Preventive Maintenance Work Order Optimization

Rosemarie Alcocer Sánchez
Engineering Management Program
Héctor J. Cruzado, PhD, PE
Graduate School
Polytechnic University of Puerto Rico

Abstract *— In the bio-pharmaceutical industry, maintenance is required to ensure equipment functions properly. Maintenance can be defined as activities performed on an equipment to ensure it functions with-in specification and established functionality; whereas, preventive maintenance is conducting these activities preemptively to reduce breakage. Increases in the number of preventive maintenance work performed on equipment have led to increases in the indirect maintenance cost prompting the maintenance department of a bio-pharmaceutical company to request an evaluation of the program. An analysis of the maintenance data led to the conclusion that applying preventive maintenance streamlining and sequencing would reduce the number of yearly work orders completed and reviewed by technician and supervisor. Furthermore, the maintenance department should promote an evaluation to determine if predictive maintenance would further improve the program.*

Key Terms *— Preventive Maintenance, Work Order Optimization, Scheduling.*

INTRODUCTION

In the bio-pharmaceutical industry, maintenance is required to ensure equipment functions properly. Maintenance can be defined as activities performed on an equipment to ensure it functions with-in specification and established functionality; whereas, preventive maintenance (PM) is conducting these activities preemptively to reduce breakage. Organizations establish a preventive maintenance program to ensure proper equipment functionality, by performing the equipment's preventive maintenance on a schedule basis with a set of instructions. Nowadays, most organizations manage their maintenance via a Computerized Maintenance Management System (CMMS), such as IBM Maximo, SAP PM, Fiix or Hippo CMMS to name a few.

For this current project, the company manages its maintenance through the IBM Maximo. The IBM Maximo system tracks all work-performed throughout the process beginning with scheduling, follow by execution and finally reviews and closure. Among the information track is type of work performed, hours spent working on the equipment, spare part usage and review time. This information is useful as it can be analyzed to determine areas of opportunities in cost, time spent and maintenance inventory usage.

Recently, the maintenance department of a bio-pharmaceutical company in USA has noticed an increase in the number of preventive maintenance work performed on equipment. These increases in the number of preventive maintenance work performed on equipment have led to increases in the indirect maintenance cost. Due to these increases, the maintenance department wants to conduct an analysis on the preventive maintenance program. The objective of this paper is to reduce the number of yearly preventive maintenance work orders.

BACKGROUND

Preventive maintenance and the optimization of maintenance has been studied and evaluated throughout the years. With these studies, several factors have been observed that impact a successful preventive maintenance optimization program. Any organization looking to optimizing their maintenance program needs to be aware and understand that these factors are important in order to achieve a successful implementation. Factors that impact this preventive maintenance optimization implementation discussed in this paper are organizational culture, maintenance and productions

schedule, over maintenance and new scheduling technologies.

Organizational Culture

Organizational culture is how an organization works and does things. When speaking of maintenance and the reduction of cost, a positive organizational culture is needed as it leads to better employee response and engagement in an environment where employees are working for a common goal. On the other hand, a negative or toxic organizational culture leads to low morale and self-serving employees that will not work to achieve the company's goals. Therefore, a company not only needs means to track work performed/cost, but there also needs to be an organizational culture change [1]. Having a cultural change established, from upper management to operators, provides a progressive way to tackle company's maintenance cost since everyone is involved in providing new and innovative ideas to the different problem areas. This engagement in turns allows for better root cause analysis for maintenance areas such as for equipment critical failure, PM interval, spare parts utilization, and determining when third party maintenance versus developing company resources is preferable and vice versa. This is especially important in companies where there is a low profitability margin since every improvement, especially innovative ones, counts [1].

Manufacturing and Production Scheduling

A company's production schedule is in place to ensure the equipment produces as much productions units as possible; whereas a maintenance schedule is in place to ensure equipment functions with specification and established functionality to prevent breakage. Most maintenance and production managers see the importance of maintaining the production equipment. However, at the time to perform maintenance on equipment production managers are reluctant to release equipment. Not releasing the equipment contributes to under maintenance of the equipment, which in turn leads to more equipment failures. These failures cause an increase in equipment downtime, thereby increasing the cost due to production losses and maintenance repair costs [2]-[4]. This situation can be solved by integrating the maintenance and production schedule [2]. Taking into account the production schedule leads to an effectively maintenance planning; thereby ensuring equipment is maintained properly.

As mentioned above, preventive maintenance is put in place to ensure equipment works properly and reduce breakdowns, especially breakdowns on critical equipment [3]. Aside from a good schedule, the preventive maintenance program needs have the appropriate maintenance resources, specifically personal. This will ensure the preventive maintenance schedule is met [3]. This brings the question of what should be done when maintenance schedule on critical vs non-critical equipment clash. If deciding between doing maintenance on critical vs non-critical equipment arises, maintenance could be sacrificed on non-critical equipment, gaining resources and hours needed to work on critical equipment [3]. This information is crucial because it assists the maintenance scheduler in the decision making process. Furthermore, this information should be stated in the preventive maintenance program documents.

Over Maintenance

Over maintenance is when a piece of equipment is maintained more regularly than needed, serviced several time in a month for different reasons, and/or work performed is not written or optimized. Aside from under maintenance, having over maintenance is problem associated to the preventive maintenance program. Over maintenance is most times overlooked and there is waste associated with it [4]. This waste pertains to misuse of maintenance resources, additional work to review work performed and increase of equipment downtime. Moreover, over maintaining the equipment can introduce additional problems or areas of failures. After analyzing the preventive maintenance program via a case study, it was determined that adjustments in maintenance frequency minimizes waste [4].

New Scheduling Technologies

Performing maintenance must always constitutes taking down equipment. For this reason, equipment maintenance needs to be planned taking into account the condition of the equipment. Never is this so pressing as when the equipment involved is highly critical or affects most of the production area. New mathematical algorithms and programing have been developed to better address conditional monitoring and scheduling. Linear programming with fuzzy objectives can be utilized to establish new techniques that engineers and maintenance personal can use to improve the maintenance of equipment and monitoring tools [5]. It is essential that any organization is aware of new scheduling technologies that are being studies and implemented, as these will provide additional tools to continue the process improvement of the maintenance program.

ARGUMENTS AND ANALYSIS

The first step in this project was to establish the requisites/parameters. In order to provide an effective assessment and implementation, preventive maintenance program evaluation was narrowed to one manufacturing site. Furthermore, the project focusses on the maintenance work groups that performed preventive maintenance work in the manufacturing area. The project evaluation does not contain information from work performed for facilities (i.e. utilities) or site operation (i.e. office space) maintenance groups. These parameters were established to center the information with maintenance and manufacturing, capture areas of opportunities and implement in an agile way. Additionally, having a pilot implementation assist in obtaining lessons learned in order to improve execution at other sites.

In order to analyze the current equipment preventive maintenance program, several reports were created to extract the data from the IBM Maximo system. The search criteria for the reports were established based on the parameters determined for the project. Data extracted from the system included, total of manufacturing assets (equipment), preventive maintenance schedule for these assets, and instructions on the maintenance performed. As shown on Table 1, the evaluation determined that a total of 957 manufacturing equipment/assets were impacted. These assets have a total of 1513 preventive maintenance schedules to go to the assets and performed work.

Table 1
Number of PMs tied to an asset

Number of PM/Assets	Number of Assets	Total of PM to Schedule
1	565	565
2	245	490
3	142	426
4	1	4
5	1	5
6	1	6
7	1	7
10	1	10
Total	957	1513

When conducting the data analysis, it was observed that out of the 1513 preventive maintenance to schedule, 1186 had either no clear set of instructions on how to perform the work, or the instructions were unclear. This led to recurring interviews with technician, planners and supervisor to obtain the data. Even though this finding caused a delay to the analysis, it was necessary to gather the necessary data to properly evaluate areas of streamline and sequencing to achieve the work order reduction.

RESULTS

After the evaluation of the current preventive maintenance program and the CMMS system it was determined that preventive maintenance streamlining and sequencing was the best option to reduce the number of yearly preventive maintenance work orders. Preventive Maintenance (PM) streamlining focuses on the reduction of maintenance costs by eliminating waste; were waste is anything that is performed during maintenance that does not add value. PM Streamlining was chosen because information gathered via the interviews showed that technicians were performing non value added activities such as wait time, transit

time and inadequate repairs due to lack of clear and precise instructions. PM sequencing is the scheduling of multiple levels of maintenance work at a set frequency. PM sequencing was chosen because the maintenance for these assets is repeated on a monthly, quarterly, semi-annual and annual timeframe. Based on this decision, a total of 392 assets PM schedules were updated. The update in the schedule of the assets saved technicians and supervisors a total of 1884 work orders to execute and review, respectively. Additionally, 1186 PM work instructions were added to the CMMS system which reduced transit time and provided a better tool to adequately work on equipment.

After updating the PM in the CMMS system, an addition/update/removal process was developed in order to maintain reductions achieved and ensured that new equipment was properly entered and the right preventive maintenance work was performed. The process consists of having the user complete a new established maintenance form which contains the basic information of the equipment and action. The form is then reviewed by the maintenance planner, which is the subject matter expert. The planner determines the preventive maintenance work that needs to be added, updated and/or removed based on information provided on the form. Finally, the information is added/updated or equipment inactivated (removed from service) from the CMMS system depending on the request. Because of his expertise, adding the planner to the process was crucial, as he/she is the person best fit to determine appropriate PM work, frequency and sequencing.

REPORTS AND KPI

Throughout the progress of this project, several reports were created and updated to review changes made and determine work order reductions. After all changes were completed in the system, a forecast report was generated to review and compare the new schedule with the previous schedule. This report determined that a total reduction of 1884 work orders what achieved. This forecast report is now part of the process to determine amount of work expected throughout the year. Additionally, the report shows when assets have more than one PM and it is not utilizing the sequencing process in place. One other report was created for review purposes of added or updated PM in the system. This report provides the information required for the planner to check that when assets PM instruction or sequencing are updated, it is done in accordance with information provided in the addition/update/removal form.

To finalize the process, a key performance indicator (KPI) was established to see right the first time execution. This KPI measures the addition/update/removal of equipment from the system and how many where completed correctly. This KPI is aligned with the company goal of first time pass, which measure the number of documents or batches that made it through a process with no errors.

CONCLUSION

As it has been shown, proper maintenance is required to ensure equipment functions with specification and established functionality. However; inadequate scheduling, unclear set of instructions, and over maintenance can lead to an increase of waste, thereby increasing the direct and indirect cost of maintenance. Based on an evaluation of the current preventive maintenance program and the CMMS system, it was determined that preventive maintenance streamlining and sequencing was the best option to improve the preventive maintenance program and reduce waste. These improvements led to the reduction of number of yearly preventive maintenance work orders performed and reviewed by technicians and supervisor by 1884 work orders. Throughout the project, one major gap was encountered. A large amount of preventive maintenance work had no clear set of instructions. In order to be able to successfully

continue the project, additional time was taken to interview the technician, planners and supervisor to fill the void. Furthermore, in order to keep improving the maintenance program, evaluation should be done to review benefits that could be achieve by changing preventive maintenance work with predictive maintenance work.

REFERENCES

[1] Knoedler, Heather and Delotto, Bob. "Cost Reduction Strategies for Equipment Repair and Maintenance." CS MANTECH Conference (2014), p.57-60.

[2] Cassady, Richard C. and Kutanoglu, Erhan. "Integrating Preventive Maintenance Planning and Production Scheduling for a Single Machine." IEEE Transactions on Reliability, Vol. 54, No. 2, JUNE 2005, p. 304–309.

[3] Hasnida Ab-Samat, Livendran Nair Jeikumar, Ernnie Illyani Basri, Nurul Aida Harun and Shahrul Kamaruddin. "Effective Preventive Maintenance Scheduling: A Case Study." Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management Istanbul, Turkey (2012), p. 1249–1257.

[4] Anderson, Deryk. "Reducing the Cost of Preentive Maintenance" Oniqua Enterprise Analytics (2002), p.1-14.

[5] Sittithumwat A., Tomsovic, K. and Soudi, F. "Optimizing Maintenance Resources in Distribution Systems with Limited Information." Elsevier B.V (2003), p. 208–220.