Challenges Affecting the Reliability of Diesel Locomotives of Railway Corporation in Developing Country

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ABSTRACT

The study examined the concepts of reliability engineering and maintenance management as a challenge affecting the reliability of diesel locomotives of Railway Corporation in developing country and suggested ways to improve it. The questionnaires were administered and expert opinions within the Railway Corporation were congregated in the area of diesel locomotive maintenance for the primary data. This formed the primary data that was developed with the aim of identifying factors that are regarded as causes of diesel locomotives failure and contributing factors to reliability within the Corporation. Individuals were requested to participate by marking an appropriate answer that best suits them from the questionnaire without the influence of the study. The copies of questionnaire were collected and their results were analyzed. The findings revealed that some of the challenges facing the reliability of diesel locomotives in the country were caused by the maintenance crew and the government not showing keen interest in the aspect of funding. Besides, if all the necessary reliability and maintenance operations are being carried out, the reliability target expected to be accomplished by the developing Railway Corporation is 90% with a maximum failure rates of 7% and either reliability target or failure rate of 3%.

KEYWORDS: reliability, maintenance, time, quality, resource, failure

1. INTRODUCTION

Reliability is defined as the probability that a device will perform its required function under stated conditions for a specific period of time, and quality can be defined as how the recipient of the product

or service views the product [1, 2, 3]. Reliability engineering is closely associated with maintainability engineering and logistics engineering. Many problems from other fields can also be tackled using reliability engineering techniques [4]. The locomotive, electric or diesel electric, can be described as a highly complex machine with a multitude of different main and sub-systems that have to interact in such a way that it can perform in accordance with its design parameters. It can then fulfill its primary function of hauling predetermined calculated maximum loads at certain calculated running times. The main inputs for these loads and running times are the maximum power ratings (KW) and maximum tractive efforts (KN) for each class-series of locomotive, the number of locomotives that may be coupled in multiple unit (MU) operation, as well as the ruling gradient and any permanent speed restrictions on a particular section of railway line [5, 15]. The first railway lines began operating in most European countries around 1830 and most railway networks attained maximum density at the beginning of the 20th century. A factor contributing to the massive growth of railways was high speed, which enabled fast connections [6, 7]. [8, 9] states that reliability engineering can be seen as the way the product/service is assessed against a specification or set of attributes, and when the product or service is delivered to the customers. It is usually concerned with failures in the time domain that make reliability time dependent. Reliability management strategies monitor unscheduled discrepancies that can significantly affect product reliability, maintenance workload and costs. It monitors the individual component reliability, helping to transform unscheduled maintenance into scheduled maintenance, and triggers engineering changes based on reliability information. The functions performed by maintenance management constitute an optimization system of the greatest importance. The functions are cyclical in nature and are repeated over and over. They are never ending, each time improving the total performance of the product [10, 16, 17]. The process of continuous improvement is best described in Figure 2. It has four phases. The first phase is planning during which alternative maintenance strategies are evaluated in terms of the probability of success as well as costs and benefits. The next phase work is then scheduled, resources allocated and timing is finalized. After this,

the third phase work is executed and data is generated at the same time. In the last phase, collected data is analyzed for continuous improvement purposes.

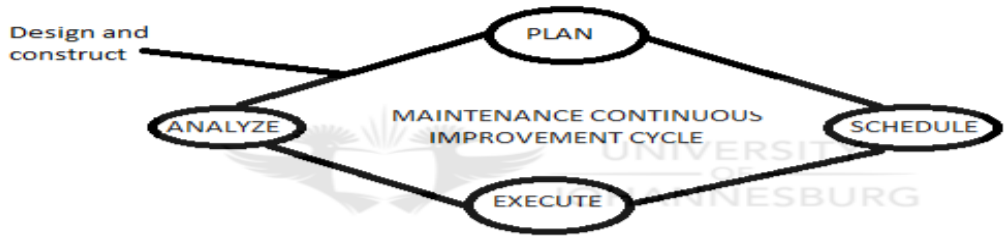

Figure 1: Continuous improvement cycle [11]

General Electric (GE) supplies equipment for railroad, marine, drilling, wind and mining industries. General electric (GE) provides freight and passenger locomotives, railway signaling and communications systems, information technology solutions, marine engines, motorized drive systems for mining trucks and drills, high-quality replacement parts and value added services [12, 13]. The figure below indicates how product reliability is being monitored in order to obtain the root causes of failures.

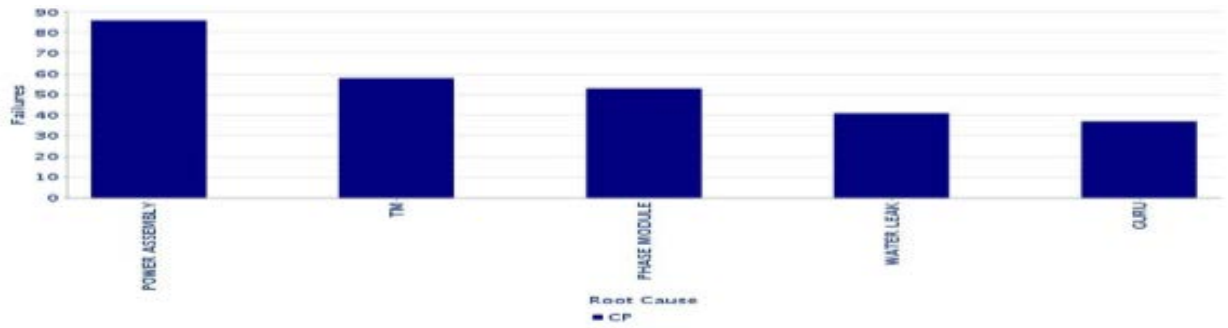

Figure 2: Diesel Locomotives failure rate [14]

The above figure indicates that failures have been categorized per part or unit, and it has been noted that the highest failures are due to power assemblies, traction motors, phase modules, water leak.

2. METHODOLOGY

The copies of questionnaire were administered and expert opinions within the Railway Corporation were sought to gather data / information related to diesel locomotive maintenance. The objective of the data / information is to identify factors that contribute to diesel locomotives failure and sustainability within the Corporation. The investigation carried out include: to identify the challenges affecting the reliability of diesel locomotives operated by the Railway Corporation from the management perspective and the possible strategic planning to improve the reliability of the diesel locomotives within the Corporation (Tables 1 – 15).

Table 1: Knowledge of the Research Topic

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	1	2.9	2.9	2.9
	Moderately agree	6	17.1	17.1	20
	Agree	14	40	40	60
	Strongly agree	14	40	40	100

Only 2.9% of the participants were not familiar with the research topic. Majority of the participants had a fairly good understanding of the subject matter, in which 40% of the participants agreed, and another 40% strongly agreed and the rest 17.1% moderately agreed that they know the subject matter fairly well. It shown that the accuracy of participants regarding the causes and effects of challenges as valid.

Table 2: Government role in the unreliability of diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	1	2.9	2.9	2.9
	Moderately agree	6	17.1	17.1	20
	Agree	16	45.7	45.7	65.7
	Strongly agree	12	34.3	34.3	100

A large percentage of the participants agreed that the government plays a vital role in the unreliability of diesel locomotives in the country, with 17.1% of the participants moderately agreed, 45.7% agreed and 34.3% strongly agreed to the subject and a few percent (2.9%) of the participants disagreed.

Table 3: Government participation in the maintenance of diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	4	11.4	11.4	11.4
	Disagree	5	14.3	14.3	25.7
	Moderately agree	9	25.8	25.8	51.5
	Agree	11	31.4	31.4	82.9
	Strongly agree	6	17.1	17.1	100

17.1% of the participants strongly agreed, 31.4% agreed and 25.8% moderately agreed that the government cannot handle the maintenance of diesel locomotives with 14.3% of the participants disagreed and 11.4% strongly disagree.

Table 4: Effectiveness of maintenance in the organization/department

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	1	2.9	2.9	2.9
	Disagree	7	20	20	22.9
	Moderately agree	11	31.4	31.4	54.3
	Agree	9	25.7	25.7	80
	Strongly agree	7	20	20	100

A high moderate percentage (31.4%) was recorded on the effectiveness of maintenance strategies on rail Engineering Corporation, followed by 25.7% of participants that agreed and 20% strongly agreed. The literature further indicated that rail industries in Developing country are using maintenance management systems to achieve reliable products. However, the total percentage of 20% and 2.9% of

participants that felt that their current maintenance is not effective is still too high, and improvements are still required in this regard.

Table 5: Maintenance of locomotives and number of workers in the organization/department

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	7	20	20	20
	Disagree	10	28.6	28.6	48.6
	Moderately agree	13	37.1	37.1	85.7
	Agree	5	14.3	14.3	100
	Strongly agree	0	0	0	100

A high moderate percentage (37.1%) was recorded on Maintenance of locomotives depends on the number of workers in an organization/department, followed by 14.3% of the participants agreed. However, the total percentage of 20% and 28.6% of participants that felt that the maintenance of locomotives does not depends on the number of workers in an organization/department.

Table 6: Failures in diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	5	14.3	14.3	14.3
	Disagree	5	14.3	14.3	28.6
	Moderately agree	13	37.1	37.1	65.7
	Agree	10	28.6	28.6	94.3
	Strongly agree	2	5.7	5.7	100

A high moderate percentage (37.1%) of the participants agreed that failures in diesel locomotives can be totally eradicated, with 28.6% agreed and 5.7% strongly agreed. However, 14.3% and 14.3% of the participants felt that failures in diesel locomotives cannot be totally eradicated.

Table 7: Proper maintenance management of diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	1	2.9	2.9	2.9
	Moderately agree	0	0	0	2.9
	Agree	8	22.8	22.8	25.7
	Strongly agree	26	74.3	74.3	100

A high percentage (74.3%) of the participants strongly agreed that proper maintenance management can improve the reliability of locomotives in Developing country, and 22.8% agreed. However, a small percentage (2.9%) of the participants disagreed with this.

Table 8: Reliability of diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	1	2.9	2.9	2.9
	Disagree	2	5.7	5.7	8.6
	Moderately agree	6	17.1	17.1	25.7
	Agree	15	42.9	42.9	68.6
	Strongly agree	11	31.4	31.4	100

It is noted that majority (42.9%) of the participants agree, 31.4% strongly agreed and 17.1% moderately agreed that the maintenance management strategies that an organization adopts plays a role in achieving reliability targets. What this means is that one of the key requirements for achieving reliable products are the right maintenance strategies.

Table 9: Preventative maintenance on diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	0	0	0	0
	Moderately agree	0	0	0	0
	Agree	9	25.7	25.7	25.7
	Strongly agree	26	74.3	74.3	100

It is noted that all the participants agreed that more preventative maintenance must be carried out on diesel locomotives from time-to-time, with 74.3% strongly agreed and 25.7% agreed. This means that more preventative maintenance really needs to be carried out on diesel locomotives from time-to-time.

Table 10: Supervision of diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	1	2.9	2.9	2.9
	Moderately agree	2	5.7	5.7	8.6
	Agree	14	40	40	48.6

	Strongly agree	18	51.4	51.4	100

A high percentage (51.4%) of the participants strongly agreed that proper maintenance & supervision by maintenance managers can increase the availability of diesel locomotives in Developing country, with 40% agreed and 5.7% moderately agreed. However, a small percentage (2.9%) of the participants disagreed with this. Thus, as a result of this, maintenance managers should ensure more proper maintenance and supervision of diesel locomotives.

Table 11: The application specialist techniques in diesel locomotives

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	0	0	0	0
	Moderately agree	2	5.7	5.7	5.7
	Agree	16	45.7	45.7	51.4
	Strongly agree	17	48.6	48.6	100

A high percentage (48.6%) of the participants strongly agreed that the application of engineering knowledge and specialist techniques can prevent failures and reduce unreliability in diesel locomotives, with 45.7%% agreed and 5.7% moderately agreed. Thus, as a result of this, more application of specialist techniques should be employed in the Railway Corporation will prevent failures and reduce unreliability in diesel locomotives.

Table 12: Application of maintenance strategies in the Railway Corporation

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Strongly disagree	0	0	0	0
	Disagree	0	0	0	0
	Moderately agree	0	0	0	0
	Agree	18	51.4	51.4	51.4
	Strongly agree	17	48.6	48.6	100

A high percentage (51.4%) of participants agreed that new maintenance strategies, tools, equipment and plans should be employed in the Railway Corporation, and 48.6% of participants strongly agreed to it. This illustrates that application of maintenance strategies should be employed in the Corporation in order to reduce the challenges facing the reliability of diesel locomotives.

3. ANALYSIS AND EVALUATION

The responses were evaluated in using disentative statistics based on percentage; P (%),

$$P\ (\%) = {}^{n}\!/_{N} * 100\%$$

Where; n- number of frequency

N- Total number of frequency

Table 17: Total Analysis of responses

	X	**TOTAL NUMBER OF OCCURRENCE (f)**	**PRODUCT (xf)**
Strongly disagree	1	20	20
Disagree	2	38	76
Moderately agree	3	96	288
Agree	4	239	956
Strongly agree	5	306	1530

		Σf = 699	Σxf = 2870

$$Mean\ (\bar{x}) = \frac{\sum fx}{\sum f}$$

$$Mean\ (\bar{x}) = \frac{2870}{699} = 4.106$$

$$Standard\ deviation\ \sigma = \sqrt{\frac{\sum x^2 f}{\sum f} - (x^2)}$$

$$Standard\ deviation\ \sigma = \sqrt{\frac{25\ x\ 699}{699} - (4.106^2)}$$

$$Standard\ deviation\ \sigma = \sqrt{\frac{17475}{699} - (16.859)}$$

$$Standard\ deviation\ \sigma = \sqrt{25 - (16.859)}$$

$$Standard\ deviation\ \sigma = \sqrt{8.141}$$

$$Standard\ deviation\ \sigma = 2.853$$

$$variance = \sigma^2$$

$$variance = 2.853^2$$

$$variance = 8.141$$

The overall response frequency of the participants is being represented in the chart below, with strongly disagree having 20, disagree having 38, moderately agree having 96, agree having 239 and strongly agree having 306.

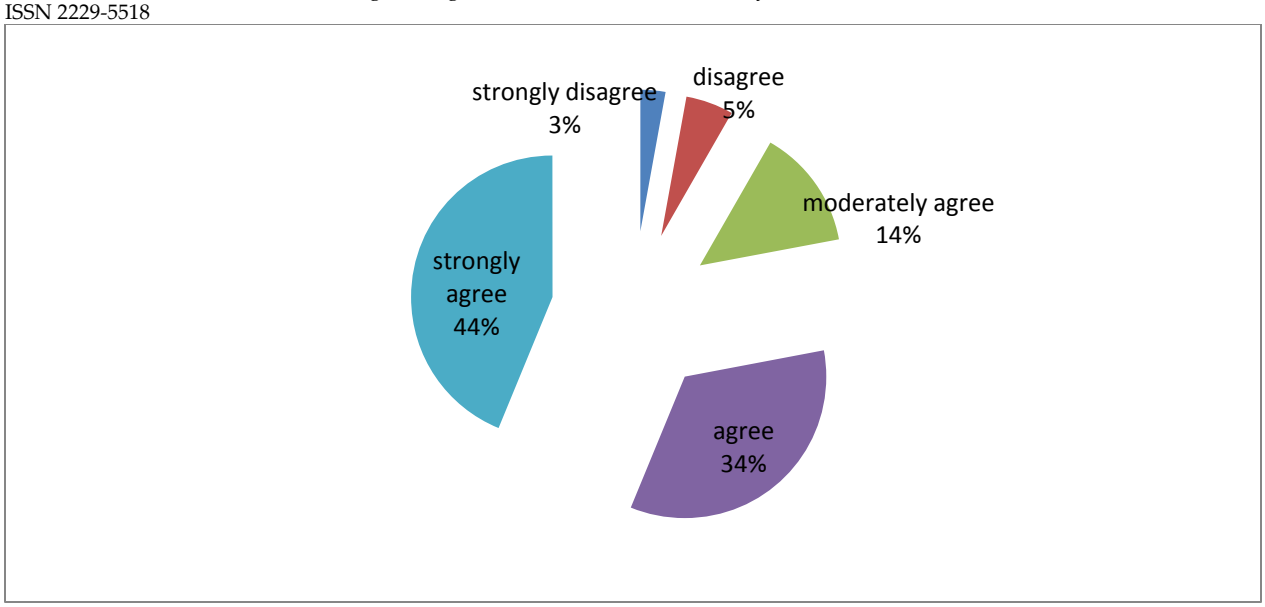

Figure 1: Overall frequency of the findings.

Expected Reliability Target

If all the necessary reliability and maintenance operations are being carried out, the reliability target expected to be accomplished by the Developing country Railway Corporation is 90% with a maximum failure rates of 7% and a probability or undecided rate (i.e. either reliability target or failure rate) of 3%.

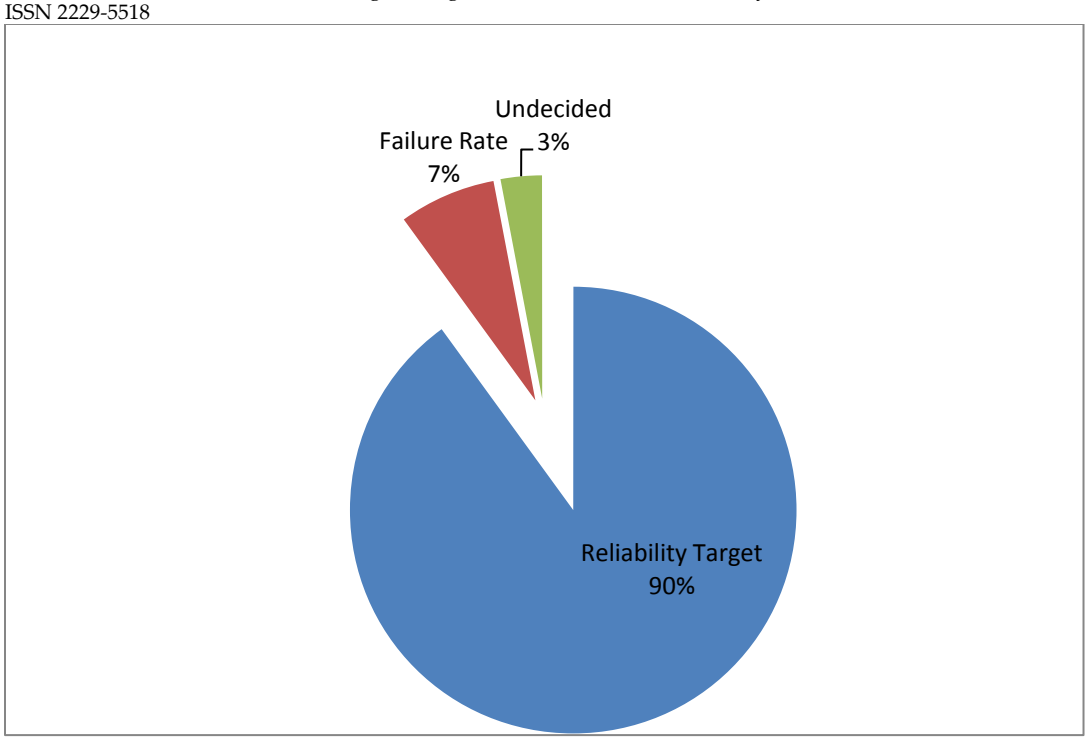

Figure 2: Expected reliability target

CONCLUSIONS

The challenges affecting the reliability of diesel locomotives of Railway Corporation in developing country can precisely be improved by implementation of maintenance strategies, improvement on the availability of spare parts and creating more training among other things in the organization. Besides, the following area needs to be improved within the organization to accomplish the reliability targets:

- Government should make policies that will favor handling of the maintenance of diesel locomotives in the country.
- The supply of labor, spare parts, tools and equipment in the Developing country Railway Corporation which thus contributing to the unavailability and unreliability of diesel locomotives should be improved.
- The new maintenance strategies should be encouraged in the Developing country Railway Corporation.

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