Prediction of Case Loss Due to Machine Downtime in Nigerian Bottling Company

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Abstract— *Statistical analysis of five years record in a bottling company was carried out during which the production in the company was at its peak and cost has remain fairly stable (1987 to 1991). Most of the maintenance failures resulting in downtime are attributed to filler, crowner and washer, hence additional maintenance effort toward these machines can significantly cut down on downtime loses. A strong correlation is established between time lost and case lost (r=0.938, p=0.000) with a linear relationship of* $y = -2.893 + 0.02x$. *Thus a fair knowledge of the expected time lost within a period can be used in predicting the case lost thereby making the needed adjustment in production planning to meet up required production targets.*

Keywords— Machine Downtime, Nigerian, Breakdown.

I. INTRODUCTION

A collective measures taken up by the industry in order to keep the equipment or machine in trouble free environment or in good working environment is called maintenance engineering. Operational availability of the machines is taken care by the maintenance department. The concept of maintenance was very old and no proper care was given to the machines. When machines stopped, these machines were discarded or repaired. But in today's age, these high complex and invested machines need to be properly examined or maintained in order to increase or maximize their availability. Sidney Tyrrell[1], when unplanned breakdown or unexpected failure happens due to equipment failure, whole production line stops and production automatically stops. Therefore it would be expensive to bring the production system into running condition under emergency situation. Most downtime is partly influenced by mechanical and electrical problems. In other words, downtime over the years could partly be attributable to some technical hitches.

Knowledge of the relationship between machine downtime and lost in production resulting from the time lost due to maintenance activities can go a long way in predicting and minimize the cost of production. In a bottling company case loss often occurs not necessarily from machine downtime but other production setbacks, but the most easily noticeable and valued is the machine downtime. This downtime can be minimize base on the maintenance strategy adopted by the organization be it preventive, predictive, breakdown and condition base maintenance strategy.

Regression analysis and other statistical analysis techniques are a valuable tool mostly used in determining the strength of the relationship between two or more variable be it linear or otherwise.

II. MAINTENANCE STRATEGIES

Maintenance can be divided into two groups

(a) Breakdown maintenance

(b) Planned maintenance

Planned Maintenance can be divided into two of the following groups:

(a) Breakdown maintenance: - It is also called emergency based policy in which the plant or equipment is operated until it fails and brought back into running condition after repair. Breakdown maintenance is useful for small factories where there are few types of equipment's. Machines and equipment's are simple and does not require any experts.

(b)Planned maintenance: - It is also called an organized type of maintenance which focused on other aspects such as control and records. In this type of maintenance, work is planned in order to avoid the failures. Other types of planned maintenances are:-

(1). **Scheduled maintenance**: - In this type of maintenance, program can be made with the help of production department in order to utilize the idle time of the equipment

effectively. If the schedule of the maintenance is known, the specialists for this can be made available during the maintenance period.

(2). **Preventive maintenance**: - As the name suggests, it is planned type of maintenance in order to prevent or detect failure before breakdown. In this type, systematic and extensive inspection of each item of equipment's is done in predetermined intervals.

(3). **Corrective maintenance**: - The preventive maintenance is useful to detect the nature of the fault. In order to avoid this fault or reoccurrence frequently, corrective maintenance can be carried out. Therefore, corrective maintenance is defined as that maintenance which is carried to restore equipment that has stopped working to acceptable standards.

(4).**Condition based monitoring (CBM)**:- This type of technique is used to detect potential failures that may not be evident even though a PM programmed. Condition based on maintenance uses actual condition of the equipment to decide what maintenance needs to be done. It is used to detect the failure well in advance and therefore appropriate measures can be taken in planned manner. CBM improves equipment reliability, minimize unscheduled downtime due to catastrophic failure, minimizes time spent on maintenance and improves worker safety.

Types of CBM:-

(a).**Vibration analysis**: - It is used to detect heavy vibration such as in rotating equipment like compressors, pumps and motors etc.

(b).**infrared**: - It is used to detect abnormal temperatures or hotspots.

(c**). Oil analysis**: - In this type of analysis sample of oil is analyzed and can detect the deterioration or breaking down of an internal equipment part.

(d).**Ultrasonic**:-It is used to detect deep surface defect.

(e).**Acoustic**: - It is used to detect gas, liquid or vacuum leaks. [1]

(5).**Reliability centered maintenance (RCM)**:- According to J Moubray [4] RCM is a process used to determine what we can do for the equipment or assets so that it can perform its intended function what the user want in its present operating condition.

III. ANALYSIS OF DOWNTIME OVER THE YEARS

The research context of this study is to assess and evaluate the underlying relationships between time lost and cases lost. Furthermore, this research is based on experimental and survey research designs. It is experimental research because time lost were determined using experimental procedures while it is considered survey research because the data collection over the years was determined through survey methodology.

Moreover, the adopted sampling design is the stratified random sampling where time lost was selected and determine from different components such as filler, crowner and washer attributing most of the downtime within the selected periods. An effective experimental strategy was adopted to minimize errors to the barest minimum. The statistical tools to be employed for data analysis include descriptive statistics,correlationanalysis, regression analysis and analysis of variance (ANOVA). The IBM SPSS version 20 was used for the data analysis.

IV. DATA ANALYSIS

The descriptive statistics for the time lost and cases lost are given below.

Table 1: Time lost and Cases lost

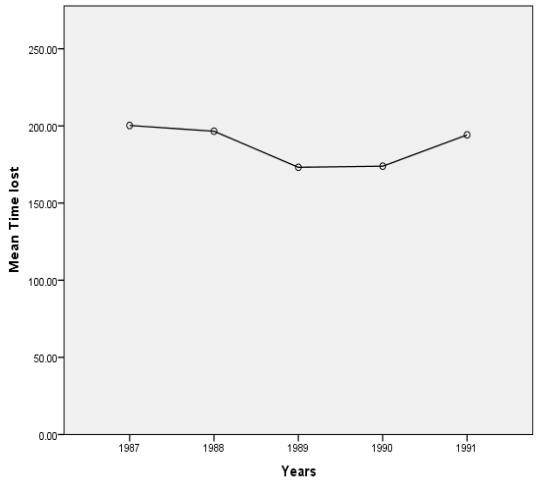
Lost	Years	Mean	Std. Dev	Std. Error	Minimum	Maximum
Time Lost	1987	200.28	312.48	83.51	5.33	1,167.37
	1988	196.57	314.75	84.12	5.28	987.67
	1989	173.19	278.92	74.54	4.18	1,075.25
	1990	173.90	257.04	68.70	7.17	997.93
	1991	194.19	337.05	90.08	4.28	1,083.85
Cases Lost	1987	115,878	160,954.3	43,016.8	5,873	597,184
	1988	74,086	127,146.1	33,981.2	7,856	506,782
	1989	100,869	141,148.7	37,723.6	10,786	534,763
	1990	100,287	130,473.5	34,870.5	6,523	497,628
	1991	116,951	182,995.3	48,907.5	6,111	586,173

From table 1 above, the mean time lost in 1987 was 200.28 while the mean case lost in the same year was 115,878. The descriptive statistics of the other years is depicted in the table 2.

Table 2: One-way ANOVA for Time lost and Cases lost

	Source	Sum of Squares	df	Mean Square
Time lost	Between Groups		4	2379.7
	Within Groups	5904295.8	65	90835.3
	Total	5913814.7	69	
Cases lost	Between Groups	16783150010.3	4	4195787502.6
	Within Groups	1462577338632.0	65	22501189825.1
	Total	1479360488642.3	69	

From table 2 above, there is no significant difference in the time lost over the years ($p=0.999$). Similarly, there is no significant difference in the cases lost over the years ($p=0.945$). In other words, time lost and cases lost are averagely the same over the five year period. The time lost is further depicted by the following mean plot.



The case lost is further depicted by the following mean plot.

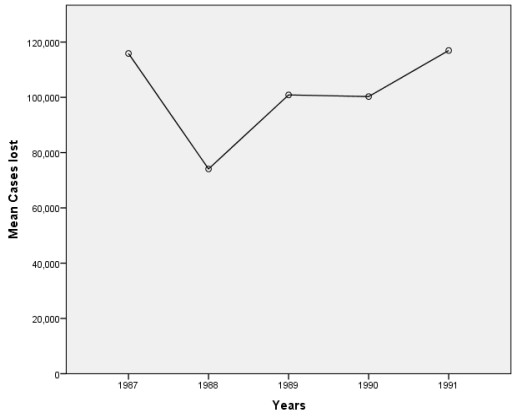


Table 3: Correlation Coefficients for Time lost and Cases lost

	Correlations	Time lost	Cases lost
Time lost	Pearson Correlation	1	0.938**
	Sig. (2-tailed)		0.000
	N	70	70
	Pearson	0.938	1

Cases lost	Correlation	**	
	Sig. (2-tailed)	0.000	
	N	70	70

From table 3 above, there is a strong and significant relationship between the time lost and cases lost($r=0.938$, $p=0.000$) as depicted by the following scatter plot. Furthermore, we need to explore this linear relationship to build a regression model.

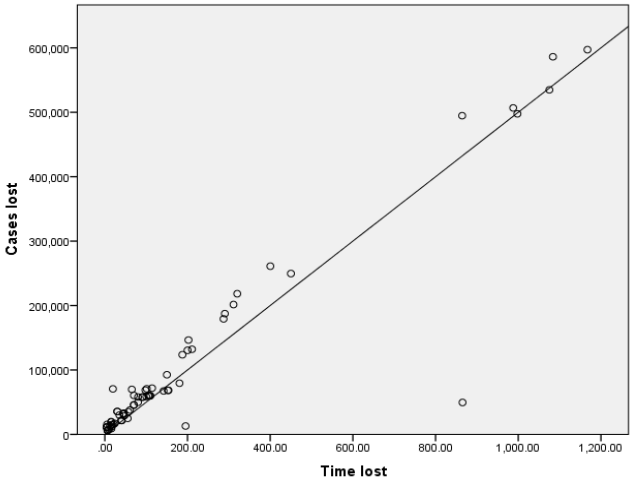


Table 4: Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.938	0.879	0.878	102.43

From the model summary above, the R Square (0.879) signifies that the model has a good prediction power (87.9%).

Table 5: Model ANOVA

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	5200358.2	1	5200358.17	495.65	0.000
Residual	713456.5	68	10492.01		
Total	5913814.7	69			

From the model ANOVA above, significance value ($p=0.000$) signifies that all the model parameters are significant.

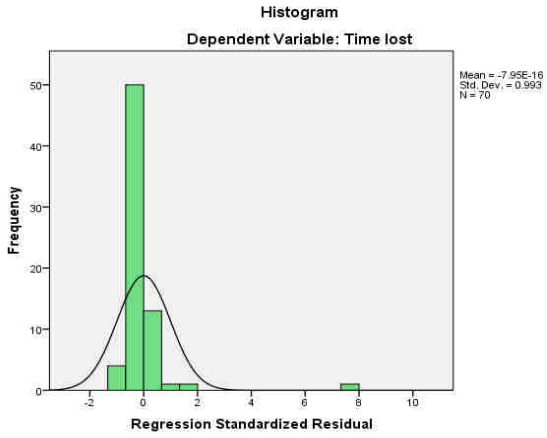
Table 6: Model Parameters

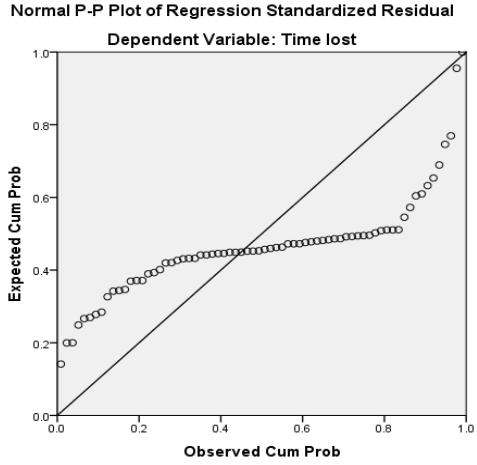
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-2.893	14.937		-0.194	0.847
Cases lost	0.002	0.000	0.938	22.263	0.000

From the model parameters above, we can obtain a linear model for predicting Time lost (y) using information from Cases lost (x).The model is as follows.

$$y = -2.893 + 0.02x$$

The validity and adequacy of the model are shown with the following histogram for normality test.





And the following p-p plots.

V. CONCLUSION

Knowledge of the relationship between machine downtime and lost in production resulting from the time lost due to maintenance activities can go a long way in predicting and minimize the cost of production. In a bottling company case loss often occurs not necessarily from machine downtime but other production setbacks, but the most easily noticeable and valued is the machine downtime. This downtime can be minimize base on the maintenance strategy adopted by the organization be it preventive, predictive, breakdown and condition base maintenance strategy. Most of the maintenance failures resulting in downtime in the bottle company are attributed to filler, crowner and washer, hence additional maintenance effort toward these machines can significantly cut down on downtime loses leading to minimization of production cost.

A strong correlation has been established between time lost and case lost (*r=0.938, p=0.000*) with a linear relationship of $y = -2.893 + 0.02x$. Thus a fair knowledge of the expected time lost within a period can be used in predicting the case lost thereby making the needed adjustment in production planning to meet up required production targets.

REFERENCES

[1] Mishra R.C. & Pathak K., "Maintenance Engineering and Management", PHI Learning Pvt. Ltd. 2012.
[2] Darius Singpurwall and Bookboon.com "A Handbook of Statistics: An Overview of Statistical Methods" 1st Edition 2013.
[3] Sidney Tyrrell and Bookboon.com "SPSS: Stats Practically Short and Simple" 1st Edition 2009.
[4] Moubray, "Reliability centred Maintenance", 2nd ed.Elsevier, 1997.
[5] Arjun Kotwal, Dr.S.S Dhami, Dr.Sarbjeet Singh, "Evaluation of Machine Downtime and Failure Analysis of Components in Paint Manufacturing Unit: Review Paper", International Journal of Mechanical and Industrial Technology ISSN 2348-7593 (Online) Vol. 3, Issue 1, pp: (170-174), Month: April 2015 - September 2015, Available at: www.researchpublish.com