INVESTIGATING THE OVERALL EQUIPMENT EFFECTIVENESS OF SMALL SCALE MANUFACTURING INDUSTRIES IN NIGERIA AND THE RELEVANCE OF CONDITION MONITORING

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ABSTRACT

The impact of productivity losses was examined and the overall equipment effectiveness of a small scale manufacturing industry in Nigeria was examined. Selected manufacturing system components were also analyzed. Results revealed that all the twelve machines under study failed to meet the standard availability value, only three machines met the standard performance efficiency (at 96.15%, 95.69%, 98.28%), two machines met the standard rate of quality (at 99.51% and 99.75%), and only one machine met the standard overall equipment effectiveness (at 85.46%). The probability of each of the machines failing within a month lies between 0.68 and 0.99. Thus, managers should pay close attention to all performance indices especifically those related to downtime. The relevance of condition monitoring cannot therefore be overemphasized if continuous smooth running of the plant with high productivity is to be achieved.

Keywords: *Overall Equipment efficiency, machine, condition monitoring, small scale industry, productivity*

1. INTRODUCTION

Atomplast is a small scale manufacturing industry that produces plastics. Its various manufacturing activities include: injection molding, plastic recycling, PVC conduit extrusion and PVC socket.

The manufacturing industry is faced with stiff competition; the need to minimize total production cost is indispensable: Otherwise, a manufacturer cannot compete favorably in the global market. The manufacturing system most times constitute several interconnected components/indices interacting and affecting each other. This multi criteria nature makes it difficult to achieve an optimal level for each indices with the goal of improving total system efficiency. It thus becomes relevant for every manufacturer to find out the actual percentage of planned production time that is truly productive, this is reflected by the overall equipment effectiveness (OEE). Productivity losses due to breakdown, setup and adjustments, reduced speed, start-up rejects and production rejects are common in small scale industries (ATS, 2010). Managers fail most times to measure the impact of these losses on productivity.

Approximately half of all operating costs in most processing and manufacturing operations can be attributed to maintenance, (Chris, 2011). Growing demand for high quality and low cost production has increased the need for automated manufacturing systems with effective condition monitoring and control capabilities (Uche, 2013). The goal of machine condition monitoring is to obtain real-time working status of the machines and use the information to identify potential machine faults and failure before they occur, thus reducing unexpected and costly machine downtime and ensure the highest possible productivity, and to more accurately control the quality of products, which is closely related to the working condition of the machines (Uche, 2013). When assets are critical in the business process chain, condition monitoring is a necessity for the delivery of effective preventive maintenance" (Eti *et al*., 2006).

According to Akindele (2010), Equipment failure is perhaps one of the major factors reducing availability of production plants. Unexpected machine breakdowns can cause significant economic losses due to the material damage and lost production time (Steve, 2007). A solution to this problem is to constantly monitor the working status of the machine, alert the machine operators of any incipient dangers, and shut down the machine before catastrophic failures occur. However, Eti, *et al*. (2006), noted that less than 1 percent of the maintenance managers in Nigerian manufacturing industries understand the effectiveness of condition monitoring maintenance programmes compared to reactive maintenance. Thus the impact of productivity losses was examined in this study and the need to adopt condition monitoring was proven. This is intended to draw the attention of small scale manufacturing industries to the impact of the salient factors they often overlook.

2.0 MATERIALS AND METHODS

The overall equipment efficiency of machines was examined using Atomplast Nigeria Ltd as a case study. Data were gathered through interview granted by the maintenance

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personnel and other management staff in the company. The number of days in test period was 78 days (Given 26 working days per month over a period of 3 months). The indices recorded are as collected from the machines within the period under review from September to November 2014. A total of twelve machines from different sections were studied.

To evaluate and develop a suitable condition monitory technique, some indices where employed. They include:

2.1 Availability:

Availability is the Probability that a system or component is performing its required functions at a given point in time or over a stated period of time when operated and maintained in a prescribed manner.
The availability of a machine is given by equation (1). (Mart and Telsang, 2012);

$$\text{Availability} = \frac{\text{Operation Time}}{\text{Loading Time}} \qquad (1)$$

Where loading time is the net available/running time per day

While: operation time = Loading time – Downtime (2)

Mean Time between Failures (MTBF)

This is referred to as the average time of satisfactory operation of the system (Mart and Telsang, 2012). It is a reciprocal of failure rate.
The MTBF of a system is given by equation (3);

$$\text{MTBF} = \frac{1}{\text{fairlure rate}} = \frac{total\ operation\ time}{total\ number\ of\ failure} \qquad (3)$$

Also, total operating time is the product of operation time per day and the number of days in test period. Therefore,

$$\text{MTBF} = \frac{\text{operation time per day} \times \text{number of days in test period}}{total\ number\ of\ failure}$$
(4)

Probability of failure

This is the likelihood that a system will fail over a specified period of time.

The probability that a system will fail over a given period of time is given by equation (5) (Mart and Telsang, 2012);

$$P = 1 - e^{-\lambda t} \qquad (5)$$

Where λ = the failure rate and

$t =$ the specified period of time

2.2 Performance efficiency

Performance takes into account speed loss i.e., any factors that cause the process to operate at less than the maximum possible speed.

The Performance efficiency of a system is given by equation (6) (Subramaniam *et al.,* 2009; VI, 2017)

$$Performance\ Efficiency = \frac{\text{Total Pieces Produced x Machine Ideal Cycle Time}}{\text{Operation time}} \qquad (6)$$

2.3 Quality

Quality accounts for produced pieces that do not meet quality standards including pieces that require rework. Quality is given by equation (7) (Subramaniam *et al.,* 2009; VI, 2017)

$$\text{Quality} = \frac{\text{Good pieces}}{\text{Total pieces}} \qquad (7)$$

2.4 OEE

OEE is a metric that identifies the percentage of planned production time that is truly productive. An OEE score of 100% represents perfect production: manufacturing only good parts, as fast as possible, with no down time (VI, 2017).
OEE can be calculated based on the product of the three factors which are Availability, Performance and Quality as given by equation (8) (Subramaniam *et al.,* 2009; VI, 2017; Martand Telsang, 2012);

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} \qquad (8)$$

3.0 RESULTS AND DISCUSSION

3.1 Results

Table 1: Atomplast machines and their Evaluation indices

		1	2	3	4	5	6	7	8	9	10	11	12
Running Time per day (mins)		660	660	660	600	660	660	660	660	660	660	660	660
Downtime per day (mins)		75	80	75	80	80	90	80	80	80	75	80	80
Output per day	**Good Pieces**	54	39	55	43	6717	29	68	180	188	6733	160	239
	Total Pieces	54	42	60	50	6750	35	75	185	190	6750	175	250
Actual Cycle Time (min/unit)		10.00	13.00	9.00	10.00	0.08	15.00	7.00	3.00	3.00	0.08	3.00	2.00
No of Failures for Test Interval		3	5	7	12	2	5	3	4	6	3	5	2
Operation time per day		585	580	585	520	580	570	580	580	580	585	580	580
Availability (%)		88.64	87.88	88.64	86.00	87.88	86.36	87.88	87.88	87.88	88.64	87.88	87.88
Performance (%)		92.31	94.14	92.31	96.15	93.10	92.10	90.52	95.69	98.28	92.31	90.51	86.21
Quality (%)		92.59	92.86	91.67	92.59	99.51	82.86	90.67	97.30	98.95	99.75	91.43	95.60
OEE (%)		75.76	76.82	75.01	76.56	81.41	65.90	72.13	81.82	85.46	81.62	72.72	72.43
Failure Rate, λ $(\times 10^{-5} mins^{-1})$		6.57	11.05	15.34	29.59	4.42	11.30	6.63	8.84	13.30	6.57	11.05	4.42
Probability of failure within a month, P		0.68	0.85	0.93	0.99	0.53	0.86	0.68	0.78	0.90	0.68	0.85	0.53
MTBF (mins)		15210	9048	6519	3380	22620	8892	15080	11310	7540	15210	9048	22620

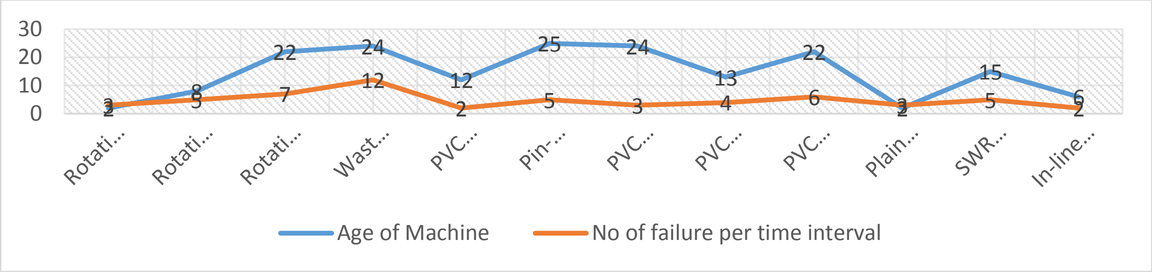

Figure 1: Age of machine and failure rates

3.2 Discussion of result

Table 1 indicates that virtually all the equipment had poor evaluation indices. While world class firms have availability greater than 90%, performance efficiency greater than 95%, and a rate of quality products greater than 99%, resulting to an overall equipment effectiveness greater than 85% (UVA, 2000: EPM, 2002), only Waste grinding machine, PVC pipe moulding machine I, and PVC pipe moulding machine II could meet the performance efficiency standard at 96.15%, 95.69%, 98.28% respectively. Also only PVC conduit extruder (20mm) and Plain PVC pipe socketing machine could meet the standard quality rate at 99.51% and 99.75% respectively. However, only the PVC pipe moulding machine (I) met the standard overall equipment effectiveness at 85.46%.

Figure1 illustrates a strong relationship between the age of the machines and the failure rates, the old machines especially the Waste grinding machine were exhibiting grossly unacceptable failures frequency (12 per 24). It is observable from figure 2 that the probability of each of the machines failing within a month is high, with the worst case scenario seen in the Waste grinding machine which is almost certain to witness failure every month. The implication is simply that as salaries are paid to workers monthly, a portion is wasted on breakdown repairs.

4. CONCLUSION AND RECOMMENDATIONS

Investigation of the overall equipment effectiveness of small scale industries in Nigeria has been carried out. The Result revealed that more than 90% of the machines were below the overall equipment effectiveness which means that very low percentage of the planned production time was truly productive.

The source of the problem was not far-fetched: production loss due to machine failure, stoppage or total breakdown. Overall maintenance and analysis were generally poor, this pointed out that there is no proper evaluation, no condition monitoring of equipment, low degree of planning, improper execution of preventive maintenance and inadequate maintenance personnel.

The ideal condition monitoring system offers many advantages. However, the Nigerian manufacturing industry has not been able to successfully apply the philosophy that underlies the application of such system in solving its industrial problems. If the condition monitoring is implemented, machines will be examined during non-productive hours and detected faults will be fixed. Also, as the age of machines increases, the frequency of the condition monitoring should be increased. This is because machine susceptibility to failure increases with its age. But if on the other hand, machines are continuously neglected to breakdown, not only is production time lost, more money is spent especially when the breakdown causes damage to a major machine component due to system interconnectivity. In some cases of catastrophic failures, even damage on products and human injury can be incurred. In this global age of industrial competition, if any industry is to survive, then machines are to be properly maintained to attain world standard overall equipment effectiveness.

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