Conceptual Logic Production Line Modelling System

Edy Fradinata [1]

[1] Industrial Engineering and Management Department, Serambi Mekkah University
Banda Aceh , Indonesia.
Email: edinata69@gmail.com

Abstract— **Many industrial sectors on the world are structured as a series as the production stages. Row material come from the beginning of the first step and enter into the process which various kind of processes like bath and continue where limited in the time as the constrain of the flow of the process to transfer to be products in to the next step, in the process they usually use conceptual logic or separately equipment to separate the eligible product and send second product to transfer to another equipment to be additional process where it should be make the added value for the second product. This modelling do the conceptual logic in production line system and analyse the factor of time between arrival raw material in the warehouse then directly process to the process unit then send it again to to the next process as well. The result of this study are decreased sharply in the beginning of the initial times for variables like number of waiting or queue, total process time, utilization and total entity time but increased the idle cost. This KPI are the indicators from the process for the triangular probability most likely value in the process.**

Keywords—conceptual logic; production line; KPI; triangular probability

I. Introduction

Process of manufacture is usually equipped with various facilities where the workstation equipment installed, sometime the intervention of the buffer to hold the product flow along the line is needed. Each workstation contains one or more machines, some operators or equipped with robotic equipment, and work in process (WIP) buffer. Once the process is complete then the workstation will flow to the next work station with the existing availability of space this mean the space at each workstations are needed to be processed. The model is defined for one or more repetitions of a particular process or series within a series of process units to work one bath, sometimes a bath is equipped with a series of vehicle or conveyor.

Discrete event simulation (DES), In the DES paradigm, the simulation model possesses a state S (possibly vector valued) at any point in time. A system state is a set of data that captures the salient variables of the system and allows us to describe system evolution over time. In a computer simulation program, the state is stored in one or more program variables that represent various data structures (e.g., the number of customers in a queue, or their exact sequence in the queue). Thus, the state can be defined in various ways, depending on particular modelling needs, and the requisite level of detail is incorporated into the model. As an example, consider a machine, fed by a raw-material storage of jobs. A "coarse" state of the system is the number jobs in the storage; note, however, that this state definition does not permit the computation of waiting times, because the identity of individual jobs is not maintained. On the other hand, the more "refined" state consisting of customer identities in a queue and associated data (such as customer arrival times) does permit the computation of waiting times. In practice, the state definition of a system should be determined based on its modelling needs, particularly the statistics to be computed ([8], [11], [15]).

Consider a failure-proof single machine on the shop floor, fed by a buffer. Arriving jobs that find the machine busy (processing another job) must await their turn in the buffer, and eventually are processed in their order of arrival. Such a service discipline is called FIFO (first in first out) or FCFS (first come first served), and the resulting system is called a queue or queuing system. (The word "queue" is derived from French and ultimately from a Latin word that means "tail," which explains its technical meaning as a "waiting line." Its quaint spelling renders it one of the most vowel-redundant words in the English language.) Suppose that job inter arrival times and processing times are given (possibly random).

Potential productivity losses occur every time the machine is idle (blocked or starvation) due to engine failure or obstacles stemming from excessive accumulation inventory between workstations. Furthermore, the production lines are rarely deterministic; their randomness is due to variable processing times, as well as random failures and subsequent improvement. The randomness makes it difficult to control the system or to predict their behavior. A mathematical model or the simulation model is then used to make such predictions.

Problems in the design of production lines is mainly a problem of resource allocation . These problems include the workload allocation and buffer capacity allocation for a given set of workstations with associated processing time . Generally, the design problem quite difficult to solve in the manufacturing system .

This is due in part to the combinatorial the nature of the problem. Analysis performance of production lines trying to evaluate the measure performance as a function of a set of system parameters. The most commonly used performance the following steps : throughput, average inventory level in buffer, probability of downtime, block probability at the bottleneck workstation, the average time flow systems (also called manufacturing lead) Using the steps for analyzing manufacturing systems can reveal a better design with identify areas where the loss of productivity of the most dangerous. For complete coverage design, planning, and scheduling problems in production and inventory systems, ([3], [6], [7], [10], [12], [20]).

II. THEORY

Many practical models may be formulated as variations on the generic production line of Figure 1, or with additional wrinkles. For example, a model may call for one or more repetitions of a certain process or a set of processes, or some of the workstations may process jobs in batches. In other cases, the transfer of jobs from one workstation to another is of central importance, so that transportation via vehicles or conveyors is modeled in some detail. Eventually, jobs depart from the system, and such departures can occur, in principle,
from any workstation. In general, production lines employ a push regime, where little attention is given to the finished-product inventory. The manufacturing line simply produces (pushes) as much product as possible under the assumption that all finished products are to be used. Otherwise, when the accumulation of finished products becomes excessive, the manufacturing line may stop producing, at which point the push regime is switched to a pull. Push and pull types of manufacturing systems are studied in detail in ([2],[6]).

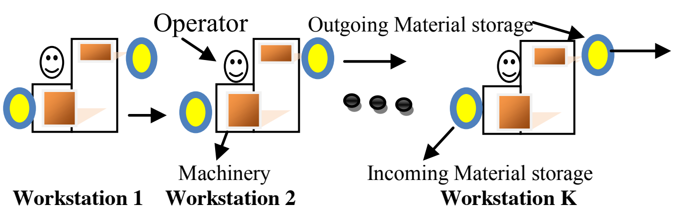

Fig. 1. A generic production line

More generally, storage limitations in workstations give rise to a bottleneck phenomenon, involving both blocking and starvation. The sources of this phenomenon are space limitations and cost considerations, which impose explicit or implicit target levels for storage between stages in a production line. Space limitations (finite buffers) in a downstream workstation can, therefore, cause stoppages at upstream workstations– a phenomenon known as blocking. Blocking policies differ on the exact timing of stoppage. One policy calls for an immediate halt of processing of new jobs in
the upstream workstation as soon as the downstream buffer becomes full. The upstream workstation is then forced to be idle until the downstream buffer has space for another job, at which point the upstream workstation resumes processing. This type of blocking is often called communications blocking, since it is common in communications systems. Another policy calls for processing the next job, but holding it (on completion) in the upstream machine until the downstream buffer can accommodate a new job. This type of blocking policy is called production blocking, since it often
occurs in manufacturing context. Various types of blocking mechanisms are discussed in detail in [19].

A. Command continuous distribution

This section reviews the most commonly used continuous distributions and the underlying random experiment, and discusses their use in simulation modeling. For more information ([5], [15]).

1. Uniform distribution

A uniform random variable, X, assumes values in an interval S =[a, b], b > a, such that each value is equally likely. The uniform distribution is denoted by Unif (a, b), and is the simplest continuous distribution.
The pdf of $X \sim$ Unif (a, b) is

$$f_x(x) = \begin{cases} \frac{1}{(b-a)}, & \text{for } a \le x \le b \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

and the cdf is

$$f_x(x) = \begin{cases} 0, & \text{if } x < a, \\ \frac{(x-a)}{(b-a)}, & \text{if } a \le x \le b \\ 1, & \text{if } x > b: \end{cases} \quad (2)$$

The corresponding mean and variance are given by the formulas.

$$E[x] = \frac{a+b}{2} \quad (3)$$

A graph of the pdf of a uniform distribution is depicted in Figure .2

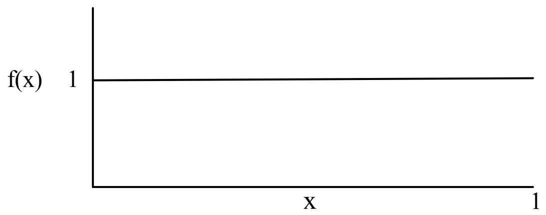

Fig. 2. Density function of the unit f(0,1) distribution

$$V[X] = \frac{(b-a)^2}{12} \tag{4}$$

A uniform random variable is commonly employed in the absence of information on the underlying distribution being modeled.

2. *Triangular distribution*

The Triangular distribution (a,m,b) is one of probability distribution describe as follow:

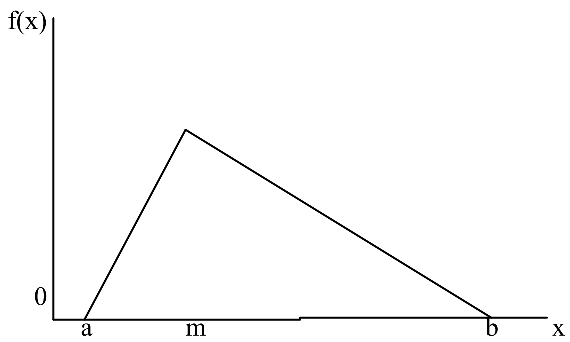

Fig.3 Density Function of Triangular Probability

A triangular random variable, x, assumes values in an interval S =[a, b], with the most "likely" value (the mode) being some point c $\in$ [a, b]. The likelihood increases linearly in the subinterval [a, c], and decreases linearly in the subinterval [c, b], so that the density has a triangular shape (see Figure 3). The triangular distribution is denoted by Tria
(a, c, b). The pdf of X $\infty A = \pi r^2$ Tria (a, c, b) is :

$$f(x) = \begin{cases} \dfrac{2(x-a)}{(m-a)(b-a)}, & \text{for } a \le x \le m \\ \dfrac{2(b-x)}{(b-m)(b-a)}, & \text{for } m \le x \le b \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

The minimum (a), mode(m), and maximum(b) values for the distribution specified as real numbers with a < m < b. The corresponding mean and variance are given by the formulas. The mean formula as such :

$$E[x] = \frac{(a+b+c)}{3} \tag{6}$$

and determine the variance for the triangular distribution shown below :

$$V[x] = \frac{a^2 + b^2 + c^c - ab - ac - bc}{18} \tag{7}$$

A triangular random variable is used when the underlying distribution is unknown, but it is reasonable to assume that the state space ranges from some minimal value, a, to some maximal value, b, with the most likely value being somewhere in between, atc. The choice of c then determines the skewness of the triangular distribution. The piecewise linear form of the pdf curve of Figure 3, is the simplest way to represent this kind of behavior.

III. APLICATION

A. *Model*

The logic modelling production flow design which is start from the module raw material, assigning, process-1, decide, process-2, production-1 and production-2 moduls.

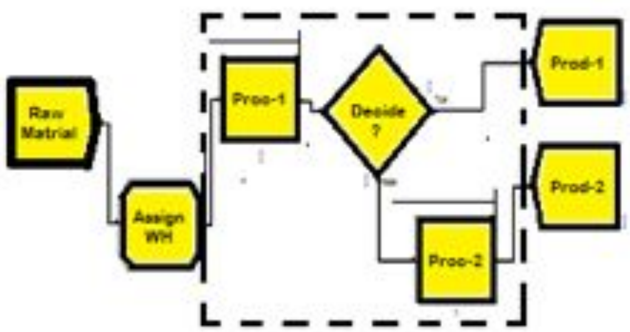

Fig.4 Simple logic production model flow

We need to identification the raw material when come and arrive (time between arrival) each periodically in variation time to measure the influence of the number of waiting or queue, total process time, utilization, total entity time and idle cost in the process.

The raw material arrived in every variation minutes with per arrival is 1 then assign warehouse planning directly sent to the next workstation 1 and 2 to be process with a logic action seize-delay-release, the delay will influence to end of product to the next station with the triangular probability for every unit, the value of process most likely with determine maximum value when it should be passed to be decided unit with the percent true is 93, the price busy is per hour, the replicate of the process, all of these variable we assume constantly and the based time is in minute.

IV. Application

A. Data

The result of the process data shown in table I. as follow :

TABLE I. CATEGORY OVERVIEW REPORT

Time b.a*	Total time entity	Total time proc	Number queue for identify	Proportion utilization of resource	Idle cost
5	2.329	10.071	0.09850	0.349	3751
10	1.997	6.958	0.01945	0.168	4792
15	1.915	5.924	0.00795	0.114	5105
20	1.878	5.652	0.00404	0.086	5264
25	1.858	5.380	0.00242	0.069	5364
30	1.832	5.108	0.00147	0.058	5424
35	1.828	4.836	0.00116	0.051	5468
40	1.823	4.563	0.00097	0.044	5509
45	1.816	4.517	0.00070	0.038	5540
50	1.812	4.498	0.00055	0.035	5561
55	1.808	4.479	0.00044	0.031	5580
60	1.800	4.460	0.00026	0.028	5600
65	1.791	4.167	0.00020	0.025	5613
70	1.799	4.141	0.00019	0.023	5626
75	1.806	4.115	0.00017	0.021	5659
80	1.814	4.088	0.00015	0.019	3751
85	1.821	4.062	0.00013	0.017	4792
90	1.828	4.036	0.00012	0.015	5105
95	1.836	4.009	0.00010	0.013	5264
100	1.842	3.983	0.00011	0.017	5364

*)the unit time is minute

B. Analyse

Analysis should be done in influencing variables belong the process in the logic modelling production flow as follow :

Figure 5 shown that total raw material spend in the model process decreased sharply in the first 35 minutes in between arrival then constant till various times to 100 minutes, this mean the material work in process no delay again because the appropriate time is more longer.

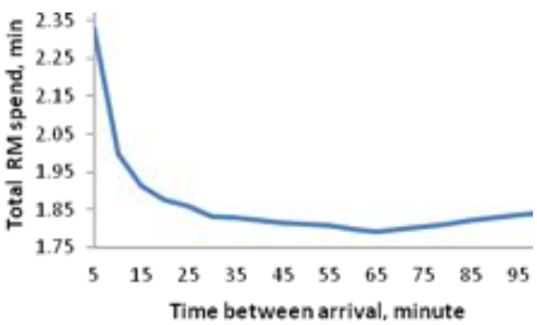

Fig.5 Raw material spend in the model process

Figure 6 tell that the total longest time spend in the process, that is in the first time from 5 till 35 minutes shown the drop sharply, meaning that the material work in process no delay to long it is directly release when the material arrive on the table work then the speed constantly seize and release.

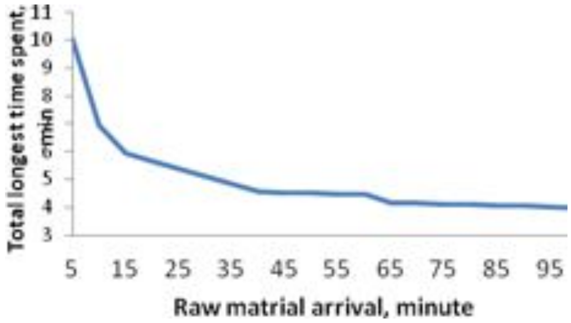

Fig.6 Total longest time spent in process

Figure 7. drawn the average material waiting to identify when checking processed it dropped sharply till 30 or 35 and then start to constant until 100 minutes time arrival, meaning when 35 minutes the identify is equal between seize and release.

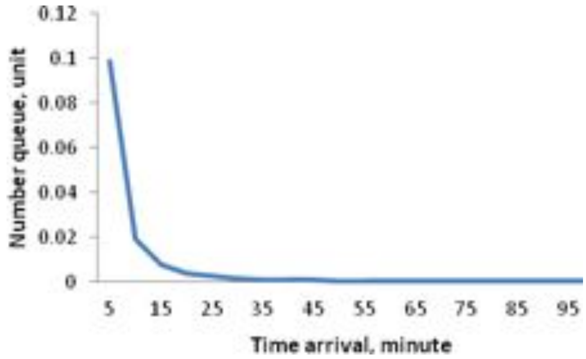

Fig.7 Maximum the avg. material waiting to identify to check

Figure 8. shown, the idle average cost from the initial time till 35 minutes is increased, then it is constantly. That because the material when work in process there is a delay time it should be increased the cost but when the seize and release equal the cost in stabilize condition.

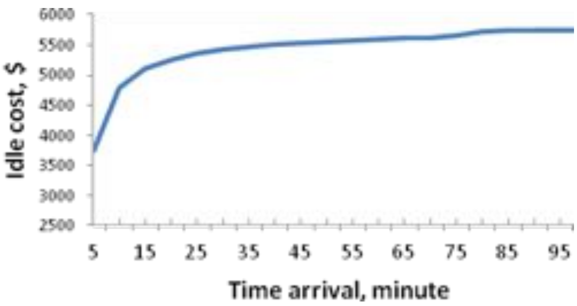

Fig.8 Idle average cost of reviewing material identification

Figure 9. illustrating the condition of the break point is 25 minutes in time arrival for the idle cost and the longest time when in process.

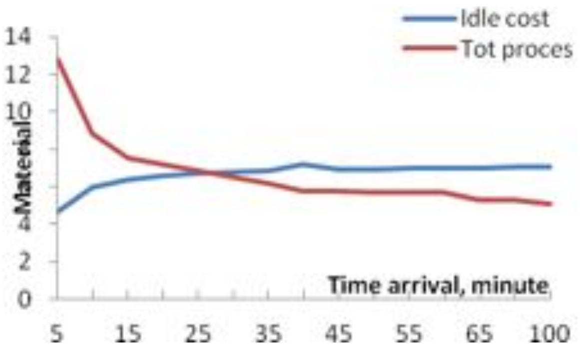

Fig.9 Break point idle cost versa total the longest time material spend

As general, all of entities drop sharply at point 25 minutes time arrival and idle cost increased sharply at the same time as well.

IV. CONCLUSION

The logic modelling production flow model which is starting from the average raw material between arrivals from the starting point to the warehouse and release directly to the process one then decided the quality and defect product in the production line process where the low quality will be processed in the second process and be the second product with different quality. The researcher conclude that with change the variability of time arrival in the production line should be some conclusion, the total longest time spend, total raw material spend time, number of queue and utilization resources will be decreased sharply that just because the time arrival for raw material changed, it should make the above variables change to decreased, but for the idle cost is increased sharply at the point 25 and stabilized for the next times.

REFERENCES

[1] A.M. Law, W.D. Kelton, Simulation Modelling and Analysis, third ed., McGraw-Hill, Singapore, 2000.

[2] Altiok, T. (1997), Performance Analysis of Manufacturing Systems, Springer-Verlag, New York.

[3] Altiok, T. (1998), "Factors Influencing Vessel Port Time in Bulk Ports," Bulk Solids Handling, Vol. 18, No. 1,27–30.

[4] Altiok, T. and B. Melamed (2001). "The Case for Modeling Correlation in Manufacturing Systems," IIETransactions, Vol. 33, No. 9, 779–791.

[5] Brateley, P., B.L. Fox, and L.E. Schrage (1987), A Guide to Simulation, Springer-Verlag, New York.

[6] Buzacott, J.A. and J.G. Shanthikumar (1993), Stochastic Models of Manufacturing Systems, Prentice-Hall,Englewood Cliffs, New Jersey.

[7] Elsayed, E.A. and T.O. Boucher (1985), Analysis and Control of Production Systems, Prentice-Hall, Englewood Cliffs, New Jersey.

[8] Fishman, G.S. (1973), Concepts and Methods in Discrete Event Simulation, John Wiley and Sons, New York.

[9] Fishman, G.S. and L.S. Yarberry (1997), "An Implementation of the Batch Means Method," .

[10] G.M. Clark, Introduction to manufacturing applications, in: J.D. Tew, S. Manivannan, D.A. Sadowski, F. Seila, (Eds.), 1994 Winter.

[11] J. Banks, J.S. Carson, B.L. Nelson, Discrete Event System Simulation, second ed., Prentice-Hall, Upper Saddle River, NJ, 1996.

[12] Johnson, M. and D.C. Montgomery (1974), Operations Research in Production Planning, Scheduling and Inventory Control, John Wiley and Sons, New York.

[13] L.F. Wilson, D.J. Burroughs, A. Kumar, A framework for linking distributed simulations using software agents, Proceedings of the IEEE 89 (2) (2001).

[14] Law, A.M. and W.D. Kelton (1982), "Confidence Intervals for Steady-State Simulations, II: A Survey of Sequential Procedures," Management Science, Vol. 28, No. 5, 550–562.

[15] Law, A.M. and W.D. Kelton (2000), Simulation Modeling and Analysis, McGraw-Hill, New York. Law, A.M. and W.D. Kelton (1982), "Confidence Intervals for Steady-State Simulations, II: A Survey of Sequential Procedures," Management Science, Vol. 28, No. 5, 550–562.

[16] M. Gravel, W.L. Price, Visual interactive simulation shows how to use the kanban method in small business, Interfaces 21 (5) (1991.

[17] M. Savsar, Flexible facility layout by simulation, Computers and Industrial Engineering 20 (1) (1990)

[18] N. Saad, Modelling, Simulation, and Analysis of Supply Chain Systems Using Discrete-Event Simulation, Ph.D. Thesis, Department of Automatic Control and Systems Engineering, The University of Sheffield, May 2003

[19] Perros, H.G. (1994), Queueing Networks with Blocking, Oxford Press, New York.Simulation Conference Proceedings, Association for Computing Machinery, New York, NY, 1994, pp. 15–21.

[20] Papadopoulos, H.T., C. Heavey, and J. Browne (1993), Queueing Theory in Manufacturing Systems Analysisand Design, Chapman and Hall, London.

[21] W.D. Kelton, R.P. Sadowski, D.A. Sadoewski, Simulation with Arena, McGraw-Hill, New York, 1998.