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A Review on Implementation of Queuing Theory Along with Lean Technique in Manufacturing Industry

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Abstract - **Within the combinatorial scheduling community, there has been an increasing interest in modeling and solving scheduling problems in dynamic environments. Such problems have also been considered in the field of queuing theory, but very few research take advantage of developments in both areas, and previous surveys on dynamic scheduling usually make no mention of queuing approaches. In this research, we provide an overview of queuing theoretic models and methods that are relevant to scheduling in dynamic settings.**

Keywords - **Productivity Improvement, Queuing Theory, CNC Machining, Bottleneck Process, Gear Manufacturing.**

I. INTRODUCTION

The queuing theory in the industry process used simulation models to study behavior of the industry process to improve work station's productivity by reducing waiting time. Engineers have applied results of queuing theory to show how cycle time is related to utilization of machine and statistic of inter-arrival time and service. These analyses provide means and predicting the average cycle time in steady-state condition. Queuing Theory can be applied in the assembly production line by using an analytical model. Validation of the task time value resulted by comparing it with the task time value based on the company database. Queuing model is a guide to improve both efficiency and performance in every workstation at the production line.

1.Basics Of Queue

Queues (waiting lines) are a part of everyday life. We all wait in queues to buy a movie ticket, make a bank deposit, pay for groceries, mail a package, and obtain food in a cafeteria, vehicles waiting at petrol pumps or to pass a road bottle neck etc. A queue, in fact doesn’t contain discrete units only, liquids entering in a sudden large volume into a tank having only a small outlet pipe can be said to be queuing in the tank.

Customers wait when the number of customers requiring service exceeds the number of service facilities. An amazing number of waiting time situations exists as when computer programs are waiting to be processed at computer center. The queuing theory is the probabilistic study of waiting lines. Although it does not solve all type of waiting line problems, yet it provides useful and vital information by forecasting or predicting to various characteristics and parameters of the particular waiting lines under study. Since the prediction about the waiting times, the number of waiting at any times, the time for which the servers remain busy, delay etc. heavily depends on the basic concept of stochastic processes, hence, queuing theory can be taken as an application of stochastic processes. Queuing theory is generally considered a branch of Operational Research because the results are often used when making decisions about the resources needed to provide services. Thus we can say queuing theory is a stochastic process in Operations Research. The queues and queuing systems have been the subject of considerable research since the appearance of the first telephone systems.

2.Economical Aspects Of Queuing Theory

Waiting for service is usually an unpleasant experience, which creates unhappiness among customers who may switch to competitive service offerings. Having to wait is not just a petty personal annoyance. Waiting time represents the loss of valuable resources and this loss translates into psychological as well as economical costs of waiting. The longer, customers wait the more dissatisfied they are to be. The amount of time that a nation’s populaces waste by waiting in queues is a major factor in both, the quality of life and the efficiency of the nation’s economy.

Taking machines wait to be repaired may result in loss of production. Airlines waiting to take off or land may disrupt later travel schedule. Delaying service jobs beyond their due date may result in a lot of future business causing manufacturing jobs to wait to be performed may disrupt subsequent production. Queuing problems in industry are more serious than those experienced in our daily life. Excessive waiting time in production will mean longer manufacturing cycle, that is longer deliveries and high investment in work in progress.

Virtually, all queuing situations have economic interpretation for their implication.

In general there are two opposing economic aspects to queues.

- It can cost money for an item to be idle in queue. An employee has to be paid while queuing at the tool store, valuable production is lost while machine stand out of order, tax receipts are delayed while document remain in the inspectors tray. And, of course, the smaller the service facility, longer the queues and higher the cost.
- On the other hand, larger the service facility quicker it will disperse queue and therefore, more often the system will stand idle and hence it costs money to increase the service facility.

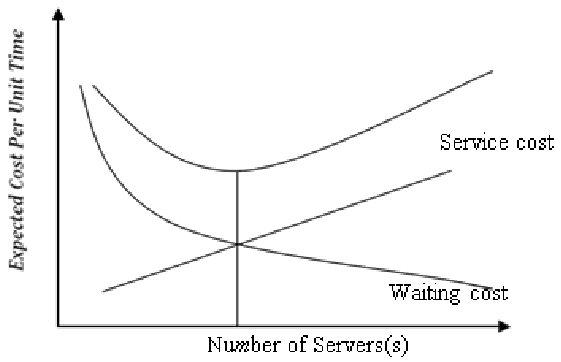

Fig.1. Expected cost per unit time vs. number of servers.

II. LITERATURE SURVEY

A. M. Adeyinka and B. Kareem (2018) carried out queuing analysis to examine an automobile assembly line performance to reduce queuing through harmonizing the tasks in each workstation. The Kendall's notation for the queuing problem is M/M/1: FCFS/∞/∞. It is a single channel multi – server service with infinite system capacity and infinite number of calling population. The arriving and service distribution data for the system were determined. These data were employed to estimate the performance parameter of the system. The results obtained from the analysis are used to predict the efficiency and effectiveness of the system and make logical recommendations on how to improve the system. Based on the results obtained, it can be concluded that if the level of automation is increased, the waiting time of parts will be reduced thereby reducing the cost of waiting.

Iman Ghalehkhondabi and Gursel Suer (2018) used the queuing theory to find the best place of the Order Penetration Point (OPP) in a production line with impatient customers.

Onoja AA (2018) examined the queuing system at Guarantee Trust Bank (GTB) putting into consideration the waiting time spend by Customers, Service time spend by a Customer and the average cost a customer loses while in queue and the service cost of each server in order to optimize the system. The First Come First Serve (FCFS) Multi-Server queuing model was used to model the queuing process. The waiting time was assumed to follow a Poisson distribution while the service rate follows an Exponential distribution. This study adopted a case study approach by randomly administering questionnaires, interviews and observation of the participants. The data were collected at the GTB cash deposit unit for four days period. The data collected were analysed using TORA optimization window based software as well as standard queuing formula. The results of the analysis showed that the average queue length, waiting time of customer with a minimum Total Cost that utilize the system is by using five Servers against the present server level of Three Servers which incur a high total cost to both the Customers and the system.

P S Murdapa (2018) discussed the single stage M/M/1 queuing model that involves emission variable. Hopefully it could be a starting point for the next more complex models. It has a main objective for determining how carbon emissions could fit into the basic queuing theory. It turned out that the involvement of emission variables into the model has modified the traditional model of a single stage queue to a calculation model of production lot quantity allowed per period.

Edson Manica (2017) presented the study on continuous assembly line power generators in a Brazilian manufacturer of electrical equipment in order, to identify how your bottleneck resource behaves, to then define the level of Constant Work in Process (CONWIP) system. The methodology was applied research, as sought solutions to the proposed problem. The result was the implementations of actions that have standardized volume CONWIP system at the level of just meet the demand scheduled for the day, reducing queues and also the cost of acquisition of raw materials.

Hyun Jeon and Vittaldas Prabhu (2017) developed an energy-aware analytical model based on queuing theory that has re-entrant network structure commonly found in fabs to analyze the impact of reducing idle power consumption in individual equipment. The proposed analytical model based on BCMP network for re-entrant lines has the same mathematical form as serial lines and is tested for using detailed simulation of a generic CMOS fab with three processing steps. Results show that the energy consumption predicted by the analytical model differs from simulation typically within 10% and worst case of 14%, in the tested cases.

Damodhar F Shastrakar et al (2016) studied the importance of waiting lines theory, how it comes in existence, and the history behind the waiting lines theory. The use of probability distributions. How to get optimum level in queuing model. Basic features of the waiting lines system. Queuing characteristics and different queuing models used in waiting lines system.

P. Sathiyabalan and V. Vidhya (2015) analyzed the instances of use of queuing theory in various applications and benefits acquired from the same.

Reza Rashid (2015) presented a mathematical model for an inventory control system in which customers' demands and suppliers' service time are considered as stochastic parameters. The proposed problem is solved through queuing theory for a single item. In this case, transitional probabilities are calculated in steady state. Afterward, the model is extended to the case of multi-item inventory systems. Then, to deal with the complexity of this problem, a new heuristic algorithm is developed. Finally, the presented bi-level inventory-queuing model is implemented as a case study in Electroestil Company.

Krommyda et al. (2015) studied an inventory control problem in which demand was satisfied using two mutually substitutable products. Their aim was to determine the order quantity for each product that maximizes the joint profit function.

Seyedhoseini et al. (2015) applied queuing theory to propose a mathematical model for inventory systems with substitute flexibility. **(Rashid et al. 2015)** also considered a location-inventory model. To prepare a stochastic inventory model, they used bi-level Markov process. Considering the effectiveness of queuing theory in inventory problems, we have also used queuing theory to develop a stochastic stock control model.

III. ELEMENTS OF QUEUING SYSTEM

The basic feature of a queue system is as follows:

1. The Input or arrival-pattern of customers or units (λ-mean arrival rate).
2. The Output or service-pattern of customers or units (μ-mean departure rate).
3. The number of service channels.
4. The capacity of the system.
5. The traffic-intensity (Ratio of mean arrival rate to mean departure rate i.e.
6. $\rho=\lambda/\mu$)
7. Queue discipline (FIFO, LIFO, and SIRO etc.)

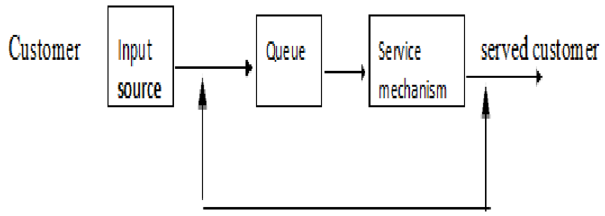

Fig.2. The basic queuing process.

1.The Input or Arrival-Pattern of Customers

The input pattern means the manner in which the arrivals occur. It is specified by the inter arrival time between any two consecutive arrivals. A measure usually considered is the average length of the inter arrival time or its reciprocal, the average number of arrivals per some unit of time. The input pattern also indicates whether the arrivals occur singly or in groups or batches. If in batches, the manner in which these batches are constituted is also to be covered in the same between any two consecutive arrivals, or it may be stochastic, when its distribution is also to be specified. Sometime an arrival may not that is, machines coming for repair whenever they fail. There may also be several classes of customers with different arrival rates.

2.Customer's Behavior

Earlier researchers did not find significant place for impatient customers with Random service but customer's behavior play very important role in study of queues. If a customer decides not to enter the queue since it is too long he is said to be balked. If a customer enters the queue and leaves it, he is said to have reneged. When there are two or more parallel queues and the customers move from one queue to other, they are said to be Jockeying.

3.The Output or Pattern of Service

By the pattern of service, we mean the manner in which the service is rendered. It is specified by the time taken to complete a service. The time may be constant (deterministic) or it may be stochastic. If it is stochastic, the pattern specification involves the distribution of service time of a unit. A measure typically considered is provided by the average time required to serve a unit or by the average no of units served per some unit of time. Sometimes service may be rendered in bulks or batches, as in the case of an elevator, instead of personalized service of one at a time. In this case, the manner of formation of batches for service also has to be specified.

3.The Number of Servers

A system may have a single server or a number of parallel servers. An arrival who finds more than one free server may choose at random any one of them for receiving service. If he finds the entire server busy, he joins a queue common to all the servers. The first customer from the common queue goes to the server who becomes free first. This kind of situation is common- for example, in a bank or at a ticket counter.

There may also be situations where there is a separate queue in front of each service facility, as in the case of a supermarket. There also arise cases of ordered entry when an arrival has to try to find a free server in the order the servers are arranged.

4.The Capacity of the System

A system may have an infinite capacity – that is, the queue in front of the server(s) may grow to any length. Against this there may be limitation of space, so that when the space is filled to capacity, an arrival will not be able to join the system and will be lost to the system. The system is called a delay system or a loss system, according to whether the capacity is finite or infinite. If finite, it will have to be specified by the number of places available for the queue as well as for the one(s) being served, if any.

5.Traffic Intensity

The demand for service is often expressed as $\rho=\lambda/\mu$, the mean number of arrivals per unit time taken as the mean service time. This quantity is called offered load (or traffic intensity); it is a dimensionless quantity and is expressed in Erlang. This offered load is a measure of what the customers want. It is also called utilization factor or server utilization.

6.Queue Discipline

Although most queues are based on a first come first serve (FIFO) system. This is not always so, sometimes certain queue components have priorities (e.g. ambulances at traffic lights), sometimes a LIFO system work (as when a tax inspector always takes the top document first from his in tray), and sometime components are served at random (SIRO) (as when a number of people persist in trying to get through to the same telephone number and successful caller is the one who is lucky enough to dial just at the moment the receiver is replaced after the previous call). There are, therefore different method of determining the order of service. The method appertaining to any situation is known as queue discipline.

IV. CONCLUSION

Queuing theory based on probability concept gives an indication of the capability of a given system and of the possible changes in its performance with modification to the system. With the help of queuing theory the executive can at most make an informed guess of what could be the balance between the customer's waiting time and in preventing waiting time. He first takes into consideration several alternatives, evaluates through queuing models, their effects on the system and makes his choice. The criteria for evaluation will be the efficiency of the system like the average length of the queue, expected waiting time of a customer and the average time spent by the customer in the system.

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