Machine Utilization Evaluation Model for Nigerian Industries.

P. K. Oke; A. A. Atoyebi

Abstract: In Nigeria industries, machines are procured most times without taking into consideration the utilization of available machines(s) because there is no too tool for evaluation. Therefore, there is a need to develop a mathematical model to serve as a tool to be used to analysis and evaluate the machine(s) throughput per month and to know the number of machine(s) to service customers. All the factors affecting machine utilization were identified in this work and used in the model development to determine the machine throughput per month. The model was validated with data which were collected from two industries which include Top Stay Nails and Wires Company (T.S.N.W.C) Osogbo and Aquados Table Water Company (A.T.W.C), Osogbo, Osun State, Nigeria. It was observed that from the result, T.S.N.W.C had M_T of 49240.58 kg/month of September with eleven (11) machines which is k and A.T.W.C had M_T of 48567 bags/month and 43056 cartoons/month of October with two (2) machines each. Machine utilization evaluation model will help to minimize or eradicate low production output of the company and facilitate effective machine procurement process for future expansion. This will also help the company to know actual number of machines to service customers. This developed model is highly recommended to any company, small, medium and large scale that servicing of customers is paramount to them as a result of competitive products.

Keywords: machine, procurement, productivity, utilization.

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1. INTRODUCTION

THE accurate estimation of the equipment utilization is very important in capital-intensive industries (e.g. the semiconductor and chemical industries) since managers in these industries want to utilize their equipment as properly as possible to get an early return on their investment. Based on the utilization estimated, managers can identify the causes of the time losses and attempt to reduce these losses (Puvanasvaran *et al.,* 2013).

Machine Utilization measured the percentage of scheduled time that machine is actually productive (Shirose and Nakajima, 2011). Machine(s) in an industry can be underutilized, properly utilized and over-utilized as the case may be. Under-utilization of machine is mostly caused by either planned or unplanned downtime and sometimes as result of improper planning caused by poor feasibility study to know actual customer's demand which may be less than planned or available facilities.

According to Mojekwu and Iwuji (2011)**,** machines being under-utilized may be as a result of so many factors such as planned downtime and unplanned downtime.

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Planned downtime is the time the machine is not available to produce based on scheduled events as set up time, adjustment time, employee breaks, scheduled maintenance, and shop floor meetings. The unplanned downtime is the time the machine is not available to produce based on unscheduled events such as corrective maintenance, idling and minor stoppage (Shirose and Nakajima, 2008). The high setup time cost is another reason why capital-intensive industry should try to minimize non-scheduled time since frequent stoppages of the equipment require warm-up time and cost (Jeong and Phillips). In case the industry actually planned properly well and make provision for adequate machine, the industry must guide against all kind of delay for the machine available to be properly utilized. Likewise, over-utilization of a machine should also be looked at in order not to cause production downtime.

Industrial machine efficiency is one of the factors that are frequently overlooked by the management and this can lead towards losses which reduces the yield (Konopka, 1996). Machines are meant to work efficiently, but in some circumstances machines can be less productive due to improper preventive maintenance (Shirose and Nakajima, 2008). Preventive maintenance is a key factor that keeps the machine running efficiently through the production process

(Jonsson and Lesshammar). The maintenance activity on machines needs extra attention by the management along with the responsible personnel to ensure optimum usage of machineries which will eliminate production downtime due to machine breakdown (Daniel, 2006).

Industries try to maximize the actual operation time and minimize the unplanned downtime to improve their capacity in all means (Pherson, 2006).

Leachman (2002) observed from the Total Productive Maintenance (TPM) point of view that losses of equipment availability and equipment utilization are causes for management concern, but they are not the only types of efficiency losses that occur.

In Nigeria, due to economic situations and epilepsy power supply situation, there is need for a company to know the level at which they can produce in terms of machine throughput, whether they are theoretically producing to what the machine can produce or not. Therefore, in other to ensure that machine in most industries are properly utilized, there is a need for mathematical model in form of a tool to check the utilization status of the machines. In the same vein, this tool will also help the industry to decide at the managerial level either to procure more machines in case of over-utilization and for effective utilization, to plan ahead for procurement of machines, and if under-utilized, to try and minimize all necessary causes like mechanical delays and improve on market feasibility study of output products. The model developed will adequately calculate machine throughput per month and actual Number of Machine to service customers.

2.   METHODOLOGY

In order to identify all the parameters needed to formulate the required mathematical model, some companies were visited to know what causes machine not to be properly utilized according to the manufacturer's production status. These parameters include:-

(i) Number of machines in the company

(ii) Machine hour rate per day (usually specified by the manufacturer)

(iii) Production rate per day/week/month,

(iv) Time required to produce a components/parts/products,

(v) Number of shifts per day,

(vi) Output requirement of the company in a day/week/month to service customers,

(vii) Number of hours per shift per day,

(viii) Number of days per week,

(ix) Number of weeks per month,

(x) Public Holidays,

(xi) Number of non-working days

(xii) Service rate per month.

This mathematical formulation to be developed in this work has put all these factors into consideration in order to determine accurately the machine throughput in order to help in determining the require number of machine that will be enough to service customers.

2.1   Nomenclature

Symbol   Meaning

N_m − Number of machines in the company

M_h − Machine hour rate (usually specified by the manufacturer)

P_R − Production rate per hour

N_s − Number of shifts per day

N_h − Number of hours per shift per day

N_d − Number of days per month

N_{PH} − Number of Public Holiday

N_{nwd} − Number of non-working days

S_R − Service Rate

A_p − Actual production quantities per day

A_h − Actual number of hours per day

A_d − Actual number of days of production per month

M_T − Throughput of machine(s) per month

3.   MODEL DEVELOPMENT

In getting all the actual production quantities per hour, number of all the machines for production (N_m) will be multiplied by production rate per hour (P_R).

$$A_p = N_m \times P_R \qquad (1)$$

Also,

In getting Actual number of hours per day for production, it will be number of shift per day (N_s) multiplied by number of hours per shift (N_h)

$$A_h = N_s \times N_h \qquad (2)$$

In getting the actual number of days for production, it will be by subtracting the number of public holidays (N_{PH}) and the number of non-working days (N_{nwd}) from number of days per month (N_d).

$$A_d = N_d - (N_{PH} + N_{nwd})$$

or

$$A_d = N_d - N_{PH} - N_{nwd} \qquad (3)$$

Therefore, Machines Throughput will now be;

$$M_T = A_p \times A_h \times A_d \qquad (4)$$

3.1 Relationship Between Service Rate and Company's Output.

The product of Number of machine (N_M) and Service rate (S_R) is a function of company's output (C_O) which means, product of number of machine (N_M) and service rate (S_R) is directly proportional to company's output, i.e ($N_M \times S_R$) α C_O and the proportionality constant is K which helped in predicting the number of machines to service customers.

$$N_M \times S_R = k \times C_O$$

Hence $k = \frac{N_M \times S_R}{C_O}$ $\qquad (5)$

where $C_O = M_T$

C_O = Company's output

k = the proportionality constant = number of machines for service rate.

$$M_T = A_p \times A_h \times A_d$$

Where M_T = Machine(s) Throughput

A_p = actual production of quantities per day

A_h = actual number of hours per day

A_d = actual number of days of production

Output capacity C_O of the company is a function of time required to produce a component/part/product.

3.2 Machine(s) Throughput per month (M_T): The throughput of all the machines on ground for production in a month depends on variables such as actual production of quantities per day (A_p) multiplied by actual number of hours per day (A_h) multiplied by actual number of days of production (A_d).

$$M_T = A_p \times A_h \times A_d.$$

Where A_p ; A_h & A_d are as follows respectively.

$$A_p = N_m \times P_R$$

$$A_h = N_s \times N_h$$

$$A_d = N_d - N_{PH} - N_{nwd}$$

4.0 MODEL VALIDATION

Data were collected from two industries to validate the developed model which include Top Stay Nails and Wires Company (T.S.N.W.C) Osogbo and Aquados Table Water Company (A.T.W.C), Osogbo, Osun State, Nigeria. From T.S.N.W.C., 3" nails were studied during the production and data were taken and recorded in the Table 1. Also, Bottle and Sachet table water were studied during the production and data were taken at AQUADOS Table Water Company (A.T.W.C), Osogbo, Osun State and recorded in the Table below 1. The data are as follows;

Table 1: Data collected for the Model's Validation

	Symbol	Top Stay Nails & Wire, (08/2014)	Aquados Table Water (sachet water), 09/2014	Aquados Table Water (sachet water), 09/2014
Service Rate	S_R	132088.52kg/month	46220bags/month	21999bags/month
Number of machine	N_M	4	2	3
Production rate	P_R	1.165kg/min (69.944kg/hr)	2.2 bags/min(132bags/hr)	1.3 cartoon/min(78cartoons/hr)
Number of shift per day	N_S	1	1	1
Number of hours per shift per day	N_h	8hrs	8hrs	8hrs
Number of day per month	N_d	24days	26days	26days
Number of public holidays	N_{ph}	2days	3days	3days
Number of non-working days	N_{nwd}	0	0	0

5.0   RESULTS AND DISCUSSIONS.

The application of the developed models are in Table 2 below, where the Actual number of machines to service customers (k) is greater than the Number of Machines on ground (N_M) in the case study T.S.N.W.C. and for A.T.W.C., the Actual number of machines to service customers (k) is equal and less than the Number of Machines on ground (N_M) respectively.

Table 2: Application of the equations above

	Developed Model	Top Stay Nails & Wire, (08/2014)	Aquados Table Water (sachet water), 09/2014	Aquados Table Water (Bottle water), 10/2014
Actual quantities/ day	$A_p = N_m \times P_R$	279.28kg/hr	264bags/hr	234cartoons/hr
Actual hour/day	$A_h = N_s \times N_h$	8hrs/day	8hrs/day	8hrs/day
Actual day/month	$A_d = N_d - N_{PH} - N_{nwd}$	22days/month	23days/month	23days/month
Machine(s) Throughput	$M_T = A_p \times A_h \times A_d$	49240.58kg/month	48567bags/month	43056 cartoons/month
Actual Number of Machine (k)	$k = \frac{N_M \times S_R}{C_O}$	11 machines	2 machines	2 machines

6.0   CONCLUSION

This study help industry to man or monitor their machine through Actual production quantities per month, Actual number of hours per day, Actual number of days per month throughout the year. With the help of this model development, it will help producer, manufacturers, management to understand service rate, machine throughput, whether to procure more machines to service their customers adequately or to reduce the number of machine producing in order not to have more products on ground because of expiring date especially consumable goods that has short-life span.

Also, as a matter of records due to this developed model, the company would able to predict the service rate for peak periods (such as el-del- fitri, el-del-kabir, easter festival, Christmas festival etc) as applicable with each product, in order to service their customer very well.

The developed model can also be a tool in the maintenance department of the industry. It can also help in proper planning for the machine procurement based on the level and the rate of production process and future expansion of the industry.

Acknowledgement

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