



Modeling a Multivariable Process Control System using PID Optimization

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ABSTRACT

Many process control model have been observed to have unsatisfactory output variables, such as pressure, composition, temperature, at specified values, giving rise to overshoot and unbounded responses. A lot of methods have been adopted to curb this undesirable effect, starting from the use of different configurations of controllers. This paper presents the model of a multivariable process control using labview proportional, integral and derivation controllers (PID). Modeling and control of multivariable process using optimization can be effectively achieved by optimization of proportional, integral, derivative volume of liquid L coupled with using appropriate transfer functions and accurate labview controllers for the modeling to achieve the controlling of the volume of cold and hot water to be in the proportion of 3:1.

Keywords: Labview, PID Controller, Multivariable, Overshoot, simplex optimization

INTRODUCTION

Modeling and control of multivariable process using optimization is the control of level and temperature of liquid in tanks and flow between tanks are the basic problem in the process industries. To achieve this level control of liquid, optimization using PID method is used in this project. The process control industries require liquids which are to be pumped as well as stored in tanks and then pumped to another tank. Most of the times, the liquids will be processed in the tanks, but always the level and temperature of liquid in the tanks have to be controlled and the flow between tanks have to be regulated. As the tanks are so coupled together that the levels in tanks interact with each other and this must also be controlled. Systems which have more than one input and or more than one

output are called multiple input multiple output (MIMO) system (Wayne Bequette, 2003)

Tank level control system are used frequently in different processes. All of the process industries, the human body and fluid handling system depend upon tanks level control systems. The control system engineers have to understand how thermal control systems work and how the level control problem is achieved. However, interactions existing between loops make it more difficult to design PI and PID controllers (Wang, 2009) for MIMO processes than for single input single output (SISO) ones and have attracted attention of many researcher in recent years.

Thermal control systems are also used frequently in different processes. The thermal control system is non linear time varying and consists of multivariable. Hence, the control of such system is complex and challenging. It is a challenging task for control system engineers to understand how thermal control systems work and how the control of temperature of liquid in the tank is achieved. The description of a system using mathematical concepts and language is called a mathematical model. A mathematical model helps to explain a system and to study the effects of different components, and to make predictions about their behavior. Mathematical models can take many forms like dynamical systems, statistical models or differential equations. Hence, mathematical model of the components of the thermal control system is very important for design and analysis of the control system.

The output of the MIMO process can either be interacting or non-interacting. If one output is affected

it by minus one. Finally remove the constraint in equation 4 by introducing.

$$\begin{aligned} L - 60p - 45I - 25D + MS_4 &= 0 & -5 \\ 4p + 8I + 2D + S_1 &= 160 & -6 \\ 6p + 3I + 4D + S_2 &= 168 & -7 \\ 4p + 3I + 3D - S_3 + S_4 &= 128 & -8 \end{aligned}$$

To find the key row use the positive numbers in the key column to divide their respective solutions, whatsoever gives the smallest answer is where the key row falls.

$$\text{E.g } \frac{160}{4} = 40$$

$$\frac{168}{6} = 28$$

$$\frac{128}{4} = 32$$

The smallest answer here is 28 whose divisor is 6. So, the key row falls at s_2

Step A

Fill in the coefficients of equations 5, 6 and 7 in the table1 for iteration.

Step B

The key column falls at the most negative at L row of iteration I which is - 60, so it falls at P column.

Step C

Table 1: iteration 1

No of iterations	Basic	L	P	I	D	S1	S2	S3	S4	solu
S ₂	L	1	-60	-45	-25	0	0	0	M	0
Leaves	S ₁	0	4	8	2	1	0	0	0	160
P	S ₂	0	6	3	4	0	1	0	0	168
Enters	S ₄	0	4	3	3	0	0	-1	1	128

Table 2: iteration 2

S ₂	L	1	0	-15	15	0	10	0	M	1680
Leaves	S ₁	0	0	6	-2/3	1	-2/3	0	0	48
I	P	0	1	1/2	2/3	0	1/6	0	0	28
Enters	S ₄	0	0	1	1/3	0	-2/3	-1	1	16

Table 3: iteration 3

S ₄	L	1	0	0	40/3	5/2	25/3	0	M	1800
Leaves	S ₄	0	0	1	-1/9	1/6	-1/9	0	0	8
I	P	0	1	0	13/18	-1/12	2/9	0	0	24
Enters	S ₄	0	0	0	10/9	-1/6	-5/9	-1	1	8

- L = 1800 LITRES
- I = 8
- P = 24
- D = 0

System Simulation and Data Analysis

The model and control of multivariable process using optimization is designed in figs 1 and 2 which are meant for 1800 liters to generate 1350liters for cold water and 450liters for hot water respectively when simulated .

The maximum liters of liquid which is 1800 got from the optimization is used to pour in the system for it to be processed into hot and cold water.

The design was done in such a way that the proportional of the cold water to the hot water when processed is 3:1.

Although maximum liters of liquids were varied as follows 2500, 3000, 3500, 4000, 4500 and 5000 liters which were also poured in the system for it to be processed into cold and hot water. When the process rounded up, the proportion of the cold water to the hot water obeyed the specification of the design which is 3: 1 ratio.

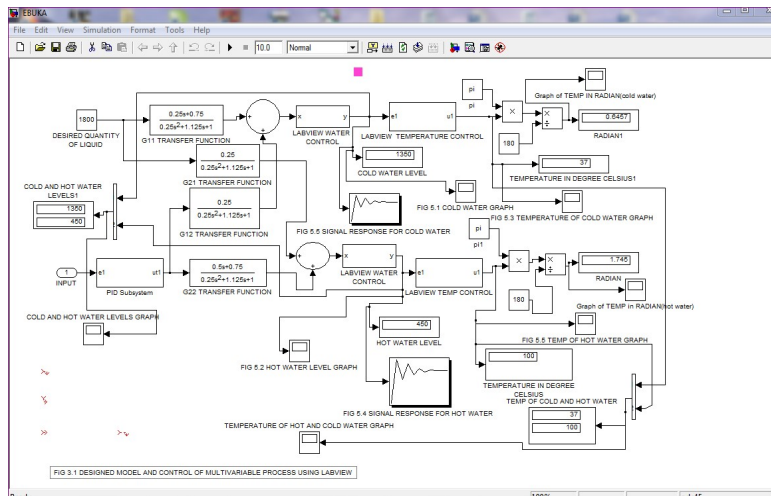


FIG 1 DESIGNED MODEL AND CONTROL OF MULTIVARIABLE PROCESS USING OPTIMIZATION AT A VOLUME OF 1800 LITERS

Fig 1 shows that when 1800liters of water is simulated with appropriate transfer function the volume of cold water is 1345 liters while that of hot water is 450 liters respectively.

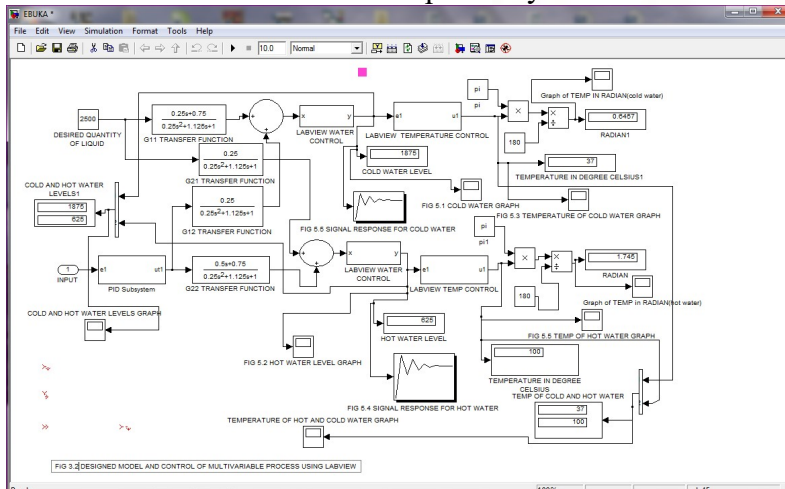


FIG 2: DESIGNED MODEL AND CONTROL OF MULTIVARIABLE PROCESS USING OPTIMIZATION AT A VOLUME OF 2500 LITERS

Fig 2 shows that when 2500 liters of water is simulated with appropriate transfer function the volume of cold water is 1875 liters while that of hot water is 625 liters respectively.

The results gotten in figs 1 and 2 show that the proportion of cold to hot water is 3:1

Result Analysis

Firstly, when 1800 liters of water is simulated the volumes at different times are shown in tables 1 and 2 for cold water level of 1350 liters and hot water level of 450 liters.

Table1 Cold Water Level 1350 Liters

Time(s)	Volume (liters)
10	1350
9	1350
8	1350
7	1350
6	1350
5	1350
4	1350
3	1350
2	1200
1	1000
0	0

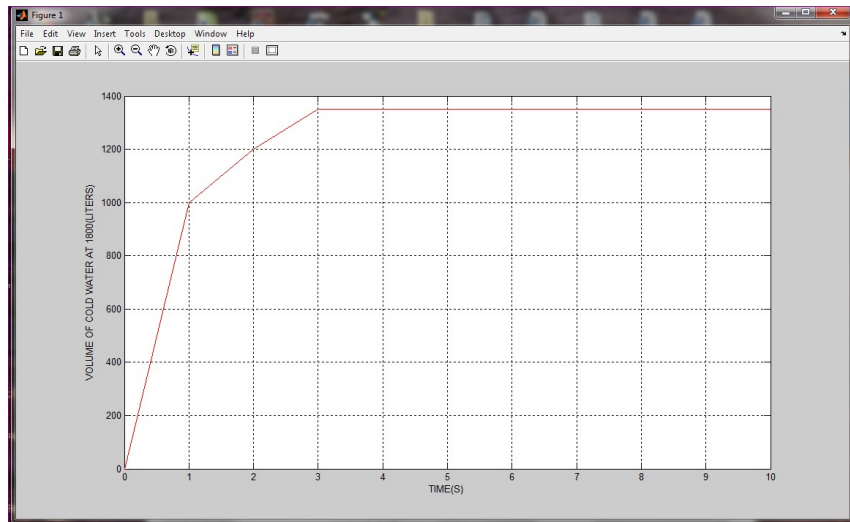


FIG 3 COLD WATER LEVEL AT 1350 LITERS

Fig. 3 shows the graph of cold water level when 1800 liter of water is poured in the system for it to be processed. It is seen from the graph that from 0 sec through 2 seconds the graph is linear and from 3 seconds through 10 seconds the volume of cold water in the tank is controlled to a constant level of 1350

Table2 Hot water Level 450 Liters

Time(s)	Volume (liters)
10	450
9	450
8	450
7	450
6	450
5	450
4	450
3	450
2	250
1	1000
0	0

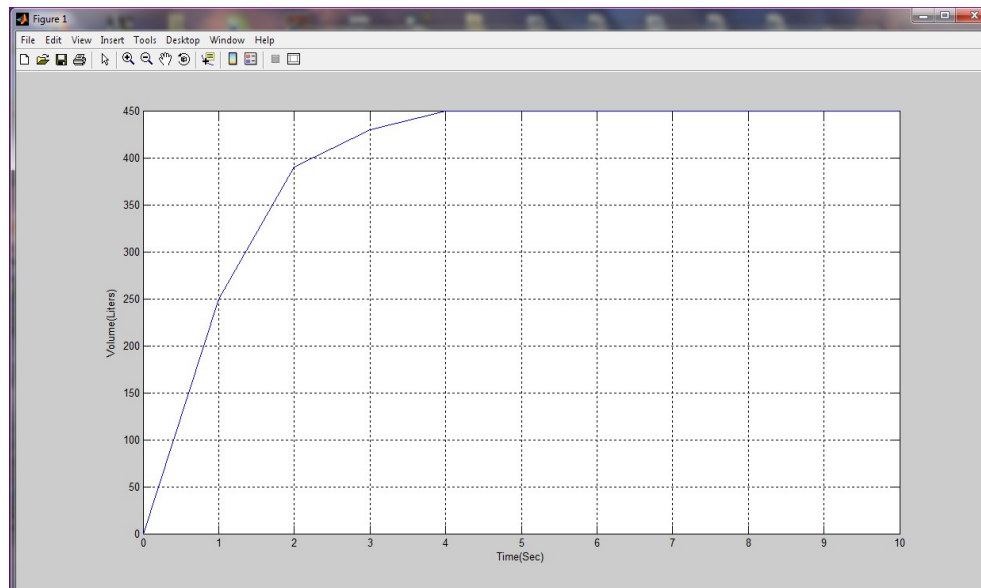


FIG 4 HOT WATER LEVEL AT 450 LITERS

It is equally seen from fig 4 that from 0 second through 3 seconds the level of water in the tank increases linearly while from 4 seconds through 10 seconds the water in the tank maintained a constant volume of 450 liters.

From the result gotten it is seen that the proportion of cold water to hot water is 3:1

Conclusion

Modeling and control of multivariable process using optimization can be effectively achieved by optimization of proportional, integral, derivative volume of liquid L coupled with using appropriate transfer functions and accurate labview controllers for the modeling to achieve the controlling of the volume of cold and hot water to be in the proportion of 3:1.

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