Dynamic Maintenance Strategy, the Panacea to Materials Wastage from Machinery

M.K. Adeyeri, B. Kareem, S.P. Ayodeji, and I. Emovon

ABSTRACT - Many findings on the determination of the performance and efficiency of Nigeria industries were not favourable. The past studies found the performance of many of the indigenous manufacturing and production industries to be low. Low efficiency or poor output was attributed to some factors including inadequate infrastructural facilities, poor maintenance culture and materials wastage from machinery poorly maintained. The research work is aimed at discussing the material wastage from machinery.

Production data are collected from two viable industries through a structured questionnaire to ascertain the losses accrued from machinery engaged for production for five (5) years taking cognizance of machinery age, wear-out and failure. It is to be noted that the fifth year data is used as a control when proper maintenance culture had been adopted by the industries used as case studies.

Statistical analysis test was carried out on the data and it is evident that the machinery efficiency is far better when proper maintenance is adopted compared to the initial practice. Indeed maintenance cannot be traded off for any reason in a virile production firm. As to this, it is recommended that industries should adopt maintenance culture, which are suitable and as well increase production efficiency and better products.

Key words: Dynamic strategy, low efficiency, Machinery, maintenance culture, material wastage

I. INTRODUCTION

From literature, the definition of the term "maintenance strategy" is viewed from the perspective of maintenance policies such as corrective or breakdown maintenance, preventive maintenance and predictive maintenance or condition based maintenance. Sometimes, maintenance concepts like total productive maintenance or reliability-centered maintenance are also included.

Maintenance strategies such as reactive strategy (corrective maintenance), proactive strategy (Preventive Maintenance and Condition based Maintenance); and aggressive strategy (Total Productive Maintenance) [3]. These are further viewed under four strategic dimension as service-delivery options; organization and work structuring; maintenance methodology; and support systems [4].

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The maintenance strategy is defined as a functional hierarchy level similar to manufacturing or any other function. It is a series of unified and integrated pattern of decisions that are based on Hayes and Wheelwright's decision elements of manufacturing strategy [5].

The maintenance strategies are generally categorized as corrective (reactive) and preventive (proactive). The corrective maintenance is an unscheduled maintenance attempting to restore a system after a failure occurs. The preventive maintenance strategy, on the other hand, is to schedule proactive maintenance routinely by designed inspection, detection, and repair/replacement. A cost-effective preventive maintenance policy can significantly extend a system's life and reduce the number of failures, which, in return, reduces the total cost of maintenance. Most systems inevitably experience performance deterioration, which ultimately leads to a system's weakness that causes failures [6].

In the literature, there are several published papers on field of maintenance.

Equipment maintenance and reliability are important strategies that considerably influence the organization's ability to compete effectively. The present work is aimed at strategizing maintenance with product demand in order to reduce material wastage from machineries failures or breakdown, inventory and order backlog.

II. FORMULATED MAINTENANCE STRATEGIES

The maintenance strategies developed for the research work entails inculcating demand (D) for the product and the range of severity μ_i, which is a function of the mean time to maintain machine (t_b), and expected running time of machine (t_e). This severity is expressed in equation (1) below as

$$\mu_i = t_b / t_e \qquad (1)$$

The range of severity μ_i will determine whether to carryout preventive, breakdown and predictive maintenance, or their combination in group or otherwise.

High value of $t_b \dfrac{t_b}{t_e} \approx \mu$ i.e. above 0.5 indicates high maintenance severity, and at this level, opportunistic preventive and breakdown maintenance back up with condition monitoring (predictive) maintenance based on static and opportunistic grouping will be worthwhile, depending on the level of demand.

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If demand can be satisfied at this level, opportunistic breakdown maintenance could be good, if it is not, opportunistic preventive maintenance backup with condition monitoring could be better. In case of $0 \leq \mu \leq 0.2$ which shows that not more than 20% of time is available for predictive and preventive maintenance, opportunistic predictive maintenance based on dynamic grouping or opportunistic grouping is good. If demand is satisfied at this level, dynamic grouping is adopted, if not, opportunistic grouping is carried out.

In case of $0.2 \leq \mu \leq 0.5$, at this level, maintenance severity is moderate. Planned preventive and breakdown maintenance will be worthwhile based on static and opportunistic grouping. If demand is satisfied, static grouping is good, else, opportunistic grouping is proposed. Spare part inventory is necessary when $\mu \geq 0.5$. The actual production, P_{actual} is expressed as

$$P_{actual} = P_t - P_i \qquad (2)$$

Where

P_t = total output/ expected output

P_i = total loss due to maintenance activities

The following dynamic conditions are being strategised for actual production as a function of demand and the maintenance activities:

i. If P_{actual} < demand, and $\mu < 0.5$, breakdown maintenance based on opportunistic and static grouping is preferred.
ii. If P_{actual} < demand, and $\mu > 0.5$, preventive and dynamic maintenance based on opportunistic grouping is recommended.
iii. If P_{actual} < demand, and $\mu < 0.5$, breakdown maintenance based on static opportunistic grouping is preferred.
iv. If $P_{actual} > demand$, and $\mu > 0.5$, preventive, predictive maintenance with opportunistic and dynamic grouping is recommended.
v. If $P_{actual} = demand$, and $\mu > 0.5$, dynamic maintenance strategy based on static and opportunistic grouping with little or no inventory is employed.
vi. If $P_{actual} = demand$, and $\mu < 0.5$, opportunistic or static maintenance strategy is employed with little or no inventory

III. METHODOLOGY

Structured questionnaires were administered to a vegetable oil and cocoa industries as well as oral interview were used to ascertain the research objectives and major machineries in the industries were considered. The process starts from the point of loading raw material (soya beans) into the silos, from silo to crusher, crusher to flaker and this runs through to the process end point. Four consecutive years' records on input of materials at each process unit as conveyed by the conveyor are considered. For the purpose of the number of pages constraint of this conference, a process unit is considered by noting the number of tons input into the cracker and as well as determining the cracker's output. Thus, the material wastage is determined.

The fifth year, which is the year when the dynamic strategies formulated above were adopted, data collected during this period were as well analysed to ascertain the effectiveness of the strategies formulated.

Table (1-10) shows the tabulated input, output and monthly wastes of material records for both industries A and B.

Table 11 shows the efficiency of the two machines which are calculated for from table 1-10.

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Table 1: Industry A Material input and output data in ton at year 2005 on cracker machine

	Month	Jan	Feb	Mar	Apr	May	Jun
Cracker Machine	input	1650	1540	1705	1705	1705	1700
	output	1620	1512	1674	1674	1674	1670
	Waste (ton)	30	28	31	31	31	30
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	1650	1680	1700	1705	1705	1730
	output	1620	1650	1670	1674	1674	1699
	Waste (ton)	30	30	30	31	31	31

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Table 2: Industry A Material input and output data in ton at year 2006 on cracker machine

	Month	Jan	Feb	Mar	Apr	May	Jun
Cracker Machine	input	1650	1540	1705	1705	1705	1700
	output	1620	1512	1674	1674	1680	1670
	Waste (ton)	30	28	31	31	25	30
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	1649	1670	1700	1700	1710	1740
	output	1619	1648	1670	1670	1675	1710
	Waste (ton)	30	22	30	30	35	30

Table 3: Industry A Material input and output data in ton at year 2007 on cracker machine

	Month	Jan	Feb	Mar	Apr	May	Jun
Cracker machine	input	1800	1680	1800	1800	1800	1800
	output	1770	1652	1770	1770	1770	1770
	Waste (ton)	30	28	30	30	30	30
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	1800	1850	1850	1850	1850	1850
	output	1769	1820	1820	1820	1820	1820
	Waste (ton)	31	30	30	30	30	30

Table 4: Industry A Material input and output data in (ton) at year 2008 on cracker machine

	Month	Jan	Feb	Mar	Apr	May	Jun
Cracker Machine	input	1800	1680	1800	1800	1800	1800
	output	1785	1660	1775	1765	1768	1780
	Waste (ton)	15	20	25	35	32	20
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	1800	1850	1850	1850	1850	1850
	output	1780	1835	1835	1835	1820	1820
	Waste (ton)	20	15	15	15	30	30

Table 5: Industry A Material input and output data at year 2009 on cracker machine (with adoption of dynamic maintenance strategies)

	Month	Jan	Feb	Mar	Apr	May	Jun
Cracker Machine	input	1800	1680	1800	1800	1800	1800
	output	1785	1660	1775	1765	1768	1780
	Waste (ton)	15	20	25	35	32	20
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	1800	1850	1850	1850	1850	1850
	output	1780	1835	1835	1835	1820	1820
	Waste (ton)	20	15	15	15	30	30

Table 6**:** Industry B Material input and output data in (ton) at 2005 on Choco ball mill

	Month	Jan	Feb	Mar	Apr	May	Jun
Choco Ball Mill	input	1800	1680	1800	1800	1800	1800
	output	1785	1660	1775	1765	1768	1780
	Waste (ton)	15	20	25	35	32	20
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	1800	1850	1850	1850	1850	1850
	output	1780	1835	1835	1835	1820	1820
	Waste (ton)	20	15	15	15	30	30

Table 7: Industry B Material input and output data in (ton) at 2006 on Choco ball mill

	Month	Jan	Feb	Mar	Apr	May	Jun
choco ball mill	input	420	370	520	520	520	600
	output	395	340	500	505	495	580
	Waste (ton)	25	30	20	15	25	20
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	525	635	670	640	520	362
	output	500	620	660	630	500	345
	Waste (ton)	25	15	10	10	20	17

Table 8: Industry B Material input and output data in (ton) at year 2007on Choco ball mill

	Month	Jan.	Feb.	Mar.	Apr.	May	Jun
ChoCo balll mill	input	420	370	520	520	520	600
	output	395	340	510	500	490	578
	Waste (ton)	25	30	10	20	30	22
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	525	635	670	640	520	362
	output	498	628	655	625	505	340
	Waste (ton)	27	7	15	15	15	22

Table 9: Industry B Material input and output data in (ton) at 2008 on Choco ball mill

	Month	Jan	Feb	Mar	Apr	May	Jun
Choco Ball Mill	input	420	370	520	520	520	600
	output	393	343	500	500	495	579
	Waste (ton)	27	27	20	20	25	21
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	input	525	635	670	640	520	362
	output	498	625.5	650	622.5	505	342
	Waste (ton)	27	9.5	20	17.5	15	20

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Table 10: Industry B Material input and output data at year 2009 on choco mill (with adoption of dynamic maintenance strategies)

	Month	Jan	Feb	Mar	Apr	May	Jun
Choco Ball Mill	Input	420	370	520	520	520	600
	Output	420	370	520	518	520	595
	Waste (ton)	0	0	0	2	0	5
	Month	Jul	Aug	Sep	Oct	Nov	Dec
	Input	525	635	670	640	520	362
	Output	525	635	668	640	515	362
	Waste (ton)	0	0	2	0	5	0

Table 11: Efficiency of the machines over the years

Year	Cracker's efficiency (%)	Choco mill efficiency (%)
2005	98.2	97.0
2006	98.3	96.3
2007	98.3	96.2
2008	98.7	96.8
2009	99.9	99.8

V. ANALYSIS ON THE MACHINES

Based on the data shown on tables(1-10), we have

a. Machine A (Cracker)

Total output from 2005 to 2008 = 82,462 tons
Total input from 2005 to 2008 = 83,809 tons
Total loss of material wastage from 2005 to 2008 = 1347 tons

b. MachineB (Choco ball mill)

Total output from 2005 to 2008 = 24,224 tons
Total input from 2005 to 2008 = 25,127 tons
Total loss of material wastage from 2005 to 2008 = 903 tons

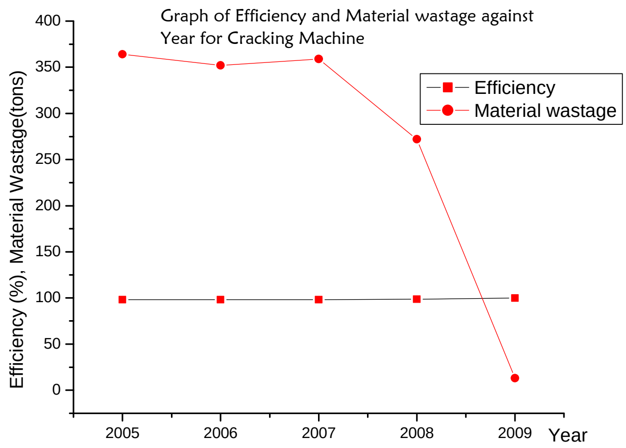

Figure1: Graph of Efficiency and Material wastage against year for cracking machine

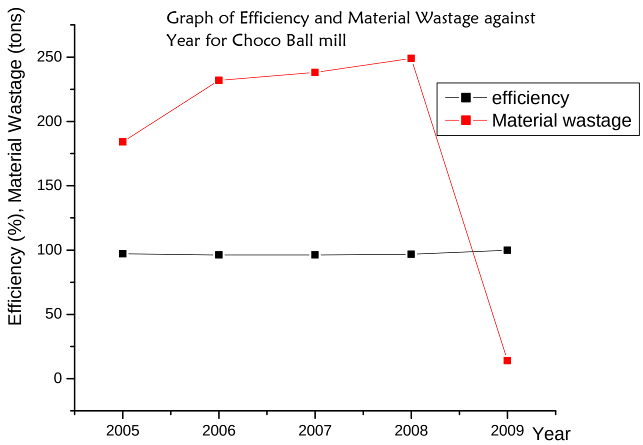

Figure2: Graph of Efficiency and Material wastage against year for choco ball mill

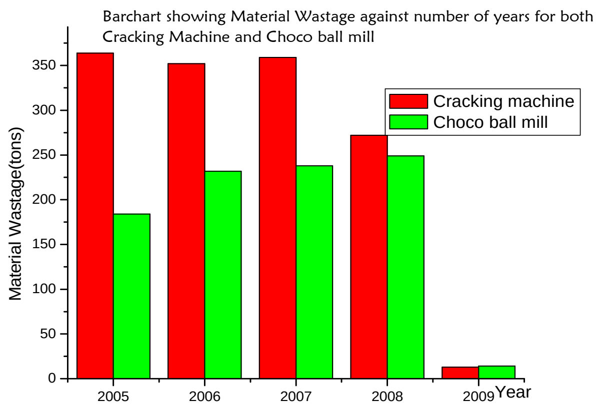

Figure 3: Chart showing Material wastage against number of years for cracking and choco mill

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VI. RESULTS AND DISCUSSION

The results obtained from the analysis of the data collected from the industries investigated as shown in table (1-10) revealed the enormous monthly material wastage from 2005 to 2008 when the industries maintenance approach was purely breakdown maintenance. When the formulated maintenance strategies were introduced, the material wastage from the machinery was reduced to bear minimum if not eliminated as shown in figure 3 above.

In figure 1and figure 2 it is evident that the efficiency of the machine is moderately okay but material wastage could not be married with this. The drop in the two figures still pointed to the drastic reduction in the wastage in year 2009 as the formulated strategies were adopted by the industries.

VII. CONCLUSION

The result of the material analysis of the selected machinery from the two industries showed that the material wastage is of the increase when a rigid approach was used in maintaining the machinery. With the formulated dynamic strategies, it is evident that machinery performance keeps improving, thereby reducing raw materials wastage, increasing product quality and enhancing product demand.

It is recommended that industries should adopt dynamic maintenance strategy culture, which are suitable and as well increase production efficiency and products.

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