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The Effect of Lean Manufacturing Tools on Waste Reduction at Arjo Didessa Sugar Factory

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Abstract
This study has main objective of assessment on the effects of lean manufacturing tools on waste reduction on Arjo Didesssa Sugar factory. The specific objectives of the study are from the perspective of Total productive maintenance, Mistake proofing, workplace organization (5S), continuous quality improvement and worker involvement. The research design for this study is explanatory, while the research approach is mixed approach. The target populations for this study are teams in the department of factory operation, department of kaizen and quality control. Both probability and non-probability sampling techniques are used and 208 samples selected. 188 questionnaires were completely filled and returned. Both primary data and secondary data were used to fulfill the research objective. Quantitative part of data was analyzed by using SPSS version 20. The result of the study indicates that lean manufacturing tools are not implemented effectively therefore production waste is evident. Total productive maintenance, mistake proofing, worker involvement and continuous quality improvement have positive and significant effect on waste reduction. Secondary data shows there is production waste in the factory but wastes are continuously reducing. Based on the evidence from questionnaire and secondary data it was concluded that lean manufacturing tools were not performed in excellent manner as result production wastes were evident in the factory. The researcher recommends based on the research findings and if lean manufacturing tools are performed in excellent manner by improving maintenance, training, preventive and control devices for mistake proofing, Plan do check act cycle and enhancing the skills of employees the factory they can reduce production wastes. Finally the researcher suggested for future research to be conducted by including other lean manufacturing tools to reduce production waste.
Keywords: Lean Manufacturing, total productive maintenance, workplace organization (5s), mistake proofing, workers involvement, continuous quality improvement

1.1. Background of the study

Lean Manufacturing is a philosophy that aims to maintain smooth production flow by continuously identifying and eliminating waste resulting in increasing value of activities in the production process (Rakesh & Vikas, 2012). According to (Zahid Abbass, 2016), the impact of lean practices on business cannot be ignored. Lean manufacturing is considered as the best production system of 21st century. It requires least investment as compared to other manufacturing systems. One of the most important reasons that make it an ideal it is appropriate for almost all types of organizations irrespective of their type. According to (Mulugeta, 2016), Arjo Didessa sugar factory is found Oramia national regional state in eastern Wollga zone with in Didessa river valley. The factory is far from the capital city of Ethiopia Addis Ababa by 395 kilo meters. The factory has embraced kaizen one of the lean manufacturing philosophy in 2013.

1.2. Problem statement

Manufacturing operations are continually striving to increase productivity and output of their operations. Their goal is to satisfy the customer with the exact product, quality, quantity, and price in the shortest amount of time (Belekoukias, Garza-Reyes, & Kumar, 2014). According to (Alhuraish, Robledo, & Kobi, 2015), One of the major the major purposes of the use of lean production to eliminate manufacturing waste. Many researchers conducted their researches on lean manufacturing tools and waste reduction. Researchers like (Cua, Sweet, & Schroede, 2006; Tigist, 2015; Alemayehu, 2014; Asayehgn, 2014; Bonavia & Marin-Garcia, 2011; Mayatra & Trivedi, 2016; Inela, Apreutsi, & Suciu, 2010; Minale, 2014) finds that lean manufacturing tools reduce production wastes. On the other hand searchers like (Modi & Thakkar, 2014; Ranjan, Mahesh, & Sandesh, 2014), value stream mapping is used to identify non value adding activities, but not reducing waste, rather it is other tools such as Kanban used to reduce production wastes. Furthermore, (Amin & Karim, 2013)finds that some of lean manufacturing tools will increase waste rather than reducing it. The waste of Motion' comes from the implementing of several lean strategies such as 'workplace organization (5S), and total productive maintenance. In addition (Abdallah & Matsui, 2007), total productive maintenance is not related to over processing waste and waiting waste. Finally researchers like (Wamalwa, Onkware, & Musiega, 2014; Mgenyi, 2009) find that workplace organization (5s) have insignificant effect on waste reduction. According to (Asayehgn, 2015) & (Ayisha, 2014) Ethiopian manufacturing firms have problems on the implementation of lean manufacturing and there is excess production waste. Similarly (ESCo, 2016), Ethiopian sugars factories have problems on lean manufacturing implementation especially Total productive maintenance, worker involvement and there is

production wastes in these factories. The future research suggestion of (Abebayehu, 2016) and (Rajesh & Naveen, 2012), further research needs to be conducted on lean manufacturing tools and production wastes. After all none of the above researchers have conducted researches by including together lean manufacturing tools such as total productive maintenance, mistake proofing, workers involvement, workplace organization (5s)and continuous quality improvement from seven production wastes perspective. In line with these gaps the researcher has formulated the next general and specific objective.

1.3.1. Objectives of the study

General objective

The objective of the study was to assess the effect of lean manufacturing tools on the waste reduction of Arjo Didessa sugar factory.

Specific objectives

- To assess the effect of total productive maintenance on waste reduction
- To analyze how workplace organization (5s) affect waste reduction
- To know to what extent of mistake proofing affect waste reduction
- To assess how workers involvement affects waste reduction
- To asses in what extent continuous quality improvement affects waste reduction

2. Review of Related Literature

2.1. Lean manufacturing tools and waste reduction

Lean Manufacturing can be defined as an approach to the identification and elimination of waste (non-value added activities) through continuous improvement by flowing, the product in a way to "pull" from the customer in pursuit of perfection (Santamaria & Kalkowska, 2013). All lean manufacturing cannot apply everywhere, therefore researchers and authors identified lean manufacturing tools that can be applied for sugar factories and continuous process flow industries. According to many authors such as (Ondiek & Kisombe, 2014; Kivilä, 2015; Rahani & Muhammad, 2012),identified Total productive maintenance, Kanban, production smoothing, value stream mapping, Visual Displays and Controls, workplace organization (5s) , quality at the source , value stream mapping and worker involvement as lean manufacturing tools which can be applied to continuous process flow industries including sugar factories. Researchers in Ethiopia also identified lean manufacturing tools that can be applied for sugar factories and continuous processes flow industries. According to (Kassu & Daniel, 2015; Tigist, 2015; Asayehgn, 2014)list Total productive maintenance, 5S(workplace organization) for sugar factories. Finally (Minale, 2014; Tariku, Wassihun, & Ramulu, 2015)deals with the necessity of total productive maintenance for sugar factories.

According to (Wisner, Tan, & Leong, 2012), the objective of lean manufacturing is to eliminate all forms of waste in the production process. The Japanese term for waste is “Muda” Forms of waste include; waste of overproduction waste of waiting, transportation waste, over processing waste, waste of inventory, wasted motions and waste of defects.

2.2 Gaps on existing researches: There is argument between researchers and many researchers cannot reach full consensus in that lean manufacturing tools reduce wastes. Researchers like (Cua, Sweet, & Schroede, 2006; Tigist, 2015; Alemayehu, 2014; Asayehgn, 2014; Bonavia & Marin-Garcia, 2011; Mayatra & Trivedi, 2016; Inela, Apreutsi, & Suciu, 2010) finds that lean manufacturing tools reduce wastes. On the other hand searchers like (Modi & Thakkar, 2014; Ranjan, Mahesh, & Sandesh, 2014), value stream mapping is used to identify non value adding activities, but not reducing waste, rather it is other tools such as Kanban used to reduce wastes. Furthermore, (Amin & Karim, 2013)finds the waste of Motion’ comes from the implementing of several lean strategies such as ‘workplace organization (5S), ‘Visual Management System, Cellular Manufacturing’ and total productive maintenance. In addition (Abdallah & Matsui, 2007), total productive maintenance is not related to over processing waste and waiting waste.

2.3 Conceptual framework of the study

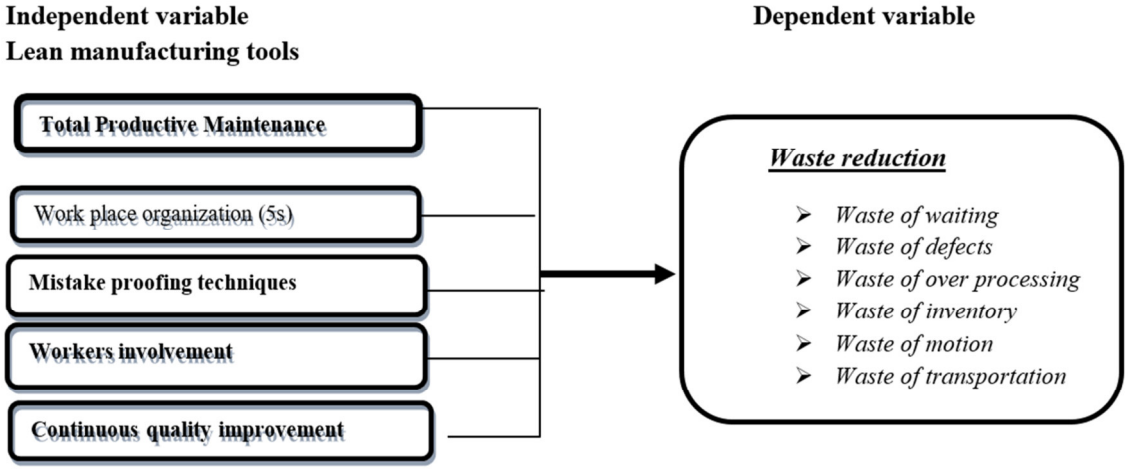

Figure 1: Conceptual Framework of the study
Source: developed by researcher after reading literatures

3. Research Methodology

3.1. Research approach and design; the research approach for this research is a mixed approach (contains both qualitative and quantitative aspects the research design for this research is explanatory design, because in this research the researcher studied the cause and effect between lean manufacturing tools on waste reduction**.**

3.2. Target population: The populations for this study were the Employees of Arjo Didessa sugar factory working in Factory operation (technique team, Power generation and utility team and sugar production team) quality control, and kaizen. The researcher used both probability and non-probability sampling technique. The researcher selected departments purposively, which is related to the study. With regard to probability sampling the researcher used simple random sampling with stratification. The base of stratification is department.

3.3. Sample size: in this research the formula of Yamane 1967 as cited by (Kasiulevičius & R, 2006)was used for sample size, the reason for using this sample size formula is researchers adopt this formula which is similar in this research study.

$$n = \frac{N}{1+ N e^2}$$

Where: N=population**,** n=sample size, e=margin of error (5%) =432/1+432*0.05*0.05=20

Table 1: sample size

Department and teams	Population	Selected sample
Sugar production	182	182/432*208=88
Technique team	146	146/432*208=70
Quality control	20	20/432*208=10
Power generation and utility	82	82/432*208=39
Kaizen	2	2/432*208=1
Total	432	208

3.4. Data Sources and Data Collection Technique

3.4.1. Data sources; There are two data sources: primary and secondary sources; primary data sources are firsthand information. In this research both primary and secondary data were used.

3.4.1.1. Data collection

In this research both primary and secondary data used regarding primary data closed format questions used. The closed formats questions in this research listed as Lickert style (e.g. rate the extent to which the respondents agree with a statement: strongly agree, agree neutral, disagree, and strongly disagree). Secondary data was used in this research. The data's that related to the study starting from 20014/14-16/17. Due to the factory inaugurated production on 2014 it was impossible to obtain further secondary data.

3.5. Data Analysis: In this research descriptive statistics, correlation and regression was analyzed by using SPSS version 20. The researcher used regression model, since the research shows cause and effect.

$Y=\beta 0+\beta 1x1+ \beta 2x2+ \beta 3x3+ \beta 4x4+ \beta 5x5+£$

Y=Dependent variable (Waste reduction)
a=the "y" intercept, X1= mistake proofing, X2= total productive maintenance, X3= workplace organization, X4= worker involvement X5=continuous quality improvement ε =error term β =the regression coefficient

3.6. Validity and Reliability: regarding validity the researcher used different types of data sources such as questionnaire and secondary data. The researcher was also elaborate questionnaires to those of respondents who have some problem of understanding what has been said in the questionnaire. After all the researcher also collects analyzes and interprets data as impartially as possible. The researcher used Cronbach alpha to test reliability. 30 questionnaires were distributed to the respondents to test the reliability and the following outputs were obtained.

Table2: reliability result

No	Study Variables	Cronbach's Alpha value
	Mistake proofing	.704
	Continuous quality improvement	.783
	Worker involvement	.719
	workplace Organization	.823
	Waste Reduction	.728
	Total productive maintenance	.733

Source: own survey (April 2017)

As it can be seen the Cronbach alpha statistics of 6 study variables were entered and the result shows that between 0.704 and 0.823, which is reliable. Because if the cronbach's alpha value is greater than 0.7 then items are reliable.

3.7. Ethical Consideration: In this research the researcher keeps the privacy of the respondents, and assured the data that is going to be collected is only for research purpose. In addition the researcher did not violet ethical gridlines such as acknowledge the work of others or in other hand not commit plagiarism.

4. Data Presentation, Analysis and Discussion

4.1 Descriptive statistics: This section presents the questionnaires which is close ended questionnaires that respondents rated on how they are applying lean manufacturing tools in the factory on a five-point Likert type scale ranging from 1 being strongly disagree to 5 strongly agree. The mean statistical value approaching were based on the assumptions of (Robert & Richard, 2008) .If the mean value is between (1 to 1.5) this implies the respondents strongly disagreed, if the mean value is between [1.50 to 2.50) it indicates the respondents disagreed, the mean value between [2.50 to 3.50) indicates the respondents were neutral, the mean value between [3.50 to 4.50) implies the respondents agreed and a mean value 4.50 and above shows the respondents strongly agreed.

Table3: the overall mean score of research variables

No	Research variables	N	Overall Mean score	Std. Deviation
	Total Productive Maintenance	188	2.5112	.56592
	Mistake Proofing	188	2.5805	.50508
	Continuous Quality Improvement	188	2.1413	.50900
	Worker Involvement	188	2.5243	.55413
	Workplace Organization	188	3.0114	.60174
	Waste Reduction	188	2.5790	.51523

Source: own survey (April 2017)

As indicated in the above table the mean score of respondents shows that total Productive Maintenance, Mistake Proofing, Worker Involvement, Workplace Organization, and Waste Reduction scores neutral which indicates there is no guarantee that these variables may be performed in very bad manner. Whereas Continuous Quality Improvement scores disagree which means it is performed in negative manner. Generally the overall mean observation shows the raised research variables were not performed in excellent manner.

4.2 Correlation Analysis: This part of the study presents the relationship that exists between variables by using Pearson correlation coefficient. According to((Robert & Richard, 2008; Field, 2009)All the relationship that exist between all variables presented and interpretation given based on assumption of correlation Values between 0 and 0.3 (0 and -0.3) indicate a weak positive (negative) linear relationship via a shaky linear rule, Values between 0.3 and 0.7 (0.3 and -0.7) indicate a moderate positive (negative) linear relationship and values between 0.7 and 1.0 (-0.7 and -1.0) indicate a strong positive (negative) linear relationship via a firm linear rule. Therefore, in this study all correlation results are interpreted in light of this rule.

Table 4: correlation between variables

Correlations							
		Total productive maintenance	Mistake proofing	Continuous quality improvement	Worker involvement	workplace Organization	Waste Reduction
Total productive maintenance	Pearson Correlation	1	.554**	.512**	.593**	.454**	.712**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
Mistake proofing	Pearson Correlation	.554**	1	.443**	.483**	.408**	.638**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
Continuous quality improvement	Pearson Correlation	.512**	.443**	1	.455**	.361**	.590**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
Worker involvement	Pearson Correlation	.593**	.483**	.455**	1	.511**	.661**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
workplace Organization	Pearson Correlation	.454**	.408**	.361**	.511**	1	.505**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
Waste Reduction	Pearson Correlation	.712**	.638**	.590**	.661**	.505**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
**. Correlation is significant at the 0.01 level (2-tailed).							

Source: own survey (April 2017)

Total productive maintenance has relationship with mistake proofing Continuous quality improvement, Worker involvement and workplace organization (5s) with the value of 0.554, 512, 0.593 and 0.454 respectively .therefore total productive maintenance has moderate positive correlation other variables. The exception is Total productive maintenance has strong correlation with waste reduction with the value of 0.712. Mistake proofing has moderate positive correlation with Continuous quality improvement, Worker involvement, workplace organization (5s) and waste reduction with the value of 0.638, 0.443, 0.483, 0.408and 0.638 respectively. Continuous quality improvement has moderate correlation with Worker involvement workplace organization (5s) and waste reduction with the values of 0.455, 0.361and 0.590 respectively. Worker involvement has also moderate relationship with workplace organization (5s) and waste reduction with value of0.511 0&0.661respectivly. Finally the same moderate relation is observed with workplace organization and waste reduction with the value0.505. All correlations are significant at0.001level.

4.3. Testing regression assumptions

In this section the assumptions of regression such as Multi- co linearity, Normality and linearity are tested.

1. Multi- co linearity

Table5: Testing for Multi- co linearity

Model	Collinearity Statistics	
	Tolerance	VIF
Total productive maintenance	.510	1.962
Mistake proofing	.624	1.601
Continuous quality improvement	.675	1.482
Worker involvement	.546	1.832
workplace Organization(**5S)**	.685	1.460

Source: own survey (April 2017)

As it can be seen from the above table Multi- co linearity, is not the problem in this model. According to (Field, 2009), Multi- co linearity, will be a problem if variance inflation factor (VIF) is greater than 10 and tolerance below 0.2. In this model neither the tolerance below 2 nor VIF greater than 10.

2. Normality

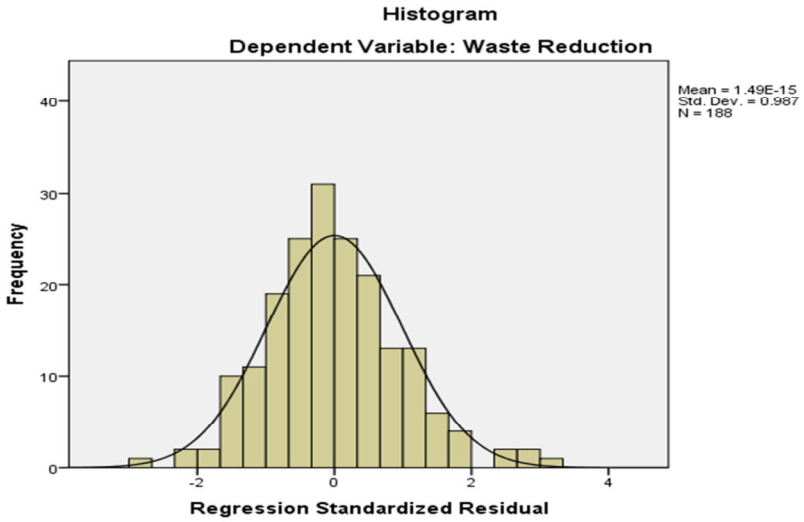

Figure2: Normality graph
Source: own survey (April 2017)

As we can see from the above figure it is bell shaped curve therefore it fulfills the normality assumption.

3. Linearity

Figure3: Normality graph
Source: own survey (April 2017)

In the above figure we can observe almost straight line. According to (Field, 2009)so as to fulfill the assumption of linearity the line should not be curved rather it should be straight line, therefor it fulfills the assumption of linearity. Furthermore the relationship between independent variable and dependent variable is linear.

4.4. Regression Analysis of Study Variables

Table6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.824[a]	.678	.670	.29616

Source: own survey (April 2017)
Predictors: (Constant), workplace Organization, Continuous quality improvement, Mistake proofing, Worker involvement, Total productive maintenance
Dependent Variable: Waste Reduction

R in this model represents a correlation between the predicted and observed values of the outcome is 82.4.8%. So the correlation shows there is strong relationship between variables. The value of R square tells that independent variables can account 67.8% variation in waste reduction. The adjusted R square tells us that independent variables can predict waste reduction by 67%. The Standard Error of the Estimate tells us that nearly 29.616% may be wrongly estimated.

Table 7: ANOVA statistics

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33.678	5	6.736	76.792	.000[b]
	Residual	15.964	182	.088		
	Total	49.642	187			
a. Dependent Variable: Waste Reduction						
b. Predictors: (Constant), workplace Organization, Continuous quality improvement, Mistake proofing, Worker involvement, Total productive maintenance						

Source: own survey (April 2017)

From the ANOVA statistics we can understand that from the total number of observation (49.642) the regression model explains 33.678. The remaining 15.964 is not explained by the model. From this we can understand the regression explains most of observation whereas the lesser observations are explained by other extraneous variables. Mean square of the model (regression) represents the average amount of variation explained by the model is 6.736 whereas mean square of the residual is .088 is a of the average amount of variation explained by extraneous variables (the unsystematic variation). The F-ratio is a measure of the ratio of the variation explained by the model and the variation explained by extraneous variables. ANOVA has been used to test the overall fit of the model. This test is significant, $F(5,182) = 76.792$, $p < .001$.

Table8: Coefficients of Waste Reduction.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.080	.138		.580	.563
	Total Productive Maintenance	.278	.054	.306	5.188	.000
	Mistake proofing	.241	.054	.236	4.445	.000
	Continuous Quality Improvement	.193	.052	.191	3.735	.000
	Worker Involvement	.221	.053	.238	4.187	.000
	workplace Organization(**5S)**	.068	.043	.079	1.565	.119

Source: own survey (April 2017)

From the above table it can be understand that Total productive maintenance, Mistake proofing, Continuous Quality improvement and worker involvement have significant effect on waste reduction at $P<0.05$. The objective of the regression in this study is to find such an equation that could be used to find the effect of predictors on dependent variable. The specified regression equation takes the following form:

$$\mathbf{Y = 0.080 + 0.278X1 + 0.241X2 + 0.193X3 + 0.221X4 + 0.068X5 + e}$$

Where Y= waste reduction, X1= Total productive maintenance; X2= Mistake proofing: X3 =continuous quality improvement; X4= Worker involvement X5=Workplace organization (5S): e = the residual amount. The regression equation above shows that, by taking all factors into account constant at zero, the waste reduction in the factory will have the value of 0.080. The findings presented also show that taking all other independent variables at zero, a unit increase in Total productive maintenance increases will be increasing to reduce wastes by will increase by 0.278. A unit increase on Mistake proofing increase will reduce wastes by reduced by 0.241. A unit increase on Continuous Quality improvement will be reducing wastes by 0.193. A unit increase on worker involvement will be more reduced wastes by 0.221. Workplace organization has positive but, insignificant effect on waste reduction. A unit increase on workplace organization will be reducing wastes by 0.068.

4.5 Secondary Data Analysis

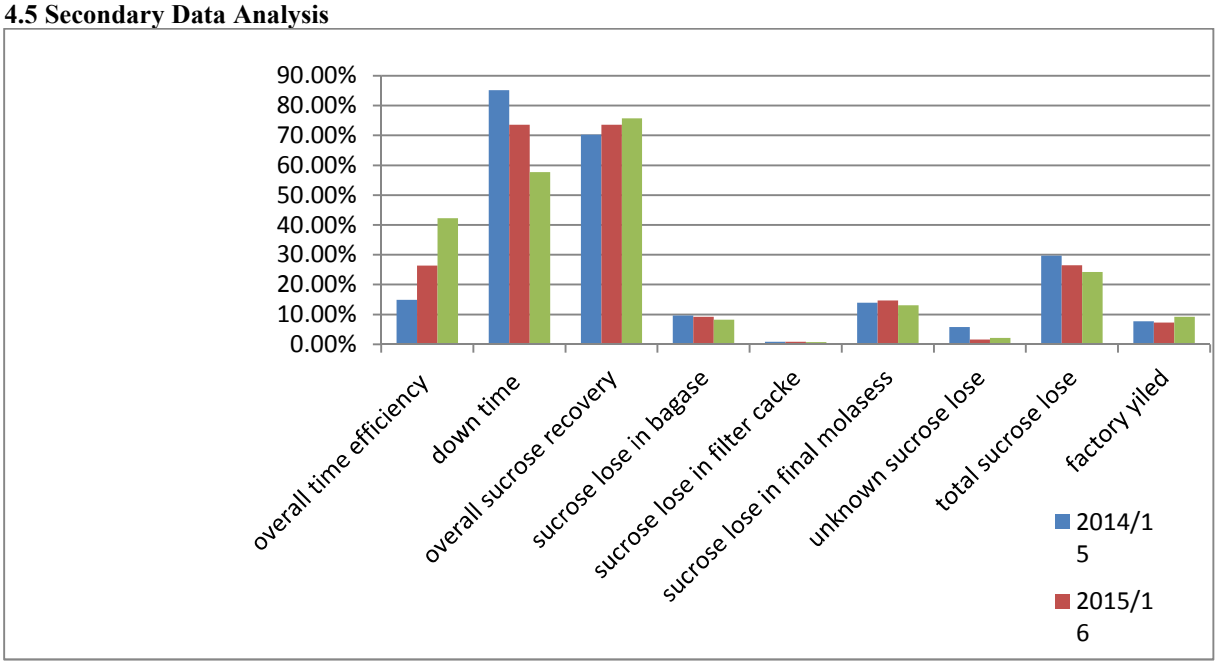

Figure5: factory performance graph
Source 2014/15-2016/17 data from factory

According to the graph shown above, this secondary data includes data's of 2014/15, 2015/16&2016/17. Secondary data's related to production wastes especially waste of waiting due to down time, work in process inventory lose (sucrose lose) and factory yield related to productivity. Secondary data shows that the factory has high amount of waiting time due to down time. Even during operation the waste of waiting due to downtime is higher than milling days (production days). The secondary data shows that there is also excessive work in process inventory (sucrose lose) in all three years. Even though there are wastes they are on the way of improving when go along from 2014/15-2016/17.

4.6 Discussion

This section deals with discussion of results by linking with theories and problems rose initially in problem statement. The arguments of the previous researchers on the effect of lean manufacturing tools and waste reduction rose as gaps on previous researches also discussed, to create linkage with which of previous research this research have similarity and with which of previous research this research has contradiction. From this study we can understand that total productive maintenance is not performing in effective and proper manner since the mean score of the respondents show that there is no guarantee on Total productive maintenance is performing effectively. In addition the frequency of respondents show that most of them were on negative side (strongly disagree and disagree) on the raised issues. But according to, (Mahaparta & Mohanty, 2007), Maintenance should perform effectively to reduce production wastes. Regarding Total productive maintenance, this research is similar to (Tariku, Wassihun, & Ramulu, 2015), A Case Study on Ethiopian Metehara Sugar Factory finds that the preventive maintenance to stop machine failure is almost nonexistent. They respond only after failure occurs. And the adequacy of spare parts for maintenance was very low which contributes to increase for waste. The effect of total productive maintenance on waste reduction of this study is positive and significant which is similar to Researchers like (Mayatra & Trivedi, 2016), total productive maintenance reduce production wastes. This research finding is similar to (Asayehgn, 2014); in that total productive maintenance have appositive significant impact on waste reduction. Due to total productive maintenance, Methehara sugar factory reduces production wastes. Furthermore it is similar to (Asayehgn, 2014), research conducted on Analysis of Kaizen Implementation in Northern Ethiopia's Manufacturing Industries by find that that the lean tools and techniques used by the pilot companies did not implement lean tools and techniques therefore production wastes did not minimized. However this study on to Total Productive Maintenance is against to the study of (Amin & Karim, 2013), research conducted on a time based quantitative approach for selecting lean strategies for manufacturing organizations that finds that Total productive maintenance will increase production waste rather than reduces wastes.

This study finding on mistake proofing is similar to According to the research finding of (Inela, Apreutsi, & Suciu, 2010), finds that mistake proofing have significant effect on waste reduction. In workers involvement ,the factory has problems on there is no culture of experience sharing in the factory because majority of the

respondents have negative view on the existence a good culture of experience sharing in the factory. In this regard it supports the problem raised by (ESCo, 2016) on the existence of problems on sharing experience. But in lean manufacturing employees shall be cross trained and share experiences one another (Feld, 2001). Majority of the respondents 39.9% disagreed and 30.3 Strongly disagreed on that managers are not depend on traditional bureaucracy again which supports the problem raised by (ESCo, 2016), Finally the model indicates that worker involvement has positive significant effect on significant effect on waste reduction. Due to worker involvement in the factory is low the factory is also in low performs to reduce wastes. This research finding on waste reduction is similar with (Manzouri, Ab-Rahman, & Zain, 2014), Cross functional team, Expansion of autonomy and responsibility, Team decision making, significantly eliminates waste. The study finding on workplace organization is similar with (Wamalwa, Onkware, & Musiega, 2014; Mgenyi, 2009) research conducted in Kenya that which finds that workplace organization (5s) have insignificant effect on waste reduction. But the research is against the finding of (Amin & Karim, 2013), that finds lean manufacturing tools such as workplace organization (5S), will increase waste rather than reducing it.

5. Summery Concussion and Recommendation

5.1. Summary of Findings

- Regarding to the objectives of the study the research finds:
- Total productive maintenance has the highest positive effect on waste reduction
- Workplace organization insignificantly affects waste reduction
- Mistake proofing has positive and significant effect on waste reduction.
- Workers involvement significantly and positively affects waste reduction
- Continuous quality improvement significantly affects waste reduction

5.2 Conclusion

In this study, the major determinant tools for waste reduction Were Total productive maintenance, Mistake proofing, continuous quality improvement, worker involvement and workplace organizations (5S) five main research questions were developed in this research. Total productive maintenance, mistake proofing, worker involvement and continuous quality improvement were found to have a positive and significant effect on Waste reduction .Based on the findings of the study it will not be unwise to merely conclude that Total productive maintenance, mistake proofing, worker involvement and continuous quality improvement should be improved to bring change in waste reduction. Because the regression model is telling us still 0.29616 nearly 30% of the model is wrongly estimated and other factors may need to be considered.

5.3. Recommendation

Based on the findings of the study, the researcher suggested the following points which if performed effectively that the factory can reduced waste and thereby improved productivity. It is advisable if the factory is make improvement on variables which have significant effect on waste reduction, such as Total productive maintenance, Mistake proofing and continuous quality improvement so as to reduce production wastes.

5.4 Suggestion for future research

The current study was carried out only in Arjo Dedessa sugar factory. The next research shall include other sugar factories and continuous process flow manufacturing firms such as pharmaceutical firms. The next research shall also include variables such as Kanban, and value stream mapping to identify non value adding activity (wastes) in the production process.

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