THE SOLUTION TO QUEUING PROBLEM AT FIRST ALUMINIUM PORT-HARCOURT

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ABSTRACT
This study was designed to examine the effect of specific number of service facilities/channeles that are obtainable at First Aluminium Company of Nigeria Plc, Port-Harcourt. The study was carried out in the company. Data were obtained from twenty (20) customers from the company. The data were analyzed based on single phase queuing model with Poisson arrivals and exponential service time using First come, First served queue discipline where the expected number of arrivals per time period, \( \lambda \) and the expected number of service possible per time \( \mu \) were considered as vital tools for the analysis. Based on the data, analysis, we discovered that a significant difference between the service time (in minutes) in a service facility for a sample of twenty custo.

therefore supports the assumptions that the more we increase the number of service channels, the more customers we serve, and the less the waiting time.

Introduction
First Aluminium Company is located at Trans-Amadi Industrial Layout Port Harcourt, Rivers State. It is an indigenous company that deals in the manufacture of aluminium coils, sheets, circles, and tubes (laminated and seamless plastic). Incorporated in 1960 as Alcan Aluminium of Nigeria Limited, the company later changed its name to First Aluminium Company (Nigeria) Plc in 1991. subsequently, it secured its quotation on the Nigerian Stock Exchange (NSE) in 1992. Its activities are driven by operations in 3 key Strategic Business Units (SBUs) namely, Rolling mill, Aluminium city and Packaging, with Aluminium city limited existing as a full fledged subsidiary.

Owing to the fact that the company has grown so large, calls for a queuing system in operation to reduce waiting time. As a result, the single channel model is chosen to solve the so-called long waiting time or down time problem.

Based on the information collected at the company, experience has shown that the queues are caused by problems of the continuous coating lines. Such factors are

1. Mechanical work on exit bridle
2. Tripping-off of electric lines
3. Strip breakage
4. Changing of colours etc.

Several other researchers have worked on the queuing problems.

Cox and Miller (1965) identified vehicle traffic at a road junction as a queuing problem. They see cars moving from a minor road to a major road as a queue. This is so because the car from a minor road has to wait for a traffic signal to proceed. The symbolism above tries to identify queues in every area of life. When the service channel is only one, example grading of examination scores, college registration, lines at supermarkets, etc.

The study therefore aims at:

1. Striking the best balance between the cost of providing the best service facilities to customers/materials, and the amount of time users of service must wait in line.
2. Identifying an optimal solution for minimizing service time while maximizing profit.

Materials and Methods
Data for this study was collected from First Aluminium Company Plc, Trans-Amadi Industrial Layout Port Harcourt.
A single server single-phase queuing where customers relieve service from the only available service facility after which they depart. In this system, the average arrival rate is constant. Customers arrive at random as the arrival of a customer is independent of the arrival of another, following a Poisson distribution. Customers are served on a First come first serve basis, and the service time of each customer also varies depending on the type of service desired. The service times in this system follow an exponential probability distribution, through the average departure rate is constant.

In collecting the data, two main parameters were sort for; inter-arrival time from which the average arrival rate, \(\lambda\), was obtained and the service time which also gave the average service rate, \(\mu\), whose products \(\lambda/\mu\) is a very important tool for analyzing queuing systems as the need arises.

Describing queuing system as a birth-and-death process, a state \(E_n\) which corresponds entire system is thought of. Deriving an equation which describes the birth-and-death process, we have:

If \(n \geq 1\), the probability \(P_n(t + h)\) that at time \(t + h\), the system will be in state \(E_n\) has any one of the following four components:

1. The probability that it was in state \(E_n\) at time \(t\) and no transitions occurred.
2. The probability that the system was in state \(E_{n-1}\) at time interval, \(h\) and no death occurred but a birth.
3. The probability that the system was in state \(E_{n+1}\) at time interval, \(h\) was no birth but one death occurred.
4. The probability that two or more transitions occur between times \(t\) and \(t + h\) is zero.

From the above we have a solution for all values of \(n\), taken into consideration specified conditions.

Hence;

\[ P_{ni}(t) = -\lambda P_{i}(t) + P_{i}(t) \]
TABLE 1: FIRST ALUMINIUM COMPANY PLC, TRANS-AMADI PORT HARCOURT
ANALYSIS OF DATA

<table>
<thead>
<tr>
<th>S/N</th>
<th>ta (mins)</th>
<th>tb (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.3</td>
<td>3.5</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>4.1</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>6.4</td>
</tr>
<tr>
<td>4</td>
<td>1.7</td>
<td>5.7</td>
</tr>
<tr>
<td>5</td>
<td>4.2</td>
<td>4.9</td>
</tr>
<tr>
<td>6</td>
<td>1.8</td>
<td>3.5</td>
</tr>
<tr>
<td>7</td>
<td>2.4</td>
<td>6.5</td>
</tr>
<tr>
<td>8</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>9</td>
<td>3.7</td>
<td>9.7</td>
</tr>
<tr>
<td>10</td>
<td>5.2</td>
<td>9.9</td>
</tr>
<tr>
<td>11</td>
<td>3.1</td>
<td>1.4</td>
</tr>
<tr>
<td>12</td>
<td>2.4</td>
<td>3.2</td>
</tr>
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</tr>
<tr>
<td>14</td>
<td>4.5</td>
<td>2.5</td>
</tr>
<tr>
<td>15</td>
<td>2.6</td>
<td>3.7</td>
</tr>
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<td>9.9</td>
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<td>6.7</td>
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<td>9.8</td>
</tr>
<tr>
<td>20</td>
<td>5.0</td>
<td>3.8</td>
</tr>
</tbody>
</table>

\[ \Sigma ta = 58.5 \text{ mins} \quad \Sigma tb = 106.9 \text{ mins} \]

Based on the single channel queuing model with Poisson arrivals and exponential service time, using First come, first served queue discipline the following deductions were made.

\[ \lambda = \text{Expected number of arrivals per time period (mean arrival rate)} \]

\[ \mu = \text{Expected number of service possible per time period (mean service time)} \]

\[ P_n = \text{Probability of exactly n units in system} \]

\[ e = \text{Potential utilization of the service facility defined as } (\lambda / \mu) \]

\[ n = \text{Number of units in the system} \]

\[ nt = \text{Average number waiting in line} \]

\[ ns = \text{Average number in system (including at, being served)} \]

\[ tt = \text{Average time waiting in line} \]

\[ ts = \text{Average total time in system} \]

\[ Po = \text{Probability that there is no one in the queue} \]

\[ n = \text{Average number of people in the system} \]

\[ t = \text{Average time a person spends in the system (queuing and service)} \]
\[
C = \text{service channels} \\
P_w = \text{probability that a person has to wait in a queue.}
\]

Average time between arrival mean inter arrival time.
\[
\text{Time} = \frac{\sum t_a}{n} = 58.5 = 2.925 \text{mins}
\]

\[\therefore \text{Arrival rate } \lambda = \frac{1}{2.925} = 0.342 \text{ mins}^{-1}\]

For \[\frac{\sum t_y}{n} = 106.9 \quad = 5.345 \text{mins}\]

Arrival rate \[\lambda = \frac{1}{5.345} = 0.187 \text{ min}^{-1}\]

Considering one server out of the four servers
\[\frac{\sum t_y}{4} = 106.9 = 26.73 \text{mins}\]

Mean service time will be \[\frac{106.9}{4} = 26.73 \text{mins}\]

Service rate \((\mu) = \frac{1}{0.75} = 0.75 \text{ min}^{-1}\)

Utilization, \[P = \frac{\lambda}{C \mu} \text{ and if } P < 1 \text{ then } P = \frac{\lambda}{C \mu} \]

\[P = \frac{0.342}{1 \times 0.75} = 0.456\]

Average number waiting in line
\[nt = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{(0.342)^2}{0.75(0.75 - 0.342)}\]

\[= \frac{0.116964}{0.116964} = 0.116964 \quad \frac{0.75(0.408)}{0.306} \]

\[= 0.38 = 0 \text{ person}\]

\[nt = 0.38 = 0 \text{ person}\]

\[t_w = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{0.342}{0.75(0.75 - 0.342)}\]

\[= 0.75(0.75 - 0.342)\]

\[= 0.342 \quad = 0.342\]

\[0.75(4.08) \quad 0.306\]

\[t_w = 1.12 \text{mins}\]

The probability that a person has to wait in a queue \(P_w = \frac{\lambda}{\mu} = \frac{0.342}{0.75} = 0.456\)

**Results and Discussions**

The results for \(\sum t_x, \sum t_y, \lambda, \mu, P, n_t, t_w, \) and \(P_w\).

The results for \(\sum t_y\) was calculated by summing up all the values of inter arrival times. The value of the sum of inter arrival time \(\sum t_y\), was calculated to be 58.5mins. The service time, \(t_y\) was summed up to get the value of its summation, \(\sum t_y\), which was calculated to be 106.9minutes. The arrival rate, \(\lambda\) which is the reciprocal of the average time between arrival mean inter arrival time was calculated to be 0.187min\(^{-1}\).

Considering service time, its sum \(\sum t_y\), aided in the calculated average time for the service time; this average time value was calculated to 5.345mins. The arrival rate for service time was also calculated to be 0.187 min\(^{-1}\).

The service rate, \(\mu\) was calculated from mean service time considering one server out of the four servers, \(\mu\) value was calculated to be 0.75min\(^{-1}\). Furthermore, utilization \(P\) which from literature was considered to be less than one, was calculated to be 0.0456.

Following the utilization, is the average number waiting in line, \(n_t\), which was calculated to be 0.38, which was later approximated to 0, which makes that no person is waiting on the queue. Averagetime waiting in line was calculated to 1.12mins.

Finally, the probability that a person has to wait in a queue, \(P_w\) was calculated to be 0.456.
Conclusions

Based on the calculated parameters, the service rate value was found to be greater than the arrival rate. The probability that a person has to wait in a queue was calculated to be 0.456 which is minimal. This implies that an increase in the service channels will result in the reduction of the waiting time, and as such, more customers are served and queues are reduced.

Recommendations

Based on the results of this study, the following recommendations were made:

1. First Aluminium Company should always have a functional queuing system which would perform the various queuing activities or functions they need to complete favourably.
2. The company should adopt use of queuing concept, which is imperative for long-run profitability.
3. The company should ensure that adequate maintenance facilities are always in place so as to reduce down time that is caused by faulty machines.
4. The company should put more continuous coating line facilities so as to reduce the waiting during operation.
5. More tanks should be introduced in the continuous coating line so as to have different channels of coating of aluminium coils, and at the same time considering its workability.
6. The company should also introduce more ovens in the continuous coating line.

References


