ASSESSMENT OF THE OVERALL EQUIPMENT EFFECTIVENESS IN A SACK MANUFACTURING COMPANY IN KANO, NIGERIA

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Abstract: Successes of the current government policy in Nigeria for domestic production of food crops and other products require continuous and efficient functioning of other industrial production companies, such as sacks manufacturing companies, for production of good packaging for the produce or products. It is vital that productions of such companies meet the current global business competition and high customer expectations, in providing high quality products, minimizing production wastages and meeting customer needs. Companies can meet these requirements through achieving excellent equipment effectiveness for their machines. Overall Equipment Effectiveness (OEE) is a tool that is used by industries for this purpose. In this study, the OEE of the tapeline machine, the loom machine, and the cutting and sewing machine at XYZ company in Kano were evaluated and compared with the world class standard values. It was found that the values of the OEE of the three machines were below the world class standard values. Factors that caused the OEE losses were identified, and suggestions were proffered as to eliminate the losses in order to improve the OEE of the machines.

Keywords: Company, Kano, machines, overall equipment effectiveness, total productive maintenance

Introduction

Nakajima (1988) developed the Total Productive Maintenance (TPM) concept which provided a quantitative metric called Overall Equipment Effectiveness (OEE) for measuring productivity of individual equipment in a factory. The OEE identifies and measures losses of important aspects of manufacturing, namely, availability, performance and quality rates. This supports the improvement of equipment effectiveness and thereby its productivity (Peter *et al.*, 2008).

OEE, which is a function of Availability, Performance and Quality rates measures Six Big losses associated with these rates. The Six Big losses are shown in Table 1.

Table 1: The six big losses

Six Big Loss Category	OEE Loss Category	Event Example
Breakdowns	Availability	1. Equipment failure 2. Major component failure 3. Unplanned maintenance
Set up and Adjustments	Availability	1. Equipment setup 2. Raw material shortage 3. Operator shortage
Minor Stops	Performance or, Availability	1. Equipment failure < 5 minutes 2. Fallen product 3. Obstruction blockages
Speed Loss	Performance	1. Running lower than rated speed 2. Untrained operator not able to run at nominal speed 3. Machine idling
Production Rejects	Quality	1. Scrap 2. Rework 3. In process damage
Rejects on Startup	Quality	1. Scrap 2. Rework 3. In process damage

Source: Muhammad *et al.* (2012)

Sayuti (2019) measured the Overall Equipment Effectiveness (OEE) and identified equipment losses for a pulp machine in Indonesia. The results showed that the average value for the equipment effectiveness of the pulp machine during the period January-July, 2016 was 74.01%, which was below the world class standard value. Reduced speed was identified to be the loss element. Finally suggestions were made as to eliminate the bottlenecks responsible for the OEE losses. Disha *et al.* (2013) evaluated the OEE of an insulation unit in a cable manufacturing organization, which was found to be below the world class level, and identified the main loss elements of the process. Continuous improvement measures were proffered as to improve the OEE of the insulation unit. Muhammad *et al.* (2012) measured the performance of a CNC cutting section of a shipyard in Bangaledash by calculating its OEE, and identified major productivity losses. The OEE was found to be 35.01%. Recommendations were proffered as to eliminate the loss factors in order to improve the efficiency of the CNC section. Khairun *et al.* (2012) calculated the Overall Equipment Effectiveness (OEE) of a sewing machine of a knit factory in Bangaledash. The OEE was found to be 51%, thus requiring significant upgrading. Breakdowns were the major loss category responsible for the OEE losses. Set of techniques like Autonomous Maintenance activities, Training, and Office TPM were suggested for improvement of the OEE.

Recently, XYZ company has experienced failure in meeting delivery dates for its customers. The reason for this failure could be due to one or more of the company's operations not being effective. This could be in terms of management or product processing; it could also be that the customers' demand within some specific time limit has exceeded the company's investment capability. To meet customer demand within time limit, the company had initially considered investing more in equipment by purchasing more machinery. But since having effective equipment is a key to meeting customer delivery date, the management of the company was advised to first chase away the bottleneck associated with their equipment before dealing with the next problem. The aim of the study is to assess the Overall Equipment Effectiveness of the key machines on the production floor of XYZ company.

Materials and Methods

The Production floor of XYZ Company has the following categories of machines:

(1) The Tapeline machines
(2) The Loom or Circular weaving machines
(3) The Lamination machines
(4) The Printing, Cutting & Sewing machines

Only the OEEs of the Tapeline, the Loom and the Cutting & Sewing machines were calculated as these were the three machines on the production floor that were necessary for the production of the sack. The lamination and the printing machines are only value adding machines, and so their OEEs were not considered.

As there were 3 nos. tapeline machines, 60 nos. loom machines and 6 nos. cutting & sewing machines on the production floor of the company, the following assumptions were made:

(1) All the machines in the same category are of the same make
(2) All the machines in the same category have the same operating conditions
(3) All the machines in the same category receive equal treatments by their operators who have the same training and skills
(4) All the machines in the same category will require the same OEE improvement measures

Given the above assumptions, only the OEE of one representative machine from each category was assessed. Data were obtained by consulting the production manager, the production engineer, the machine operating manual, and by direct observation during the morning shift of 21st January 2020, at the time of production of a certain order received from XCB Company. The order had the following specifications:

Sack size: 70 x 110 cm
Lamination: none
No. of sacks required: 150,000
The data obtained were:

(1) Shift Length
(2) Breaks (time duration)
(3) Total Units Processed (TUP), Rejected Units (RU) and Good Units (GU) for each machine
(4) Downtime for each machine during the examined period
(5) Ideal run rate for each machine

The availability metric (Muhammad *et al.,* 2012), performance and quality metrics (Soniya *et al.,* 2012), for each machine were calculated according to the following equations:

$$Availability\ (A) = \frac{Operating\ time}{Planned\ production\ time} \quad (1)$$

$$Performance\ (P) = \frac{Total\ units\ produced / operating\ time}{Ideal\ run\ rate} \quad (2)$$

$$Quality\ (Q) = \frac{Good\ units}{Total\ units\ processed} \quad (3)$$

The OEE of each machine was determined according to the following equation (Davis, 1995):

$$OEE = A \times P \times Q \quad (4)$$

The world class standard values of the Availability, Performance and Quality are presented in Table 2

Table 2: World class OEE standard metrics

OEE Metrics	World Class Value
Availability	90%
Performance	95%
Quality	99%

Source: (Smith & Hawkins, 2004)

For manufacturing industry, the World Class OEE Standard is 85% (Smith & Hawkins, 2004). Thus, comparison was made with the company calculated values. The losses hindering the OEE were identified, and suggestions were made for improvement.

Result and Discussion

The following data were as provided by the production manager at XYZ Company and as observed by the authors, with the necessary computations performed.

(1) Shift Length: 11 h.
(2) Breaks: 1.5 h.
(3) Total Units Processed (TUP), Rejected Units (RU) and Good Units (GU) presented in Table 3.
(4) Downtime (DT) presented in Table 4.
(5) Ideal Run Rate (IRR) presented in Table 5.

Table 3: Total units processed (TUP), rejected units (RU) and good units (GU) for the machines

Machine Category	TUP	RU	$GU = TUP - RU$
Tapeline Machine	2012 Kg	40 Kg	1972 Kg
Loom Machine	704 m	20 m	684 m
Cutting and Sewing	12207 pcs	251 pcs	11956 pcs

Table 4: Downtime for the machines

Machine Category	DT (hours)
Tapeline Machine	0.33
Loom Machine	2.23
Cutting and Sewing Machine	2.4

Table 5: Ideal Run Rate for the machines

Machine Category	IRR
Tapeline Machine	250 Kg/h
Loom Machine	120 metres/h
Cutting and Sewing Machine	1800 pieces/h

Having obtained the OEE data above, the following calculations were performed:

1. Planned Production Time (PPT) calculated in accordance with Muhammad *et al.* (2012)
   $$PPT = shift\ lenth - breaks \quad (5)$$
   $$PPT = 11 - 1.5 = 9.5 hours$$
2. Operating Time (OT) calculated in accordance with Muhammad *et al.* (2012) is presented in Table 6.
3. Availability (A) calculated according to equation (1) is presented in Table 7.
4. Performance (P) calculated according to equation (2) is presented in Table 8.
5. Quality (Q) calculated according equation (3) is presented in Table 9.
6. Availability (*A*), Performance (*P*), Quality (*Q*) and Overall Equipment Effectiveness (*OEE*). OEE was calculated according equation (4). These are presented in Table 10.

Table 6: Operating time for the machines

Machine Category	DT	$OT = PPT - DT$
Tapeline Machine	0.33	9.17 h
Loom Machine	2.23 h	7.27 h
Cutting and Sewing Machine	2.4 h	7.1 h

Table 7: Availability for the machines

Machine Category	$A = {OT}/{PPT}$
Tapeline Machine	97%
Loom Machine	81%
Cutting and Sewing Machine	75%

Table 8: Performance for the machines

Machine Category	$P = \frac{TUP/OT}{IRR}$
Tapeline Machine	88%
Loom Machine	81%
Cutting and Sewing Machine	96%

Table 9: Quality for the machines

Machine Category	$Q = \frac{GU}{TUP}$
Tapeline Machine	98%
Loom Machine	97%
Cutting and Sewing Machine	98%

Table 10: OEE and its metrics

Machine category	Availab (*A*)	Perfor. (*P*)	Qual. (*Q*)	$OEE = A \times P \times Q$
Tapeline Machine	97%	88%	98%	84%
Loom Machine	81%	81%	97%	64%
Cutting and Sewing Machine	75%	96%	98%	71%

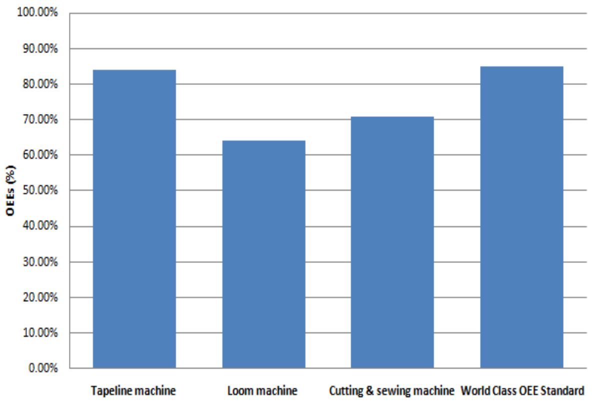

Fig. 1: Comparison of calculated OEEs and world class OEE standard

The tapeline machine

As seen in Table 10 and Fig. 1, for the tapeline machine, availabilty was 97%, performance was 88%, quality was 98% and OEE was 84%. In comparison with the world class standard values, only the availability metric is satisfactory. The OEE is below world class standard. The below world class standard OEE value obtained is found in similar studies conducted by Sayuti (2019), Disha *et al.* (2013), Muhammad *et al.* (2012), and Khairun *et al.* (2012).

After careful observation, discussion and interview with the maintenance staff, operators and management, factors responsible for the OEE losses were discovered. The factors were time losses and are shown in Table 11.

Loom machine

As seen in Table 10 and Fig. 1, for the loom machine, availability was 81%, performance was 81%, quality was 97% and OEE was 64%. In comparison with the world class standard values, all the metrics are not satisfactory. The OEE is much below the world class standard. The below world class standard OEE value obtained is found in similar studies conducted by Sayuti (2019), Disha *et al.* (2013), Muhammad *et al.* (2012), and Khairun *et al.* (2012).

After careful observation, discussion and interview with the maintenance staff, operators and management, factors responsible for the OEE losses were discovered. The factors were time losses and are shown in Table 12.

Table 11: Tapeline machine OEE losses and remedies

Time Loss Factor Identified	OEE loss Category Affected	Six Big Loss Category	Suggestion for Elimination of the Losses
Changing of broken down filter	Availability	Breakdowns	Ensure the raw material is sufficiently pure, free of dirt
Fixing disordered tape wrapping on roller	Performance	Minor stops	The operator should pay attention to the tapes coming from the slitting unit, and ensure prompt fixing of the tape wrapping if it happens. Implementation of Total Productive Maintenance (TPM)
Fixing overheating of the water bath	Availability	Breakdowns	The maintenance engineer should always ensure the water chiller is in good condition and functioning well

Table 12: Loom machine OEE losses and remedies

Time Loss Factor Identified	OEE loss Category Affected	Six Big Loss Category	Suggestion for Elimination of the Losses
Fixing shuttle problem	Performance	Minor stops	All measures for avoiding cutting of the tape threads should be implemented
Fixing heald wire problems	Performance	Minor stops	All measures for avoiding cutting of the tape threads should be implemented
Fixing tape thread motion slowing problems	Performance	Speed loss	The rollers should be regularly maintained
Fixing compensator problems	Performance	Minor stops	All measures for avoiding cutting of the tape threads should be implemented

Table 13: Cuuting & sewing machine OEE losses

Time Loss Factor Identified	OEE loss Category Affected	Six Big Loss Category	Suggestion for Elimination of the Losses
Fixing needle breakage	Availability	Breakdowns	Implementation of Total Productive Maintenance (TPM)
Fixing improper sewing	Quality	Production rejects	Ensure regular overhaul of the entire machine
Fixing picker problems	Availability	Minor stops	Implementation of Total Productive Maintenance (TPM)

Cutting and sewing machine

As seen in Table 10 and Fig. 1, for the cutting and sewing machine, availabilty was 75%, performance was 96%, quality was 98%, and OEE was 71%. In comparison with the world class standard values, only the quality metric is satisfactory. The OEE is below the world class standard. The below world class standard OEE value obtained is found in similar studies conducted by Sayuti (2019), Disha *et al.* (2013), Muhammad *et al.* (2012), and Khairun *et al.* (2012).

After careful observation, discussion and interview with the maintenance staff, operators and management, factors responsible for the OEE losses were discovered. The factors were time losses and are shown in Table 13.

Conclusion

In this study, the Overall Equipment Effectiveness (OEE) of key machines on the production floor of XYZ Company was assessed. Thus, the OEEs of the tapeline machine, the loom machine and the cutting and sewing machines were respectively evaluated to be 84%, 64% and 71%. Comparison of these OEE values was made with the world class standard value for manufacturing industries which stands at 85%. Therefore, all the OEEs evaluated for tapeline machine, the loom machine, and cutting and sewing machine, are below the world class standard values. For each of the three machines, reasons for the OEE losses were identified and suggestions made in order to improve equipment effectiveness.

Conflict of Interest

The authors declare that there is no conflict of interest related to this work.

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