Process Improvement for Machinery Equipment Preventive Maintenance in Olefins Production Plant

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ABSTRACT: The aim of this research is to develop and improve the implemented Preventive Maintenance (PM) process at a Petrochemical Company. The Total Productive Maintenance (TPM) concept is applied to solve the problems of high variance times and unbalanced monthly man-hour utilization in the process. The results of this research were a reduction in variance time and improved balance of the man-hour utilization. The improved PM process resulted in PM plan compliance of 95.52%, hence, achieving the Key Performance Index (KPI) of 85% or more set by the business.
KEYWORD: PM; Maintenance Process; TPM; Variance; Man-hour Utilization; Improvement

1 INTRODUCTION

The maintenance efficiency is recognized as one of the primary factors affecting the performance of manufacturing industries. This research was conducted in one of olefin plants of the biggest petrochemical manufacturing company in Thailand, operating in continuous-production process. The objective of the research is to improve the preventive maintenance (PM) process of machinery equipment. In 2013, the preventive maintenance in the machinery groups of the plant achieved only 41.68% of the plan. This was the lowest plan compliance as compared with other equipment groups as shown in Figure 1. Therefore the plant has set a new monthly target of preventive maintenance with plan compliance of at least 85%. The description of machinery equipment types and the PM activities are shown in Tables 1 and 2, respectively.

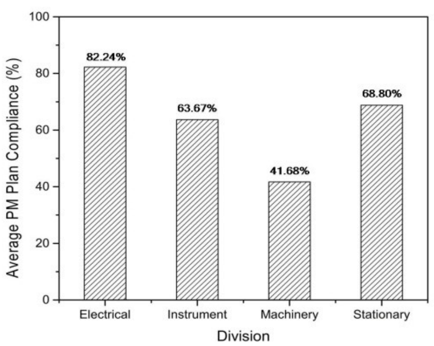

Figure 1. PM plan compliance compared with other equipment.

Table 1. Machinery equipment.

Equipment	Amount of Equipment
Pump	223
Steam Turbine	56
Blower	14
Compressor	36
Cooling system	6
Accessory	316

Table 2. PM activities for machinery equipment.

PM Activity	Amount of PM	Std. Time (Hrs.)
Change Lube Oil	180	2
Change Lube Oil and Inspection	10	3
Change Lube Oil and Clean	76	2
Change Lube Oil and Hydraulic Oil	2	4
Change Lube Oil and Grease	18	2
Grease Service	29	1
Grease Service and Inspection	3	1
Check Governor Linkage	24	3
Clean Suction Strainer	30	4
Inspection	12	3
Inspection Diaphragm and Clean	4	4
Over speed Trip Test	19	3
Others	54	2

Two of the main problems to be addressed by an improvement process of PM works are the high variance time and the unbalanced of man-hour utilization. In the case analyzed by this study, the variance time in the execution work (defined as time delay between the planned start and actual start of work) as compared to the PM plan schedule, was 445 $hours^2$ in the average. Additional data analysis of maintenance time recorded by technician after completion of the work in the SAP system used by the business for PM management showed that, the variance of the working time for process completion (defined as time lag between the factual completion of work and the date on which the work was confirmed in the system as completed) was 1,383.53 $hours^2$. These variances are considered to be very significant. To address this and to give recommendations for improving the PM process of machinery equipment, this research applies the Total Productive Maintenance (TPM) theory.

2 LITERATURE SURVEY

2.1 *Maintenance Management*

Prasanma & Desai (2011) applied several management and maintenance tools to the petrochemical industry, e.g. Quality Circle, Kaizen, Reliability Centered Maintenance, Risk-Based Inspection, Root Cause Analysis, Total Productive Maintenance and Total Quality Management. They suggested that management and maintenance efficiencies were based on the purpose and functions of the organization.

2.2 *Total Productive Maintenance (TPM)*

The Total Productive Maintenance is a concept to improve the maintenance process by involving of everyone in the organization. The maintenance activities play an important role in indicating the reliability of the production system. In general, industries that require high production efficiency must have manufacturing process control, production quality control, cost control, delivery, safety and continuous development of staff skills (Sangbangpla, 1995). TPM is maintenance method that is developed to improve the maintenance procedure continuously. The purpose of TPM is to increase the work of the people involving with the machines in terms of maintenance, engineering and manufacturing (Raadnui, 2002). The principle of TPM consists of 8 pillars focusing on the production performance of maintenance, e.g. focus improvement, autonomous maintenance, plan maintenance, training and education, early management, quality maintenance, office TPM, safety health and environment.

2.3 *Maintenance Planning and Scheduling*

The preventive maintenance can increase the production (output) with zero failure, zero defect and zero accidents and at the same time can also reduce the cost in the maintenance process. Furthermore, proper planning and maintenance scheduling can reduce overtime working and backlog which means that more time remain for the PM process. Planning is the process of defining the necessary maintenance resource and estimating the needed man-power, materials and equipment. Scheduling is the process of determining the maintenance starting time and duration of time by using appropriate man-power, materials and equipment (Chutima, 2012).

2.4 *Literature Review*

Frost & Dechter (1998) proposed a method to prioritize the maintenance of power plants by applying the condition or regulation to solve the problems, then finding a way to fulfill the criteria. This method is called CSPs (Constraint Satisfaction Problems) and can be applied to solve problem where the minimum cost is the condition of the experiment. The iterative learning can be used to find out the sequence that results in a minimal cost. However, there are limitation in amount of works needed to ordering the priority since the CSPs is kind of problem that need the continuous experiment and research to find out solutions. The complexity and amount of data will result in longer time CSPs needed to solve those problems.

Moghaddam & Usher (2010) proposed a method of ordering and replacing the maintenance work to find the sequence of work, with the lowest cost and the highest system reliability. Dynamic programming is a solution approach by breaking down problems into smaller components. This dynamic programming was normally used only on small problems. In order to use it, to solve large problems, the results from experiments have shown that the Genetic Algorithms (GAs) can be applied to sort out the best appropriate sequence defined in this case Pareto optimal which is the relationship between maintenance cost and reliability of the production system.

Siener and Aurich (2011) proposed guidelines for ordering the sequence of maintenance work using the product quality product as the objective applying Artificial Neural Network (ANN) model to predict the influence of the machine on the quality.

3 RESEARCH METHODOLOGY

3.1 *Process PM Improvement*

As one of the PM process problems was high variance time in the execution phase which is 446.60 $hours^2$, as compared to the PM plan schedule. This research applied the focus improvement approach from the Kaizen theory to give recommendations how to improve the work flows in the PM process; the recommendation were structured using the 4 steps of the Deming cycle theory, i.e. Plan, Do, Check and Action for continuous improvement and development.

Plan: Schedule the PM works and manage the resources related to the scope of works in each month i.e. man-power, materials, master plan of equipment running, etc. Then inform those works to technicians one week in advance. Nevertheless, technicians must prepare work permit and submit it to the planner for reviewing and making a commitment work.

Do: This relates to developing and testing potential solutions. A common problem found in this step is the communication among the team members. In order to solve this problem, the meeting of all involved employees, e.g. planner, shift manager of operation, technicians and stand by man needs to be set up. During this meeting, the planner has to summarize and present the approved works and communicate the agreed work plan to all related parties approximately one week in advance. The production, maintenance and safety department should fill in the form of commitment before starting the planned works.

Check: After the work has been finalized, the planner should gather and check the filled-in hardcopy work permits with the data entered by the technicians into the system to verify whether the actual works carried out, comply with the approved works as PM schedule.

Action: The target of this step is to find the appropriate solutions and take corrective action, if the actual works differ significantly from the PM plan. In the particular case analyzed in this study, the recorded variance time between a job finished and input data in the SAP system as completed was 1,383.53 hours^2. This variance can be reduced by strict compliance with the implemented work permit system and maintenance management procedure monitoring of related KPI of PM plan compliance.

3.2 *Planning and Scheduling*

Resulting from lagging of the PM works, the variance working time was about 446 hours^2. This can be reduced by improvements in the planning process. A common problem in the planning process in the past was inaccuracy and unbalanced man-hour utilization throughout the year. To solve this problem, the planner must consider the varieties of PM works and equipment needed before establishing working schedule for technicians. The different PM workload in August - December in 2014 is shown in Figure 2. In order to improve PM schedule, the planner must take into account the working conditions required by operations and maintenance units, i.e. the staff capability, the interval time of PM works, the compatibility of PM plan and the equipment switching plan. If the scheduled PM plan can be executed on time, the planner would be able to adjust PM workload to balance manpower. The PM workload which considers the conditions of individual task and responsibility is shown in Figure3.

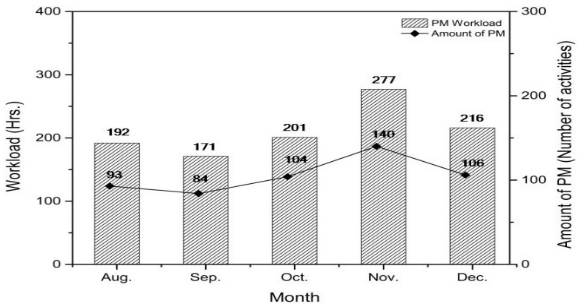

Figure 2. PM workload in August-December 2014.

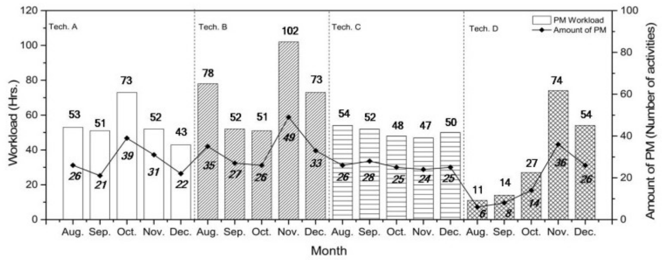

Figure 3. PM workload by technician before PM schedule improvement.

4 RESULT OF RESEARCH

4.1 *Variance Time of PM Process*

After applying the proposed approach to commitment process, there is a better communication in maintenance process as all participants could receive accurate information regarding the planning in advance. This resulted in reduction of the variance time of PM work initiation. Further, the recorded data in the SAP system was more accurate as shown in Table 3. As result of the PM process improvement, the variance of PM initiation was decreased from 446.6 to 21.26 hours^2 and the working time for process completion from 1,383.53 to 261.57 hours^2. The achievement of the PM plan was 95.52%, hence achieving the KPI of the business (85% or more).

Table 3. Variance time after PM process improvement.

Variance type of PM process	Time (hrs^2)
PM work initiation compared with PM schedule plan	21.26
Variance of working time for process completion in the SAP.	261.57

4.2 *Man Hour Utilization*

An analysis of the PM works for machinery PM, some of activities could not be executed as planned due to the fact that the interval time of PM works conflicted with the operating equipment plan. A PM scheduling improvement was performed taking into consideration both plans as well as the manpower capability and conditions of operation process.

The result of the improvement is shown in Figure 4. An improved man-hour utilization plan is shown in Table 4 (assuming that all activities consume equivalent man-power per job). While the average man-hour utilization before improvement in 2013 was 15.70%, after improvement this could be significantly increased the average estimated utilization in August-December 2014 is to 31.70% achieved by PM scheduling improvements is shown in Table 5.

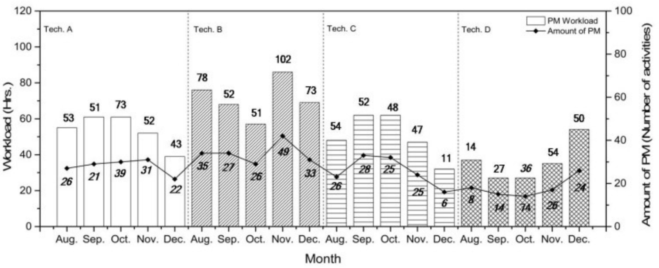

Figure 4. PM workload by technician after PM schedule improvement.

5 CONCLUSION

Based on the results of this study, the key success factor in PM management is the strong commitment of all involved parties to the PM plan. Sufficient information is needed to develop a proper PM plan and to achieve better systemic working environment. Coordination and cooperation between all participants as well as timely exchange of information among all involved departments is an important prerequisite to achieve PM management improvement in organization. It is beneficial to stipulate the new working process with all responsibilities and due dates in procedure to ensure that the PM process has been clearly understood and accepted. In summary, the implementation of the PM management improvements discussed in this study resulted in PM plan compliance of 95.25% and man-hour utilization 31.70% respectively.

Table 4. Percentage of man-hour utilization by technician after improvement.

2014	% Man-hour Utilization by Technician				
	A	B	C	D	Average
Aug.	33.13	47.50	30.00	23.13	33.44
Sep.	34.66	39.20	35.23	15.34	33.11
Oct.	34.66	32.39	35.23	15.34	29.40
Nov.	32.50	53.13	29.38	21.88	34.22
Dec.	24.38	43.13	20.00	33.75	30.31

Table 5. A comparison between the man-hour utilization in 2013 and 2014.

Month	% Man-hour Utilization	
	In 2013	In 2014
Aug.	17.15	33.44
Sep.	19.51	33.11
Oct.	19.26	29.40
Nov.	11.06	34.22
Dec.	11.54	30.31
Average	15.70	31.70

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