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LabVIEW based real time implementation of dual controller scheme for robust tuning in level process

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ABSTRACT
The aim of this work is to implement a dual controller scheme for robust tuning in level process. This method contributes for the independent adjustment of servo response and regulatory response. The dual controller design has better robustness than single conventional scheme. The three main loop attributes has been maintained using this scheme with fast settling time. The independent tuning without interaction will improve the performance of this scheme as compared with other scheme. Dual controller scheme has been implemented in real time using Lab VIEW platform.
Keywords: *Robust Tuning, servo- regulatory response, LabVIEW, dual controller scheme*

I.INTRODUCTION

The main objective of a control system is to follow a reference signal and eliminate external noise signal and process variation. The main challenge in analysis of the system is to maintain the robustness of the process. Different adaptive scheme has been introduced to track the exact set point at different region. The main problem is to get an exact model. Many of the offline system identification method have been introduced. But eliminating the model mismatch is tedious. Also the settling time is very large. The dual controller scheme has one controller dedicated for servo response and other for regulatory response [1].The additional noise by sensor and actuator chattering can be eliminated by disturbance rejection controller. Thus controlling disturbance is more accurate in this method. Robustness is the ability of a system to be insensitive to component and process variation. It is one of the main property of feedback system.Performence is well related with robustness of a process. None of the real time process is linear.

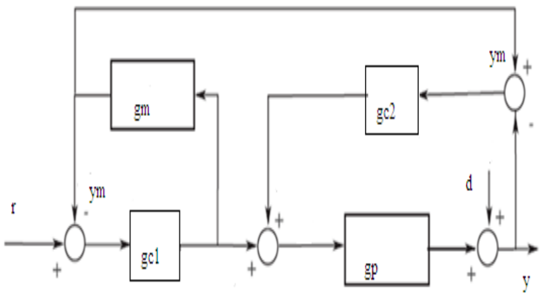
Disturbance is inevitable for every process which reduces the robustness of the process. This scheme also used in process with dominant delay [2].The model can be reduced as first order system with time delay and used for tuning each controller in dual controller scheme [3].

II. SYSTEM DESCRIPTION

The experimental setup consist of cylindrical tank, pneumatic control valve, voltage to current converter (V/I),a current to voltage converter(I/V),rotameter, level transmitter, DAQ and a personal computer.

Fig 1: Experimental Setup of a single Tank level system

III.Block diagram



The dual controller scheme has high robustness and better performance. According to a dual controller scheme the settling time is so fast with reduce peak over shoot. The independent tuning of controllers is obtained by adjusting the open loop gain margin of each controller. Each controller is tuned using phase margin gain margin formula [4].

IV.Process model

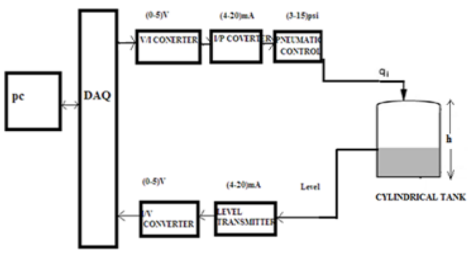


Fig 3: Process model of proposed system

Where
LT : Level transmitter.
I/V : Current to voltage converter.
V/I : Voltage to current converter.
I/P : Current to pressure converter.
DAQ : Data acquisition card.

The voltage from a DAQ (0-5v) is given to V/I converter from where a I/P converter gives a pneumatic signal. The pressure is given to a control valve which is the final control element. The level sensor is used to sense level. The voltage from sensor is given to an I/V converter and again given back to DAQ.

V. Mathematical modelling

Considered a cylindrical tank [5] which is given in Fig 4

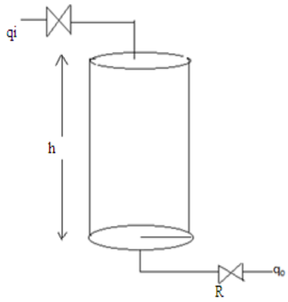


Fig 4:Cylindrical tank system

Assume that 'q_0', the volumetric flow rate through the resistance is related to the head 'h' by the linear relationship

$$q_0 = \frac{h}{R} \qquad (1)$$

Consider a time varying volumetric flow 'q_i' of liquid of constant density 'ρ' enters the tank.

We can analyze the system by writing a transient mass balance around the tank.

Mass flow in – Mass flow out = rate of change of accumulation of mass in the tank

By rearranging the mass balance equation and re-substitution we get,

$$, \frac{H(s)}{Q(s)} = \frac{R}{ARs+1} \qquad (2)$$

$$R = \frac{\text{Change in level difference(m)}}{\text{Change in flow rate}(\frac{m^3}{s})}$$

i.e. k_p = process gain

Therefore, $\frac{H(S)}{Q(S)} = \frac{Kp}{Ts+1}$ (3)

Equation (3) is the transfer function of cylindrical tank system. The above transfer function is for a process without time delay for a first order plus time delay process the transfer function is expressed as

$$\frac{H(s)}{Q(s)}=\frac{k_p\ e^{-st_d}}{Ts+1}$$

therefore, $\frac{H(S)}{Q(S)}=\frac{Kp}{Ts+1}$ (4)

The equation (4) is first order system with time delay.

VI. Design of a dual controller scheme

Let u1 be the controlled signal form set-point controller and u2 is the controlled output of disturbance rejection controller [6].

$$u_1=[r-ym]g_{c1} \quad (5)$$

$$ym=u_1 g_m \quad (6)$$

$$u_1=[r-u_1\,g_m]g_{c1}$$

$$u_1[1+g_m g_{c1}]=rg_{c1} \quad (7)$$

$$u=u_1+u_2 \quad (8)$$

$$u_2=[-y+u_1\,g_m]g_{c2} \quad (9)$$

substitute (7) and (9) in (8)

$$u=r\frac{g_{c1}}{1+g_m g_{c1}}+[-y+u_1\,g_m]g_{c2} \quad (10)$$

The output y of dual controller scheme is given by

$$y=\frac{g_p\,[1+g_{c2}\,g_m\,]}{g_m\,[1+g_{c2}\,g_p\,]}\frac{[g_{c1}\quad g_m\,]}{[1+g_c 1\,g_m\,]}r+\frac{[1]}{1+g_{c2}g_p}d$$

$$s_r(g_p=g_m)r+s_d(g_p=g_m)d$$

VII. Real time implementation of dual controller scheme.

The dual controller scheme with high robustness is compared with conventional control structure is implemented .The response of a conventional scheme has been given in Fig 5.

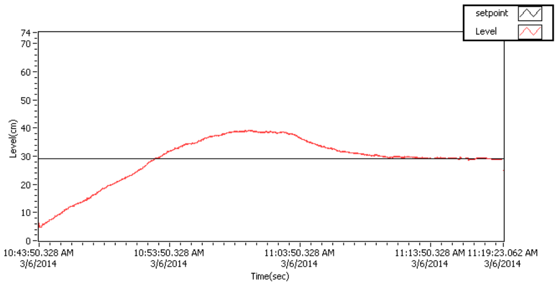


Fig 5.Response of a conventional control scheme.

The response for a dual controller scheme is better as compared with conventional scheme.Here the freedom of distubance rejection is more as compared with conventional scheme.The comparison has been given in table 1.

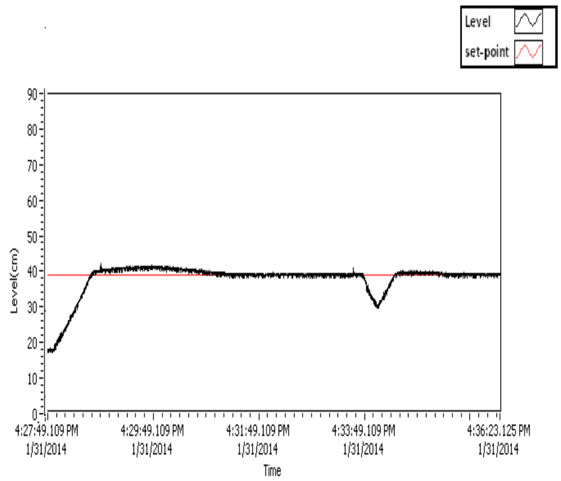


Fig 6: Response of a dual control scheme with disturbance

VIII. Comparison of a conventional control scheme and dual controller scheme

Parameter	Conventional controller	Dual controller scheme
Peak Overshoot (%)	**9**	**1.3**
Settling time(sec)	**1800**	**120**

Table 1. Comparison of a conventional control scheme and dual controller scheme

IX.Robustness of a dual controller scheme

The controllers have been tuned by phase margin and gain margin formula. They are [kp,ki,kd]=[72.2,1.64,0] for 1 to 2 v.

The response of a dual controller scheme for different set point and disturbance is given in Fig 7.Different set point of 30cm, 40cm, 50cm etc has been controlled by a controller tuned by parameters obtained with a transfer function [7].The model mismatch is compensated by the additional load rejection controller.

$$G(s) = \frac{.23925}{44s+1} e^{-1s}$$

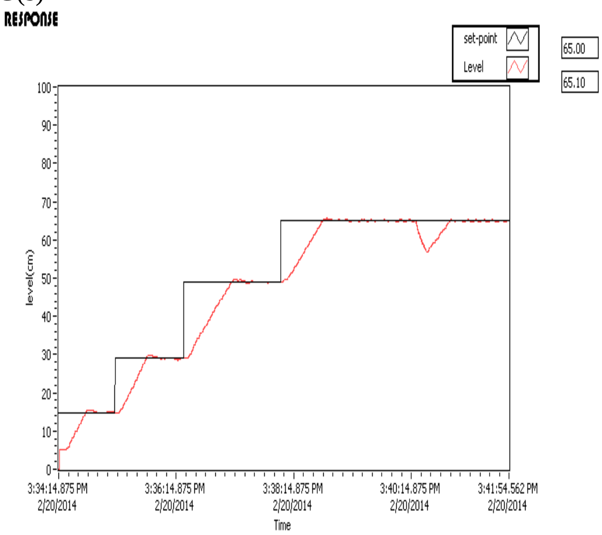


Fig 7: Response of a robust dual controller scheme with disturbance

X EXPLANATION:

The performance of the process has been maintained without sacrificing the robustness .Thus the robustness of process variable is maintained at different set point. The proposed scheme has high compensation for variable flow, sensor noise and actuator saturation.

XI. CONCLUSION

Here the method has high robustness than conventional scheme with improved performance. The servo response is obtained at different set point.A perfect tracking is obtained at any region of the system with high precision. The disturbance has been tuned independently by another dedicated disturbance rejection controller.

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REFERENCES

[1] O. Arrieta, A. Visioli , R. Vilanova, PID autotuning for weighted servo/regulation control operation: *Journal of Process Control 20 (2010) 472–480.*

[2] Y.C Tian,F Gao,Double controller scheme for process with dominant time delay,*IEEE procedings control theory application vol 145,september 2008*

[3] Sigurd skogestad,simple analytical rule for model reduction and PID controller *tuning, journal of process control 13(2003)* pages 291-309

[4] Zhuo-Yun Niea, Qing-Guo Wangb, Min Wua, Yong Hea, Tuning of multi-loop PI controllers based on gain and phase margin specifications: *Journal of Process Control 21 (2011) 1287– 1295*

[5] George Stephanopoulos,An introduction to theory and practice,*chemical process control:page 174-175*

[6] Giridharan Karunagaran, Cai Wenjian; The Parallel Control Structure for Transparent Online Tuning: *Journal of Process Control 21 (2011) 1072– 1079*

[7] Qing Xiong,Wen jian Cai,Mao-Jun He, Equivalent transfer function method for PI/PID controller design for MIMO process, , *journal of process control 17(2007)* pages 665-673