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PROPOSAL OF QUEUING THEORY (WAITING LINE MODELS), FOR IMPLEMENTATION IN THE PRODUCTION-LABELING PROCESS OF PET CONTAINERS

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Abstract: Currently, companies carry out different types of analysis in their production system, in order to increase the effectiveness of the time involved in said process. One of the most common problems in bottling companies is the downtime present in the manufacturing and labeling of PET bottles, which can be used in other activities. It is proposed to apply queuing theory, starting from the selection of a theory model that resembles the process that is carried out, comparing the ideal time with the current time in which the process is carried out and labeling a bottle, thus detecting activities that do not add value to production.
Keywords: Queuing theory, Sequential services, Bi-oriented blowing, Labeling.

INTRODUCTION

Queuing theory is a discipline, within Operations Research, that aims to study and analyze situations in which there are entities that demand a certain service, in such a way that said service cannot be satisfied instantly, which is why it is They cause waits.

As is evident in the previous definition, the scope of application of queuing theory is enormous: from waiting to be served in commercial establishments, waiting to process certain computer programs, waiting to be able to cross an intersection for circulating vehicles. around a city or waiting to establish communication or receive information from a web server, through the Internet, among many others (Abad, 2002).

Referring to S. Hiller & J. Lieberman (2006) they comment that in recent years, perhaps queuing theory has been applied more to internal service systems, where the customers who receive the service are internal or part of the organization.

METHOD DESCRIPTION

REVIEW OF THE DIFFICULTIES OF THE SEARCH

For this case, the focus of the topic in question, a comparative study will be applied between the theory of queuing and the production of PET bottles; For this purpose, one of the different existing classes of queuing theory is selected, in which this type of production can be assimilated.

Making a comparison with the production of containers, we have that the servers would be the machines that perform the bi-oriented blowing (SIDEL machine) and the labeling machines (B&H machine), and the clients are the preforms which are transformed into bottles.

To give a clearer idea about this comparison, the schematic of a queue is diagrammed with the aforementioned elements (Figure 1).

Taking into account the previous information, now, we detect that the queue system to be analyzed is a queue with sequential services, since first, the preforms are on the loading rail to subsequently go to bi-oriented blowing and then the same ones queue again. bottles to be labeled.

For the corresponding analysis of this waiting line, the formulas of a queue, a server, and another similar one, with the queue made by the bottles towards the server, which is the labeling machine, will be taken into consideration.

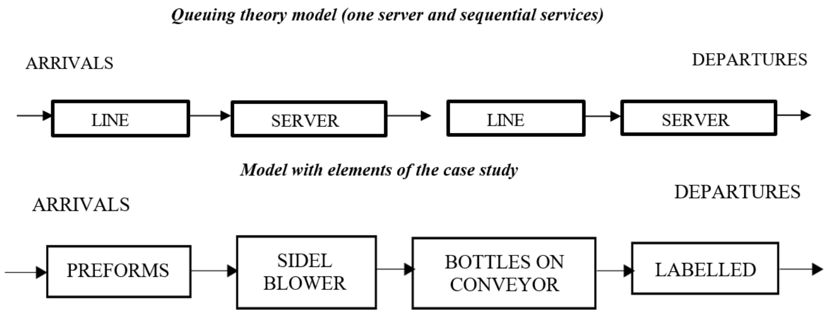

Figure 1. Replacement of bottle production elements in a one-queue scheme with sequential services.

Source: Own elaboration, 2016

QUEUE STRUCTURE FOCUSED ON THE CASE STUDY

The elements of the queue that apply to the case study are described below (Lieberman & Hiller, 2006).

- INPUT SOURCE: Infinite size since it is not known at what time they will arrive, this means that the probability of an arrival at any instant of time is the same as at any other time, for arrival times the distribution of exponential probability.

- GLUE: In this case, two different types of tails are generated, one where the preforms are supplied through the loading rail to the SIDEL machine for bi-oriented blowing, and another is the Zechetti conveyor to the labeling machine, but the entire process It is done in a single line.

- QUEUE DISCIPLINE: It is the order in which its members are selected to receive the service, in this case, it is a normal model to the discipline of first in, first out.

- SERVICE MECHANISM: For this study, they are serial service channels; To determine the service time, a deterministic model is used, since the service (bi-oriented blowing) is constant (considering that there are machine stoppages sporadically).

OPERATION FEATURES

λ = Average number of arrivals per time period

μ = Average number of people or things served per time period

n = Number of units in the system

$X=i$ = Number of arrivals per unit of time

e= 2.7183 (which is the base of natural logarithms)

L_S = Average number of units (customers) in the system:

$$L_S = \frac{\lambda}{\mu - \lambda} \tag{1}$$

ρ = System utilization factor n:

$$\rho = \frac{\lambda}{\mu} \tag{2}$$

W_S = Average time a unit remains in the system = (waiting time + service time):

$$W_S = \frac{1}{\mu - \lambda} \tag{3}$$

P(x=i) = Probability distribution describing the arrival rate

$$P(x=i) = \frac{e^{-\lambda}}{x!} \tag{4}$$

Operation Description						Time (seconds)
Preform warehouse						0.0
Line transport						1.52
Transport by turner						1.02
Hopper turner						1.06
Conveyor belt raises preform						1.04
Preform arrangement						0.82
preform rail						15.92
Penetration furnace						13.39
Stabilizer						3.05
Distribution furnace						13.52
Load wheel						2.54
Stretched						0.75
Pre blow						0.65
Soplado						0.56
Degassing						0.43
Output wheel						1.01
bottle inspection						4.52
Conveyor zecchetti						101.58
B&H labeling machine						02.06
Label inspection						4.52
Zecchetti conveyor						11.32
Totes						0.0
Finished product warehouse						0.0
TOTAL TIME						**182.28**

Table 1. Pet production process diagram

Source: Own elaboration, 2016

FINAL COMMENTS

SUMMARY OF RESULTS

Table 1 shows the process diagram, as well as the current times that are carried out in the company for the complete process.

The necessary parameters are established to carry out the exponential distribution of the SIDEL and B&H machines.

SIDEL	
ELEMENT	AMOUNT
Demand for bottles by Coca Cola of 112,500 1°T for 7 hours of work	4 Bot/Seg
Time it takes for a preform in the queue to reach a mold	54 Seg/Pref
Number of bottles blown by the SIDEL blowing machine	7 Bot/Seg
Time it takes for the SIDEL blower to blow and deliver a bottle	3.4 Seg/Pref
Preforms from the loading rail to the blow mold	226 Pref/Min

Table 2. Parameters necessary to calculate the exponential distribution of the Sidel machine.

Source: Own elaboration, 2016

B&H	
ELEMENT	AMOUNT
Demand for bottles by Coca Cola of 112,500 1°T for 7 hours of work	4 Bot/Seg
Time in which a bottle waits in line until it reaches the labeling machine	101.58 Seg/ Pref
Number of bottles labeled by the B&H machine	6 Bot/Seg
Time it takes for the B&H labeler to label and deliver a labeled bottle	2.06 Seg/Bot
Bottle in the endless as a waiting line	1 Bot/Seg

Table 3. Parameters necessary to calculate the exponential distribution of the B&H machine.

Source: Own elaboration, 2016

Now the data are substituted into the Poisson distribution formula for each case:

SIDEL

Data:

λ = 268 B/Min = 4 B/Seg.

x = 226 P/Min = 3 P/Seg.

$$P_{(3)} = \frac{2.71828^{(-4)}[4^3]}{3!} = \frac{0.01831\ (64)}{6} = 0.1953$$

B&H

λ = 268 B/Min = 4 B/Seg.

x = 5 B/Min = 1 B/Seg.

$$P_{(1)} = \frac{2.71828^{(-4)}[4^1]}{1!} = \frac{0.01831\ (4)}{1} = 0.073$$

BASIC MODEL

SIDEL

λ = 268 B/Min = 4 B/Seg.

μ = 410 B/Min = 7 B/Seg.

Expected quantity in the system

$$Ls = \frac{4}{7-4} = 1.33$$

Quantity expected in the waiting line

$$Lq = \frac{4^2}{7(7-4)} = 0.76$$

Expected wait time (includes length of service)

$$Ws = \frac{1}{7-4} = 1.33$$

Expected time in waiting line

$$Wq = \frac{4}{7(7-4)} = 0.19$$

Probability that the system is empty

$$Po = 1 - \frac{4}{7} = 0.42$$

B&H

λ = 268 B/Min = 4 B/Seg.

μ = 350 B/Min = 6 B/Seg.

Expected quantity in the system

$$Ls = \frac{4}{6-4} = 2$$

Quantity expected in the waiting line

$$Lq = \frac{4^2}{6(6-4)} = 1.33$$

Expected wait time (includes length of service)

$$Ws = \frac{1}{6-4} = 0.5$$

Expected time in waiting line

$$Wq = \frac{4}{6(6-4)} = 0.3$$

Probability that the system is empty

$$Po = 1 - \frac{4}{6} = 0.33$$

CONCLUSIONS

As it can be seen, the times and quantities expected on the line are minimal considering that they are seconds in which the process is carried out, however, if a more in-depth analysis is generated, where problems that arise throughout transportation stand out of said bottles, it can be a shorter time compared to the current one and thus convert that dead time into time that adds value to the process, thus carrying out other activities of the same.

Take as an example the time in the waiting line at the SIDEL blow molding machine, this time if the system does not have any delay we will have 0.19 second, however, as on some of the occasions it has happened where the forklift operator takes a while to supply preforms, calling it shortage, you have 6 more minutes in the waiting line.

Therefore, all of the above shows that the calculated time, although it is ideal, is not the one recorded in the transportation of the bottles.

RECOMMENDATIONS

Since there is an ideal time made by the calculations of the selected queuing theory model, a standard time that has to be carried out in the process and a real time that is currently shown, which does not yield many benefits to production, A detection of activities must be carried out, which are generating downtime in the transport of the bottles until they are stored, as well as a simulation of the three existing times and a proposal that determines how to best take advantage of the time that is valued. not added to the generation of PET bottles.

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