https://doi.org/10.15623/ijret.2018.0707017 Received: 05-05-2018, Accepted: 16-06-2018, Published: 07-07-2018

COMPARATIVE ANALYSIS OF ROBUST CONTROL AND CONVENTIONAL CONTROL FOR A NON-LINEAR PROCESS

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Abstract

The level tank control of a coupled tank system is relatively crucial when compared to the conventional control scheme. Due to continuous variation in the plant dynamics, controlling is complex one and hence they were approximated as piecewise linearized systems. The various combination of the conventional controller was implemented to maintain the level at particular height. The robust PID is used to achieve the required setpoint. Mathematical model of coupled tank system is computed using material balanced equation approach. The performance of the controllers was compared for the analysis purposes.

Keywords: *- Conical, Robust, and Pre-filter*

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1. INTRODUCTION

In most of the process industries controlling of level, flow, temperature and pressure is a challenging one. Based on the plant dynamics, they can be classified as linear and non-linear processes. The efficiency in the drainage system can be improved further if the tank is fully conical.

A tank system is in the shape of conical that are mainly used in Colloidal mills, Leaching extractions in pharmaceutical and chemical industries, food processing industries, Petroleum industries, Molasses, Liquid feed and Liquid fertilizer storage, Chemical holding & mix tank, Biodiesel processing and reactor tank.

2. ROBUST CONTROL

Robust control considers the design of decision or control rules that fare well across a range of alternative models. Hence robust control is a uncertain in model inherently. This control scheme is particularly focusing on the implications of model uncertainty for decisions.

In order to design control systems to meet the needs of improved performance and robustness when controlling complicated processes.

A standard technique of improving the performance of a control system is to add extra sensors and actuators. This necessarily leads to a multi-input multi-output (MIMO) control system. The modern feedback is required to the system design methodology that it be able to handle the case of multiple actuators and sensors. H-Infinity control, Sliding mode control are the two various methods of robust controller. The ultimate aim is to control a particular system in a real environment. Using mathematical model permits to make predictions about the system. The Robust control model encountered two important problems that are follows. Disturbance signal is added to the control input to the plant. Noise is added to the sensor input.

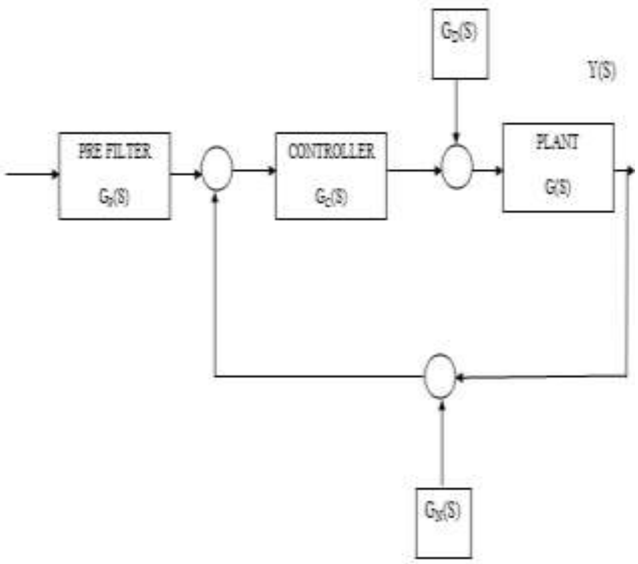

Fig 1: Robust Block Diagram

Here,
$G_D(S)$ –Disturbance signal at Plant
$G_N(S)$ –Noise signal at sensing element.

Decrease in sensitivity of the system to variation in the parameter of the process. The disturbance rejection is improved of the disturbance and noise signals within the system. Improvement in steady-state error of the system.

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3. MATHEMATICAL MODELING

The fig.2 shows the process and instrumentation diagram of Non-interacting model of the two conical tanks. The tank 2 acts as a process tank and Tank1 as a supply tank. In this case the dynamics of the one doesn't affect by another one. The pump P connected on the sump also outlet is connected with the hand valve V_3. The R Rotameter is used to regulate the inlet flow at particular LPH. The pneumatic actuated valve V_4 is a final control element is a forward acting one. The valve controlled by pneumatic signal that came from the current to pressure converter IPC. The current signal passed through the data acquisition system DAQ that is processed in the PC by accounting the present level of the process tank by means of level transmitter LT. C is a compressor.

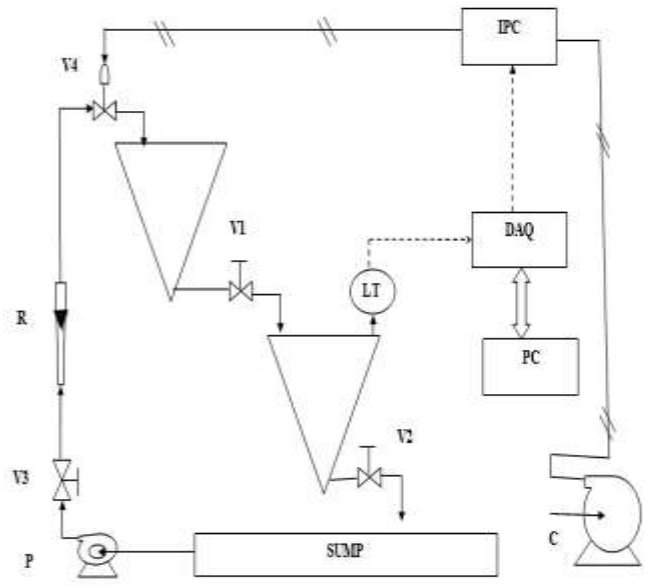

Fig 2: P&I Diagram of Non-Interacting system

Using the Newton's law of mass conservation the difference in two flow rates (Inlet, Outlet) is proportional to the rate of accumulation. The input flow rate F_{in}, outlet flow rate F_{out} and the in between flow rate F_1. The output flow rate will be K√h.Where K is a valve coefficient and h is a deviation height.

$$F_{in} - F_1 = dV/dt \quad (1)$$

$$F_1 = K_1\sqrt{h_1} \quad (2)$$

In the conical shaped tank the tanθ can be taken for the actual physical shape and at the deviation height. The following equation (3) shows the equalities of the variables.

$$\tan\theta = r/h = R/H \quad (3)$$

Taking volume of conical shape follows it is taken to derive the modeling for the tank process.

$$V = \frac{1}{3}\pi r^2 h \quad (4)$$

$$dh_1/dt = \alpha\left(F_{in} - K_1\sqrt{h_1}\right)/h_1^2 \quad (5)$$

Using Taylor's series approximation used to approximate the non-linear components. After the approximation the final Equation will be equation (6).

$$H_1(S)/F_{in}(S) = C_1/(\tau_1 S + 1) \quad (6)$$

The Time constant $\tau_1 = (2/\beta)h_{1s}^{5/2}$ and the Steady state Gain $C_1 = 2\alpha/\beta\, h_{1s}^{1/2}$.

Similarly for Tank2

$$H_2(S)/H_1(S) = C_2/(\tau_2 S + 1) \quad (7)$$

$$\frac{H_2(S)}{F_{in}(S)} = \frac{C_1 C_2}{(\tau_1 S + 1)(\tau_2 S + 1)} \quad (8)$$

On substituting the values

$$\frac{H_2(S)}{F_{in}(S)} = \frac{0.149e^{-4s} * 0.144e^{-7s}}{(30.42S + 1)(35.095S + 1)} \quad (9)$$

The Tank 1 has a dead time of 4 seconds and 7 seconds transportation lag in Tank2.

The following Fig.3 shows the piping & instrumentation diagram of model of Interacting system. The Interacting system affects the dynamics of one on another one.

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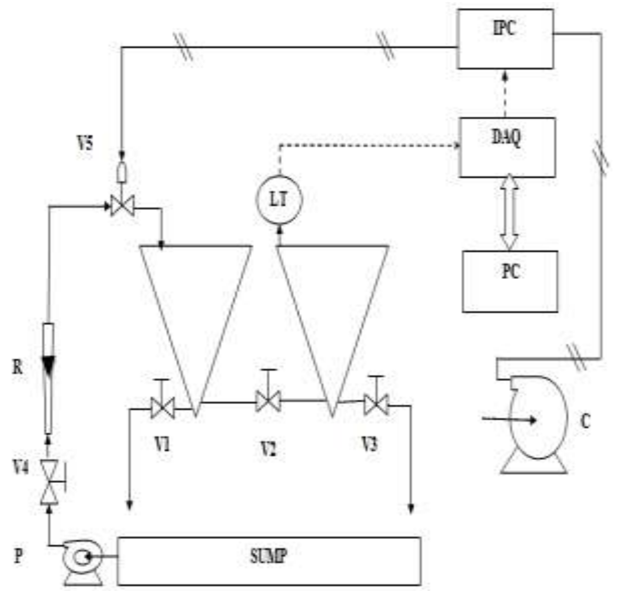

Fig 3: P&I Diagram of Interacting system

The modeling of interacting system is also like the Non-interacting model but this particular model includes the interacting part in the transfer function. The time constant and steady-state gain is same as the non-interacting model. But the interacting system has a interacting part $C_1{*}K_2$ in the equation (12). That stands the parameter of one tank affected by another tank's parameter.

$$F_{in} - F_1 = dV/dt \qquad (10)$$

$$F_1 = K_1\sqrt{(h_1 - h_2)} \qquad (11)$$

$$\frac{H_2(s)}{F_{in}(s)} = \frac{1}{\tau_1\tau_2 s^2 + (\tau_1 + \tau_2 + C_1 {*} K_2)S + 1} \qquad (12)$$

The transportation lag of the system is 17 seconds. After substituting the values

$$\frac{H_2(s)}{F_{in}(s)} = \frac{e^{-17S}}{1574.088 s^2 + 131.523S + 1} \qquad (13)$$

4. SIMULATION

The simulation Simulink model of the both Non-Interacting and Interacting system shows in the following figures Fig.4 and Fig.5 respectively. The pre-filter is used in both the systems.

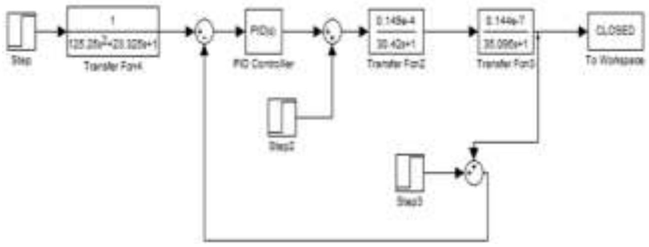

Fig 4: Simulation for Non-Interacting system

The pre-filter is connected in front of the summing block. The pre-filter designing discussed in the chapter II. The two transfer function block stands that the transfer function of two tanks that are connected in non-interacting mode.

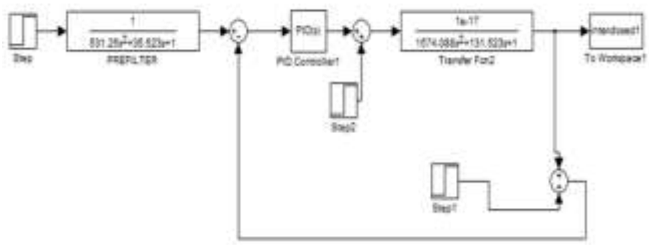

Fig 5: Simulation for Interacting system

The transfer function block represents the mathematical model of the entire interacting setup. Also the system has a total transportation lag of 17 seconds. The pre-filter reacts for the dead time also.

5. RESULTS

The following Fig.6 shows the response of the Non-Interacting system while the Robust control scheme used as a control algorithm. It has a pre-filter. From the response of both systems the second order characteristics like dead time, peak over shoot, settling time and peak times are tabulated in the chapter VI.

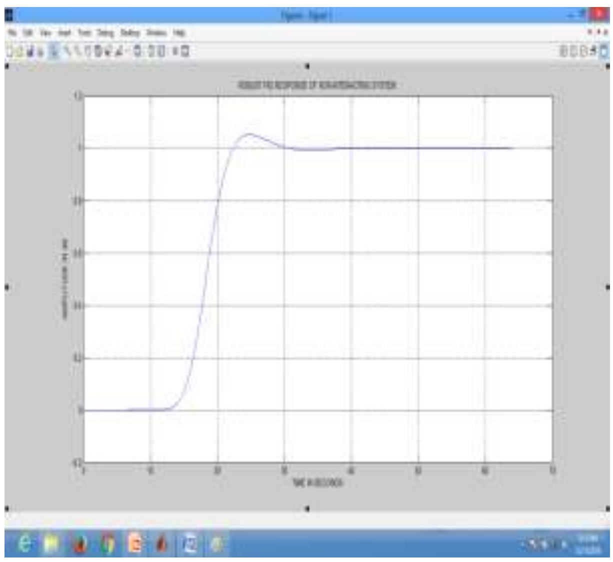

Fig 6: Response of Robust control for Non-interacting system

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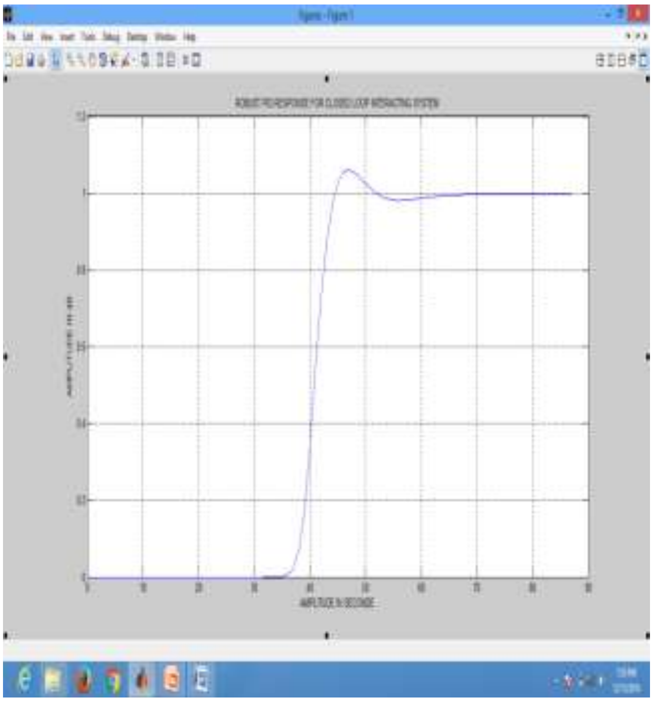

Fig 7: Response of Robust control for Interacting system

6. CONCLUSION

The results of the both Non-interacting and Interacting model controller parameters are tabulated in Table 1 and Table 2.

Table 1: Non-Interacting result

PARAMETERS	PID	ROBUST PID
DEAD TIME	14sec	14sec
PEAK OVERSHOOT	1.8dB	1.2dB
SETLLING TIME	36sec	30sec

Table 2: Interacting results

PARAMETERS	PID	ROBUST PID
DEAD TIME	35sec	33sec
PEAK OVERSHOOT	1.8dB	1.4dB
SETLLING TIME	68sec	62sec

From the tables 1 and 2 the performance of the both control schemes can be viewed. Use of pre-filter helps to fine tune of PID controller.

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