NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 7, ISSUE 4, Apr.-2020

KEY SUCCESS VARIABLES INFULENCING TOTAL PRODUCTIVE MAINTENANCE PERFORMANCE INDICATOR: A CASE STUDY IN WATER BOTTLING FACTOR, ETHIOPIA, EAST AFRICA

TEKALIGN LEMMA WOLDESILASSIE,
Department of Industrial Engineering, Institute of Technology, Ambo University, Ambo, Ethiopia, Africa,
Email: tekalignlemma507@gmail.com

VENKATA MALLIKHAJUNA KISHAN IVATURY
Department of Industrial Engineering, Institute of Technology, Ambo University, Ambo, Ethiopia, Africa,
Email: kishan.ivatury@gmail.com

ABSTRACT
The aim of this research paper is to detect key success variables influencing TPM performance indicators in XYZ Bottling factory in Ethiopia. The six independent variables management, employees, organizational, personal, material and equipment factors and the TPM performance indicators: cost, quality, delivery, productivity, moral and safety were identified by the researchers. And theoretical model is established to develop and test six hypotheses. Data's were collected by self-administered structured questionnaire from general managers, production managers, maintenance managers, supervisors and lower level workers of the case factory. For the purpose of data collection the researchers were distributed 141 questionnaires and 134 papers were returned back with a response percentage of 95.03%.The questionnaires were loaded in SPSS v20 and the results were analyzed by mean, standard deviation, Pearson correlation, ANOVA and regression analysis. The finding of this research paper revealed that Employees, Organizational, Personal, and Equipment factors accounted 65.9% for improving TPM performance indicators in the factory. These four variables have positive effect and statistically significant determinants for improving total productive maintenance success factors of the factory except management and material factors.

KEY WORDS: Dependent variables, Total productive maintenance, performance indicator, Pearson correlation and ANOVA.

INTRODUCTION

According to [1] Maintenance is grouping of technical, personal and supervision assistance to keep an item or system in its required function In other word it is related to keeping a systems facilities in functioning order. The primary maintenance target is ensuring the production system and machineries functional. Maintenance should try to provide the right parameter like Cost, Reliability, Availability, Maintainability and Productivity advanced production systems. It has a great impact on companies' competency to optimize its production system in order to meet its long term objective. It is an effort taken to keep the condition and working effectiveness of the device always like the condition, when it is still new.

In today's competitive market the manufacturing activities, in which in which due attention is not given leads to the system producing defective products which leads the firm for profitability loss [2].

A good maintenance program requires companywide participation and support by everyone ranging starting from company manager to low level workers. TPM is an innovative approach to maintenance activities that improve effectiveness of the device, reduce failure and involve all workers in the factory by introducing autonomous maintenance [3]. It is a special Japanese thinking which has been developed based on the Productive Maintenance idea and practice. This idea was introduced by MS Nippon Denso Co. Ltd. of Japan, a supplier of MS Toyota Motor Company, Japan in the year 1971.

The idea of Total productive maintenance is targeted to improve competitiveness of the organizations and it includes a powerful structured approach to change the mindset of employees thus making an observable change in the work culture of an organization. TPM is used to increase the electiveness of the production system by engaging all levels of the factory to reduce mistake and accidents.

According to [4] TPM is a world class manufacturing initiative that seeks to optimize the effectiveness of manufacturing equipment, it strive for participating labors from all departments.

According the study of [4] and [5] the execution of TPM approach by a careful consideration on the influential variables, idea has proven to enhance the maintenance efficiency and have an important role towards profitability of the organization through an increased in the production efficiency, by improving quality of the product, by reducing the cost of operations, by delivering the product to the market on time, by confirming safety of the work place, ensured safety of the workplace and by improved morale of the employees. Particularly, the emphasis on the idea of influential TPM indicator variables would decrease the learning curve in implementing the TPM procedure [6] [7]; [5]. According to Japan Institute of Plant Maintenance (JIPM) TPM include 8 implementation elements..

According to the study of [8] TPM implementation programs revealed significant achievements of manufacturing performance and leading to improved core competitiveness of the organizations. TPM has tangible and measurable effects on production quality and profits. It improve quality, decrease cost, improve equipment uptime, cutting inventory, cutting delivery time, practicing employee participation and experiencing a cleaner working environment. Similarly, [9] confirmed that the actual targets of TPM are fixed more concretely in terms of productivity, quality, cost, delivery, safety and morale. According to [10] Investing for maintenance is the basic functions of a firm, returns improved quality, safety, dependability, flexibility and lead times. According to the research of [11] Maintenance is strategic tool used to increase competitiveness. The aim of TPM program is used to improve the overall equipment effectiveness, increase labor productivity, make equipment failure zero, reduce defects and industrial accident zero [12].

According to different studies TPM performance indicators namely productivity, quality, cost, delivery, safety and moral are affected by different input variables for example, according to the study of [13] TPM programs are affected by top management and employee's involvement and commitment. Similarly according to [12] it depends on effective leadership, commitment and demonstrating reliability Excellency from top managements and low level employees in the organization. Organizations are unsuccessful in TPM execution due to behavioral, cultural and bureaucratic challenges (personal factors) and especially due to their inflexible attitude to change and to accept the change [20]

According to [7] and [12] the achievement of TPM is closely connected to equipment utilization and employee management. For the achievement of TPM execution commitment of the manager and low level employees play a vital role. An effective performance of TPM is depends on empowerment and encouragement of personnel from all areas of the organization [13], [14].

For the achievement of TPM the goal of employees and firm must be stated in numbers and figures [7], [19]. According to [15] Management has an important function for determining the TPM policy, objectives and strategy to bring it with the firm business goals [15]. To carry out TPM in industry effectively it needs time, money, labor, resources (material factors) and commitment from all the stake holders. The organization as a whole should be willing to change its outlook and adapt itself to the new practices and cultural changes that are required for the successful performance of TPM.

According to [17] the performance of TPM is affected by political, financial, departmental and inter-occupational obstacle. According to [16] have expressed their point of view that insufficient resources, resistance to change, incomplete understanding of the methodology, treating TPM as additional burden and inability to invoke cultural change are some of the difficulties faced for the effectiveness of TPM performance. Lack of management support, lack of training and failure to allow sufficient time for evolution are some of the obstacles for the performance of TPM as mentioned by [18]. For the aim of this research paper the researcher classified the input factors that affect TPM performance indicators in to six factors:- personal factor, employees factor, management factor, material factor, organizational factor and equipment factors.

The above literature review, even if, TPM are implemented in the organization, there are different input factors that affect the performance or success of TPM performance indicators. This research paper identified the performance indicator of TPM as productivity, cost, quality, delivery and moral. The researcher classified factors that affecting TPM performance indicators' (productivity, cost, quality, delivery, safety and moral) in to 6 input variables (independent variables): management factors, employee's factor, organizational factor, personal factor, material factor, and personal factor and equipment factors.

THEORETICAL MODEL WORK AND HYPHOTHESIS TESTING

THEORETICAL MODEL

Depending on the literature reviews, a new theoretical model was developed for identifying and evaluating determinant factors influencing TPM performance indicators. The theoretical model is illustrated in figure 1. It considers(reflects) the relationships between six independent variables:- Personal factors, Employees factor, Management factors, Material factors, Organizational factors and Equipment factors with TPM performance factors (dependent variables).

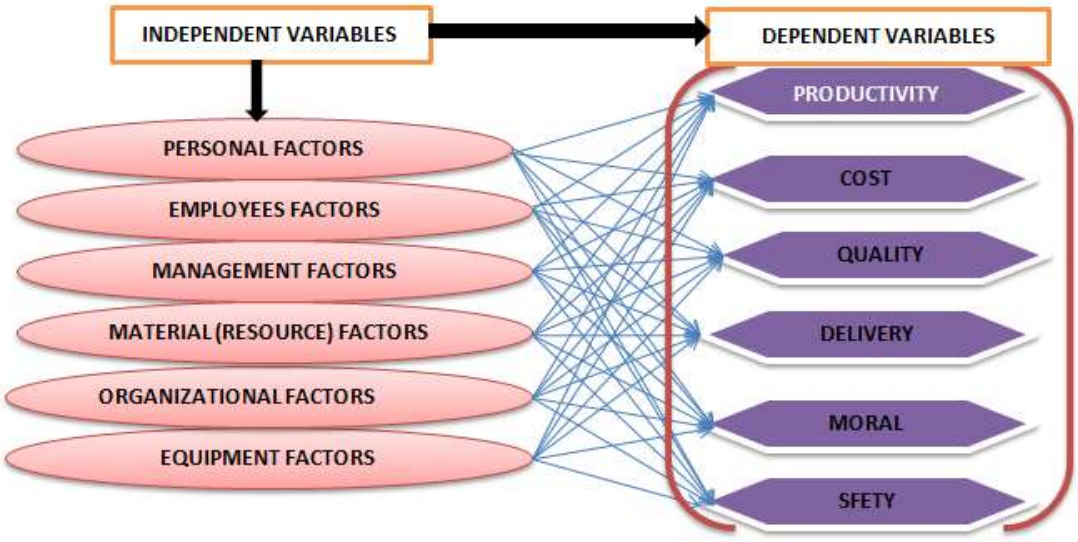

Figure1 Theoretical model developed by the researchers

RESEARCH HYPOTHESIS

H1:-Personal factor is positively affects TPM performance indicators.
H2:- Employees' factor is positively affects TPM performance indicators.
H3:- Management factor is positively affects TPM performance indicators.
H4:- Material factor is positively affects TPM performance indicators.
H5:- Organizational factor is positively affects TPM performance indicators.
H6:- Equipment factor is positively affects TPM performance indicators.

RESEARCH METHODOLOGY

3.1 Research Design

This research was conducted at XYZ bottling factory which is found in Oromia special Zone Burayu town in the Northern direction of Addis Ababa, Ethiopia and the values chosen are meant for justifying the research initiatives only. The main products of this factory are drinking water, soft drink and nonalcoholic beverage.

3.2 Data collection instrument

The survey questionnaire was used as the main primary data gathering instrument in this research study. The questionnaire used a 5 point Likert scale sorted starting from 1 = strongly disagree to 5 = strongly agree having 30 items under six independent variables and 40 items under six dependent variables. Data was analyzed using mean, standard deviation, correlation and regression analysis methods. An interval class was developed for descriptive analysis as shown in Table 1.

Table- 1: Criteria to scale mean score (Saunders Et Al. 2009)

NO.	DEGREE	INTERVAL
1	NOT TRUE AT ALL	1.00 < mean < 1.80
2	TRUE TO MINIMAL DEGREE	1.81< mean < 2.60
3	TRUE TO A MODERATE DEGREE	2.61< mean < 3.40
4	TRUE TO A HIGH DEGREE	3.41< mean < 4.20
5	ABSOLUTELY TRUE	4.21< mean < 5.00

Pearson‟s Correlation analysis was used to check whether any relationship exists between the dependent (total productive maintenance performance factors) and independent variables (Personal factors, Employees factor, Management factors, Material factors, Organizational factors and Equipment factors). In interpreting the relationships between variables, the guidelines suggested by [20] were followed.

Table 2 correlation strength interval

NO.	INTERVAL	STRENGTH
1	< 0.1	VERY WEAK
2	0.1 < r < 0.3	WEAK
3	0.3 < r < 0.5	MODERATE
4	0.5 < r < 1	STRONG

3.3 **Target Population, Sample Size, and Sampling Procedure**

Data's were collected from XYZ bottling factory which was found in Burayu, Ethiopia, Africa. The factory has 453 permanent workers. The educational level of the employees are MSC/MBA, BSC/BA, and College Diploma,.

The questionnaires were distributed for the Employees which have 3 years and above working experience.

The total numbers of questionnaires distributed are calculated as per Equation (1) (Yamane, 1967).

$$n= N/ [1+N (e)^2]$$

$$n= 453/ [1+453(0.07)^2] =140.6= 141$$

Where n is sample size required, N = 453 is number of permanent employees, e is allowable error in %, e=0.07. From the total target population of 453 employees, 141(30.9%) respondents were selected randomly.

I. DATA ANALYSIS

RELABILITY AND DESCRIPTIVE ANALYSIS

The reliability of the data is checked using SPSS 20.Cronbach's alpha is calculated to determine the reliability of the data obtained from the questionnaires. Table 2 shows the reliability and descriptive result of the construct. Alpha value which has a bad loading ($\alpha < 0.6$) was deleted. After deleting some variables the Cronbach's Alpha value is increases (0.675 – 0.934) which is considered as more than satisfactory

Table 3 Reliability and descriptive analysis result

DESCRIPTION Of variables	#ITEM *	MEAN (1-5 SCALE)	STD. DEVIATION	α-values	
				BEFORE ITEM IS DELETED	AFTER ITEM IS DELETED
Input variables					
Management factors	5(10)	3.3313	1.18133	0.776	0.934
Employees factor	4(7)	3.3694	.99374	0.698	0.787
Organizational factors	9(12)	3.6932	.83239	0.903	0.920
Personal factors	4(5)	3.1604	.81250	0.645	0.675
Material factors	3(6)	3.2861	.88348	0.557	0.898
Equipment factors	5(7)	3.9358	.82466	0.704	0.791
TPM Performance indicators					
Productivity	5(8)	3.2896	.73067	0.644	0.718
Qualityα	9(10)	3.5547	.69027	0.820	0.843
Cost	3(7)	3.2239	.95406	0.544	0.716
Delivery	6(8)	3.1082	.81579	0.614	0.736
Safety	6(8)	3.3197	.82135	0.726	0.789
Moral	11(12)	3.7849	.76885	0.919	0.928

#Item* 5(10) 5= item after deleting, (10) = item before deleting

The result in Table3 showed that the larger mean value revealed that the presence of high degree of lack of equipment due to inefficient utilization of machinery, ineffective utilization of production time (working hrs.) (Mean=3.935, standard deviation= 0.824)

The second highest is organizational factor that indicates the factory has high degree of poor practice of this factors due to absence of ongoing training, lack of team work, insufficient allocation of time for system evaluation, lack of TPM measurement system, lack of information system about TPM, bad working environment and lack of rewarding system, barriers between department (mean = 3.693, standard deviation =0.832). The result in Table 3 indicates that moderate degree of poor practice in employees (Mean=3.369, standard deviation= 0.990), management (Mean=3.331, standard deviation= 0.1.181), material (Mean=3.286, standard deviation= 0.0.883) and personal factors (Mean=3.160, standard deviation= 0.812) due to (lack of setting clear goal, lack of employees encouragement and empowerment, lack of shop floor workers competency),(lack of higher managers support and commitment, lack of understanding about TPM approach, lack of initiatives from top management towards maintenance), (lack of skilled manpower, lack of the required number of manpower, lack of equipment), (cultural difference between workers, personal behaviors, bureaucratic challenges, inflexible attitude to change) respectively.

CORROLATION ANALYSIS AND HYPOTHESIS TESTING

In this analysis part the linear relationship between independent variables i.e. Personal factors (PRF), Employees factor (EF), Management factors (MF), Material factors (MAF), Organizational factors (ORF) and Equipment factors (EQF) and dependent variables (TPM Performance Factors) and hypotheses were tested based upon p value

The result in Table 4 infer that TPM performance indicator factors has strong positive and important relationship with organizational factors(r= 0.752, p=0.000), employees factor(r= 0.572, p=0.000), personal factors (r= 0.699, p=0.000), and equipment factors(r= 0.590, p=0.000). In addition the study confirmed that TPM performance indicator factors has weak and non-significant correlation with management factors(r= 0.152, p=0.072) and material factors(r=0.090, p= 0.303). The result of this analysis part supported to the hypotheses H_1, H_2, H_5 and H_6, since the significance value was less than 0.01. But the result did not support H_3 and H_4 Since their significance value was greater than 0.01

Table 4 Correlation coefficients of the constructs (N=134)

	Management Factors	Employees Factor	Organizational Factors	Personal Factors	Material Factors	Equipment Factors	TPM Performance Factors
Management factors	1						
Employees factor	0.377**(.000)	1					
Organizational factors	0.183*(.034)	0.477**(.000)	1				
Personal factors	0.368**(.000)	0.771**(.000)	0.638**(.000)	1			
Material factors	0.873**(.000)	0.368**(.000)	0.089(.308)	0.300**(.000)	1		
Equipment factors	0.230**(.008)	0.400**(.000)	0.734**(.000)	0.420**(.000)	0.189*(.029)	1	
TPM performance factors	0.156(.072)	0.572**(.000)	0.756**(.000)	0.699**(.000)	0.090(.303)	0.590**(.000)	1

Where, 0.377** (0.000), 0.377**=r, 0.000=p, ** r is significant at the 0.01 level (2-tailed), *r is significant at the 0.05 level (2-tailed),

REGRESSION ANALYSIS

Analysis of regression was conducted to examine the fundamental relationships between TPM performance indicator factors and independent variables (Personal factors, Employees factor, Management factors, Material factors, Organizational factors and Equipment factors).The regression result explores (investigate) the necessary indicators of TPM performance indicator factors using the variables identified in the model.

These regression coefficients are used to construct a structural equation modeling represented in eq. (1).

$$\mathbf{Y= \beta_o+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4……eq.\ (1)}$$

Where Y= dependent variable, βo= constant, $ß_i$ =coefficients of input factors.

TPMF=1.576 + 0.0.036 (Employee) + 0.245 (Organizational) + 0.176 (Personal) + 0.056 (Equipment)……..eq. (2)

As indicated in Tables 5 and 6 the appropriate indicators of the variable that are used to detect TPM performance indicator factors were explored.R^2 indicates how much of the variance in the TPM performance indicator factors identifies the model. The larger R^2 indicates the better the model is. The analysis of this research paper revealed that R^2 is equals to 0.659. This showed that the four predictor variables of the input factors accounted for 65.9% of the variation in TPM performance indicator factors and the rest 34.1% are other unknown variables which are not included in this study. Moreover, the model summary (Table 6) also shows the significance of the model by F-statistics (p = 0.000), and F = 62.422 implies that there were strong association with predictors and the outcomes of the regression variables and are at best fit model to predict TPM performance indicator factors of the case factory.

As Shown in Table 7 Beta sign of EMFM, ORFM, and PRFM AND EQFM shows positive effect of the predicting independent variable. That means any increase in this independent variables lead to increase in the TPM performance indicator factors of the factory. The study indicated that keeping TPM performance indicator factors at a constant of β_o = 1.576 (Sig. = 0.000), increasing organizational factors by one unit will increase TPM performance indicator factors by 24.5%, increasing personal factors by one unit will increase TPM performance factors by 17.6%, increasing equipment factors by one unit will increase TPM performance factors by 5.6% and increasing employees factors by one unit will increase organizational performance by 3.6%. The management (MF) and material (MAF) input factors have been excluded from eq. (1), since they do not have significant association (correlation) with dependent variables. Similarly, the result of this part indicated that only two independent variables (ORFM and PRFM) are statically important determinants for TPM performance indicator factors of the factory.

Table5 Model summary

Model	Dependent Variable	R	R^2	Adjusted R^2	Std error	F.	Sig
1		.812[a]	.659	.649	.27152	62.422	.000

a. Predictor:(constant), EQFM, PRFM, ORFM, EQFM
b. Dependent variables: TPMPM

Table 6 AOV

Model 1	Sum of Squares	df	Mean Square	F	Sig.
Regression	18.408	4	4.602	62.422	.000[b]
Residual	9.510	129	.074		
Total	27.918	133			

a. Dependent variable: TPMPM
b. Predictors(constant), EQFM, PRFM, EMFM, ORFM

Table 7 Regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.576	.125		12.597	.000
	EMFM	.036	.038	.079	.956	.341
	ORFM	.245	.050	.446	4.916	.000
	PRFM	.176	.053	.312	3.310	.001
	EQFM	.056	.043	.101	1.302	.195

a. Dependent variables :TPMPM

CONCLUSION

This study has identified determinant (influential) factors affecting TPM performance indicator factors by developing theoretical model from the literature reviews. The developed theoretical model was tested by developing hypothesis, and the collected data's were analyzed by correlation and regression analyses then following conclusion were drawn.

The Correlation analysis part of this paper revealed that four predicting variables (employees, organizational, personal, and equipment factors) which have the direct and significant impact on TPM performance indicator factors (cost, quality, productivity, delivery, moral and safety).

The analysis of regression part of the paper showed that TPM performance indicator factors were improved when there were more favorable condition in employees factor (EMF), organizational factor (ORF), personal factor (PRF) and equipment factor (EQF).

In this study, the determinant variables of TPM performance indicator factors of the case factory can be explained by four of the six independent variables that contribute for improving TPM performance indicator factors. However, management and material factors have no contribution for improving TPM performance indicator factors of the case factory since they have weak correlation with the dependent variables.

REFERENCE

1) Zineb S.A., Benoit I., Jean B. L., Fatime L.Y(2000).Maintenance in the Manufacturing Systems.Management and Control of Production and Logistics, Grenoble, France
2) Obamwonyi m.e, Gregory A (2010). Maintenance impact on production profitability, 4sE3IE Linnaeus University
3) Bhadury, B. (2000).Management of productivity through TPM", Productivity, Vol. 41 No. 2, pp. 240-51
4) Singh, R., Gohil, A. M., Shah, D. B., & Desai, S. (2013). Total productive maintenance (TPM) implementation in a machine shop: A case study. Procedia Engineering, 51, 592-599
5) Ahuja, I. P. S. and Khamba, J. S. (2008). Total productive maintenance: Literature review and directions. International Journal of Quality and Reliability Management 25(7), 709-756.
6) Poduval, P. S., Pramod, V. R. and Raj, J. V. P. (2013). Barriers in TPM Implementation in Industries. International Journal of Scientific and Technology Research. 2(5)
7) Majumdar, J. P. and Manohar, B. M. (2012). Implementing TPM programme as a TQM tool in Indian manufacturing industries. Asian Journal on Quality. 13(2), 185-198.
8) Ahuja, I.P.S. and Khamba J.S. (2008). An evaluation of TPM initiatives in Indian industry for enhanced manufacturing performance. International Journal of Quality and Reliability Management, 25(2), 147-72
9) Tajiri M. and Gotoh F. 91992). TPM Implementation: A Japanese Approach, McGraw-Hill, New York.
10) Teresko, J. (1992), Time Bomb or Profit Center, Industry Week, Vol. 241, No 3, pp. 52-7.
11) Schuman, C.A. and Brent, A.C. (2005), Asset Life Cycle Management towards Improving Physical Asset PerformanceIn The Process Industry, International Journal of Operations and Production Management, Vol. 25, No 6, pp. 566-79.

12) Shirose, K. (1992), TPM for Workshop Leaders, Productivity Press Inc., Cambridge
13) Sharp J.M., Irani, Z.N., Wyant T. and Firth, N. (1997). "TQM in maintenance to improve manufacturing performance", Proceedings of Portland International Conference on Management of Engineering Technology (PICMET-97), Portland State University, Portland, OR, July 27-31, pp. 811-4
14) Tajiri M.(1992).TPM Implementation, McGraw Hill, New York
15) Teresko J. (1992).Time Bomb or Profit Center, Industry Week, Vol. 241, No 3, pp. 52-7
16) Gupta R.C., Sonwalkar J. and Chitale A.K. (2001). Overall equipment effectiveness through total productive maintenance Prestige Journal of Management and Research, 5(1), 61-72
17) Fang lee Cooke (2000). Implementing TPM in Maintenance: Some Organizational Barriers, International Journal of Quality and Reliability Management, Vol. **7**, No 9, pp. 1003-1016
18) Willmott P. (1994). TPM: Total Productive Maintenance: The Western Way, Butterworth-Heinemann Publication. Oxford, United Kingdom.
19) A.A Wali, S.G. Deshmukh, and A.D. Gupta (2003). Critical success factors of TQM: a select study of Indian organizations Production Planning & Control, vol. 14, no. 1, pp. 3-14 20.Choudhury, Amit (2009). Statistical Correlation. Retrieved [1st January 2012] from Experiment Resources: http://www.experiment-resources.com/statistical-correlation.html
20) Shirose, K. (1995), TPM Team Guide, Productivity Press Inc., Portland.