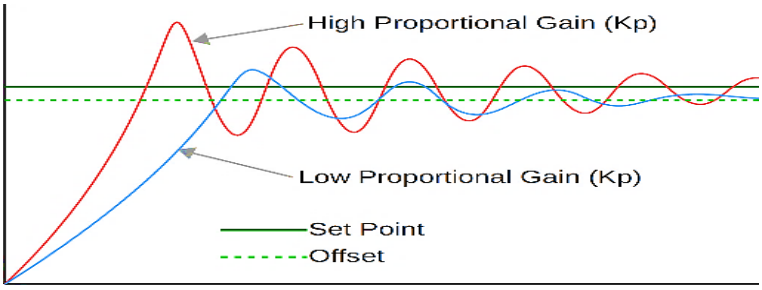


Figure 2. the (K_p) relations in P-control loop.

Mathematic equation: the output of P-control has linear relationship with error and shown by :

$$C(t) = K_P e(t) + b \qquad (1)$$

C(t)- controller output, K_p- gain, e(t)-error and b is the base which is constant with K_p.

$$K_P = \frac{\Delta output}{\Delta input} \qquad (2)$$

2.4- Integral control

It is denoted by I-term in the PID controller, it is used when required that the controller correct for any steady offset from a constant reference signal value, integral control overcomes the shortcoming of P-control by removing offset without the use of excessively large controller gain. The I-controller able to return the control loop to its steady state and remove all deviations therefore I-control is used more in process control.

Mathematical equation: the I-controller compute the output signal due to error and it is sum of errors due to time, the bellow equation illustrated the I-control.

$$C_{(t)} = \frac{1}{T_i}\int e(t)dt + c(t_0) \qquad (3)$$

C(t)- output signal, T_i- integral time, and e(t) is error. Integral time is the time that when the controller changes the output signal due to error, the output signal of controller is equal to output of integral time when (t=0). The output is determining by some parameters in I-controller but in P-controller determining by error. The I-controller need more time to prepare the output signal to control the loop; the diagram for mutation changes of output in I-control is shown in figure bellow.

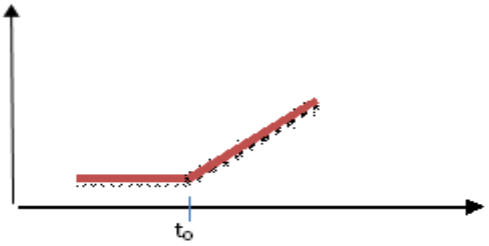


Figure 3. The mutant change of I-controller output.

3.4- Derivative control

It is the third section of PID controller, symbolized by the D-term and it is used by the rate of changes of an error signal, if a controller can use the rate of change of an error signal as an input then this introduces an element of prediction into the control action (Michael A, 2005). D-controller is not able to maintain steady state of the control system therefore it is used with the P and I-controller together.

Mathematical equation: the D-controller related the output value to derivative of error due to time.

$$C_{(t)} = \frac{1}{T_i}\int e(t)dt + c(t_0) \qquad (3)$$

4.4- Proportional and derivative control (PD)

The property of derivative control that should be noted arises when the controller input error signal become constant, but not necessarily zero, as might occur in steady state of process condition. in these position the derivative of the constant error signal is zero and the derivative controller produce no any control signal. Consequently the controller not taking any action and it is unable to correct offset of steady state, for example to prevent the controller setting into somnambulant state, the derivative control term is always used in combination with a proportional term, this combination is called proportional and derivative (PD) control (Michael A, 2005).

5.4- Proportional, derivative and integral control (PID)

It is showing the combination of three types control, because of high efficiency, it has wide application for process control, due to existence of P-controller it has less adjusting time, and due to existence of D and I-controller the remaining deviation will decrease to minimum limit or being zero. PID control is suitable for process control but it is costly therefore when the process needs high accuracy with stability the PID controller will use.

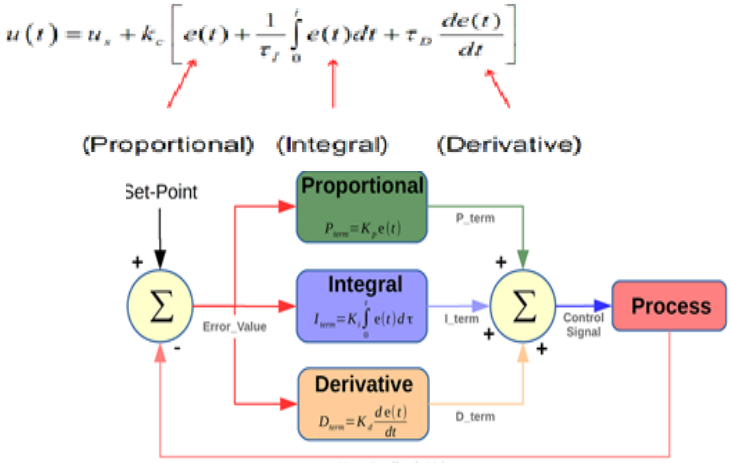


Figure 4. Diagram of PID-control

Result and discussion

By applying of modern automatic PID control instrument to design the suitable condition to control the parameters of product process such as pressure, temperature, flow rate and level, with this instrument all parameters were controlled automatically by the help of computer software and the final obtained values were calculated, the effected parameter values on process are important for control process which given to the process and the changes were visible in practical. We found those values for control parameters which the parameters were more stable, the control time and oscillation was minimum, the efficiency of proportional, integral and derivative are the important factors of control, due to these factors can determine the stability, oscillation amount ant control time. To find the suitable control conditions the coefficient values were repeatedly changed and the obtained result noted comparatively, we achieved to suitable values which reduced the measured error, the minor error were shown the exact and suitable coefficient of control.

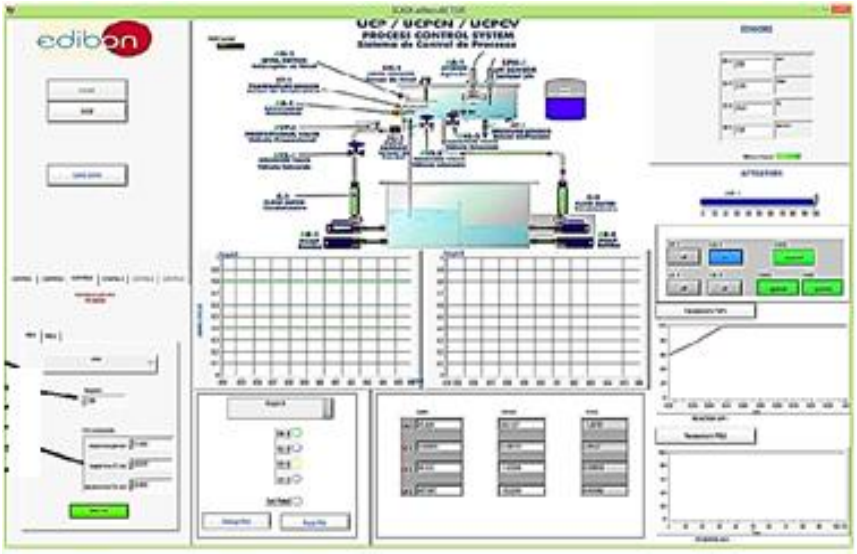


Figure 5. control diagram

The efficiency coefficient (gain) for level control in P-control selected (1) , for I and D-control selected (0.08), in this case the output of PID control was (73.6615) which was for (202cm) level, it shown the level (2cm) more, this shows more difference of the set point and process variable.

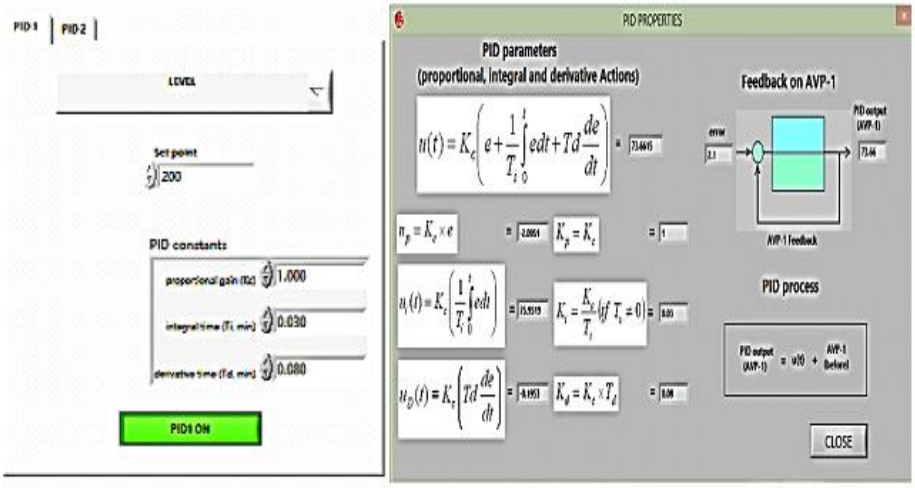


Figure 6. Shows the relation of the gain and error.

The gain for P-control, I-control and D-control selected (1), (0.50) and (0.050) then the output measured for the level of (200cm), in this case the error was (0.33) and the process variable was (99.27) these was the suitable values for level control. We selected the gain (1) for P-control, (0.010), (0.0) for I and D-control, the error was very less (-0.46) it shows the better control which was proportional to the output, the obtained result shown that the measured set point is same to process variable as shown in figure 7.

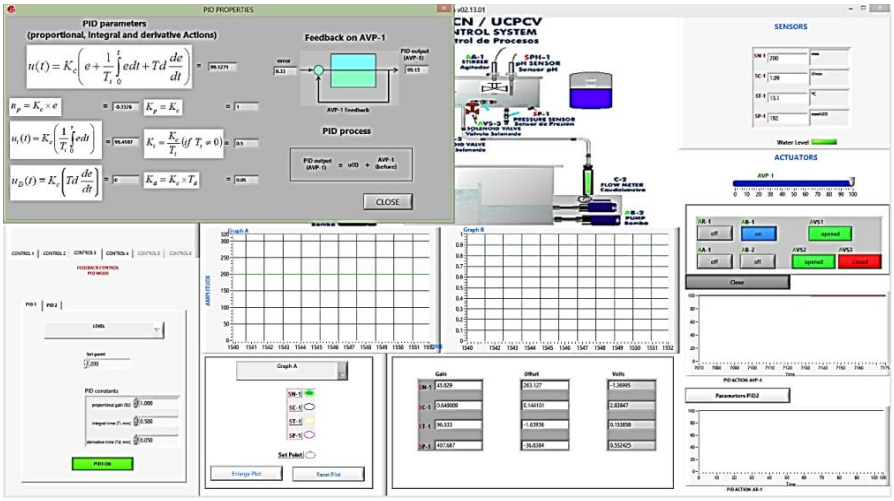


Figure 7. the relation of gain with the measured error.

Conclusion

PID controllers are the suitable and comfortable controllers for an operator, it is sensitive for measurement and control of parameters in a process product which decrease the oscillations, improves the application, decreasing raw material, wastes and high quality of products. as we know the PID controller formed of three sections, therefore by the changing of gain for each section the measured variable process will maintain close to set point. The changes in the gain of P-controller couldn't maintain the exact control and there was a remained deviation, for removing of this deviation we applied the I-controller, but the process was not stable and contained of oscillation, for removing of oscillation and stability of process control, we applied the third section of PID which named D-controller, by the changing of its gain the process system was stable and took acceleration. It is mentionable that the gain for each controller has a related limit value.

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