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Maintenance Function for Manufacturing Excellence Program: a case study of the Sri Lankan manufacturing industry

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Abstract : ***The Manufacturing Excellence program is a novel productivity improvement strategy implemented in the Sri Lankan manufacturing industry. This research was to identify its maintenance function composed of related maintenance practices adopted by the selected company. Data were collected through a self-structured questionnaire. By using multivariate analysis, the pertinent maintenance function was determined.***

Keywords: Manufacturing Excellence Program, Productivity Improvement, Maintenance Function, Maintenance Practices

I. Introduction

During the last two decades, productivity researches and applications have not been given adequate importance when trying to attain excellence in the management of manufacturing enterprises (Murugesh et al. 1997, 310-320). The old models of productivity improvement techniques do not perform well further due technological advancement and never ending customer demand. Today, the manufacturing industry of Sri Lanka faces the same scenario so that the industry needs to adopt new strategies. The Manufacturing Excellence program is one such a new productivity improvement strategy.

The Manufacturing Excellence program acts as an integrated technique of lean manufacturing and Six Sigma. This concept was reinforced during the recent economic slowdown to assure the sustenance of the manufacturing industry. Therefore this strategy can withstand for any situation of whichever the competition exists in the industry.The Manufacturing Excellence program is a combination of disciplined process control, process capability and equipment reliability, 100% on time delivery to customer and a priority focus on safety.

The Manufacturing Excellence program can improve performance of any manufacturing system through a good maintenance management. Recent literature has addressed maintenance managers emphasizing the necessity of a good track on maintenance process and its results to ensure the desired productivity improvement (Muchiri et al. 2010). Further he has said that the success of the maintenance function depends on the maintenance management. Once the maintenance function is identified, it shows the effective maintenance practices that should be implemented in the work floor so that the company can gain maximum use and longer existence of the strategy.

But when we referred to the current practice of implementing this strategy, we could not find such a maintenance function identified by the company. Also the previously implemented productivity improvement strategies had failed due to this weakness of the company. Therefore it is very important to understand possible pitfalls in earlier implementations of productivity improvement strategies and to identify a proper maintenance function for Manufacturing Excellence program to assure its success and the sustenance.Jabar (2003) has explained that another perspective of identifying a maintenance function is not only to maintain but also to enhance the process or the plant operation system as a turnaround planning. Also the proper maintenance function of this strategy can guide workers to improve their performance through identified effective practices and hence to minimize excessive work load. Therefore we have reviewed added advantages as well.

This research attempts to investigate such a proper maintenance function for the Manufacturing Excellence program by identifying related effective maintenance practices. This is the primary objective of this study.Since the Manufacturing Excellence program is new to the Sri Lankan manufacturing industry, present researchers and practitioners have focused their studies related to this area. Therefore, this study supports to fill the empirical gap between the Manufacturing Excellence program and its maintenance.

II. Material and Methodology

Research Design:

We selected only one company in the Sri Lankan manufacturing industry where the Manufacturing Excellence program was implemented. The company was awarded for the excellent performance in manufacturing. Therefore we designed the research as a case study based on this company.

Research Model:

Maintenance function describes the relationship between the selected maintenance practices of Manufacturing Excellence program and its performance. We found different indicatorsfrom substantive literature and used them to measure the performance and the relevantmaintenance practices.

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The dependent variable was the performance measure which has been defined by Tangen (2003); as the process of quantifying the efficiency and effectiveness of the practices. Literature suggested the indicators to measure the dependent variable to be level of decision making, utility of machines and materials, flexibility, time loss and quality of the product (Slack 2001).

Further reviewing the recent literature, we found six maintenance practices as the independent variables for this research model. They were:

1. Communication and coordination
2. Leadership
3. Extent of training
4. Team working
5. Employee involvement
6. Equipment failure responsiveness

Past experience of the company showed that these maintenance practices created impact on the performance. Also different authors studied and showed evidences for this impact (Clampitt and Downs 1993, Loke 2001, Schronberger 1986, Miller and Schenk 1997, Jabar 2003, Barret and Connel 2001). Based on these findings, we formulated following hypotheses.

H_i: There is a significant relationship between the performance of Manufacturing Excellence program and i^{th} maintenance practice.

Where i= 1, 2, …., 6

Sampling:

The survey was done among 80 top level, middle level and low level managers of the selected company for the sample. But we collected responses only from 50 of them assuming that they were much educated enough to respond for the research.

Research Instrumentation:

The primary data were collected by using a self-structured questionnaire. The first part was designed to get a general idea of the respondents and the second part was to measure the performance of the Manufacturing Excellence program and selected maintenance practices. We presented all the measures instatements so that the responses were obtained in a 5-point Likert scale in which values were assigned from 1 to 5 respectively from “strongly disagree” to “strongly agree”.

Data Processing and Analysis:

The data were analyzed using Minitab and SPSS soft wares to derive conclusions.

We performed normality and reliability tests for the data with suitable hypotheses. Reliability test with the value of Cronbach’s alpha explained the internal consistency of the data.

Then principal component analysis was used to find the components of maintenance function of the Manufacturing Excellence program. The Eigen correlation matrix clearly selected the number of significant vectors and hence the total dimensions were reduced.

We performed Factor analysis to select the corresponding maintenance practices for each principal component identified. For further clarity of factor extraction, we used factor analysis with Varimax rotation. Therefore the results supported to determine the proper maintenance function for the Manufacturing Excellence program.

III. Results and Tables

Sample Representation:

Sample representation for responding to the questionnaire was as depicted in Figure 01.

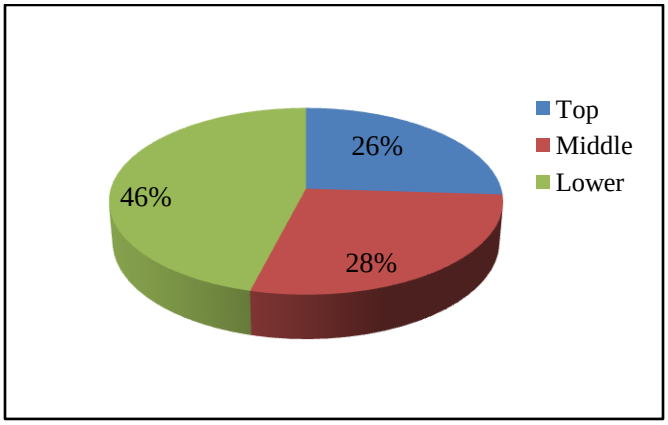

Figure 01: Participation of Different Levels of Hierarchy (in Percentage)

Figure 01 represented the majority as low level managers and others to be nearly equal. Low level managers are the people who had closer contacts with the workers so their experience was very important. Therefore the data were justifiable enough to derive conclusions.

Reliability and Normality of Data:

Nunnally (1978) recommended a minimum level of 0.7 for Cronbach’s coefficient alpha to make the set of data to be reliable enough. We got 0.733 for that value suggesting our data set was reliable.

Then we hypothetically tested the data to be normal with Anderson-Darling test. The results were shown in Table 01.

Table 01: Normality Test Results with Anderson-Darling Test

Component	AD Value	p-value

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Performance of MEP	1.140	0.005
Communication and Coordination	1.533	<0.005
Leadership	1.028	0.01
Extent of Training	0. 908	0.019
Team Working	1.544	<0.005
Employee Involvement	1.6	<0.005
Equipment Failure Responsiveness	0.935	0.016

Since all p-values were less than the significant level of 0.025 (with the confidence limit of 5%), we concluded that the data were normally distributed.

Identifying Components of the Maintenance Function:

Principal component analysis was then performed to identify the number of significant components in the maintenance function. Eigen values selected four significant factors as depicted in Figure 02.

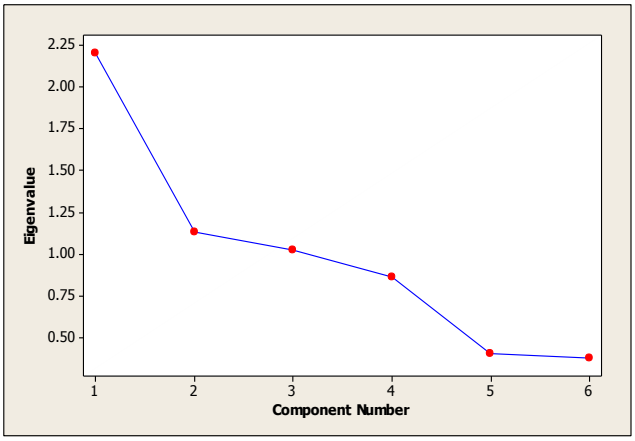

Figure 02: The Scree Diagram for Six Independent Variables

We proved this number of dimensions by using the Eigen values which were closer to 1 in Eigen correlation matrix as in Table 02 below.

Table 02: Eigen Correlation Matrix

Eigenvalue	2.20	1.13	1.02	0.86	0.40	0.38
Proportion	0.37	0.19	0.17	0.14	0.07	0.06
Cumulative	0.37	0.56	0.73	0.87	0.94	1.00

This reduced dimensionality was further used to perform Factor analysis so that the maintenance function was identified. The values gained for rotated factor loadings were as in Table 03.

Table 03: Factor Loadings with Varimax Rotation

Variable	Factor				Communality
	1	2	3	4	
Leadership	0.04	0.07	0.99	-0.02	0.98
Communication & Coordination	0.10	-0.97	-0.07	-0.05	0.95
Team Working	0.00	0.04	-0.02	1.00	0.99
Extent of Training	0.87	0.09	-0.15	-0.09	0.80
Employee Involvement	0.84	-0.07	0.19	0.06	0.75
Equipment Failure Responsiveness	0.77	-0.38	0.03	0.04	0.74
Variance	2.08	1.10	1.03	1.01	5.22
% Variance	0.35	0.18	0.17	0.17	0.87

Table 03 identified four main factors to be functions of following maintenance practices.

Factor 1 = f (Leadership)
Factor 2 = f (Communication & Coordination)
Factor 3 = f (Extent of Training, Employee Involvement, Equipment Failure Responsiveness)
Factor 4 = f (Team Working)

Since all three components explained the resource flexibility, we presented factor 3 as a function of the single component called as "flexibility of resources".Therefore we found the maintenance function of Manufacturing Excellence program to be;

Performance of Manufacturing Excellence program

= f (Leadership, Communication & Coordination, Flexibility of Resources, Team Working)

IV. Conclusion

We identified the maintenance function for the Manufacturing Excellence program, currently practiced by the Sri Lankan manufacturing industry. It was composed of four maintenance practices ensuring the maximum use and the sustenance of this strategy by well implementing them. This research also provided future insights to investigate and model this relationship.

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