

Simulation Of Three Tank System Using Hybrid Petri Net For Batch Process

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Abstract

This paper proposes a method to simulate chemical batch process..Simulation is a commonly used tool in the phase of planning and during operation of batch process. Batch process are discontinuous process .they have characteristics of both discrete and continuous, what usually leads to a recipe based process design .The work in this paper is based on a behavioral study of Batch process in a pharmaceutical industry for preparation of paracetamol tablet. The simulation process of tablet manufacturing is analyzed by using two valuable techniques .They are (1).Invariant or Mathematical analysis.(2) Evolution graph. Both analytical and graphical results are obtained which are highly useful to understand plant behavior and accuracy.

Key words: Hybrid Petri net, modeling, three tank system.

I. Introduction

In this chapter we are going to discuss about the batch process, a Batch process is a process in which a desired amount of input quantity is given to the system and according to the input a estimated output is obtained. Some examples of batch process are biscuit manufacturing, tablet manufacturing, bottle filling, etc.

Benefits Of Batch Process

It can shift the time of the job processing to when the computing resources are less busy.It avoids idling the computing resources with minute-by-minute manual intervention and supervision.By keeping high overall rate of utilization, it amortizes

the computer, especially an expensive one. It allows the system to use different priorities for batch and interactive work

Preparation Of Paracetamol

For preparing a paracetamol in a powdered form, we need three main ingredients such as

1. Acetic anhydride
2. 4-amino-phenol
3. Distilled water

First 4-aminophenol mixed with the distilled water in desired proportion and taken in the first tank, then the second tank is filled with 4-amino phenol solution then the two solutions are added in the final third tank in the ratio of 10:4 to obtain a solution from which we can obtain a Paracetamol powder

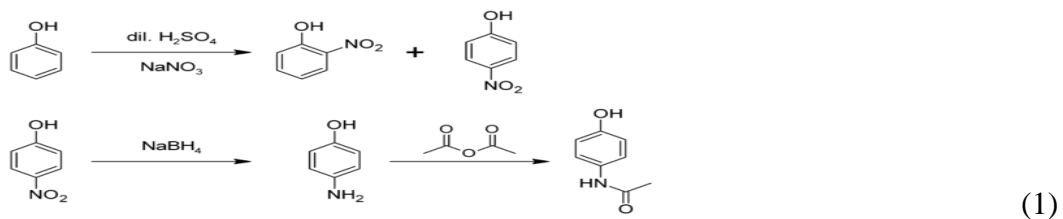


Figure 1. Chemical equation of paracetamol

II. Hybrid Petrinet

Over the past few decades, petrinet is widely used in pet bottle manufacturing systems and discrete event systems. A petri net is a graphical mathematical modeling tool for describing and simulating dynamic and concurrent activities of system (Murata, 1989). A petri net is formally defined as:

$$N = (P, T, \text{pre}, \text{post}, m)$$

$$m = m_0 + w \cdot s \tag{2}$$

where P is the set of places, T is a set of transitions, $\text{pre}(\text{Post})$, the $\text{pre}(\text{post})$ incidence function representing the input (output) arcs; m represents the current marking of places; a is the incidence matrix and m_0 is the initial marking of places; s is the characteristics vector of firing sequence which implies a string of successive marking and is a vector corresponding to the no of firing of the corresponding transition.

A petri net is graphically represented by a directed bipartite graph, and it consists of structural components of places, transitions, and arcs. In a petrinet, places drawn as circles are used to describe local system states and transitions drawn either as bars or boxes are used to describe events that may modify the system state. Arcs that connect places and transitions represent the relations between local states and events. In discrete petri net, the initial number of tokens is drawn as black dots in each place.

comparison with discrete petri net, the marking of place in continuous petri net is marked by real numbers, and the transition firings are continuous process.

A hybrid petrinets system is defined as:

$$N=(P,T,Pre,Post,m,h)$$

Where P,T,Pre, Post,m are quite similar for petri net and h is a hybrid function that indicates a discrete or continuous node. Hybrid petri nets informally contain a discrete part and a continuous part .considering the time for the hybrid petri nets, the marking m at time t of hybrid petrinet can be written as

$$m(t) = m(0) + w(n(t) + \int_0^t v(u)d(u)) \quad (3)$$

Where w is the incident matrix,and n(t) denotes the number of firings of the discrete transitions from the initial time to time t. v(u) is the firing speed of the continuous transitions at an arbitrary time u.

III. Block Diagram Of Three Tank System

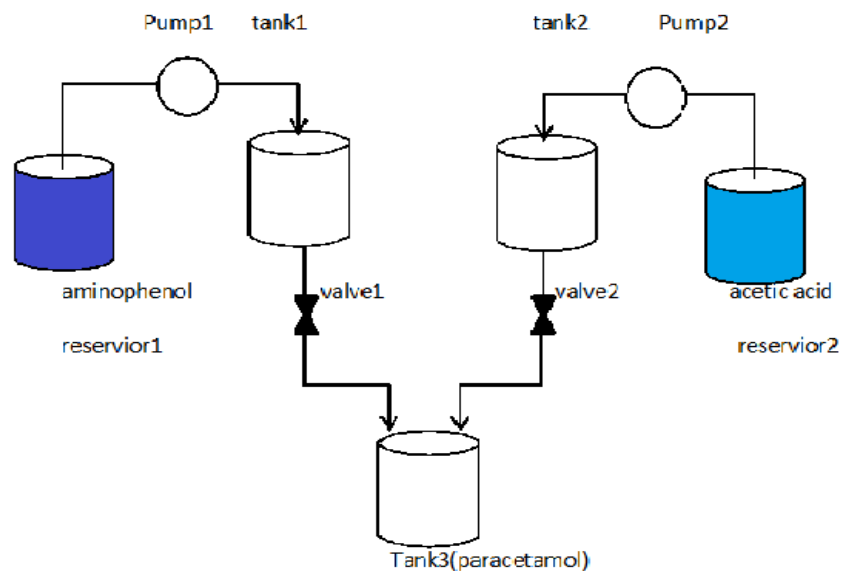


Figure 2. Three tank system

Three tank system is taken for modelling of Petri nets in Sirphyco simulation software, system consist of three main tanks and two reservoir, two pumps and three valves. In the reservoir large amount of required solution is stored and then pumped into the main tank at required time, valves are used to regulate the flow of the solution.

In the working process, required amount of aminophenol and acetic acid solution is pumped into the first tank and second tank respectively. Aminophenol in tank1 and acetic acid in tank2 is drained to the third tank in the ratio of 1:0.4. Then the two

solutions starts to mix in the third tank at prescribed proportion with the help of the of the flow regulatory valves, then final mixture is obtained in the third tank.

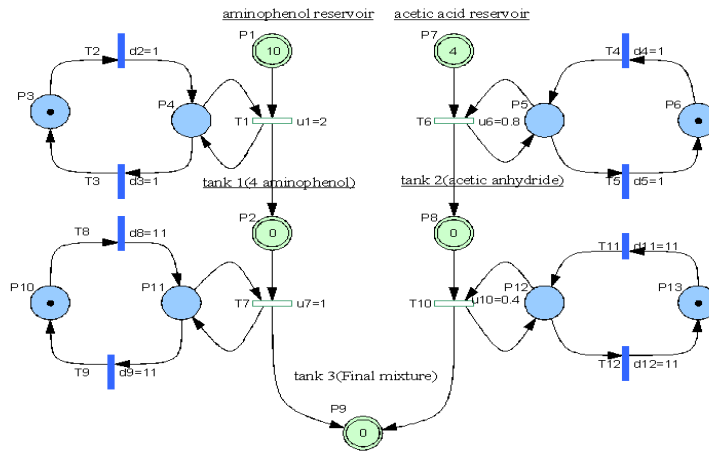


Figure 3. Equivalent hybrid petri net model developed for three tank system

Working Of The Model

Process works like flow diagram and it is also called as bipartite graph. Each firing in the process is taken as one second, thus process can be studied easily by using this method of approach. After each firing, the token value of discrete places P3, P4, P5, P6 changes and after each eleven seconds the token values places P10, P11, P12, P13 changes. Due to this change in the discrete values T1, T7, T6, T10 also changes, and the formula is given as $V(\text{Flow})=U(\text{Valve speed}) * M(\text{No. Of Markings})$ and this represents draining of the tank. Thus the process also explains how slowly the reaction starts and mixing is done in the three tank system.

Initially during the first firing (t1), the token from P3 and P6 moves to P4 and P5 thereby turning on the pump1 and pump2 therefore 2liters from p1 and P7 are drained to P2 and P8 respectively. During the second firing (t2), the token from P4 and P5 moves to P3 and P6 thereby turning off the pump1 and pump2. Similarly the fluid is drained to P2 and P8 till eleventh firing (t11). From twelfth firing to twentieth firing, the token from P10 and P13 moves to P11 and P12 and remains same thereby turning on the valve1 and valve2 for eleven seconds thus draining a sum of 14liters in P9. Finally at twenty first firing the token from P11 and P12 moves to P10 and P13 and thus turning off the valve1 and valve2 respectively.

Simulation Ggraph

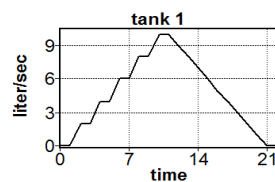


Figure 4. Response of Tank1

The above figure 3.1 shows that tank1 level reaches maximum of 10liters at t=11 and starts draining to become empty at t=21

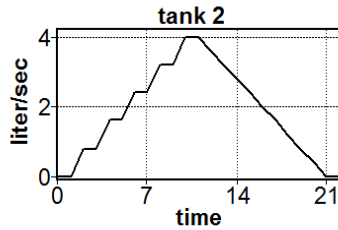


Figure 5 Response of Tank2

The above figure 3.2 shows that tank2 level reaches maximum of 4liters at t=11 and starts draining to become empty at t=21

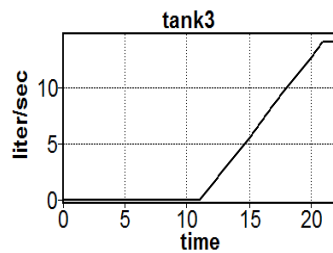


Figure 6. Response of Tank3

The above figure 3.3 shows that tank3 level remains constant till t=11 and then reaches maximum of 14liters at t=21 and starts to constant

IV. Mathamatical Analysis Of System Model

$$m_k = m_i + w.s \tag{4}$$

Where, m_k -marking of petrinet, m_i -initial marking, W -incident matrix, S -firing sequence

$$W=(W^-)+(W^+) \tag{5}$$

W^- =input incident matrix, W^+ =output incident matrix, $W_{ij}^- = \text{pre}(P_i \rightarrow T_j)$, $W_{ij}^+ = \text{post}(T_i \rightarrow P_j)$

At Firing,

$$M1 = \begin{bmatrix} 10 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \\ 4 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} \quad S1 = \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad M2 = M1 + W.S = \begin{bmatrix} 10 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \\ 4 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ -1 \\ 1 \\ 1 \\ -1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \\ 0 \\ 1 \\ 1 \\ 0 \\ 4 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

V.EVALUTION GRAPH:

In this method, analysis is derived in graph like structure it represents this method as evaluation graph. This method mainly deals with the firing of tokens from one place to the other place through the transition. It also represents the past, present and future information of the token. It also denotes the step by step proceedings of the process.

													T1	T7	T6	T10									
													2	1	0.8	0.4									
													P1	P2	P7	P8	P9								
													10	0	4	0	0								
P3	P4	P5	P6	P10	P11	P12	P13	T2	T3	T4	T5	T8	T9	T11	T12										
1	0	0	1	1	0	0	1	1	0	1	0	0	0	0	0										

													1					P1	P2	P7	P8	P9							
													T2	T4					10	0	4	0	0						
P3	P4	P5	P6	P10	P11	P12	P13	T2	T3	T4	T5	T8	T9	T11	T12														
0	1	1	0	1	0	0	1	0	1	0	1	1	0	0	0														

													2					P1	P2	P7	P8	P9							
													T3	T5					8	2	3.2	0.8	0						
P3	P4	P5	P6	P10	P11	P12	P13	T2	T3	T4	T5	T8	T9	T11	T12														
1	0	0	1	1	0	0	1	0	1	0	1	1	0	0	0														

													3					P1	P2	P7	P8	P9							
													T2	T4					8	2	3.2	0.8	0						
P3	P4	P5	P6	P10	P11	P12	P13	T2	T3	T4	T5	T8	T9	T11	T12														
0	1	1	0	1	0	0	1	0	1	0	1	0	0	0	0														

4

		T3 T5		P1 P2 P7 P8 P9										
				6	4	2.4	1.6	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
1	0	0	1	1	0	0	1	1	0	1	0	0	0	0

5

		T2 T4		P1 P2 P7 P8 P9										
				6	4	2.4	1.6	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
0	1	1	0	1	0	0	1	0	1	0	1	0	0	0

6

		T3 T5		P1 P2 P7 P8 P9										
				4	6	1.6	2.4	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
1	0	0	1	1	0	0	1	1	0	1	0	0	0	0

7

		T2 T4		P1 P2 P7 P8 P9										
				4	6	1.6	2.4	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
0	1	1	0	1	0	0	1	0	1	0	1	1	0	0

8

		T3 T5		P1 P2 P7 P8 P9										
				2	8	0.8	3.2	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
1	0	0	1	1	0	0	1	1	0	1	0	0	0	0

9

		T2 T4		P1 P2 P7 P8 P9										
				2	8	0.8	3.2	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
0	1	1	0	1	0	0	1	0	1	0	1	0	0	0

10

		T3 T5		P1 P2 P7 P8 P9										
				0	10	0	4	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
1	0	0	1	1	0	0	1	1	0	1	0	1	0	1

11

		T2 T4		P1 P2 P7 P8 P9										
				0	10	0	4	0						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
0	1	1	0	0	1	1	0	0	1	0	1	0	0	0

12

		T3 T5		P1 P2 P7 P8 P9										
				0	9	0	3.6	1.4						
P3	P4	P5	P6	P10	P11	P12	P13 T2	T3	T4	T5	T8	T9	T11	T12
1	0	0	1	0	1	1	0	1	0	1	0	0	0	0

13

		T2 T4		P1 P2 P7 P8 P9										
				0	8	0	3.2	2.8						
P3	P4	P5	P6	P10	P11	P12	P13T2	T3	T4	T5	T8	T9	T11	T12
0	1	1	0	0	1	1	0	0	1	0	1	0	0	0

VI. Conclusion

In this paper of three tank system is simulated with a new technique called hybrid Petri nets and the process is first designed using a three tank model and the same model is implemented in the sirphyco simulation software using Petri nets. Then the system is theoretically proved by analysis methods namely the invariant matrix analysis method and reachability graph analysis method, these methods explain the how the solutions in the tank is mixed and also explains us the behaviour of the system It is implementing the same process in a hardware model using the same concept of hybrid Petri nets and using embedded plc for controlling the process. which will be more useful in studying the same concept and we can easily figure the difference between the existing processes. And we can also modify the existing process to a more advanced process and include the new techniques in the process. The Petri nets is a wide area where we can do more thing in the field of industries and other mathematical process and has many applications.

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