

Inventory Management and Control using ‘Probability Distribution Function’

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ABSTRACT

For any organization, inventory management has come up as a big challenge to handle. Since, there are extensive variations in the products; the hurdles related to this issue get more intensified. Thus, the prediction of correct number of inventory between two different manufacturing systems is difficult and needs absolute understanding about the respective behavior of the system. In this paper the illustrations are about the application of ‘probability distribution function’ (or the PDF) in order to gain understanding about the behavior of the system in different working conditions, such as FTQ, uptime, etc. PDF assists in representing line behavior in terms of graphic distribution and comprehensive. Thus, the process gets easier to control inventory within the confidence level and further saves procurement costs, area of shed and costs of material handling. This is applicable for an automobile OEM that has savings over items with ‘A’ class ranking within procurement cost.

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INTRODUCTION

In the automotive, electronics, fashion goods and many other industries, some consumers will wait to buy a product, but others will not. To set appropriate inventory levels, a manager must estimate customer demand and the likelihood that, when a product is out-of-stock, a customer will wait for replenishment.

The research agenda on the efficiency of DBR approach in PPC of manufacturing systems has received increased attention during the last decade [1]. As manufacturing enterprises move ahead in the 21st century, it is becoming increasingly difficult to compete on a global scale without strong inventory management strategies [2].

As stated in [3] WIP inventory is measured by the number of items in each buffer and should stay small because of various reasons as given below:

- Capital invested to inventories as long as they remain in the factory or the warehouse provides no profit.
- High in-process inventories increase cycle times and decreases responsiveness to customers.

- High in-process inventories require more space and expensive material handling equipment increasing the invested capital.
- Inventory quality decreases as the unfinished items remain to the factory because they are vulnerable to damage.

Sahib Sankar Sana has developed an inventory model for imperfect production process to achieve optimal product reliability and production rate to obtain the biggest total integrated profit. In developing the model, the author has considered certain set of assumptions which are not true in practice [5]. Management Scientists and Industrial Engineers have given more importance to three dimensions of inventory management namely utilization, performance and productivity [5].

Georgiadis and Politou proposed a dynamic, goal seeking, feedback mechanism to define production time buffer for short/medium term production planning and control (PPC) [1].

Sachin Jain came up with constraint-based model for buffer management and the same optimizes inventory among two machines. This shows enough reduction in terms of inventory noted within the supply chain management and

system as a whole [6]. The scheduling technique of Drum-Buffer-Rope (or the DBR) accommodates reality within the shop floor, like statistical fluctuations, dependent events and finite capacity variances [7]. Togar M Simatung emphasizes significance of buffer management in building preventive mode of maintenance within the organization [8].

This paper concentrates over the act of cutting-cost of inventory that comprises space requirements, carrying costs, energy costs, overheads and procurement costs. According to this research, the scientific proceedings under buffer management are subject to outperform all the other conventional approaches for optimum levels. It signifies the reduction noted in the costs of procurement as well as storage. However, demands related to inventory will drop to a significant optimum level for the extension of the ways to control parameters and handle fluctuation of inventory quantity.

An Automobile industry's finished aggregate includes subassemblies and parts, which are meant to form a single product. A continuous flow of all these notable parts assists in terms of smoothly running line of assembly. Enough buffer quantity must get maintained, in order to prevent any lack in the main line of assembly. Further, the maintenance of higher mode of buffer quantity is liable to increase handling costs and production, along with possible obsolescence. Consequently, it results in the running of multi-model-mix in the production segment. Decisions over optimum mode of buffer quantity for every model will be further discussed in this paper.

The building of engine basically follows five C's. These are -

- a. Crankshaft,
- b. Cylinder Block,
- c. Cylinder Head,
- d. Camshaft and
- e. Connecting rod.

The organization is liable to manufacture just three of these enlisted models. Table no.1 distributes these models in accordance to their types -

Table 1. Classification of Model under component 1, 2 and 3

	Component 1	Component 2	Component 3
M O D E L	MODEL 1	MODEL 1	MODEL 1
	MODEL 2	MODEL 2	MODEL 2
	MODEL 3	MODEL 3	MODEL 3
	MODEL 4	MODEL 5	

Different kinds of parts are needed for buffer within the machinery and assembly process. This leads to material procurement and storing costs (including) trolleys as well as floor space). Mode of optimizing quantity of buffer can assist in reducing material procurement costs, machining or the power costs and storage costs.

Parameters governing buffer quantity- :

i. *Line speed* measures the production mode of fast jobs through Jobs Per Hour or the JPH unit.

ii. *Line Changeover* is a single machining module creating variances in multiple products, and to attain the same, it is important to perform the process of changeover in some of the operations related to machining line. This can lay emphasis over line speed.

iii. *Uptime* metric calculates parts tagged with 'OK' from production line, against the real line speed.

iv. *First Time Quality* (or the *FTQ*) is for lost jobs due to defects in quality.

v. *Reliability* is the capability of respective line to create in accordance to real line speed while initiating changeover.

vi. *Storage constraint* is about the finished parts kept on trolleys as first constraint. All the filled trolleys are kept in supermarket assembly line, where availability of space is a matter of concern.

This study concludes line behavior as a continuous distribution. Data get collected from various strategic points, like exit of the line of machining and starting point of assembly line. Table no 2 gives the sample observation table for collecting data.

Table 2. Observation table

Date	Clock Time	Actual Time	Reasons for deviation	Model	Total Time
18 Sept	10:03-11:01	58	OP 220 station 4 was down; started at 09:25	Model 1	58
18 Sept	11:01-11:40	39	3 suspect parts	Model 1	39

ANALYSIS AND SOLUTION

The prediction procedure related to buffer quantity amongst the machining and the assembly contents is evaluated by the multi-model mix system. Statistical proceeding has been selected as the fair means to attain accurate method for the prediction of buffer sizes. Thus,

'Probability Distribution Function' is considered for the collection of necessary data through the points that are recognized at every machining as well as assembly nodes.

Selected points for the collection of data are goods filling in trolley (that is at machining) and parts consumed from trolley (that is at assembly). All these nodes are represented as per correct replenishment and demand for machining line and assembly line, respectively. Points noted for machining line are trolley storages in buffer area and assembly line are trolley pull in assembly stations with true 'OK' marking of parts produced and further consumed through the line. Data attained are for understanding the systems and the way it acts under diversified factors such as uptime, changeover, operator variability, FTQ (or the first time quality), etc. Table 3 represents the collection of data at Component 1 at the machining buffer area.

EQUATIONS AND GRAPHS

The real time attained from Table no.3 aims in deriving the features of probability distribution curve, in reference to shop floor for the representation of right trend and behavior of the system. This further exhibit diversified influencing factors. There are three tests meant for fitting goodness. These are -

- Kolmogorov Smirnov test,
- Anderson Darling test and
- Chi-Squared test [9].

Applications are maintained in accordance to the results derived and the best fitting of the curve to the selected distribution. Following graphs and equations related to the component 1 machining are noted here.

Hypersecant distribution seemed to be the best fitting approach to the data. Function of probability density gets represented by equation (1) as -

$$f(x) = \frac{\operatorname{sech}\left(\frac{\pi(xec)}{2e}\right)}{2e}$$

Domain: $-\infty < x < +\infty$

(1)

Here, σ = continuous scale parameter and μ = continuous location parameter [9].

Following graphs are related to data fitting (as in trolley replenishment) and getting replenishment based on time over the percentage of confidence level (that is estimated at 90, 95 and 99). All the graphs noted below get represented by X-axis for time taken by manufacturing system in order to replenish/consume trolleys items; and by Y-axis for the value attained from governing equation related to distribution model.

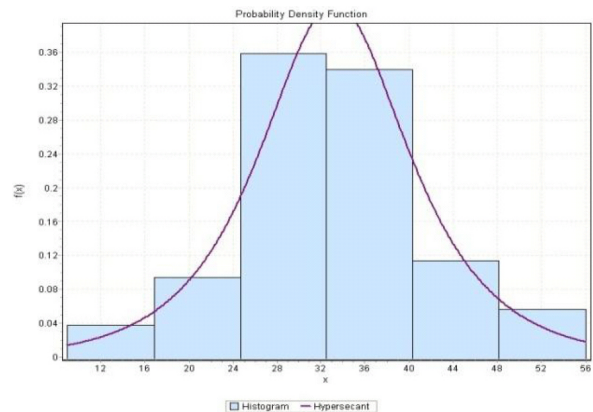


Figure 1. Hypersecant Distribution related to Component 1 (MODEL 1)

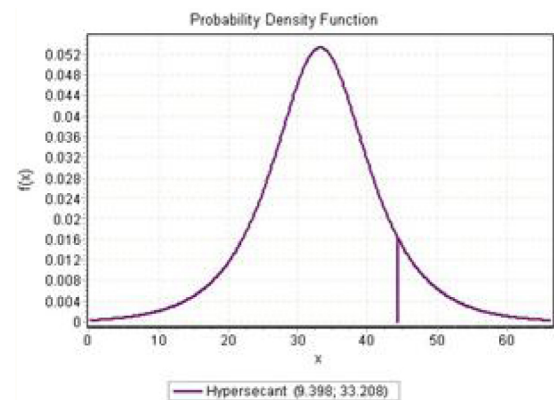


Figure 2. Time-taken in fulfilling the trolley at the rate of 90% confidence level

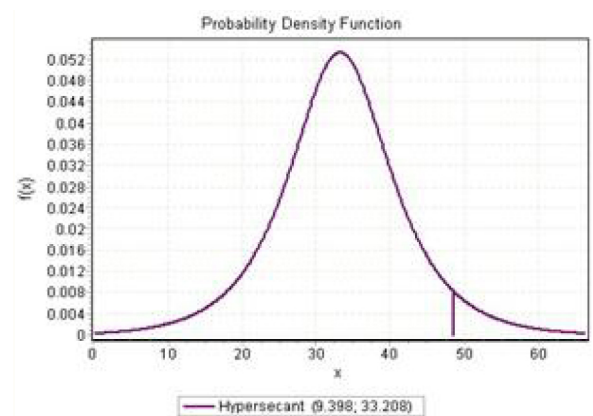


Figure 3. Time-taken in fulfilling the trolley at the rate of 95% confidence level

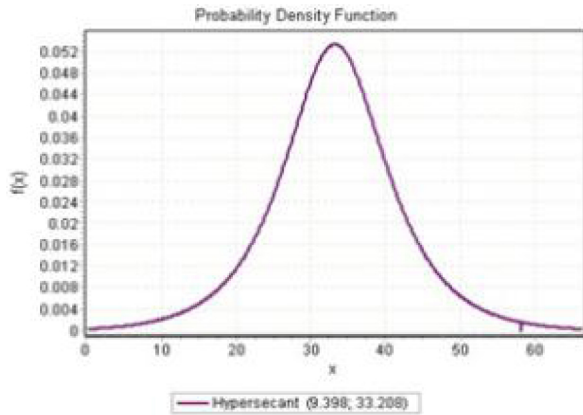


Figure 4. Time-taken in fulfilling the trolley at the rate of 99% confidence level

In the same way, the graphs get plotted for deriving the pulling nature from assembly noted in component 1. All these are assessed against replenishment graph of component 1 from machining in reference to model 1. Graphs are compared for both types of distributions attained for varied intervals of confidence with 'Lead-Lag factor'. It defines levels of inventory as well as factor of moderation that must be applied in the process of managing relevant constraints.

Distribution of Dagum (4P) is best fit to collected data with a function of probability density under equation (2)-

$$f(x) = \frac{\alpha k \left(\frac{x-\gamma}{\beta} \right)^{\alpha k - 1}}{\beta \left(1 + \left(\frac{x-\gamma}{\beta} \right)^{-\alpha} \right)^{-k}}$$

Domain: $\gamma \leq x < +\infty$

(2)

Here,

k = continuous shape parameter ($k > 0$), α = continuous shape parameter ($\alpha > 0$),

β = continuous scale parameter ($\beta > 0$) and γ = continuous location parameter ($\gamma = 0$ yields the three parameter Dagum distribution) [9].

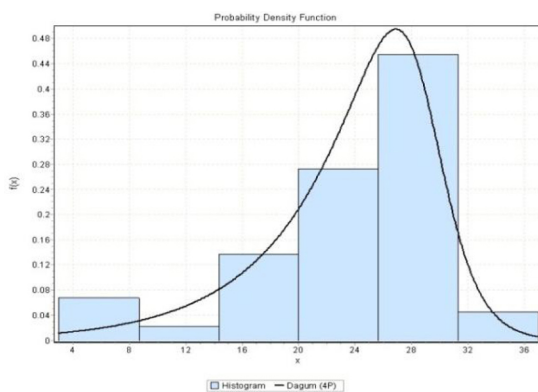


Figure 5. Dagum distribution over Component 1 (MODEL 1)

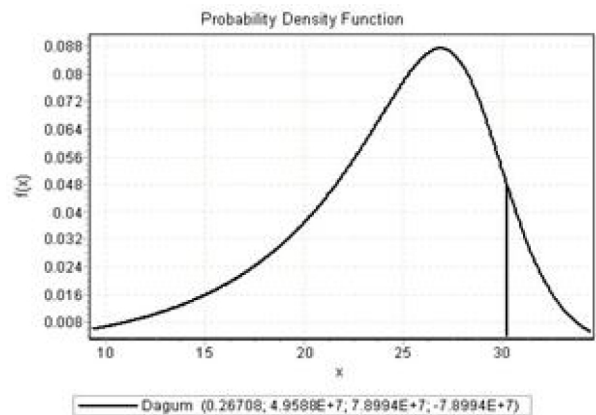


Figure 6. Time-taken in consuming the trolley at the rate of 90% confidence level

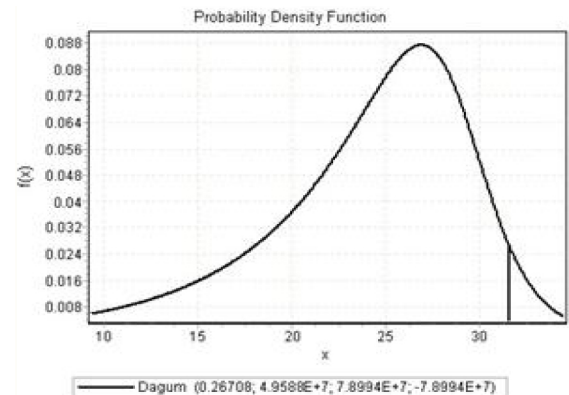


Figure 7. Time-taken in consuming the trolley at the rate of 95% confidence level

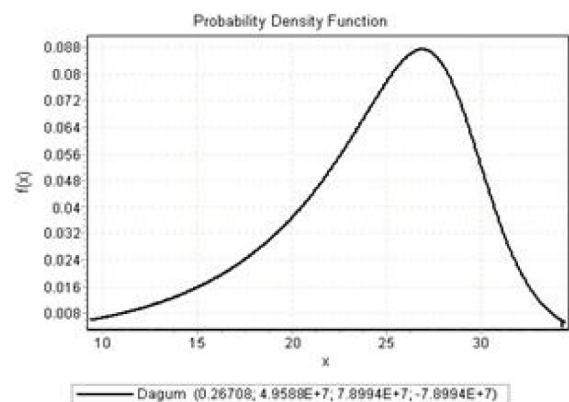


Figure 8. Time-taken in consuming the trolley at the rate of 99% confidence level

DERIVATIONS AND DISCUSSIONS

The factor of lead-lag assists in making a decision over (see Table 5) buffer sizes relevant to individual model and other parameters of influences such as floor space, line speed,