SIMULATION AND OPTIMIZATION OF UNLOADING POINT OF A SUGARCANE INDUSTRY – A CASE STUDY

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ABSTRACT

The problem of finding the required number of unloading points in the sugarcane industry can be solved by the application of Queuing theory. This paper deals with the optimization of unloading time in continuously operating process industry such as sugarcane industry with the help of a simulation model. In this case study, the company selected, located in the northern part of India, and was facing the problem of high waiting time of trolleys. The data were collected for the inter-arrival time of trolleys arriving there and the service time of trolleys. The data were analyzed to find out the suitable probability distribution with the help of Minitab software. After fitting the suitable distribution to the data, a simulation model was developed with the help of extend simulation software keeping in mind the complexity involved in the system. The idea behind it was to model the existing system and then compare the performance of this model with the existing system to check whether it matches with the performance of the existing system or not. If it does so, it means that the model is fairly representative of the existing system. Then we varied the number of service points and the corresponding waiting time was found out which resulted in the computation of waiting cost per trolley. Having found out the waiting cost per trolley, the service time per trolley was also calculated. The cost model was then applied to get the optimum number of service points.

KEYWORDS: Waiting time, service time, service points, waiting cost.
INTRODUCTION

The Company was facing the problem of high waiting time of trolleys in the queues of parking place. The average waiting time of trolleys was 15 hours. The factors responsible for the trolley detention were as follows: Uncertainty in trolley arrival, Under-utilisation of cranes or machines, No store at the place of service points, Number of queue, Lower average output. As no standard model is suitable for such industries and the complexities involved are high, some specific reliable method is needed.

METHODOLOGY

As the data was in haphazard form, a small program was written to sort out these data into ascending order, converting them into minute and then finding the inter-arrival time. Then these data were fed to the Minitab software to find out the suitable probability distribution. Similarly, the service time data have also been fed to the same software for the same purpose.

After finding out the distribution of the inter-arrival time and service time, we tried to find out a suitable multi-server queueing model. Unfortunately, we could not find out the same, so we decided to simulate it with Extend simulation software. The idea behind it was to model the existing system, and then allow running for a long period & then compare its performance with the existing system. If the performance of the simulation model matches with the existing system, it will mean that our model is valid. Then the strategy would be to change the number of service points and measure the performance e.g. waiting time corresponding to these service points.

Having found out the waiting time for different number of service points, we decided to use the cost model to find out the optimum number of service points. Strategy here is to find out the waiting cost per trolley and service cost per trolley corresponding to the different service points, thereby finding out the total cost which in turn will decide the optimum number of service points. The service points corresponding to the minimum total cost would be the optimum one.

ANALYSIS

Finding the probability distribution of inter-arrival time

The total number of data points (inter-arrival time) = 493.
By feeding the data to Minitab software, the parameters and A-D value for different possible distribution are as follows:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Parameter</th>
<th>A-D value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exponential</td>
<td>Mean= 9.03</td>
<td>662.5</td>
</tr>
<tr>
<td>Weibull</td>
<td>Shape= 0.415; scale= 2.601</td>
<td>28.48</td>
</tr>
<tr>
<td>Logistic</td>
<td>Location= 3.29; scale= 7.02</td>
<td>72.21</td>
</tr>
<tr>
<td>Log logistic</td>
<td>Location= 1.20; scale= 2.30</td>
<td>38.92</td>
</tr>
</tbody>
</table>

Table 1. Comparison of probability distributions for inter-arrival time.

This comparison represents that the A-D value is minimum for Weibull Distribution. So the Weibull Distribution has been selected for inter-arrival time data. In other words data have been fitted to Weibull Distribution.
Finding the probability distribution of service time

The total number of data points (service time) = 64
By feeding the data to Minitab software, the parameters and A-D value for different possible distribution are as follows:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Parameter</th>
<th>A-D value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weibull</td>
<td>Shape= 1.775; Scale= 22.025</td>
<td>0.42</td>
</tr>
<tr>
<td>Lognormal</td>
<td>Location= 2.884; Scale= 0.324</td>
<td>1.113</td>
</tr>
<tr>
<td>Normal</td>
<td>Mean=20.051; St. Dev =8.670</td>
<td>0.398</td>
</tr>
<tr>
<td>Log logistic</td>
<td>Location= 4.133; Scale= 0.368</td>
<td>0.708</td>
</tr>
<tr>
<td>Logistic</td>
<td>Location= 23.015; Scale= 4.55</td>
<td>0.438</td>
</tr>
</tbody>
</table>

Table 2. Comparison of probability distributions for service time.

This comparison represents that the A-D value is minimum for Normal Distribution.
So the Normal Distribution has been selected for service time data. In other words data have been fitted to Normal Distribution.

MODELING OF THE EXISTING SYSTEM

The model corresponding to the existing system with the help of extends simulation software i.e. model with 3 service points and its performance measurement is shown below:

Figure 1. Model of the existing system
Performance Measurement of the Existing Model

For smooth running of the simulation model, the inputs of the model are the characteristics of the distribution i.e. outputs of the Minitab software. After allowing the model i.e. system to run for 9 years, the outputs of the simulation model obtained is as follows:

- Average Queue length = 48 trolleys
- Average Waiting time = 14.15 hour
- Maximum Waiting time = 42.95 hour

Comparison with the Performance of Existing System:

The average waiting time of trolleys in the sugarcane industry of the existing system is 15 hour. The performance obtained from the simulation model is more or less similar to the performance of the existing system i.e. 14.15 hour, which reasonably confirms that our model is valid or it is true representative of the existing system. Now the strategy would be to change the number of service points in a simulation model and measure the performance i.e. waiting time corresponding to these service points.

MODEL WITH 5 SERVICE POINTS

For Model, figure 2 can be referred. After allowing it to run for 9 years, the outputs of the simulation model obtained is as follows:

- Average queue length = 4 trolley
- Average waiting time = 132.6 minute = 2.21 hour
- Maximum waiting time = 12.72 hour

Figure 2. Model with 5 service points
SUMMARY OF AVERAGE WAITING TIME FOR DIFFERENT SERVICE POINTS

After running the simulation model with different service points, the outputs of the simulation model obtained is shown below:

3 service point = 849.00 min. = 14.15 hr.
4 service point = 443.21 min. = 7.38 hr.
5 service point = 132.60 min. = 2.21 hr.
6 service point = 78.26 min. = 1.30 hr.

COST MODEL

After finding out the waiting time for different number of service points, we then use the cost model to find out the optimum number of service points. Strategy here would be to calculate the waiting cost per trolley and service cost per trolley corresponding to the different service points. Then the total cost is determined which in turn will decide the optimum number of service points. The service points corresponding to the minimum total cost would be the optimum one.

Graphical Analysis

The waiting cost, service cost & the total cost can be represented on the same plot as shown below:

Figure 3. Total cost representation

The figure 3. clearly shows that there is a point where waiting cost, service cost and total cost is minimum. This point gives the optimum number of service points. It is clear from the above graphical analysis (fig. 3) that the optimum number of service points is 5.

RESULTS

The results based on the simulation model and cost model are shown below:

The optimum number of service points = 5
Corresponding average waiting time of trolleys = 2.21 hr
CONCLUSION

According to the results obtained and analysis of data, it is concluded that the optimum number of service points is five, which means that there is a deficiency of two service points in the existing system of the continuously operating process industry here. To increase the service points, the selected industry needs to install a new crane machines. The approach adopted in this work is of collecting the data related to inter-arrival time of trolleys, service time of arriving trolleys, finding the suitable probability distribution of the data, developing a simulation model of the existing system, waiting time, computation of waiting cost per trolley and the resultant cost involved has been found to be useful in modeling a proposed system which enables to lower the costs involved due to waiting time. The same approach can be adopted for any such process industry which experiences losses due to excess waiting time.

REFERENCES