Effect on The Performance Test Towards Flow controller And Level controller using Zieglar Nichols Tuning Rule

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***Abstract*— The project is relies on step input change of level control process and also flow control process and the step change must between ±10%. Level control (LIC11) DeltaV operate system and also flow control (FIC21) DeltaV operate system are demonstrate at process control laboratory located in pilot plant UiTM Shah Alam. The method used consist of open loop tuning and also a close loop tuning. The results express different values in term of settling time and the values needed for closed loop tuning method. The basic of process control is, when all of four block are connected the process control loop is called close loop system and when any of the blocks is disconnected the process control loop is called open loop system. In the close loop system, the controller compares the process measurement signal (PV) from set point (SP) and make necessary corrective action to the final control element. In open loop system, the controller has no control over the final control element therefore, the adjustment is made manually by operator.**

Keywords*— *flow controller, level controller, open loop test, close loop tuning method, Ziegler Nichols tuning rule, set point, process variables.

I. Introduction

In modern era, feed-back control system is applied to all new inventions and it is widely used in chemical plant, where it is capable of slipping on or off as limit to the process limitations. Even though, the pumps that equipped can have a several speed motor where it may be more efficient It is believe, at that particular time this pump are costly to secure and keep up particularly for small and medium enterprise [1]. Automatic water level controllers are an invention that can automatically control a motor, that helps to ensure a constant reserve amount of water in a storage tank. These automatic water level controllers are used to automatically fill the over-head tank whenever it starts or has become empty as well as maintain the level of water in it. Automated water level controllers switch the motor on whenever the water level drops below a certain level and shuts the motor off when the water rises well above a fixed level. The motor will also switch off when the sump water is exhausted before it fills the over-head tank, or if the pump is running dry as well as maintains voltage fluctuations. There are several importance of the level controller which can clearly be seen in chemical reactor, fermentation vessel, steam drum and surge drum [3]. In order to run a level controller in DSC system, ensure the valve to flow the water into the tank is opened. Then open the second valve that flow the water out to the system, to ensure the process can be run. The flow control valve fittings are utilized to diminish the real flowrate in the exact portion of the pneumatic circuit. This serves to diminish the actuator speed of the system. While a needle valve controls the stream in two bearings, a flow control valve fitting is utilized to coordinate the system stream in as it were one course. This way, free flow of the gas or fluid is permitted in the inverse course. One of the most imperative components to consider while choosing a flow control valve for a particular system application, are the flow control necessities [2].

II. Methodology

A. Open loop test for flow controller

Stabilize the process of FIC 21 either in manual or automatic mode If the controller is in automatic mode and the process water stabilize, switch the controller to manual mode. Record the initial value of manipulated variable (MVi) and the initial value of process (PVi). Make a step change between 5% to 10% to the (MVf) for self regulating process (SR). Once the process has increased to about 7% to 10% of the process span, set the controller to automatic mode and let the process stabilize to the original operating condition. Print the entire event. The calculation to calculate the response rate RR, dead time Td, time constant Tc using reformulated tangent method are as follows:

Response rate (RR):

$$RR = \frac{\tan\theta}{\Delta MV}\frac{a}{b} \qquad \text{.................... (1)}$$

Dead time (Td):

Td (time) = Td (length) x b .... (2)

Time constant (Tc):

Tc (time) = Tc (length) x b .... (3)

Where,
RR = response rate 1/time
a = scaling factor for y-axis %/length
b = scaling factor for x-axis time/length
ΔMV = change in controller output, %

B. Close loop tuning test for flow controller

P + integral (I) mode of control is use since flow controller is a noisy process. Ziegler-Nichols tuning rule is used to identify the values of P = Kc (gain) and also I

Mode	P	I	D
P	100 RR Td		
PI	111.1 RR Td	3.33 Td	
PID	83.3 RR Td	2 Td	0.5 Td

Table 1: Tuning Rule Parameters

C. Load disturbance test for flow controller

The controller is set to manual mode. A change about 10% of current MV is made. After 3 seconds, the controller is set to automatic mode. Wait and the response become stable

D. Set point test for flow controller

The set point test is the continue from load disturbance test. The system is in automatic mode. A change in set point is made. Wait until the response become stable. Both response curves is combined and graph is printed.

E. Open loop test for level controller

Stabilize the process of LIC 11 either in automatic mode then, switch the controller to manual mode once the process is stable. When the process has established at a new steady state, record the final (MVf) and (PVf) for non self regulating process (NSR).Once the process has increased to about 7% to 10% of the process span, set the controller to automatic mode and let the process stabilize to the original operating condition. Print the entire event. The calculation to calculate the response rate RR, dead time Td, time constant Tc using reformulated tangent method are as follows:

Response rate (RR):

$$RR = \frac{\tan\theta}{\Delta MV}\frac{a}{b} \qquad \text{………….. (4)}$$

Dead time (Td):

Td (time) = Td (length) x b ………….. (5)

Time constant (Tc):

Tc (time) = Tc (length) x b …………… (6)

Where,
RR = response rate 1/time
a = scaling factor for y-axis %/length
b = scaling factor for x-axis time/length
ΔMV = change in controller output, %

F. Close loop tuning test for level controller

P + integral (I) mode of control is use since level controller is a noisy process. Ziegler-Nichols tuning rule is used to identify the values of P = Kc (gain) and also I

Mode	P	I	D
P	100 RR Td		
PI	111.1 RR Td	3.33 Td	
PID	83.3 RR Td	2 Td	0.5 Td

Table 2: Tuning rule parameter

G. Load disturbance test for level controller

The controller is set to manual mode. A change about 10% of current MV is made. After 3 seconds, the controller is set to automatic mode. Wait and the response become stable

H. Set point test for level controller

The set point test is the continue from load disturbance test. The system is in automatic mode. A change in set point is made. Wait until the response become stable. Both response curves is combined and graph is printed.

III. RESULTS AND DISCUSSION

A. Open loop test analysis

Open loop test empowers plant or refinery staff to characterize the procedure by deciding the process time consistent, process gain, and process deadtime. Utilizing these qualities, new controller settings can be calculated and connected and can result in improvising the open loop test and eventually lead to better general control of the process and upgraded efficiency.

A(1) Open loop test analysis for flow controller

Open loop test is accomplished by increasing the step size which is the manipulated variable in this process by 10% and it is from 40% to 50% . Once the process has achieved, the response curve has been analyzed as show in figure 1. The scaling factor (a,b) are calculated since the values are needed to calculate RR, Td and Tc. The value for a is 0.61 %/mm and value for b is 1.25s/mm. RR value as obtain from equation 1 is 0.0845/s, while Td value calculated from equation 2 is 1.25s and Tc values from equtio n 3 is 22.5s.

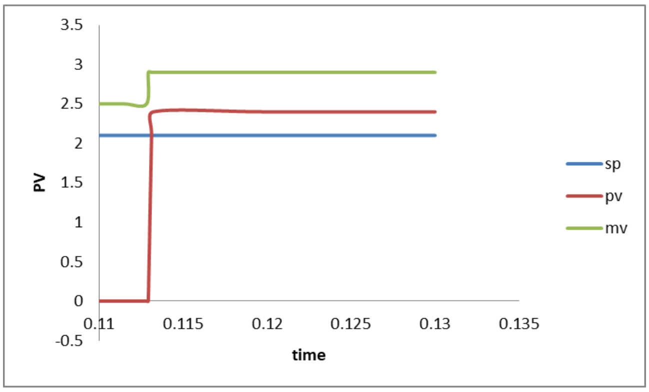

Figure 1: open loop response curve

B. Tuning test analysis

Since Proportional-Integral-Derivative (PID) control is the largest typical control algorithm used in industry and it has been universally welcomed in industrial control. The knowledge of PID controllers can be characterized partly to their robust performance in a wide range of operating conditions and partly to their functional simplicity, where it allows engineers to operate them in a simple, straightforward term. As the name given, PID algorithm consists of three basic coefficients which are proportional, integral and derivative and they varied to get optimal response curve [4].

There are several benefits from closed-loop PID testing. First, the process variable can be kept close to normal operating conditions and therefore cause less disruption to the process. Second, since the loop is in automatic mode, there is no need for authorized personnel to spend time watching the loop closely, as in manual cases. In manual mode, a step test could result in the process variable moving too far from a desired value. A disturbance could have the same affect while the PID is open-loop. In automatic, a safe target can be set, and the loop has some chance at recovery from a disturbance.

B(1) Tuning test analysis for flow controller

The result obtained that used parameters in table 1 PI controller mode are, P/Kc (gain) is equal to 11.735% while I (reset) is equal to 4.163s for the first trial. The response curve has gone abruptly oscillate as shown in figure 2 since the values of proportional gain is much higher and cause the speed of the control system response increase. If Kc is increased further, the oscillations will become larger and the system will become unstable and may even oscillate out of control.

The integral component is the sums of error term over time. The result is that even a small error term will cause the integral component to increase slowly. The integral response will continually increase over time unless the error is zero, so the effect is to drive the Steady-State error to zero. Steady-State error is the final difference between the process variable and set point. For the second trial the Kc value and I value is 037 and 2.4 respectively and it is the optimum value.

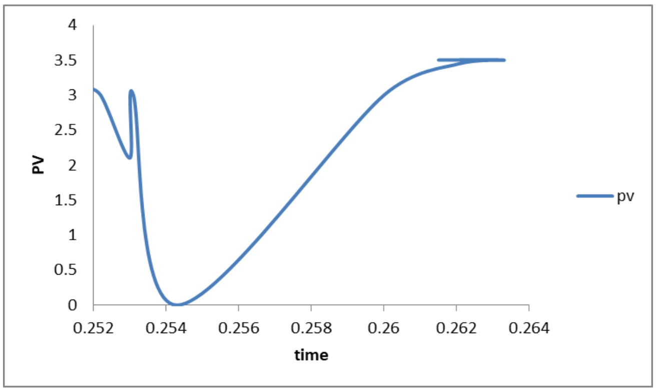

Figure 2: Tuning response curve

C. Load disturbance test analysis

The main objective of a feedback controller itself is for disturbance rejection or setpoint tracking. A controller designed to reject disturbances will take action to force the process variable back toward the desired setpoint whenever a disturbance or load on the process causes a deviation. Thus function of load disturbance test is to see whether the process variable can back to normal or know as optimum condition. [7]

C(1) Load disturbance test analysis for flow controller

Load disturbance test is done by changing the value of manipulated variable of the process by 10% which was from 53.4 to 63.4. It takes about 1 minute for the process to stable and after it become stable, the process continue to the set point test. The result can be clearly seen as in figure 3.

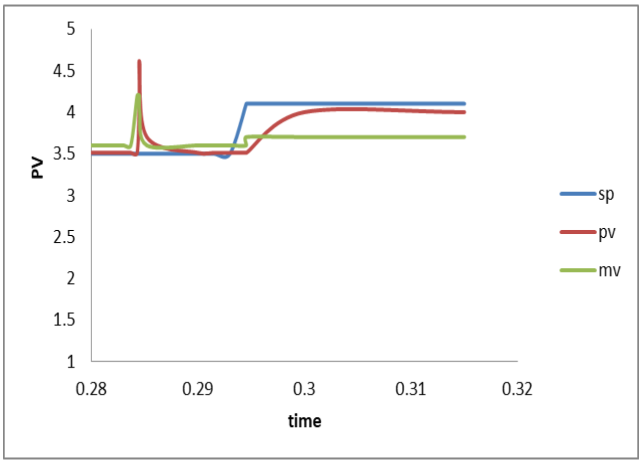

Figure 3: load disturbance test and set point test response curve

Step Test that should be followed to have a better result for tuning is that it should involve a large enough change to the SP so that it results in a clear PV response without putting either the process or plant personnel at danger. It can be practiced by changing the SP to an amount that's equal to at least 4 times the process noise band. This Step Test result in producing the required data to model and tune the PID. Changes in SP caused a clear response in the PV and CO signals [6].

D(1) Set point test analysis for flow controller

The set point test is accomplished by changing the SP value from 400 to 410 with 0.2s settling time and 0 steady state error. The type of closed loop process response is positive off-set as shown in figure 3.

A(2) Open loop test analysis for level controller

Open loop test is accomplished by increasing the step size which is the manipulated variable in this process by 10% and it is from 10% to 20% . Once the process has achieved, the response curve has been analyzed as show in figure 4. The scaling factor (a,b) are calculated since the values are needed to calculate RR, Td and Tc. The value for a is 0.58%/mm and value for b is 1.304s/mm. RR value as obtain from equation 4 is 0.0152/s, while Td value calculated from equation 5 is 4014s and Tc values from eqution 5 is 22.76s.

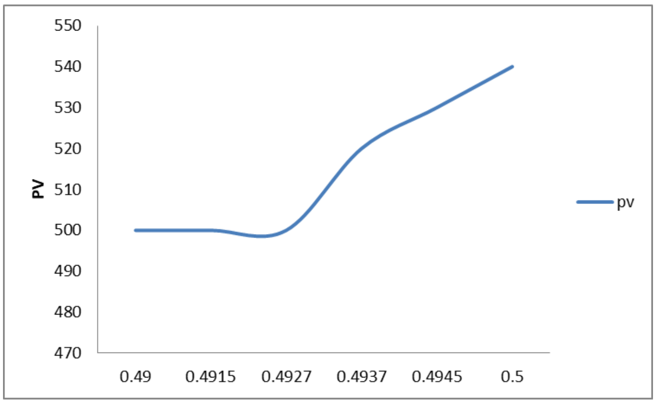

Figure 4: Open loop response curve

B(2) tuning test analysis for level controller

The result obtained that used parameters in table 2 PI controller mode are, P/Kc (gain) is equal to 7% while I (reset) is equal to 13.8s and it is the optimum value. As can be seen in figure 5 the response curve does not oscillate. This is because liquid level is a non self regulating process where the process does not tend towards self-regulation. These processes have no self-regulating feedback characteristics and will tend towards being unstable if not controlled externally [5].

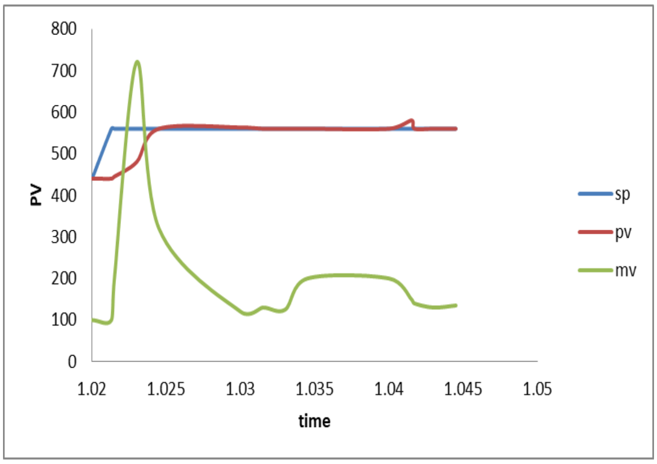

Figure 5: Tuning test, set point test, load disturbance test response curve

C(2) Load disturbance test analysis for level controller controller

Load disturbance test is done by changing the value of manipulated variable of the process by 10% which was from 12 to 22. It takes about 28s for the process to stable.

IV. Conclusion

Flow controller is a self regulating process which Self regulating processes are processes that are inherently self-regulating. Self-regulated processes have built-in feedback characteristics that cause the process to tend towards self-regulation. Besides, level controller is a non self regulating process and it cause the liquid level to maintain and do not affect the flow out of the tank, when changes is made to the manipulated variable regardless the of the head pressure. The setlling criteria for both controller is differ in time taken to achieve stabilization. The performance test run in flow and level controller is to ensure that the plant can operate in critical situation and eventually can react positively towards changes and to get the optimum condition towards running the process. It shows that Zieglar Nichols tuning rule has a positive feedback since all the run test back to its set point value which was the optimum condition for the process.

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