ANALYSIS OF MAINTENANCE COST PROFILE IN TANZANIAN INDUSTRIES

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Abstract

This paper presents results of a research conducted in six Tanzanian Industries in their maintenance departments with regard to the cost of maintenance. The main contributors to the maintenance costs were analysed. Research findings show that costs related to the management of the maintenance department (such as inventory cost of spare parts, cost of preparation of maintenance workorders, etc.), were not taken as the cost of maintenance department in those surveyed industries. Likewise, some of the enterprises did not take into account downtime cost as a cost caused by maintenance. However, it is revealed from the data from few companies, which recorded the downtime costs, that downtime cost is the largest cost block in the maintenance department. For the companies, which did not keep the record of downtime costs, the personnel costs appeared to be the largest cost block.

Key words: maintenance, cost, downtime, cost-block, personnel

INTRODUCTION

Maintenance is gaining more importance in the production systems due to its influence in the quality of production and its influence on the efficiency of the machine, which affect the efficiency of the production system. It is well known that poor maintenance reduces the availability of the production equipment, which will reduce the throughput of the production system. That is to say, the efficiency of the production department depends to the large extent to the efficiency of the equipment. Kemmner [1992, p. 1] established that sufficient maintenance actions can sustain the required level of the quality and efficiency of the production process.

Every enterprise would like to carry out sufficient maintenance; however, by so doing there arise a number of maintenance costs and other maintenance related costs. A research conducted in some American companies shows that the cost of maintenance ranges between 15 to 40% of the value of the goods produced depending on the type of the industry [Mobley, 1990, p. 1]. For the case of the Federal Republic of Germany the maintenance expenditures represent 10% of GNP (Gross National Product) per year, which represented about 226 billion-DM [Warnecke 1992, p. 5]. From this economic point of view, it is obvious that the maintenance departments contain high potential of reducing the costs of production and increasing the profitability of the company.

It is to be noted that fierce competitions in the market coerced enterprises to set forth massive costs' reduction programs. This rationalisation pressure has more effects nowadays in the indirect departments (i.e. maintenance, transportation, etc.), since in the past intensive rationalisation measures were taken in the production department, such that an additional improvement in the production is only possible with massive investments [cf. Löffler 1994]. Therefore the main task nowadays is to search for means of reducing the size of the maintenance department. The maintenance department could be slimmed down using the so-called "***flat rate***" cost reduction program.

However the cost reduction processes based on the "***flat rate***" have pushed the maintenance in some enterprises to the limits of its functioning capability [cf. Löffler 1994]. According to the estimate of experts, this limit is already partly exceeded. On the other hand it can be that, with this "***flat rate***" costs' reduction exercise, a superfluous capacity is not known so that possible savings in the costs from other cost centres could be achieved.

Additional measures for the optimisation of maintenance activities lead to a change in structure and process organisation. In order to cover the costs of maintenance service, enterprises introduced the following organisational measures:

- Outsourcing of maintenance services-i.e. contracting maintenance task to an external firm;
- integration of maintenance personnel in the production;
- transferring of maintenance service to the production personnel; and
- Group work.

The main objective behind all the above mentioned rationalisation measures is to reduce the maintenance costs. To be questioned is that did those measures really reduce the maintenance costs? The author of this article believes that a through analysis of the cost profile of the maintenance department could reveal areas when rationalisation measures could have resulted in massive cost cuts in the maintenance department than doing rationalisation randomly.

One should also note that maintenance is an operation function, which has a precise economic value to be measured in relationship to the production system. If the value of maintenance could be determined and expressed in monetary terms, managers could have means of comparing the cost effectiveness of different maintenance policies. Therefore it is useful to determine both the direct and indirect costs of maintenance, lost of production and lost of profit caused by stoppage of plant or non-availability of the equipment in order to arrive at a quantifiable index of maintenance effectiveness.

Analysis of maintenance cost profile in the developed countries showed that cost of personnel constitute the largest cost block in the maintenance department [cf. Aggarwal 1982, p. 114; Jankow 1992, p. 93; Hackstein *et al.* 1987, p. 242]. Moreover, Michaelis *et al.* [1990, p. 199] established that between 70 and 80% of the costs in the indirect departments are personnel and personnel-additional costs. This situation may not be the same for developing countries like Tanzania since there is an ample availability of cheap labour. One may expect then that the cost of human resource in the maintenance department is negligible in comparison to other maintenance costs. Therefore one of the objectives of this paper is to depict the proportion of the human resource costs to the overall maintenance costs in the selected Tanzanian industries and to find out the largest cost block in the maintenance department. This analysis will help managers to decide appropriate maintenance policies, which will reduce the size of the established maintenance cost blocks.

OBJECTIVES OF THE RESEARCH

The main objective of the research was to analyze the cost profile of the maintenance departments in Tanzanian Industries so as to discover areas where cost reduction measure could result into more savings and show a great impact to the whole cost profile of the company. The analysis of the maintenance costs is important since it will enable the enterprise to forecast the maintenance costs likely to be incurred instead of waiting for surprises. This forecast is used in the preparation of the budget for the maintenance department. The maintenance cost analysis could result into the following:

- Determination of the proportion of the maintenance costs to the total operation costs of the plant;
- Determination of the appropriate maintenance policy, which will result into lower maintenance costs;
- Determination of the total downtime costs as compared to lost production opportunity;
- Ascertaining of the most expensive machine based on maintenance and downtime costs on failure;
- Determination of the Overall Equipment Effectiveness (O.E.E); and
- Determination of the availability and reliability of the production equipment, which could be used in production planning.

THEORY: DIRECT AND INDIRECT COST OF MAINTENANCE

Maintenance costs like any other operational costs can be divided into direct and indirect costs. The direct costs are easily visible, which include cost of wages, spare parts, maintenance consumables (such as lubricants, short life parts, etc.), utility costs, and other visible costs. Indirect maintenance costs on the other hand are not easily noted. These costs can be realised through close investigation of time lost when the equipment is down. The starting point is therefore to establish the average value of production per hour if the equipment is working properly. Then if the equipment is down for maintenance purposes, the time lost during this time will be converted to monetary value using the established average production value as lost production. Other indirect costs are almost invisible and they creates the so-called "iceberg effect". These costs may seem to be little but when one digs down the iceberg, one will find hidden mammoth maintenance costs. These costs include value of work-in-progress, which will be thrown away as scraps whenever the equipment fails, poor quality products produced by defective machines, management of spare parts (from acquisition, inventory, and disposal), maintenance training costs and the like, which can hardly be seen.

The direct and indirect costs are normally inversely related and the main conjoiner of the two is the reliability data of the equipment. For example, if a company puts more effort in the preventive maintenance, there will be an increase in direct cost but there will be a decrease in the downtime costs. However, if the company increases the intensity of maintenance, the direct cost become too large to be economically viable. On the other hand, if the intensity of preventive maintenance is too low, there will be an increase of breakdowns, which will increase indirect costs through downtime and breakdown related costs. Optimum maintenance cost is obtained somewhere between these two cost structures.

There are various graphical methods for evaluating the economics of maintenance by combining the direct cost curve and indirect cost curve to arrive at the optimum maintenance policy. There are, however, very few researches, which employed the numerical methods for determination of the optimum maintenance cost. One of the numerical methods includes the so-called "Corder's Maintenance Efficiency Index" [Clifton, 1982, p. 149]. The formula suggested by Corder assumes that maintenance costs are proportional to plant replacement value, and it takes the form:

$$E = \frac{K}{xC + yL + zW} \quad (1)$$

Where:

C = total cost of maintenance expressed as a percentage of the replacement value of the plant;

E = index of maintenance efficiency in the base year. In the base year it will be 100.

In the subsequent years an index over 100 indicates an improvement in the efficiency of the maintenance function and value less than 100 represent an unfavourable trend;

K = a constant such that the value of the expression is 100 for the base year;

L = downtime due to maintenance causes, expressed as a percentage of the scheduled production hours;

W = waste of materials caused as a result of maintenance responsibility, expressed as a percentage of total output at that stage of the process;

x = total cost of maintenance in the base year;

y = total cost of lost time due to maintenance causes in the base year;

z = total cost of waste material due to maintenance causes in the base year;

DISCUSSION OF RESULTS

A survey of maintenance departments in six selected companies in Dar es Salaam region was conducted in 1999. The survey covered the following companies: Tanzania Zambia Railways Authority (TAZARA), Carnaud Metal Box Ltd. (CMB), Kioo Ltd., Dar Brew Ltd., Tanzania Harbours Authority (THA), and Usafiri Dar es Salaam (UDA). The cost profile for each company will be analysed separately since there is a large discrepancy among the data obtained from these companies, the type of record keeping and the period of accounting.

Tanzania Zambia Railways Authority (TAZARA)

TAZARA is a railway company owned by Tanzania and Zambia governments, and it offers passenger and cargo services between Dar es Salaam in Tanzania and Kapiri Mposhi in Zambia. The Headquarters of TAZARA is in Dar es Salaam, Tanzania and the largest workshop for TAZARA is situated in Dar es Salaam. There are other workshops in Mbeya and Kapiri Mposhi. Maintenance cost data presented here was obtained from the Headquarters and they represent the cost profile of the maintenance department at the Headquarters.

The data depicted on Table 1 represent information obtained for the 1999/2000 financial year. Unfortunately the data did not include downtime costs, which are also part of maintenance costs. This problem of neglecting to record downtime is rampant in most of the Tanzanian Industries. In most cases, there is no data indicating the production capacity of individual equipment or production value per hour, which could be used in the calculation of downtime costs. The author has the opinion that, if downtime costs could be found, then the overall structure of the cost could be totally different. The data shown on Table 1 shows that personnel cost represent 55% percent of all the maintenance costs. Since there were no data for the calculation of the downtime costs, the personnel cost is the largest cost block compared to the other cost centres in the maintenance department of TAZARA. Therefore one could suggest that, if any meaningful reduction of maintenance costs at the TAZARA is to be achieved, then personnel structure in that department should be reviewed

Table 1. Maintenance cost analysis for TAZARA

Maintenance personnel monthly costs	
Salaries	37,597,308
17.5% NSSF and PPF	6,579,529
Allowances	
Meal allowances	5,928,000
Transport allowances	8,220,000
Education allowances	4,128,000
Entertainment	456,000
Domestic water and electricity (for senior staff)	9,326,790
Sub total	72,235,627
Maintenance of Equipment monthly costs	
Spare parts	22,081,088
Machine lubricants	11,415,480
Buildings maintenance	9,617,000
Maintenance of water supply system	3,465,000
Tools and other supplies	6,234,308
Motor vehicles maintenance	4,106,000
Motor vehicles lubricants	1,040,321
Fire fighting equipment	942,000
Sub total	58,901,197
Grand total	**131,136,824**
Ratio of Maintenance personnel to the total maintenance costs	**0.55**

Carnaud Metal Box Ltd. (CMB)

CMB was found to be up-to-date with the calculation of downtime costs. The company produces metal products, which include battery case, can and bottle crown. Therefore the company has three lines of production. At the crown line the estimated rate of production value is Tshs. 777,000 per hour whereas at the battery case line the estimated rate of production value is Tshs. 222,000 per hour and at the cane line the rate of production value is Tshs. 111,000 per hour. Table 2 depicts the indirect costs (calculated as lost production value), and direct costs of maintenance (depicted as labour and spare parts costs) for January to December 1998.

As it can be observed from the depicted data, downtime costs represent more than 90 percent of all maintenance cost at CMB. This situation can be considered as an extreme case in which the downtime cost is so dominant to overshadow all other maintenance cases. Therefore, for a company, which has maintenance cost profile similar to the case of CMB, more effort should be aimed at increasing the intensity of preventive maintenance to reduce number of failure and downtime of the equipment.

Table 2: Maintenance Cost Data at CMB

Month	Crownline			Battery Case line			Cane line			Total Lost Production Value [x1000]	Total Labour and spare parts costs x1000]	Total Cost of Maintenance [x1000]	ratio of Lost Production to Total Maintenance Cost
	Total Downtime [hours]	Lost Production Value [x1000]	Labour and spare parts costs [x1000]	Total Downtime [hours]	Lost Production Value [x1000]	Labour and spare parts costs [x1000]	Total Down time [hours]	Lost Production Value [1000]	Labour and spare parts				
1	8.0	6,216	140	4.0	888	150	4.0	444	4	7,548	294	7,842	0.96
2	12.0	9,324	170	2.0	444	100	6.0	666	6	10,434	276	10,710	0.97
3	7.0	5,439	150	3.0	666	300	8.0	888	8	6,993	458	7,451	0.94
4	6.5	5,051	240	6.0	1,332	250	7.0	777	7	7,160	497	7,657	0.94
5	15.0	11,655	300	2.0	444	80	9.0	999	9	13,098	389	13,487	0.97
6	14.0	10,878	250	7.0	1,554	160	8.0	888	8	13,320	418	13,738	0.97
7	18.0	13,986	450	10.0	2,220	230	7.0	777	7	16,983	687	17,670	0.96
8	10.0	7,770	350	3.0	666	152	5.0	555	5	8,991	507	9,498	0.95
9	8.0	6,216	180	8.0	1,776	140	6.0	666	6	8,658	326	8,984	0.96
10	4.0	3,108	230	5.0	1,110	120	3.0	333	3	4,551	353	4,904	0.93
11	10.0	7,770	210	7.0	1,554	430	6.0	666	6	9,990	646	10,636	0.94
12	17.0	13,209	320	3.0	666	210	9.0	999	9	14,874	539	15,413	0.97

Kioo Ltd.

Kioo Ltd. manufactures bottles used for packing drinks such as beer and soda. The rate of production is 100 bottles per minute, and the production value is Tshs. 180,000/= per hour. The company applies both preventive and breakdown maintenance policies. Table 3 depicts maintenance data from Kioo Ltd. for the period of January to December 1998

Table 3: Maintenance data for Kioo Ltd.

Month	Total Downtime [hours]	Lost Production Value [x1000]	Labour and spare parts costs [x1000]	Total Cost of Maintenance [x1000]	Ratio of Lost Production value to Total Maintenance Cost
1	8.0	1,440	800	2,240	0.64
2	7.0	1,260	900	2,160	0.58
3	5.0	900	600	1,500	0.60
4	6.0	1,080	80	1,160	0.93
5	4.0	720	450	1,170	0.62
6	7.0	1,260	200	1,460	0.86
7	5.0	900	400	1,300	0.69
8	3.0	540	430	970	0.56
9	10.0	1,800	540	2,340	0.77
10	4.0	720	760	1,480	0.49
11	6.0	1,080	320	1,400	0.77
12	8.0	1,440	840	2,280	0.63

The average ratio of downtime cost to the total maintenance cost is 0.68, which is high. This data indicate that downtime cost contributes more than two thirds of the total maintenance costs. The trend line on the lost production curve (see Figure 1) came up with a formula y = -0.6294x + 1099, which can be interpreted as decreasing curve. So there is an improvement in the reduction of downtime costs. However, even though this case is not so critical as in the case of CMB, Kioo Ltd. should also strive to improve the preventive maintenance intensity in order to reduce downtime costs

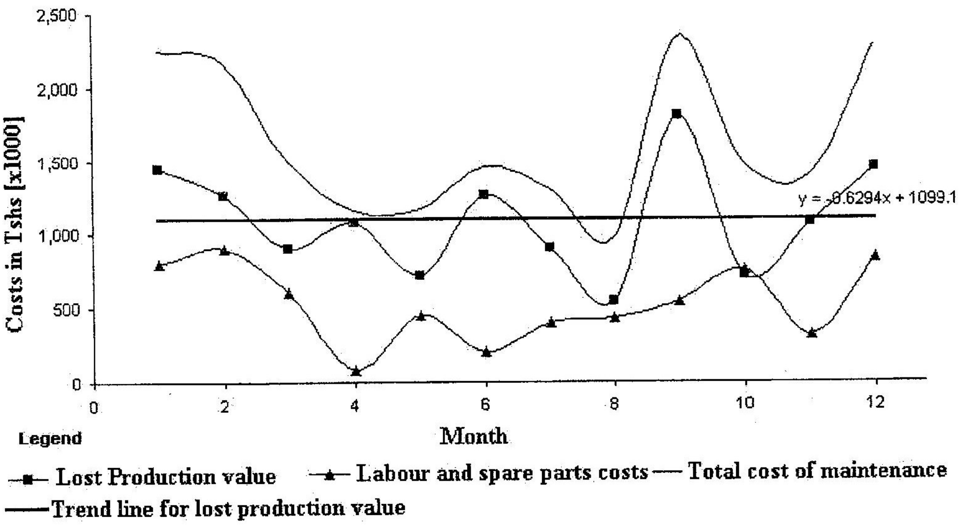

Figure 1. Maintenance Costs at Kioo Ltd

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Dar Brew Ltd.

Dar Brew Ltd. is a brewery company producing a beer brand popularly known as Kibuku. At Dar Brew Ltd. there are six major pieces of equipment which are used for beer processing: mixer, cookers, boiler, convetors, decanters and fermentors. The average production value is Tshs. 120,000/= per hour. Monthly maintenance data for Dar Brew Ltd. were unfortunately not readily available, however, the yearly data for five consecutive years were obtained and they are depicted on Table 4.

Dar Brew maintenance data show that the average ratio of downtime cost to the total maintenance cost is 0.26. This data indicate. that there are fewer serious downtimes at Dar Brew Ltd. in comparison to other companies already discussed (i.e. CMB and Kioo Ltd.). From the data available, the yearly direct cost of Kioo Ltd. (i.e. Labour and spare parts costs), is in the same magnitude as that of Dar Brew Ltd., which is in the magnitude of Tshs. 6m. However, the value of lost production at Kioo Ltd. is almost six times the value of lost production at Dar Brew Ltd. Therefore it can easily be concluded that maintenance performance at Dar Brew is much better than that of Kioo Ltd.

Table 4. Maintenance data from Dar Brew Ltd.

Year	Total Downtime [hours]	Lost Production Value [x1000]	Labour and spare parts costs [x1000]	Total Cost of Maintenance [x1000]	Ratio of Lost Production value to Total Maintenance Cost
1994	18.0	2,160	6,000	8,160	0.26
1995	20.0	2,400	6,500	8,900	0.27
1996	21.0	2,520	8,000	10,520	0.24
1997	23.0	2,760	7,000	9,760	0.28
1998	26.0	3,120	9,000	12,120	0.26

Tanzania Harbours Authority [THA]

The main functions of THA are to load and unload cargo entering or exiting the ports of Dar es Salaam, Tanga and Mtwara. The inland ports of Mwanza, Itungi and Kigoma are under the authority of Tanzania Railways Corporation (TRC). The data presented here will refer to Dar es Salaam port only and are based on the maintenance data of twenty-five portal cranes. There were no data available showing the production value per hour of each portal crane. Therefore it was not possible to calculate the total downtime costs whenever there is a failure of a portal crane. The data recorded was, however, divided into two categories: Preventive Maintenance (PM) and Corrective Maintenance (CM). PM data referred to all scheduled maintenance activities whereas CM data referred to all emergence call activities. The maintenance cost data from THA for the period January to December 1998 are as depicted on Table 5

Table 5. Maintenance cost data from THA

Month	Number of PM Activities	Number of CM Activities	Cost of PM [Tshs. x1000]	Cost of CM [Tshs. x1000]	Total Cost of Maintenance	Ratio of CM to total cost of maintenance
1	12	4	2,057	710	2,767	0.26
2	16	16	2,107	748	2,855	0.26
3	20	6	1,232	699	1,931	0.36
4	14	3	2,356	214	2,570	0.08
5	20	14	3,112	4,788	7,900	0.61
6	23	58	2,730	1,108	3,838	0.29
7	14	77	1,915	3,453	5,368	0.64
8	20	90	775	1,210	1,985	0.61
9	10	26	860	1,361	2,221	0.61
10	17	29	1,032	501	1,533	0.33
11	15	17	1,803	162	1,965	0.08
12	14	21	1,270	1,825	3,095	0.59

As it can be seen from the data on Table 5 there were high frequencies of CM calls, especially on the 8th month where there were 90 calls. It seems however that these were minor breakdowns since the cost of CM in total was only Tshs. 1.21m, whereas on the 5th month there were only 14 CM calls, but the cost of the CM was Tshs. 4.788m. The average ratio of CM cost to the total maintenance was found to be 0.39, which looks to be low. However, since there were no data regarding the downtime costs the data from THA cannot be compared to the data from CMB, Kioo Ltd., or Dar Brew Ltd.

Table 6. Production data from UDA

Year	Total output	Breakdown	Lost Production	Total Production	Ratio of lost production to the total production volume
1994	1170	110	8,250,000	87,750,000	0.09
1995	1719	138	10,350,000	128,925,000	0.08
1996	1670	122	9,150,000	125,250,000	0.07
1997	1710	132	9,900,000	128,250,000	0.08
1998	1514	126	9,450,000	113,550,000	0.08

Shirika la Usafiri Dar es Salaam (UDA)

UDA is a public parastatal offering commuter services in the Dar es Salaam City using Buses. The average production value is Tshs. 75,000/= per bus per day. Breakdowns depicted on Table 6 refer to those breakdowns in which the bus was grounded for the whole day

Data regarding the cost of maintenance at the UDA maintenance department was not readily available. However, according to the estimate of the manager of the maintenance department, the breakdown cost (i.e. lost production) is almost twice the maintenance costs for the whole department during that period of time. Interesting to be noted in table six is that the ratio of lost production due to breakdown to the total production volume is 8%. Therefore, if one considers the other part of maintenance cost, which is not considered here, this ratio will increase to almost 12%. It can be interpreted that 12% of the production turnover is spent on maintenance, which is not on the higher side when compared to developed countries where the ratio is more than 15% [cf. Mobley 1990, p.1].

CONCLUSION

In this article various maintenance costs in six companies in Dar es Salaam City were analyzed. From the analysis it was revealed that downtime cost represent the largest cost block in the maintenance departments in Tanzanian industries. This is due to the fact that, the level of preventive maintenance or its effectiveness is still low. Some companies did not, however, put any record regarding the downtime cost. To those companies personnel cost appeared to be the dominant cost block. If there were proper recording of the downtime and the value of production per unit time, the author believes that the largest cost block would have been the downtime costs in all companies.

RECOMMENDATION

In order that one could display a better picture of the maintenance cost profile in Tanzania it is necessary to have a record of downtime costs for each institution surveyed. Therefore it is recommended to carry out a research to reveal the cost of poor maintenance in Tanzania industries. The research could show more avenues for revenue through optimisation of maintenance.

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