Development and Control of Multi Input Multi Output System

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Abstract—*Today as the engineering has came to a long way almost all the industries in their most of the processes using the Multi Input Multi Output (MIMO) system. Due to which the complexity of the systems have increased and hence it is difficult to control such type of process. The designing and development procedure of a MIMO (Multi Input Multi Output) control system are hence became a topic for studies and research. In this paper an attempt has been made to develop low cost setup for MIMO process considering level and temperature as an example case study. The proposed setup can be easily used to interface the MIMO with the LabVIEW. Also the paper summarizes the PID control strategies which have been validated considering respective MIMO system and also tested for the noise rejection. Dynamic analysis has been performed using classical PID.*

Keywords: *MIMO, LabVIEW, PID.*

1. INTRODUCTION

Process control is an engineering discipline that deals with the common process input and outputs variables like flow, pressure, level and temperature. We consider level and temperature in water tank system and maintain the level and temperature of the system using water flow and heater supply. In this water tank system two manipulated variable and two controlled variable [3]. Attempt has been made to develop low cost setup, easily configuration and testing laboratory setup for MIMO process for level and temperature control, it shows in Fig. (1).The proposed setup can be easily interfaced with the LabVIEW.

In this paper, a model of the process have been obtained using system identification toolbox in MATLAB. And also to demonstrate the conventional PID and modern control algorithm in water tank plant. Quantitative feedback theory is applied in to design a robust controller to regulate the level and temperature of the water tank [4]. The conventional PID controller is a convenient reliable and removes the present error [5]

PID algorithm are written in LabVIEW and also represent all parameters in SCADA for real time data monitoring. Simulated results are analyze.
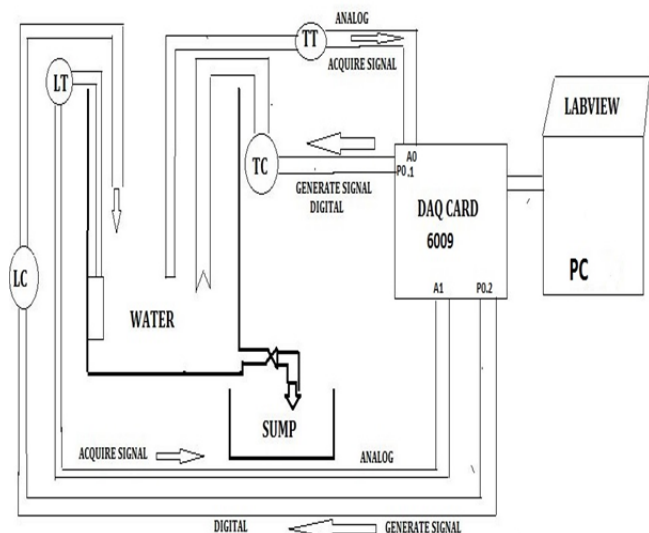

Fig. 1: Schematic diagram for interfacing apparatus with LabVIEW

2. HARDWARE IMPLEMENTATION AND CONTROL SOFTWARE

The hardware configuration of the water tank control system, which includes that level measurement and temperature measurement. Level measurement [15] using a pressure sensor [range: 0, 1m] and level controlled through DC motor [24 volts]. Temperature measurement using a Pt 100 RTD [16] sensor (range: [0 ^{0}C, 100 ^{0}C] and signal conditioning circuit are convert [4, 20] mA to [1, 5] V [19]. Input of the system is inflow of water which control through motor driver IC using PWM and heater supply [230 V] AC is controlled through TRAIC- DAIC signal conditioning circuit using PWM. Real time input and output data is acquiring through National Instrument DAQ 6009 data acquisition card [18] allocated in a Pentium PC, and the water tank plant. Fig. (2.1) shows schematic wiring diagram to interface the apparatus with LabVIEW [17]. Hence a user friendly, reliable, low cost setup of MIMO process is prepared. Fig. (2.2) shows actual hardware of the system.
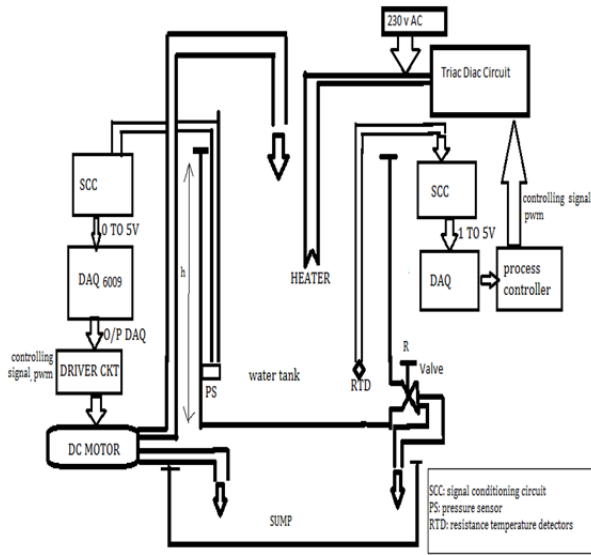
Fig. 2.1: Functional Block Diagram

Fig. 2.2: Actual hardware interfaced with LabVIEW

Pressure sensor are calibrating in terms of voltage vs level as follows:

Table 1: Scaling of pressure sensor

Voltage (v)	Level (cm)
0.107	20
0.096	15
0.23	10
0.33	5
0.58	0

Temperature sensor are calibrating in terms of voltage vs. temperature as follows:

Table 2: Scaling of RTD sensor

Voltage (v)	Temperature (^{0}C)
1	0
2	25
3	50
4	75
5	100

3. CONTROL SOFTWARE

Control software was written in LABVIEW code (VI 13) and executed in the Laptop. Such an algorithm are process level and temperature signal and generate two control signal, one for heater control and another for motor control. MIMO process system are control through PID controller in LabVIEW [6] to design PID control algorithm to control and stabilize the level and temperature. In MIMO system require two PID controller. Input of the system are acquire and generate the signal using PWM is written in LabVIEW code. Real time data and monitoring of input and output in LabVIEW. LabVIEW is used as a SCADA. Which implement the different process parameters using the graphical visual representation from the real time process [7]. Graphical represent is shown in Fig. (4.3)

4. MODELING AND SYSTEM IDENTIFICATION

Fig. (3.1) shown the water tank plant are studied here. In such a plant, water is inflow into the tank, heated electrically and outflow through valve. The plant is a MIMO type because processes have two manipulated variables: inflow rate and the heater supply and two controlled variables water level and the temperature in the tank.
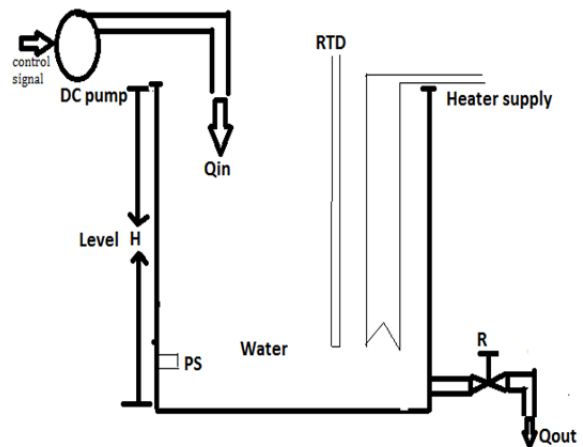

Fig. 3.1: Water Tank Plant

$$Gp11 = \frac{1.069}{16.7s+0.33} \qquad Gp12 = \frac{0.145}{21s+0.45}$$

$$Gp21 = \frac{1.637}{1.2s^2+10.9s+0.87} \qquad Gp22 = \frac{1.095}{3.9s^2 + 14.4s + 0.35}$$

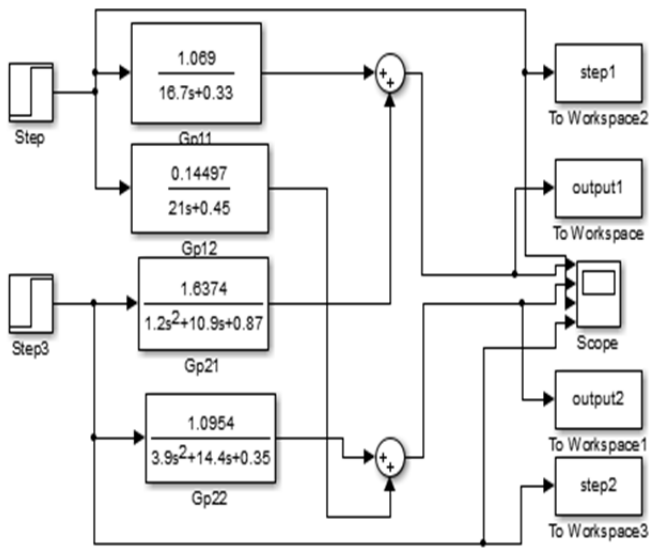## 4.1 Open Loop Vs Close Loop Response
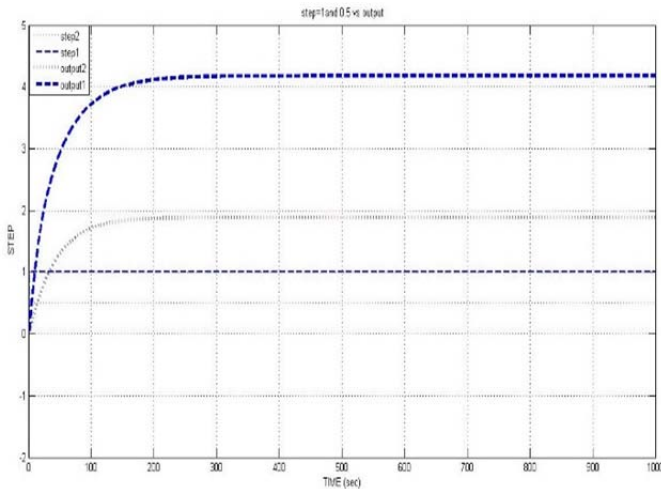

Fig. 3.2: Simulink open loop

Fig. 3.3: Open loop response for temperature and level

Fig. (3.3) analyze that both input and output are working as SISO system. Any step change in any input the output will stabilize but it is open loop response so output will not achieve the set point. Fig. (3.4) shows close loop response and analyze the output will follow the set point and stabilize the system response. In close loop performance, output will tracing the set point and stabilize very fast. Comparison of open loop and close loop response is shown in Fig. (3.5).
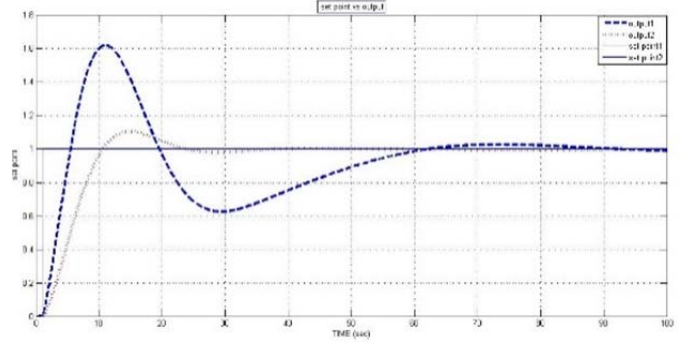
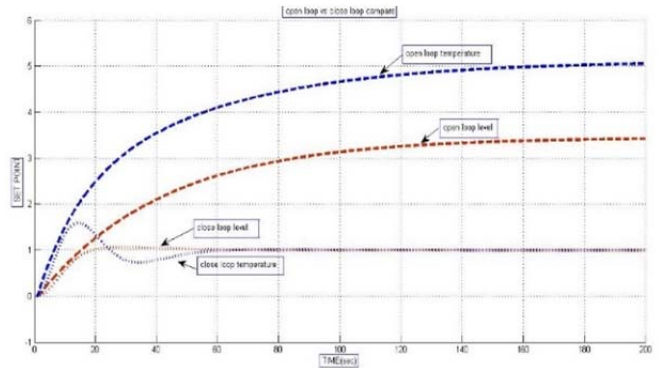**Fig. 3.4: Close loop response for temperature and level**

Fig. 3.5: Open loop vs. Close loop

5. EXPERIMENT AND RESULTS

5.1 Controller Design

In this experiment, Applying PID controller. And take real time data and monitor all parameters in LabVIEW. This PID controller block in available in LabVIEW.
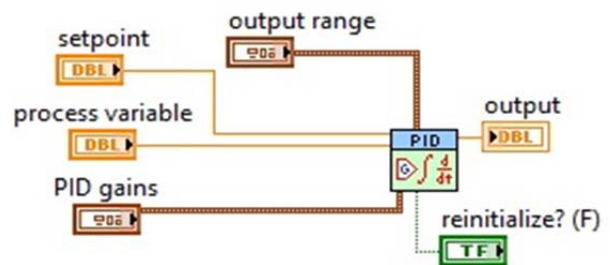

Fig. 5.1: PID controller in LabVIEW

Applying TRIAL AND ERROR CONTROL strategies and analyze all parameters of PID. In this method, take different gains of PID.
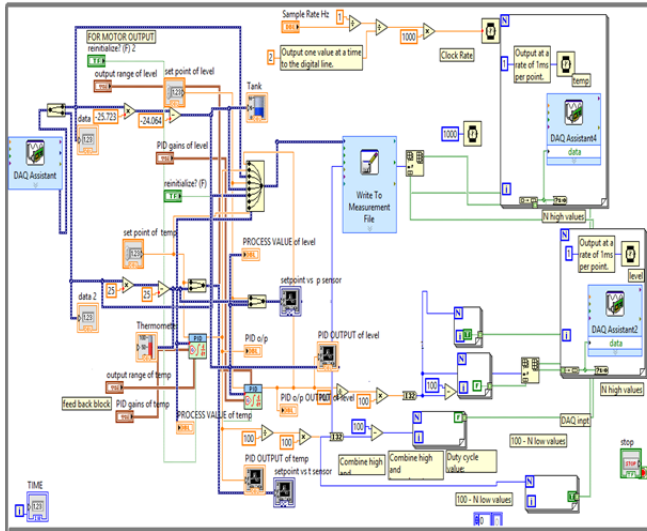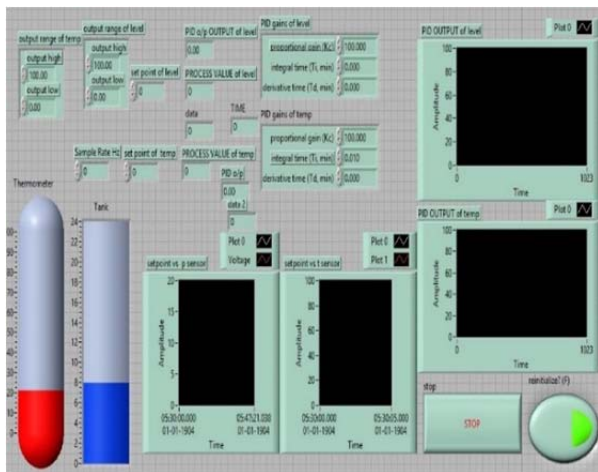
Fig. 3.1: LabVIEW code for PID

Fig. 3.2: SCADA in LabVIEW

This Fig. (3.2) tells about the monitoring of the process parameters that include alarm system, different values of system etc.
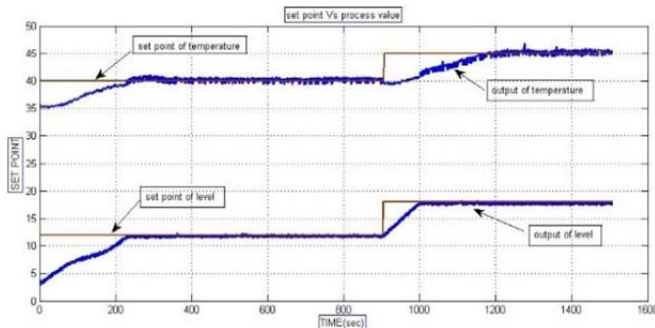
5.2 Experiment of PID

Fig. 5.2.1: step input when system is stable

For checking the stability region apply the step input before the system gets stable and maintain the level and temperature constant. It shows in Fig. (5.2.1)
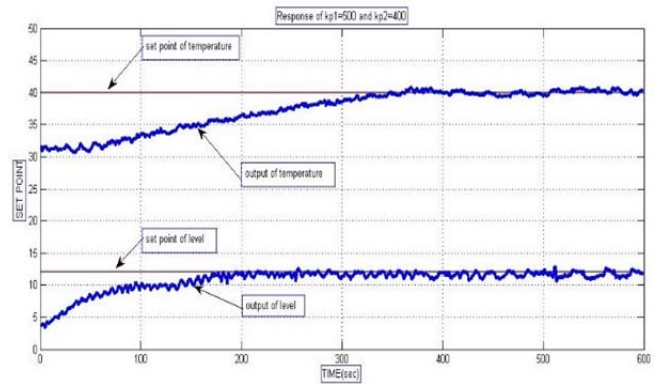

Fig. 5.2.2: Gain Kp1=500 and Kp2=400

When proportional gain is applied to both temperature and level of system then temperature will take 375 sec to reach the set point and level reaches in 180 sec. It shows in Fig. (5.2.2)
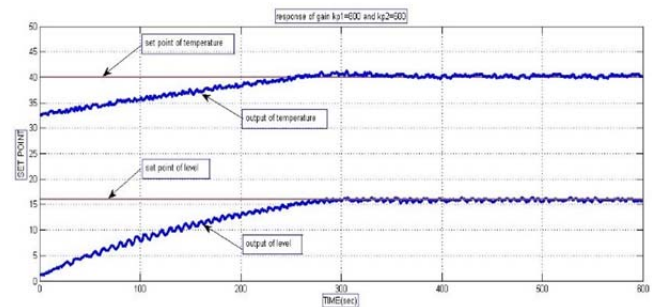

Fig. 5.2.3: Gain Kp1=800 and Kp2=600

When the values of proportional gain is increased then temperature will take less time to settle as compared to level .so it seems to be weakly coupled system. It shows in Fig. (5.2.3)
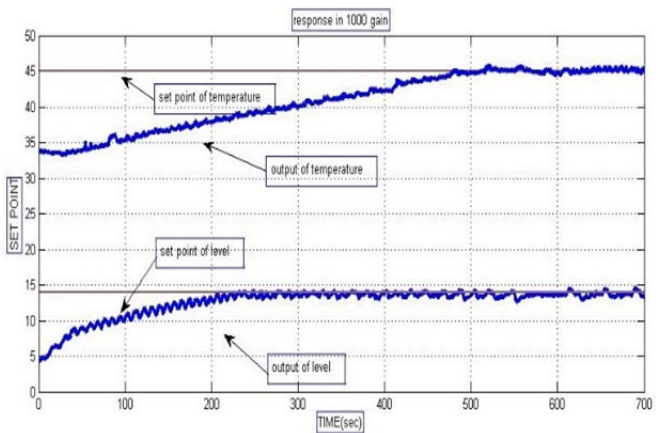

Fig. 5.2.4: Gain Kp1=1000 and Kp2=1000

When gain of both temperature and level are same, due to the flow rate the temperature will not reach the set point quickly. The system became sluggish. It shows in Fig. (5.2.4)
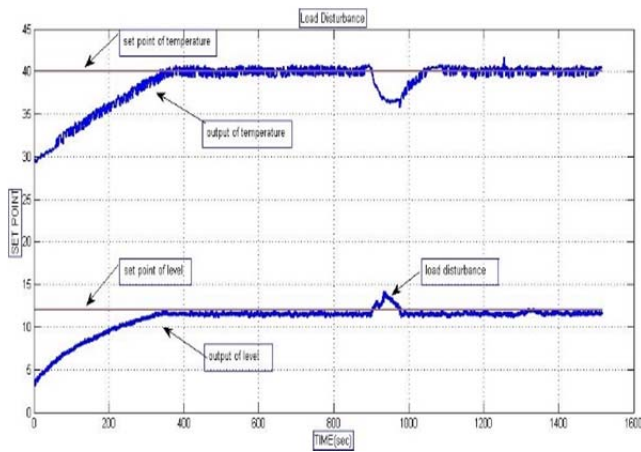

Fig. 5.2.5: Load disturbance

Any load disturbance is applied in level effects the large changes in the temperature because the system is strongly coupled. It shows in Fig. (5.2.5)

6.   CONCLUSION

This paper has presented the design and control of a multi input and multi output process control system and modling of level and temperature using system identification toolbox. A conventional PID controller was applied of both temperature and level control loop. The optimal parameter shows the improved response of the PID controller. All the experiments have done in LabVIEW platform for real time data and monitoring. However, in MIMO processes control, two loop control action are showed good performance and robustness used for any noises. This PID controller stabilizes both the level and temperature.

7.   ACKNOWLEDGEMENTS

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