Prospects of Maintenance Management Functions in Sugar Industries: A Case Study on Ethiopian Metehara Sugar Factory

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***Abstract*—** The maintenance management function contributes a share on profitability by minimizing the expenses. The main aim of the present study is to identify the factors involved in the maintenance functions in Metehara Sugar Factory (MSF) by which maintenance resources are not utilized properly. The data gathered mainly on maintenance practices/functions such as maintenance organization, work order system (WOS), planning and scheduling, preventive maintenance (PM), etc. Data was analyzed using various methods such as Statistical Package for Social Science (SPSS), Pareto principle, and wrench time analysis. The analysis indicated that the factory is in reactive mode which promotes more unplanned down time up to 26.3% and higher overtime. Unplanned maintenance in turn affects the labor and material consumption by 1: 5, thus the factory has lost more than 370 million birr due to poor maintenance practices for the past years. The maintenance organization structure is obsolete and incomplete. Wrench time is also very low (14.1%), due to this the factory has lost 115 million birr in the past years. since the factory is in reactive situation, the factory has also lost more than 24 million birr for the past five years due to high over time (19.2%). The factory also has poor preventive maintenance practices which are below 3.5% planned down time on average for the past seven years. Thus lack of proper PM practices promotes reactive situation in the factory, higher energy usage because of this the factory has wasted more than 4 million birr with little managerial control. The currently used WOS is obsolete and incomplete. Satisfaction level for replenishment orders is around 15% for the last five years which is very low. Hence, maintenance couldn't have been measured and controlled. The authors have recommended a few solutions in order to improve the current maintenance management functions in the technical department of MSF based.

***Keywords*—** Maintenance practices, Maintenance functions, Reactive maintenance, Waste areas in maintenance functions, Work order and Wrench time.

I. Introduction

MAINTENANCE is a unique business process. It requires an approach that is different from other business processes if it is to be successfully managed. Maintenance must be recognized as an integral part of the plant production strategy in order to make its proper contribution to profits, productivity, and quality. In this view, the overall plan enables the customer to get desired quality with the price he is willing to pay [1, 2]. Therefore, it is becoming increasingly difficult to ignore the effects of improper maintenance resources wastes. On the other hand to accomplish the maintenance mission, it requires the cooperation of, and the collaboration with, virtually every department including production, procurement, engineering, accounting, human resources, etc. With such cooperation, it's relatively easy to encourage maintenance improvement within maintenance organizational lines. In Metehara Sugar Factory (MSF), unscheduled maintenance downtime, and traditional maintenance costs such as labor, overtime, and repair parts are generally the major contributors to abnormal maintenance costs within the plant. According to 2009/10 fiscal year annual report the factory faced substantial problems, like excessive down time (18.2%), higher over time (22%), unacceptable absenteeism (18%), increasing operation and maintenance costs, reduced productivity and efficiency (86.2%) in the plants and high unplanned break down (14%), only 5% satisfaction level for replenishment orders. Despite of strong challenges the factory will face from the world class sugar industries to compete in the global market, the efforts that the factory is making towards improving its maintenance management is not in good condition. Even though, the cost increment could be contributed with other factors, the main one is from the improper maintenance and maintenance management systems which the factory should overcome so as to be competitive at international market.

By adopting the best maintenance management functions, the factory benefits improved in-terms of plant availability, forced down time, operational and maintenance costs, improved profitability and enhanced productivity of the company. Metehara Sugar factory has been experiencing ever increasing maintenance cost over the past five years. This has prompted management to look for a sustainable solution to this ever nagging problem. Metahara Sugar Factory has its own sugar estate with work unit divisions of Factory and Logistics, Agriculture and Overhead. The factory and logistic division comprises three departments such as technical, sugar processing and general utilities. The technical department is responsible for the overall machinery maintenance be it is electrical or mechanical as well as simple spare part fabrication and reconditioning works.

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Since five years the maintenance in MSF has been a challenge. Although some progresses have been made in maintaining equipment in the factory the result achieved is not yet satisfactory. The factory has still encountered considerable problems, like higher down time, increasing operation and maintenance costs, reduced productivity and efficiency in the plants that prohibit the factory from obtaining enough profit. Thus Maintenance is still a challenge due to factors such as materials, technology and workforce, complexity, management and etc. Today's maintenance practices should be market driven, in particular for the manufacturing and process industry just like MSF. Because of the exorbitant nature of maintenance costs, they represent the greatest potential short-term improvement. Downtimes, scheduled maintenance downtime, and traditional maintenance costs such as labor, overtime, and repair parts are generally the major contributors to abnormal maintenance costs within the plant or factory. The dominant reason for this ineffective management is the lack of factual data that quantify the actual need for repair or maintenance of plant machinery, equipment, and systems. Maintenance scheduling has been and in many instances on the actual failure of plant equipment. Until recently, middle and corporate level management have ignored the impact on sugar quality, production costs, and more importantly on bottom-line profit.

To alleviate these problems and enable the factory to be cost efficient and improve its quality, proper maintenance management functions have to be redesigned and implemented at Metahara Sugar Factory. The significance of the work is to make the factory competitive in terms of cost effectiveness and quality wise through improved maintenance and maintenance management, skilled workforces, proper maintenance planning thereby enhance productivity as well as improve profitability of the company that contributes a lot to the development of the country. The general objective of the study is to survey the current status and challenges of the factory maintenance management functions and to recommend methods that can improve its asset utilization.

II. Research Methodology

A. Research Methodology

The focus of the research work is to identify the trends, challenges and prospects of maintenance management functions of Metahara Sugar Factory (MSF) and recommend better maintenance management functions to improve productivity. The methodology was followed to come up with reliable results, collecting data on the current maintenance management practices, manpower organization plan, production constraints. The down time, critical machinery breakage, technicians training were believed to indicate the appropriate maintenance functions Various survey methods were used to assess the current situation of MSF.

B. Source of Data and Sampling Procedures

Literature survey, both primary and secondary data were used for the analysis. Primary data were obtained by means of questionnaire, interview and physical observation/case study. Secondary data sources were collected from documents such as annual report, maintenance schedule, and logbooks. All the data required for the research work were identified and collected through communication to the targeted group of technical personnel. Structured and non structured questionnaires were supplied to pertinent technical crew to collect the data. Physical observation and case study were also carried out on some critical maintenance personnel, machines and equipment to see their current status. Similarly, ten years annual reports, maintenance schedule and logbook were reviewed to have persistent and reliable information.

C. Instruments of Data collection

In this study, the instruments used to collect the data were survey questionnaires, interview and document analysis which are described under the following sub sections.

D. Literature survey

To be familiar with the concepts of maintenance function, maintenance management system and key performance indicators, improvement, literature review was carried out. Articles and journals are also reviewed to reinforce the current maintenance practices of the factory.

E. Survey questionnaires

The researcher designed survey questionnaires for assessing the maintenance management system in the company. The questionnaires were prepared in two parts; one for all levels of workers but the second did only for employees from foreman to managers' levels of logistic, maintenance, operation, and engineering crews. The former questionnaire was distributed to the management, maintenance department and production department. Totally 72 questionnaires were distributed to maintenance department, production department and management, out of which 71 questionnaires were retuned (98.5%). The selection was partially focused and partially random. Department and division heads were deliberately selected. Line supervisors, chief engineers and foremen were deliberately selected. Some workers have been preferred to the response to be in interview form, they were interviewed. Others filled the questionnaire. The second was developed for positions of foreman and above. The questionnaires contained two types of answers. The first type used a normal scale, Yes or No and the second type a comparative percentages which represents scale like best practice, good, some improvement required, fairly major improvements possible , poor major improvements require, extremely poor (none existent).

F. Interview (Structured and Unstructured)

Structured interview was conducted with concerned different managers of sections, division, maintenance, foreman and senior personnel of the factory that was designed to get necessary data for the study. The interviewed workers of the factory are concerned department, division and section heads.

G. Documentation

During document analysis the researcher has gone through company profile, factory organization chart, maintenance organization chart, work request books, repair books, monthly and annual performance reports and others relevant documents and formats.

H. Physical observation/case study

Physical observations/case studies were carried out to see the maintenance management system on some critical equipments or working stations. From the physical observation of the maintenance system, it is understood that different sections of the factory follow different maintenance processes. Among the sections, which were focused on during the physical observation include:

- Preventive and Power Generation Section,
- Fabrication Work Shop (machining, welding, forging, forming, and casting),
- Mechanical Workshop,
- Corrective Maintenance and
- Instrumentation Sections.

The researcher used this method in order to prove the persistency reliability of the data collected by means of other instruments.

Additionally Work measurement techniques and work Sampling were used in order to determine Hand-on-Wrench time.

I. Methods of Data Analysis.

Different methods were used for the analysis of the data as the nature of them was varying depending on the collection methods. The data were organized, coded, leveled with weight as (best practice, good, fair, poor and non-existent). Data from questionnaire and interview were analyzed by means of computer software i.e. Microsoft Excel and Statistical Package for Social Sciences (SPSS). Data from labor productivity was measured and analyzed using work sampling methodology and wrench time analysis. Work sample, Work order performance analysis and Pareto's principle also used. Additionally, statistical methods (inferential) were used to summarize or describe a collection of data.

III. Data Presentation And Analysis

The maintenance procedures of the factory pass through the following steps.

- Request →approve →execute →transfer or handover to operation→ feedback (work request book).
- Request →approve →perform →transfer or handover (orally or not written).

A. Analysis of Data from Questionnaires

Data from questionnaires are analyzed and summarized in the coming subsections. A summary of the date is followed by a corresponding organized table for the majority of sub sections.

Data Summarized on Maintenance Organizations

Assessment of factory maintenance organization has been done and summarized data shown in Table 1. Major question (S.No. 1,3,4,7,8) reveled that the factory organization chart were incomplete and obsolute.The is no maintenance planner and maintenance enginners in its formation and also developed many years ago. Detailed job descrtions were avilable only for line supervisors and above positions. In the factory set up a maintenance supervisor was expected to oversee more than 16 maintenance tehnicians. Even though the maintaince organization motivation level and reponsibilities were still good. The factory shop/work area, quality and quantity of tools and equipements were in poor condition. Yet the spirit of cooperation between plant management and labor was fair.

Rating A – Perfect (world standard) B – Good (few improvements required) C – Fair (major improvements possible) D – Poor (major improvements required)
E – Unsuitable or Nonexistence (No)

Similar study has carried out for the other cases also.

Table I
Assessment of MSF Maintenance Organizations

S.No	Item	Frequency									
		A		B		C		D		E	
		NoR	%	NoR	%	NoR	%	NoR	%	NoR	%
1	The maintenance organizational chart?	12	17	12	17	36	**51**	11	16	-	-
2	Job descriptions are available for:	36	**51**	4	5.7	3	4.3	29	**41**	-	-
3	Maintenance supervisor to maintenance employee ratio:	16	23	4	5.7	3	4.3	47	**67**	-	-
4	Maintenance planner to hourly maintenance employee ratio:	4	**5.7**	10	**14**	5	**7.1**	-	-	49	**70**
6	Maintenance shop/work area arrangements	1	**1.4**	27	**39**	17	**24**	23	**33**	1	**1.4**
7	Quality of Maintenance tools:	2	**2.9**	22	**31**	14	**20**	32	**46**	-	-
8	Maintenance equipments quantity:	3	**4.3**	12	**17**	30	**43**	28	**40**	2	**2.9**
9	The spirit of cooperation between plant management and labor	1	**1.4**	36	**51**	-	-	33	**47**		

IV. Results And Discussion

A. Maintenance Organization

From the results of (questionaries, interviews and documentation on factory maintaince organization), the factory organization chart were incomplete and obsolute. There are no maintenance planners and reliability enginners in its structure and it is also obsolete. Detailed job descriptions were avilable only for line supervisors and above positions. In the factory set-up a maintenance supervisor was expected to oversee more than 16 maintenance tehnicians. The maintaince department motivation level and reponsibilities were still good. The factory shop/work area, quality and quantity of tools and equipements were in poor condition. The percentages of maintenance personnel detailed for work on incentive-plan based on output were good, yet the spirit of co-operation between plant management and labor was fair.

World best practice recommends for a processing factories maintenance organization to have current and complete structure that has maintenance manager, maintenance supervisor, maintenance planner, and maintenance engineer to fulfill the demand of the factory. During organization stage authority, responsibility and specialization also should clearly be stated. For a large factory just like MSF, it should have and dispatched detailed Job descriptions for all positions to all areas in the factory with reasonable overlap. The supervision density should increase for maintenance crafts from 8 to 12. The factory shop/ work area, quality/quantity of tools, quality/quantity of equipments should be world class. The sprit of cooperation between plant management and labor should be excellent. The maintaince organization motivation level and reponsibilities should be world-class[3-5].

For the factory which does not have maintenaince planners , the factory lacks many benifits of planning. Therefore planning, scheduling and co-ordinating corrective and preventive maintence activities suffer. For this case a good indicator in MSF was the factory work requests books in 2010/11 campain year. More than 7568 work requests were generated, more than 80% of them were reactive and more than 95% were tagged urgent . According to world best practce (Terry W.), the percentage of reactive request should be lower than 10%[5-9]. Therefore MSF is in reactive maintenance practices.Estimates show that planned work verses unplanned work may have a cost ratio as high as 1:5. Metehara sugar factory has spent a total 462.5 milion birr for the last five years out of these these an amount more than 370 million birr were spent for tecnical or maintenance departement. Therefore around 296 million has been spent westfully.The reactive situation affect hands on wrench time ,uptime, worker motivation, material consumption, etc. Moreover according to Terry[8], one third of all maintenance expenditure are wasted becouse of inefficient and ineffective utilization of the maintenance resources.

Regarding to maintenance tools and equipments, the factory doesn't have proper and sufficient numbers and types. According to John C. Robertson (Abandoning adjustable wrench mentality) Maintenance personnel are often frustrated when they lack the proper tools and training needed to produce professional results. Therefore this may be the reason for lack of motivation.Evaluating the motivation level in the maintaince organization, it was found to be fair , a lot of factors are responsible among them is the reactive situation of the factory. This is the status in MSF.

Maintenace is not planned and scheduled in advance, hence many unplanned activities will be predominats such as down times and poor work order systems, additionally the supervisors become overloded by overseaing more than 16 technicians and planning activities are also expected from them .

Absentee rate has reached till 18 % in the factory in 2006/07 even though the average for the last five year indicates 9.2% which is higher than industrial average A high or varying absentee rate can be a signal of *low worker morale* and should be tracked. In addition, a high absentee rate can have a significant economic impact. On specific weeks (Nehase 18-Nehase 26, 2003 local) the absenteeism reaches to 24%. According to the CCH Unscheduled Absence Survey, employers have failed to make significant headway against the costly absenteeism problem that takes billions of dollars off the bottom line for U.S. businesses. The nation's largest employers estimate that unscheduled absenteeism costs their businesses more than $760,000 per year in direct payroll costs, and even more when lower productivity, lost revenue, and the effects of poor morale are considered [10]. Therefore MFS has spent many millions due to absenteeism.

In annual reports (2005/06 to 2008/10) of the factory Staff turnover was presented as a major problem – High turnover rates are also a sign of low worker morale. Significant costs are incurred in the hiring and training of new staff. Other costs include those associated with errors made by newly hired personnel that normally would not have been made by experienced staff. Morale can be the fuel that drives an organization forward or the fuel that feeds the fires of employee discontent, poor performance, and absenteeism. With low morale comes a high price tag. The Gallup Organization estimates that there are 22 million actively disengaged employees costing the American economy as much as $350 billion dollars per year in lost productivity including absenteeism, illness, and other problems that result when employees are unhappy at work.

Leaders who fail to address morale issues in the workplace face the following: decreased productivity, increased rates of absenteeism and associated costs, increased conflicts in the work environment, increased patient complaints and dissatisfied consumers of care, and increased employee turnover rates and costs associated with hiring and training replacement staff. Therefore the factory has lost a sizable amount of money due to poor leadership.

If you work in a highly reactive maintenance organization you will be trapped in a circle of despair and you are wasting too much time on doing the wrong things. A circle of despair is when you have to react to a problem on a short notice. You then have to correct the problem as fast as possible; the quality of the correction will then be less than perfect. This leads to poor work and has to be repaired again and this circle of despair will continue and absorb all time you could have used to do the right things.

B. Preventive Maintenance

The majority of work order are generated after failure and tagged urgent. In a Proactive Maintenance environment, PM activities should account for approximately 30% (20-40%) of total maintenance resource time. but in MSF it is less than 5%.

Additionally the ratio of PM actions to Corrective Maintenance actions to determine effectiveness of your PM program 6:1 but in MSF it is 1:1 for the majority of equipments even for the critical one like juice pumps,

According to bench mark index, the percentages of PM actions to the percentages of Reactive Maintenance ones should be 80:20, but in MSF 10:90 the reverse. The percentages of PM down time to total should be greater than 8 percentages but in MSF less than 1%. Exclusive interview with PM Head minimum result 55 out of 85. But MSF was 27.5. It implies that PM needs major improvement

According to Joel, Levitt and Terry through well developed and implemented PM, 26% possible savings of maintenance budget by PM improvement and correction of PM . It consume less energy (< 6-11%) (Joel), additionally from 5 % to 20% saving on energy bills can also be achieved through proper PM (Hunt). Highest saving in energy also obtained in MSF in 2007/08. Result of effective PM to PDM shows poorly ones it is also an indicators of Reactive/breakdown Practices.

Therefore all the maintenance practices can be concluded as predominantly reactive. Without successful PM programs, maintenance can react to given situation (Terry).

The maintenance organization can be summarized.

- The maintenance department is not given the relevant attention it deserves, as it is one of the main areas for resource efficiency and enhancer of profitability.
- Organizational structure shows there are no maintenance planners and maintenance engineers in the organizational structure (Appendix P and Appendix Q). Therefore maintenance planning and engineering has suffered.
- The supervisor/worker density is too high, hence results in overloading of supervisors.
- Quality and quantity of maintenance tools and equipments are at very low level. These hamper maintenance effectiveness and efficiency as they also negatively affect worker morale and uptime. This affects moral, labor productivity and panning efficiency.
- The spirit of cooperation between plant maintenance and labor is fair.
- A sizable amount of money (around 296 million) has been spent due to the current maintenance practices.

V. Conclusions

- In MSF maintenance is perceived as a “fix it when it breaks” function. Unless the maintenance organization works with a proactive list of goals and objectives, it will always be sub-optimized.
- With the existing maintenance function /practice (organizational structure and assets (labor force, tools, and equipments)), planning, scheduling and maintenance engineering have suffered to a higher degree. The main contributors are the maintenance organization, maintenance training program, currently running work order system, reactive maintenance practice, the inventory management, the operation/ facility involvement, incomplete data recording (documentation) and reporting, inefficient utilization of CMMS, lack of reliability engineering. Therefore the factory maintenance practice has been reactive, as the majority of the work order generated from breakdown or failure.
- In MSF, the lack of technical and managerial skills has restricted the deployment of maintenance resources and increase the overall cost of maintenance 13% per year.
- Reactive maintenance practices costs the factory in labor productivity and overtime. Through proved planning methods the factory could have been benefited 1,127,472 hours at a cost of planning or saved more than 150 million birr since 2005-2009/10.
- Having the current WO system, maintenance resources (labor & material) cannot be planned, traced and controlled at equipment level and make historical data analysis and take corrective action. Therefore it paves the way for reactive maintenance and maintenance resource wastes.
- Less attention and support has been given for PM and PDM. Less than 0.1% planned down time, lack of trained manpower, lack of tools and equipments and etc lay the ground to unplanned maintenance practice and aggravate the situation. When Better attention to PM was given, more benefit came to the factory.
- Without a well-orchestrated maintenance program, catastrophic equipment failures cannot be eliminated.
- Lacking the contribution of operation and facility involvement, maintenance has been forced to react to breakdown and failures.
- Less attention and support for inventory control ,ordering too much, predominantly over stoking (without maximum and minimum levels) as a means of fulfilling material requirements, inaccurate data recording and poor handling have been common In MSF.
- Without clearly, accurately and consistently tracked downtime, maintenance and all other contributing costs (e.g., energy, quality, contractors) for all assets at equipment level, maintenance wastes cannot be perceived by top management and other stake holders and controlled.
- Having CMMS package is one step towards improvement in maintenance management, but utilized it only for downtime and its cause analysis only is a waste.
- Without well developed and implemented PM and PDM, Reliability Centered Maintenance is inexistence.
- Having insufficient and inaccurate recordkeeping maintenance is going to fully meet its responsibility.
- Cost recording and comparison system is not established at all in MSF. Absence of cost recording and analyzing is the main cause that most of the enterprises units, machines and plants, are utilized in the condition of incurring high operation and maintenance cost.
- Lack of necessary and accurate maintenance-cost information or cost histories (all labor, material, contracting, and other miscellaneous costs) at the

equipment level has hindered the factory to track engineering information such as life cycle cost information. Such information helps in Purchasing, maintenance budgeting.

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