

An Evaluation of Maintenance Practices in Kenya: Some preliminary results

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Abstract—Over time, the definition of maintenance has evolved from activities meant to keep equipment in an operable condition, to a set of activities required to keep the means of production in the desired operating conditions or to restore them to this condition. Further, all those systematic activities geared towards the actual execution and improvement of maintenance are referred to as Maintenance practices. There is a general assumption that maintenance practices in the developing world are below standard, when compared to what happens in the developed world. However, this is not a fact that has been determined empirically, but rather a perception. This paper presents the results of an assessment of maintenance practices in Kenyan industries, using a maintenance practices evaluation tool. The analysis provides a critical overview of the current status of maintenance practices and also how these maintenance practices compare with the best practices globally. The research was carried out through a survey, using a questionnaire developed to establish the maintenance practices in a number of Kenyan companies. The survey clustered into different categories, namely, service, power generation, food manufacturing and processing, agro/chemical, metal processing, motor vehicle assemblers, transport, maintenance and construction industries. The responses from the survey were analyzed using the three aspects of maintenance practices, namely, technical, managerial and human aspects. For each of these aspects, an evaluation index was developed and calculated. Subsequently, the general evaluation index was determined. This index showed that Kenyan companies are at the managed level of maintenance practices. At this level, the processes are partially planned and performance depends on the operators' experience and competence.

It is recommended that the companies aim at improving the index to the highest level, namely the optimizing stage.

Keywords—Maintenance practices, Evaluation criteria, Maintenance in Kenya

I. INTRODUCTION

THE core function of maintenance should be to preserve components and equipment so that they can perform their desired functions. This calls for good policies and strategies in the company. Also, due to the increasing demand on increased productivity, quality and availability, machines have become more complex and capital intensive [1]. Thus, there is need for improved maintenance techniques using advanced sophisticated equipments to diagnose and even repair the machines. Also, the manpower must be trained so that they can be able to use the advanced monitoring and diagnostic equipment.

In view of the above, a good maintenance policy is a necessity in the work environment for increasing the availability of

the equipment. Unfortunately, most individuals or companies perform maintenance after an emergencies or breakdown, but mostly because it has to be done. In an effort to increase the profit and maximize availability of the equipment, maintenance is only done when the operators are not present e.g. over the weekends or on public holidays. This leads to unexpected breakdowns or poor performance because the operators do not have the actual performance history of the machine.

Maintenance practices have been defined in literature as the systematic activities that are geared towards the execution and improvement of maintenance. The two perspectives of maintenance practices are maintenance execution and maintenance improvement [2]. A company must adopt good maintenance practices in order to achieve its goals of production.

Maintenance engineering is a new area of research in Kenya. Previously, maintenance was handled as a topic in the various engineering courses. This has led to local graduates being employed without a firm grounding in maintenance. This has had a significant contribution to how maintenance is handled. Unless there is failure, no effort is made to check the probabilities and effects of a failure occurring. This is an undesirable approach to maintenance.

II. PROBLEM STATEMENT

The world has become a global market today. Thus, for the local companies to compete with others, their production costs must be kept low. One of the major areas in reduction of cost is effective maintenance. There is, therefore, a need to establish how maintenance is practiced in Kenya. Also, an area of interest is how the country compares with other nations in terms of maintenance practices.

This paper aims at establishing the maintenance practices used in Kenya, and evaluating these practices with the aim of determining how the country compares with developed economies.

A. Significance Of The Research

This research will provides an in depth analysis of the local maintenance practices and the level of these practices. Also, an evaluation of these practices has been made with the best practices globally. This knowledge gap lacks in the former research work done in the country.

III. EVALUATING MAINTENANCE PRACTICES

Over the years, the concepts of maintenance have undergone many major developments. Thus, several maintenance

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approaches, strategies, policies, methodologies and philosophies have been implemented. These concepts are normally developed with a managerial perspective, and little is known about the execution perspective, i.e. what actually is done on the shop floor.

A lot of literature has been written in the field of maintenance. Macchi and Fumagalli [3] evaluated maintenance in terms of managerial, organizational and technological capabilities. They further developed the five levels of maintenance maturity. However, their main focus was on maintenance management. Areas not covered in their study included maintenance practices with regard to activities that happen on the shop floor. Tahboub [4] investigated maintenance practices and the problems faced by Jordanian industries. The key finding of his research was that most industries had maintenance departments but did not allocate sufficient budgets to them. This research did not assess maintenance practices.

There is also a lot of literature on maintenance modeling and optimization, but for evaluation purposes there is a gap when it comes to the observable actions and practices in the manufacturing industries.

This research intends to establish the maintenance practices in Kenyan industries, and to evaluate them against a pre-defined criteria.

IV. METHODOLOGY

This paper forms part of a larger research on optimization of maintenance practices in the developing world, and specifically in Kenya. The main objective of this paper is to assess the level of maintenance practices in the Kenyan manufacturing industries. For this purpose, a theoretical framework for assessment of maintenance was used. A survey was conducted in several companies as a sample of the population. The results of this survey are presented later in this paper.

A. The Assessment Framework

Muchiri et al [2] proposed a five-level framework for classifying maintenance practices.

The framework on Table I suggests that an organization at level 1 has poor maintenance practices, and one at level 5 utilizes best maintenance practices. However, it is possible for an organization at this highest level to utilize all strong practices from the levels below. It is also possible that an organization at a lower level employs some of the practices associated with higher levels [2].

B. Data Collection

A quantitative approach was used to achieve the objectives of the research. A survey questionnaire was developed to assist the researcher to collect the quantitative data regarding the maintenance level, the operations of the maintenance department, the workforce in the department, the tools and equipment used etc. The questionnaire had 38 questions, subdivided into five sections, namely: introduction, the technical evaluation, the managerial evaluation, the human related evaluation and finally comments of the interviewee. Direct

TABLE I
THE FIVE-LEVEL FRAMEWORK FOR CLASSIFYING MAINTENANCE PRACTICES [2]

Stage	Classification	Description
Level 1	Basic practices	Practices employed tend to be unplanned and unpredictable. Performance of tasks is very subjective to the person assigned.
Level 2	Repeatable practices	Practices associated with repetitive maintenance practices. Partial planning of processes, and practices related to process monitoring is utilized.
Level 3	Proactive practices	Practices associated with planning and implementation according to organizational objectives. Use of quantitative analysis to plan and define maintenance tasks
Level 4	Managed practices	Practices related to managing and controlling maintenance, by planning based on feedback data from various maintenance processes.
Level 5	Optimum practices	Practices related to continuous improvement of maintenance and quality control, failure analysis, defect analysis, future improvements, Design Out Maintenance (DOM) practices also utilized. Testing of new maintenance methods and techniques may also feature.

interviews with the maintenance engineer or personnel was used to collect the opinions of the interviewee and their explanations on information which may not be clear from the data collected.

This approach has been used by a number of researchers in the field of maintenance engineering [4]–[9].

The questions were formulated to bring clarity on elements of the maintenance practices. The analysis of the questions answered the following:

- 1) The maintenance activities performed in the industry under investigation.
- 2) The details of the maintenance programs pursued.
- 3) The extent of the application of maintenance concepts.
- 4) The level of improvement on the maintenance concepts.
- 5) The cost elements of maintenance and budgetary provisions.
- 6) The performance measurement system used.

V. RESULTS

A total of 78 companies were approached to participate in the survey. 50 out of 78 companies responded to the survey. This represents a 64.1 % response, which is sufficient to provide a critical analysis of the maintenance practices being employed in the industries. The analysis of the responses is as shown in Table II.

The results of the survey were analyzed based on the three aspects of maintenance practices, i.e. technical, managerial and human aspects [2]. The evaluation index (E.I) as per an individual aspect was then calculated using the formula 1

$$E.I. = \frac{\text{question score} \times \text{weighting} \times \text{number of responses}}{\text{total number of questions}} \quad (1)$$

TABLE II
RESPONSE PER CATEGORY OF INDUSTRY

Category of industry	Number of questionnaires sent	Responses
Service industry	8	50
Power generation plants	5	80
Food manufacturing industries	35	79.1
Metal processing industries	5	80
Agro/Chemical industries	3	66.7
Motor vehicle assemblers	4	50
Transport industries	4	100
Maintenance industries	8	75
Construction industries	6	66.7
Total	78	64.1

Thereafter, a combined General Evaluation Index (G.E.I) was determined, as an arithmetic average of the three aspects evaluation indexes.

A. Technical Aspects

The above aspects were covered by questions 7 to 20 of the questionnaire. The cumulative responses totaled 699. A summary of the responses is presented on Table III.

TABLE III
RESPONSES ON TECHNICAL ASPECTS

QUESTION NUMBER	NUMBER OF RESPONSES PER MAINTENANCE LEVEL					No. of responses
	L1	L2	L3	L4	L5	
7	9	16	5	13	7	50
8	8	18	8	9	7	50
9	9	15	3	16	7	50
10	8	15	12	5	10	50
11	5	19	3	20	3	50
12	13	3	15	5	14	50
13	9	10	12	7	12	50
14	2	6	9	16	17	50
15	4	10	12	7	17	50
16	3	4	7	18	18	50
17	16	9	9	7	9	50
18	9	15	15	1	9	49
19	5	2	25	8	10	50
20	0	2	14	11	23	50
TOTAL	100	144	149	143	163	699

1) *The Technical Evaluation Index (T.E.I)*: The T.E.I was calculated using equation 1, and found to be **2.398**. The following rules can be defined with regard to determining the Level (L) for a given aspect:

$$\begin{aligned}
 \text{if } & 1 \leq EI \leq 2 \text{ then } L = 1 \\
 & 2 \leq EI \leq 3 \text{ then } L = 2 \\
 & 3 \leq EI \leq 4 \text{ then } L = 3 \\
 & 4 \leq EI \leq 5 \text{ then } L = 4 \\
 \text{otherwise } & L = 5
 \end{aligned} \quad (2)$$

Based on equation 2, the Level for technical aspects will be **2**.

According to Table I, the Technical aspects of maintenance practices are at the *managed level*.

Some deductions from the responses are as follows:

- (i) Maintenance and repair activities generally follow the OEM maintenance specifications, with very little innovation or modification.

- (ii) The re-ordering of spare parts is mainly done using the minimum stock levels based on experience, and very little automation to such a process is applied
- (iii) Job cards are used, and repairs are monitored based on time.
- (iv) There is a high dependency on highly specialized and experienced teams for any specialized maintenance and repair.
- (v) There is a very low utilization of CMMS/ERP among respondents. Also, modern diagnostic equipment are also not commonly used. Subsequently, failure records are poorly maintained, with a majority using manual record keeping.
- (vi) A majority of the companies have safety rules and regulations, which are also reviewed regularly.

B. Managerial Aspects

The above aspects were covered by questions 21 to 30 of the questionnaire. The cumulative responses totaled 437. A summary of the responses is presented on Table IV.

TABLE IV
RESPONSES ON MANAGERIAL ASPECTS

QUESTION NUMBER	NUMBER OF RESPONSES PER MAINTENANCE LEVEL					No. of responses
	L1	L2	L3	L4	L5	
21	3	3	25	11	7	49
22	2	8	2	16	21	49
23	0	14	5	15	14	48
24	12	1	5	18	13	49
25	10	9	8	10	12	49
27	10	8	10	2	19	49
28	1	7	6	19	15	48
29	5	5	1	6	32	49
30	5	5	5	16	16	47
TOTAL	48	60	67	113	149	437

1) *The Managerial Evaluation Index (M.E.I)*: The M.E.I was calculated using equation 1, and found to be **2.94**. Based on equation 2, the Level for technical aspects will be **2**. According to Table I, the managerial aspects of maintenance practices are at the *managed level*.

Some deductions from the responses are as follows:

- (i) Maintenance manuals a generally used, but some improvements have been made on them based on experience.
- (ii) Training of maintenance personnel s normally planned and done continuously on and off the shop floor. Where diagnostic equipment is used, training is properly structured.
- (iii) Technicians work with minimum supervision, and maintenance procedures are reviewed continuously
- (iv) Companies have safety and environmental policies which are reviewed regularly.
- (v) Most companies are certified both locally and internationally.

C. Human Aspects

These aspects were covered by questions 33 to 35 of the questionnaire. The cumulative responses totaled 140. A summary of the responses is presented on Table V.

TABLE V
RESPONSES ON HUMAN ASPECTS

QUESTION NUMBER	NUMBER OF RESPONSES PER MAINTENANCE LEVEL					No. of responses
	L 1	L 2	L 3	L 4	L 5	
33	1	4	27	10	5	47
34	2	11	15	10	9	47
35	7	2	16	0	21	46
TOTAL	10	17	58	20	35	140

1) *The Human Evaluation Index (H.E.I)*: The M.E.I was calculated using equation 1, and found to be **2.564**. Based on equation 2, the Level for technical aspects will be **2**. According to Table I, the managerial aspects of maintenance practices are at the *managed level*.

Some deductions from the responses are as follows:

- (i) Companies had a well defined organization structure
- (ii) Companies pay enough attention to detail when interviewing their technical personnel.
- (iii) Most of the companies do have safety and environmental officers.

D. The General Evaluation Index (G.E.I)

The GEI can now be determined from the average of the TEI, MEI and HEI. This was found to be **2.634**. Again, this value is classified under **L 2**. Processes are partially planned and performance analysis depends on the operator experience and competencies. Process management is weak due to deficiencies in the organizational or technical systems.

E. Index Analysis Per Category Of Industry

In order to gain a deeper understanding of the maintenance practices in different industrial sectors, an analysis is done per industrial category. Table VI presents this analysis.

TABLE VI
EVALUATION INDEX PER INDUSTRIAL CATEGORY

Category of industry	T.E.I.	M.E.I.	H.E.I	G.E.I.
Service industries	2.114	2.9	2.111	2.375
Power generation industries	2.586	3.9	2.9	3.129
Food processing industries	2.529	3.193	2.884	2.869
Metal processing industries	1.95	1.689	1.533	1.724
Agro/Chemical industries	2.957	3.989	1.633	2.86
Motor vehicle assembly	2.614	2.367	3.1	2.695
Transport	2.896	3.178	2.9	2.991
Maintenance industries	2.229	2.619	2.478	2.442
Construction industries	1.636	2.106	2.178	1.973
MEAN	2.3901	2.9400	2.4130	2.562
STANDARD DEVIATION	0.6442	0.8549	0.7409	0.6692
VARIANCE	0.4150	0.7308	0.5478	0.4478

From the tabulated data in Table VI, the construction industries are the lowest rated in terms of technical aspects. Practically, the construction sector uses a lot manual labor with very little mechanization. The highest rated is the Agro/chemical industries. The explanation may also be that due to the nature of the products, then, the use of sophisticated machines is not an option. As regards managerial aspects, the Agro/chemical industries are the highest rated with the metal processing

industries rated the lowest. Lastly, the motor vehicle sector becomes the best in terms of human aspects with the metal processing industries coming last in this category. This is also illustrated on Figure 1.

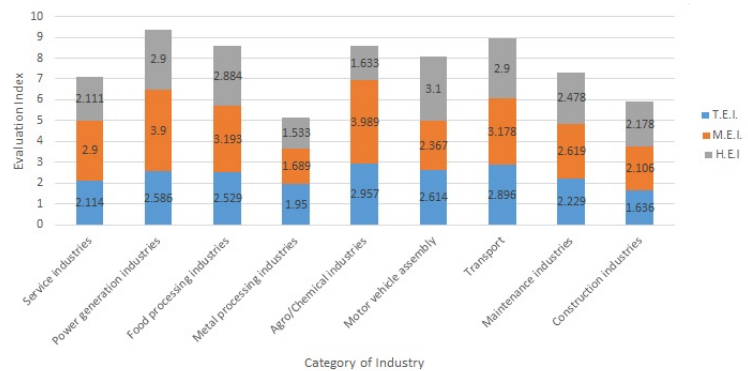


Fig. 1. Maintenance practice aspects of different categories

Where the General evaluation indexes are concerned, the power generation companies have the best general index. The Metal processing industries returned the poorest score, with a level 1

F. Other observations from the questionnaire

The questionnaire also provided an area for the assessment of the maintenance personnel in term of professional qualifications. This is necessary because the quality of work will be affected by the experience and qualifications of the workforce. Figure 3 illustrates the distribution in terms of numbers of the various cadre of professionals working in the maintenance department.

From the data provided, the ratio of engineers, technologist, engineering technician, and craft person/artisans is 1:1:3:6. According to Some [10], the ideal ratio for a developed country should be 1:2:4:16. He farther proposes that a more realistic ratio for a developing country is 1:3:12:60. Thus, industries should employ more craftsmen and artisan to improve the quality of work.

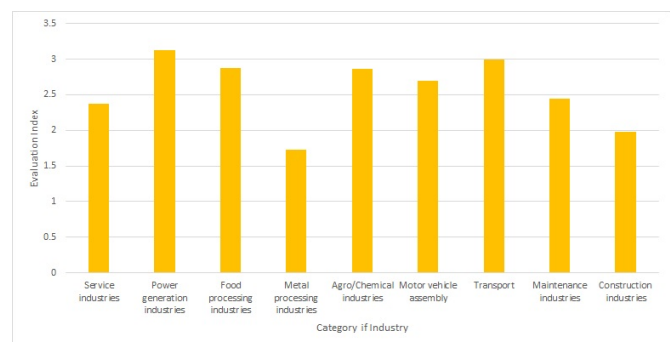


Fig. 2. The General Evaluation Index for different categories

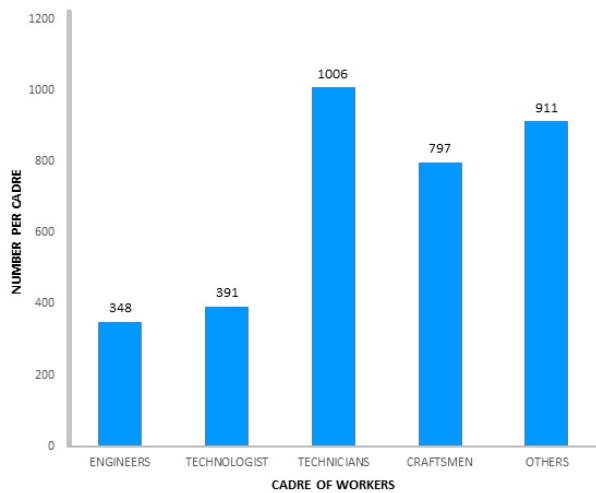


Fig. 3. Number of Maintenance personnel cadres

VI. CONCLUSIONS AND RECOMMENDATIONS

The research evaluated the maintenance practices applied in the Kenya by using the criteria referred to earlier. The G.E.I was found to be at level 2. The technical aspects (T.E.I.) ranked the lowest, with the managerial aspects (M.E.I.) ranking the best among the three aspects. The companies must aim at achieving the highest standard at level 5.

Based on the survey results, the following are recommendations that can be made to improve maintenance practices in Kenya:

- 1) Computer based Maintenance Management Systems (CMMS) and Enterprise Resource Programs (ERP) need to be introduced in many industries in the country. This should be complemented by additional training on the use of such systems on the shop floor in order to reap maximum benefits from them
- 2) There is a deficiency of craftsmen/women, and more need to be employed.
- 3) Diagnostic equipment should be introduced in the maintenance departments.
- 4) The methods of record keeping in the maintenance department should be improved.

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