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Critical Success Variables Influencing Implementation of Total Productive Maintenance

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ABSTRACT: This study is conducted to find critical variables that affect implementation of total productive maintenance at Ambo mineral water factory, Ambo, Ethiopia. By using the developed conceptual structure the study developed and tested five hypotheses. The Five independent variables considered are: Management Factors, Maintenance Factors, Employee Factors, Supportive Factors and Other related Factors and dependent variable is elements of Total Productive Maintenance. Data were gathered by self-administered structured questionnaire from the employees of the factory including general managers, production managers, maintenance managers, supervisors and shop floor workers of the factory. The sample size for the study was calculated based on Yamane's formula from a total population of (N=586), a sample size of (n= 151) were selected. Totally 147 questionnaires were properly filled and returned for analysis showing 97.335% response rate.
The result of the study revealed that the five input variables explained 88.5% of dependent variables in the factory and three input factors are statistically important and positively influence the execution of TPM in the factory.

Keywords: Dependent variables, influential Input variables, Pearson correlation, ANOVA, regression analysis total productive maintenance.

I. INTRODUCTION

Total productive maintenance is a Japanese concept developed depending on the practical repair thought and practice. For the first time, it was announced around 1971 by one of the Japan M/s Toyota Motor Company supplier. According to [1] TPM is a concept that makes the operator empowered to maintain their own equipment; it is the foundation for increasing production. It is an advanced method of repair for tools and machinery optimization and effectiveness to eliminates breakdowns and endorse autonomous maintenance for operators during day-to-day activities by involving total workforce [2].

It will result in less damage or no damage, fewer stops, and no defects. Total Productive Maintenance program creates a shared responsibility for the equipment manufacturer and it is very effective in increasing productivity. An effective TPM strategy is used to identify hidden, unused and underutilized resources like human, man-hours and machine-hours. TPM package is used to increase production, enhance workers moral and decrease job dissatisfaction [3].

In today's competitive market a steady progress of manufacturing operations do not promise continuous profitability of any organization [4]. According to [5] TPM is a method implemented for attaining very successful equipment and machine by using tools and techniques.

Therefore for the organization to be competent and remain leaders in the market they should show continuous progress.

According to [6] the Total productive maintenance has eight elements which include: planned maintenance, focused maintenance, autonomous maintenance, quality maintenance, education and training, office TPM, development management, safety and health and environment.

According to the study of [7] an organization applying TPM again and again achieve good results by reducing equipment breakdowns, by minimizing idling time and small stops, reducing quality defects increasing productivity, reducing costs and inventory, reducing accidents and increasing employee involvement.

According to [8] implementation of TPM is influenced by political, financial, departmental, inter-occupational obstacles, insufficient resources, resistance to change and incomplete understanding of the methodology.

Even if, TPM has a great role in improving organizational performance, there are input variables that affect the implementation total productive maintenance. The following paragraphs describe in brief some of the factors which have an influence on implementation of TPM.

The study of [9] revealed that top management and employee's commitment and involvement will effectively improve TPM. Total productive maintenance is expelled by the effective leadership and commitment of top and senior management and demonstrates leadership [10].

According to [11] and [12] the success of TPM is related with equipment utilization and employee management. Long term commitment of all the personnel of the organization including top management to shop floor workers of all department and professions are a precondition of successful TPM implementation. An effective TPM implementation needs support and empowerment of labors from all departments of the firm [13-17]. According to the study of [18] Clear goal developed by employees in numbers and figures, defining TPM rule and objectives by aligning with the firm goal will results for the success of TPM.

Different study points out that Cross-Functional Teams are integral to TPM implementation. Teams have to be self-directed and made up of personnel from cross-functional departments who directly have an impact on the problem along with the shift supervisors and the top management personnel [19, 20]. According to [21] the major success variables for implementation of TPM are Education and Training which important stages are in autonomous maintenance, TPM helps operators to identify common problems of the machine, to prevent the problem and how their equipment's are working [22]. Organizations functioning for TPM should be willing ready to invest for training and education to the employees, identify the required knowledge, skills and management capacity. According to [23, 24]. Total productive maintenance implementation can be successful only when the maintenance team performs scheduled repair and plan equipment design program with the operations by carrying out routine maintenance.

TPM is a group activity on protective and constructive maintenance participation all workers from top to low level operator [21]. It is the hybrid of protective maintenance activity and total quality through laborer participation including the strategy of maintenance workers protective maintenance activities to prevent machines from failure during production activity [20]. Availability of administrative support function in the office, insuring support to the manufacturing process, involvement and commitment of top management are needed for effective implementation of office TPM [25].

Treating TPM as additional burden and inability to invoke cultural change are some of the difficulties faced in TPM implementation. Lack of support from administrative, absence of training and unable to allocate enough time for change are some of the problem in implementing TPM [25]. According to [26] the key factors for TPM implementation are workers involvement and top management support. Still world class TPM implementation is possible with continual support at all the levels along with the supply of necessary resource

So based on the literature reviews this study identified the success input variables that impact the execution of TPM in to four input variables: management factors (MF), maintenance factors (MTF), employee factors (EF), supportive factors (SRF) and other related factors (ORF).

II. CONCEPTUAL STRUCTURE

The researchers developed theoretical model for identifying and evaluating critical variables influencing total productive maintenance implementation. The developed theoretical models how the relationships between five key variables (independent variables)- maintenance factors, management factors, employees factors, supportive factors and other related factors with total productive maintenance (dependent variables).

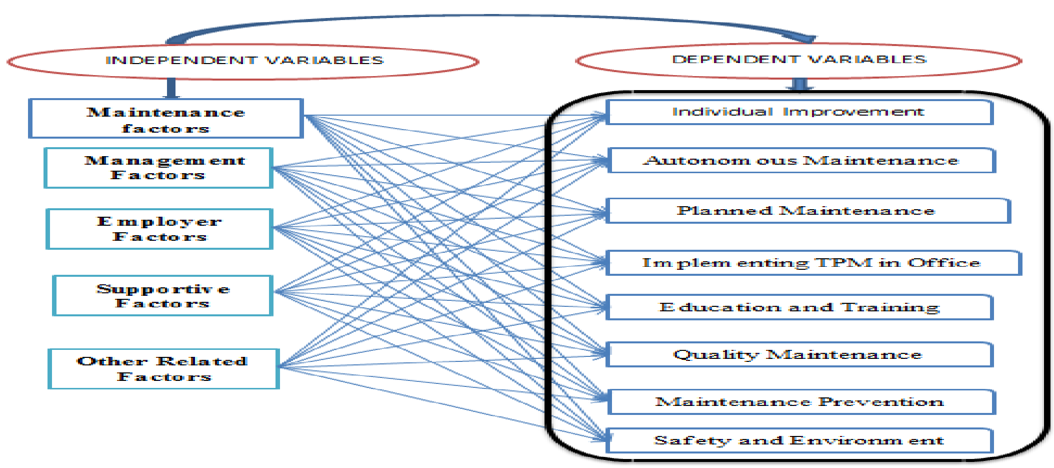

Fig. 1. Theoretical Model developed by the researcher.

III. HYPOTHESIS

A. Research Hypothesis

From the Theoretical Model the researchers hypothesized the following hypothesis:-

H_1:- Management factors positively affect execution of TPM.

H_2:-Supportive factors affect execution of TPM

H_3:- Maintenance factors affect execution of TPM

H_4:-Employee factors affect execution of TPM

H_5:-Other related factors affect execution of TPM.

IV. RESEARCH METHODOLOGY

A. Research Design and Data collection

The study was carried out in one of the Mineral Water factory which was found in Oromia National Regional State, Ethiopia East Africa in the West direction of the main capital city of Ethiopia. This factory is one of the oldest factories with its soft and nonalcoholic beverage manufacturing company in Ethiopia

The researchers used five point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree and

5=strongly agree) data collection techniques for collecting survey questionnaire from the respondent. The questionnaire has 34 items under 5 input variable and 64 items under TPM variables. Data was analyzed using descriptive and inferential statistical methods. An interval class was developed as shown in Table 1.

Table 1: Interval Class for Scale Means Score.

Explanation	Interval
STRONGLY UNHAPPY	1.00 < Mean < 1.80
UNHAPPY	1.81 < Mean < 2.60
MODERATE DEGREE	2.61 < Mean < 3.40
HIGH DEGREE	3.41 < Mean < 4.20
ABSOLUTELY TRUE	4.21 < Mean < 5.00

B. Population and Sample Size

For the use of this research study data's were collected from Ambo Mineral Water Factory, Ambo, Ethiopia, Africa. The total numbers of workers in the factory are 586 permanent and 56 daily labors. Among the permanent employees the educational standard of the workers of the company are MSC/MBA, BSC/BA, College Diploma, and Secondary School Complete. Permanent Workers having 2 years and above working experience are considered for collecting data's for the analysis of the study.

The total number of questionnaires distributed was calculated as per the following equation.

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

$n= 586/ [1+586(0.07)^2] =151.36= 151$

Where *n = Total number of questioners distributed, N =* Total number of permanent workers and *e*=0.07 (allowable error in %) (%). Totally 151(25%) questionnaires were distributed.

C. Reliability Test

The researcher tested the reliability of the questionnaire by using SPSS version 20. Tables 2 revealed the reliability result of the questionnaire before and after some of the questionnaires were removed. As per the result of the analysis the value of Cronbach's alpha (α) were fall between 0.694 – 0.925 which indicated higher reliability of the questionnaire.

Table 2: Reliability results of the constructs.

S.No.	Explanation	#Element*	(α) value Before element is Deleted	(α) value After element is Deleted
1.	Management Factors	5(8)	0.684	0.7223
2.	Employer Factors	5(10)	0.759	0.925
3.	Supportive Factors	6(8)	0.700	0.771
4.	Other Related Factors	5(9)	0.766	0.911
5.	Maintenance Factors	13(13)	0.892	0.892
6.	Autonomous Maintenance	11(16)	0.751	0.804
7.	Focused Improvement	4(5)	0.728	0.755
8.	Planned Maintenance	3(10)	0.665	0.911
9.	Education And Training	8(12)	0.601	0.723
10.	Safety, Health And Environment	5(11)	0.502	0.694
11.	Quality Maintenance	9(9)	0.704	0.704
12.	Office Total Productive Maintenance	6(8)	0.851	0.882
13.	Initial Phase Management	5(6)	0.802	0.811

#Element* 5(8) 5= Element after deleting, (8) = Element before deleting.

V. DATA ANALYSIS AND DISCUSSION

A. Descriptive Statistic Test Descriptive Analysis of input variables

The result of the study in Table 3 shows that the top most of the mean values revealed that the occurrence of the larger extent of poor maintenance factors (problem) due to lack of scheduled and routine maintenance activities, lack of support for maintenance service from maintenance department, tolerating frequent breakdown and lack of analyzing breakdown (Mean=3.637, standard deviation= 0.722).

The second highest mean is employees factors that shows the factory has moderate degree of poor implementation of this factors due to lack of involvement of supervisors and production labors in maintenance activities, poor management of employees, lack of improvement of cultural change of employees and insufficient involvement of maintenance personnel in maintenance activities(Mean=3.3347, Std. Deviation = 1.1619).

The third highest mean is management factors that shows the factory has moderate extent of weak execution of management factors because of absence of forming maintenance team, lack of management commitment for maintenance activity, lack of understanding about TPM, lack of support from top management for TPM implementation and lack of involvement in maintenance activity from the whole organization and management (Mean= 3.269, standard deviation= 0.85389).

The fourth highest mean of input factor is supportive factors that show the factory has moderate amount of poor implementation of this factor because of absence in preventive maintenance system, lack of implementing measurement system for TPM in the factory, unavailability of information system about TPM, bad working environment and lack of rewarding system (Mean = 3.1633, standard deviation= 0.81637).

The last mean of input factors is other related factors shows the factory has moderate extent of weak execution of this factor because of lack of developing cross functional team, lack of using bench marking activities and lack of changing management style (Mean=3.1361, Std. Deviation = 1.1992).

Table 3: Descriptive Statistics (N=147).

S.No.	Input Variable	Mean	Std. Deviation	Degree
1.	Maintenance factors	3.637	0.72228	High
2.	Employees factor	3.3347	1.16199	Moderate
3.	Management factors	3.269	0.85389	Moderate
4.	Supportive factors	3.1633	0.81637	Moderate
5.	Other related factors	3.1361	1.19725	Moderate

C. Correlation between Input Factors and Mean of TPM 8 Factors

Table 4 revealed the correlation analysis result of the study which demonstrates interaction between (MFM, EFM, SFM, ORFM and MTFM) and the dependent variable TPMM.

Table 4 revealed that TPM has strong +ve and important relationship with Maintenance Factors (R=0.892, p=0.000), Management Factors (r=0.677 and p=0.000) and Supportive Factors (r=0.577, p=0.000).

In addition the score of the analysis confirmed that Total productive maintenance has weak positive correlation with other related factors (r=0.266 and p=0.006) and Employee Factors (r=0.180 and p=0.029).

Table 4: Predictor and TPM relationship result (N=147).

	MF	EF	SF	ORF	MTF	TPM
MFM	1 147	.379** .000 147	.843** .000 147	.386** .000 147	.467** .000 147	.677** .000 147
EF		1 147	.440** .000 147	.872** .000 147	.379** .000 147	.180* .029 147
SF			1 147	.417** .000 147	.425** .000 147	.577** .000 147
ORF				1 147	.177* .032 147	.226** .006 147
MTF					1 147	.892** .000 147

** 0.01 level (2-tailed), *0.05 level (2-tailed), MF=management factors, EF=employees factors, SF=supportive factors, ORF= other related factors, MTF=maintenance factors, TPM= total productive maintenance

Table 5: summary of correlation result.

S.No.	Indeprndent Variables	Dependent Variables	r(p)	Strength	Hypothesis
1.	MF	TP	.677**(0.000)	Strong	Accepted
2.	EF	TP	.180*(0.029)	Weak	Denied
3.	SF	TP	.577**(0.000)	Strong	Accepted
4.	ORF	TP	.226**(0.006)	Weak	Denied
5.	MTF	TP	.892**(0.000)	Strong	Accepted

Where: -r (p), r=correlation coefficient, p=significant value, MF=management factors, EF=employer factors,
SF= supportive factors, ORF= other related factors, MTF= maintenance factors, TPF= Total productive maintenance factors.

D. Regressions Analysis

The Regression analysis was carried out to identify the association between TPM and (MF, EF, SF ORF and MTF). The result in Table 6 indicated that five predictors' variables (MTFM, EFM, MFM, SFM and ORFM) accounted for 88.5% of the variation in total productive maintenance and 11.5% of the variables are the rest 11.5% are unidentified variables. The result of model 2 indicated in Table 6revealed that the importance of the model by the value of *F*-statistics (p = 0.000), and F = 217.246 which indicated that there were strong relationship between TPM and (MF, EF, SF ORF and MTF) in the case industry.

As shown in Table 7, β sign of the independent variables (MF, ORF and MTF) revealed positive influence on TPM. An increase in (MF, ORF and MTF) results in increasing in TPM of the industry. The result in Table 7 also shows that (EMF and SFM) have a negative effect on Total productive maintenance. Similarly, only three independent variables (MF, ORF and MTF) are influential variables for execution of Total productive maintenance of the industry.

Table: 6 Results of ANOVA and Model summery.

	Description	Value
Model 1	R	0.941
	R^2	0.885
	Adjusted R^2	0.881
	R^2 Change	0.885
	df1 and df2	5(141)
Model 2	F change	217.426
	Regression(sum of square)	42.451
	Residual	5.506
	Total	47.956
	Sig.	0.000

E. Hypothesis Testing

The developed hypothesis was tested by regression analysis and is used to examine the contributions (MTFM, EFM, MFM, SF and, ORFM) on TPM execution.

H1: Management factors positively affect execution of TPM

Table 7 indicated a significant influence of the management factors on TPM execution (β = 0.256; $p < 0.05$), hypothesis1 is accepted.

H2 Supportive factors positively affect execution of TPM

In Table 8 the β value of Supportive factors has no statistical significant influence on total productive maintenance implementation β = -0.026, p=0.039. This result indicated that no important relationship between SF and TPM execution.

H3 Maintenance factors positively affect execution of TPM.

Table 8 showed a significant influence of the maintenance factors on the total productive maintenance implementation with β= 0 .583, p=0.026. As a result, the hypothesis that supposed the maintenance factors (MTF) is accepted.

H4 Employee factors positively affect execution of TPM.

Table 8 revealed that the β value of Employee factors has no statistical significant influence on total productive maintenance implementation β = -0.027, p=0.02). This result revealed that no important relationship EFM and TPM execution

H5 Other related factors positively affect execution of TPM.

Table 7 showed a significant influence of other related on the total productive maintenance implementation with β= 0 .006, p= 0.028. As a result, the hypothesis that supposed the other related (ORF) is statically significant determinant of total productive maintenance implementation (TPM) is accepted.

Table 7: Regression between input factors and total productive maintenance.

Model	Constant	MFM	EFM	SFM	ORFM	MTFM
Unstd.coeff. B(Std.error)	.644(0.093)	.256(0.037)	-.027(0.029)	-.026(0.039)	.006(0.028)	.583(0.026)
Std.coeff. Beta		0.381	-0.055	-0.037	0.013	0.735
t (sig)	6.891 (0.000)	6.963 (0.000)	-.920 (0.359)	-.678 (0.014)	.214 (0.001)	22.568 (0.000)
a. Dependent Variable: TPMM						

VI. CONCLUSIONS

From the developed theoretical model this research paper identified critical success variables that affect the execution of in the case factory by testing the developed hypothesis and correlation analysis.

The regression analysis indicated that implementation of total productive maintenance was improved when there were more favorable condition in management factors (MF), maintenance factors (MTF) and other related (ORF).

The Correlation analysis result revealed that all the five independent variables (MF, MTF, SF, EF and ORF) which have the direct and significant effect on total productive maintenance implementation.

In this study, the critical variables of total productive maintenance implementation of the case factory were described by three of the five input factors that contribute for the successful implementation of TPM. On the other hand the factors on employee's factor and other related factors cannot contribute to the implementation of Total productive maintenance of the case factory since they have weak relationship with TPM.

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