Assessing the Integrated Computerized Maintenance Management System of O&M Company for Combined Cycle Power Station

Asia Pacific Journal of Multidisciplinary Research
Vol. 3 No.5, 119-126
December 2015 Part II
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com

Rocel D. Gualberto
Department of Mechanical Engineering, Batangas State University, Gov. Pablo Borbon Campus II, Alangilan, Batangas City, Philippines, 4200
rocel_gualberto@yahoo.com

Date Received: November 27, 2015; Date Revised: December 22, 2015

Abstract - *This study sought to describe and assess the integrated Computerized Maintenance Management System applied by an Operation and Management (O&M) company to a Combined Cycle Power Station and come up with possible enhancement activities based on the results of the evaluation. The integrated Computerized Maintenance Management System is an electronic database which provides a powerful tool to deal with mechanical maintenance problems. It is a comprehensive approach that directs the maintenance personnel on what specific activity is to be applied on the equipment. The maintenance program was evaluated in terms of the maintenance organization, maintenance activities, spare parts and procurement, management assessment, program review and record keeping. Key performance indicators such as availability, reliability, efficiency and percentage of breakdown maintenance of the combined cycle power station were evaluated and measured the effectiveness of the maintenance program. The proposed enhancement activities would remediate the identified weak points of the maintenance program.*

Keywords: *availability, reliability, efficiency, breakdown maintenance, combined cycle power station*

INTRODUCTION

Operation and maintenance over the years have been treated in many different ways depending on how important management has considered these activities to be. Maintenance can be defined as a systematic action that would ensure the long term quality of production, while the regular daily operation routines should ensure quality in the short term [1]. The quality of the maintenance program is probably the best indicator of good management. Effective operation and maintenance require assigning qualified operation and maintenance program and making time available for this activity.

An Operation and Management (O&M) Company in the Philippines was awarded the operational maintenance of the 1500 MW Combined Cycle Power Plant. The O&M Company will operate and maintain the plant for at least six years or 75000 equivalent operating hours whichever comes last [2]. In order to assure high degree of reliability assuring high kWh output, low heat rate and low operation and maintenance costs, the O&M Company integrated the Computerized Maintenance Management System in the middle of year 1999 and implemented the system on February 2000 during the commissioning of the plant. A Computerized Maintenance Management System is a computer software that helps maintenance teams keep a record of all assets they are responsible for, schedule and track maintenance tasks, and keep a historical record of work they perform [3]. It provides a powerful tool to deal with mechanical maintenance problems and directs the maintenance personnel on what specific activity is to be applied on the equipment.

The Computerized Maintenance Management Systems (CMMS) automate most of the logical functions performed by maintenance staff and management. One of the greatest benefits of the CMMS is the elimination of paperwork and manual tracking activities, thus enabling the building staff to be more productive. The functionality of a CMMS lies in its ability to collect and store information in an easily retrievable format. It provides the O&M

manager with the best information to affect the operational efficiency of a facility [4].

Three fundamental tasks of CMMS include the Information System, Operative System and the Communication System. The Information System provides information according to the requirements such as the plant data, maintenance history, and maintenance strategy, work in process and planned work, spare parts inventory and current shift events and fault notifications. The Operative System offers comprehensive support of the work processes to the individual PM tasks. It includes planning, control, documentation and evaluation of PM activities. Processing news in a target focused manner as determined in the work flow is the main function of the Communication System. It sends e-mail individually and automatically based on fixed rules with and without attached activities.

While CMMS can go a long way toward automating and improving the efficiency of most O&M programs, there are some common pitfalls that have been observed. Thus, the maintenance program should be continuously monitored and assessed for improvement to ensure that the maintenance strategy is still effective, meets its objectives and has been implemented in accordance with applicable industry codes and standards.

OBJECTIVES OF THE STUDY

The main objective of this study was to assess the maintenance program of the O&M Company implemented to the 1500 MW Combined Cycle Power Plant. Specifically, it aimed to describe the Computerized Maintenance Management System and assess the existing maintenance program in terms of maintenance organization, maintenance activities, spare parts and procurement, management assessment and program review and record keeping. Benchmarking was done on maintenance programs of its peers of known international standards in terms of availability, reliability, efficiency, and percentage of breakdown maintenance. Furthermore, possible enhancement activities were proposed based on the results of the assessment.

METHODS

The descriptive method of research was utilized in this project study. This type of research concerns present situation, prevailing conditions, current practices, contemporary events, characteristics of individuals or groups, their behavioral patterns, attitudes, as well as opinions. It purports to find out quantitatively the existing conditions of relationships, practices, and beliefs, processes that are going on, effects that are being felt or trends that are developing. Its goal provides information that can serve as basis for planning, decision making and understanding behavior [5]

The aforementioned research methodology is deemed the most feasible to use in this study as the main thrust is that of describing the current maintenance practices applied to the Combined Cycle Power Station by the O&M Company. Moreover, descriptive research methodology determines quantitatively the existing conditions of the maintenance organization, maintenance activities, spare parts and procurement, maintenance assessment and program review and record keeping.

The respondents of the study were the mechanical maintenance division employees of the O&M Company. The total population of the mechanical maintenance division was considered in this study. Table 1 shows the distribution of the respondents.

Table 1 Distribution of Respondents

Type of Respondents	Number of Respondents
Senior Mechanical Engineer	2
Mechanical Engineer Grade 1	2
Mechanical Engineer Grade 2	1
Mechanical Maintenance Technician	1
Mechanical Maintenance Specialist	9
QA / QC Engineer	1
TOTAL	**16**

The data needed to meet the objectives of the study were gathered with the use of a researcher survey-made questionnaire and documentary analysis.

Documentary analysis was used to obtain information on the regulatory standards on maintenance practices. Existing maintenance practices in terms of the maintenance organization, maintenance activities, spare parts and procurement, maintenance assessment and program review and record keeping were reviewed in conformance with the standard practices.

The extent of implementation of the maintenance program manifested in terms of the five (5) variables was assessed with the use of a survey questionnaire.

The researcher survey-made questionnaire is based from the inputs taken from the journal, books, and other professional publications. It solicited the respondents' perceptions on the different maintenance practices in terms of the maintenance organization, maintenance activities, spare parts and procurement, maintenance assessment and program review and record keeping. The response made for this portion of the questionnaire was assessed using a response mode presented in Table 2 and its equivalent verbal description.

Table2 Response Mode

Response Mode	Range	Verbal Description
5	4.50-5.00	Strongly Agree
4	3.50-4.49	Agree
3	2.50-3.49	Moderately Agree
2	1.50-2.49	Disagree
1	1.0-1.49	Strongly Disagree

The researcher reviewed the content of the regulatory standards for maintenance practices from which the first draft of the questionnaire was prepared. This was presented to the adviser to see to it that the questionnaire's items conformed to the criteria of instrument development and was coherent to key concerns of the study.

A second draft was prepared according to the suggestions and recommendations of the adviser and was set for validation by the panel of examiners. Four members of the panel were requested to participate in the validation process.

After the approval of the questionnaire, the researcher sought the permission of the mechanical maintenance manager of the O&M Company to conduct the study and availed of the information and data needed from the office.

The validated questionnaire was then reproduced and personally administered to the target respondents by the researcher. Once distributed, questionnaires were accomplished and retrieval followed.

After completing the retrieval of survey questionnaire, the responses to the different items in the questionnaire were tabulated and summarized. This was followed by the statistical analysis of data and the writing of the report.

To ensure systematic and objective presentation, analysis and interpretation of research data, the following statistical tools and techniques were applied: weighted mean and composite mean.

Weighted mean (WM). This descriptive measure was used to determine the average responses on each item in the maintenance element [6]. Composite mean (CM). This was used to determine the average responses of each maintenance element.

RESULTS AND DISCUSSION

The following presents the outcomes and arguments of the study.

4.1 Description of the Maintenance Program

The maintenance program is composed of the following methodologies: identification of critical equipment, preventive maintenance task analysis, predictive maintenance assessment, maintenance strategy for critical equipment, planning and scheduling, spare parts optimization and benchmarking.

The identification of critical equipment process includes the identification of those assets or critical equipment that is most likely to negatively impact plant performance. These assets have the following consequences of failure: affect safety, affect the environment, cause loss of production or shutdown of equipment, and produce high damage cost and high secondary damage cost. However, there was no intensive review of all critical equipment by all departments. The probability to miss critical equipment was high.

Maintenance tasks were implemented based on manufacturers' recommendation, personnel knowledge on equipment, and input from skilled trade personnel and specialist. Preventive maintenance task analysis involved a thorough review on the maintenance and operation manual provided by the equipment manufacturer and a review on the recurring faults and design maintenance task to prevent re-occurrence of failure. Based on the recommendation of the specialist whether external or internal, maintenance task must be prepared to prevent failure.

This process is an extremely cost effective and practical way to develop a maintenance program for the equipment. This method, however, was not conducted in a rigorous process. There is a potential to miss critical equipment and the required task, to specify task that are not required and incorrectly specify task interval.

The predictive maintenance assessment includes a thorough review on condition monitoring tools available in the market and evaluates the benefits of

applying this predictive maintenance technology on the plant equipment. Preventive maintenance tasks on the equipment were reviewed and eliminated once this predictive maintenance technology was applied. Outsourcing for contractors offering predictive maintenance technology and training personnel on the proper application of the condition monitoring equipment are necessary in this process.

When properly applied, this form of maintenance is highly desirable allowing the user to leave the equipment on-line until its condition deteriorates to the point that failure is imminent, thus the useful life of the equipment is maximized. This process could replace some preventive maintenance task.

The maintenance strategy for the critical equipment includes the condition-based maintenance, preventive and breakdown maintenance. Condition-based maintenance is prioritized among the type of maintenance strategy since cost of condition monitoring is lesser than breakdown maintenance cost and preventive maintenance cost.

If condition based maintenance is not appropriate then preventive maintenance is implemented based on the following conditions: it affects safety, environment and production, failure cost is high, secondary damage is high and legal regulation requires it.

Breakdown maintenance is considered when the equipment has no effect in the environment and safety, does not result to production loss in case of failure, and the cost of equipment failure is low.

If the strategy is failure based or breakdown maintenance, work plan and spare parts are available in case of failure. All equipment under this program has a Work Plan encoded on the data base. The Work Plan specifies the spare parts to be used, the number of personnel who will do the work, duration of the work and work instruction. Spare Parts on this list should have a minimum/maximum level and an auto order. This ensures that spare parts are always available in the store when there is failure of this equipment.

Maintenance Planning and scheduling is ensuring the execution of maintenance strategies and plans in an efficient manner to obtain competitive advantage in any company.

In Figure 1 is a flow chart to analyze the strategy to be applied on a component. Analyzing the conditions of the system component directed the maintenance personnel on the appropriate maintenance activity to be used.

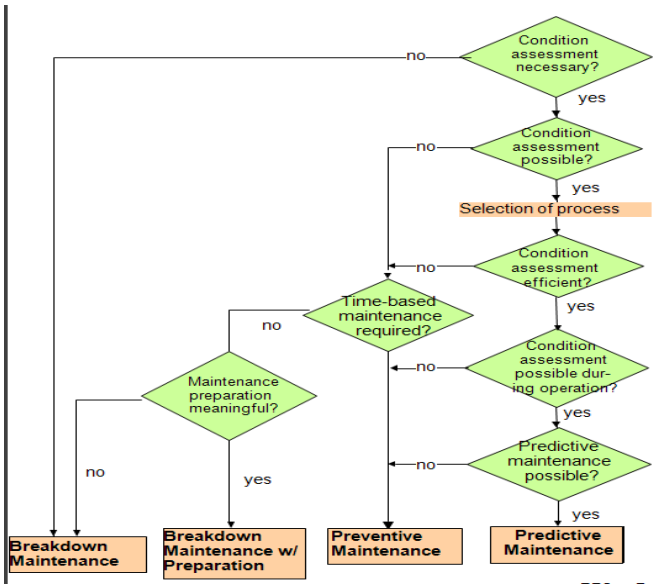

Fig.1 Maintenance Strategies Work Flow

Breakdown maintenance is done when condition assessment is not necessary. However, there may be cases that assessment is necessary but not possible and is time-bounded, thus preventive maintenance should be applied. Predictive maintenance is used when condition assessment is efficient and possible during operations.

Fig.1 shows the maintenance strategies work flow and Fig.2 presents the maintenance work flow process.

Figure 2 shows the maintenance work flow process. The process starts in the analysis of the maintenance strategy to be applied on a particular system component. The maintenance strategy may either be corrective, preventive, condition monitoring and modification. Work plans were generated from preventive maintence and condition minitoring whereas breakdown maintenance resulted to a fault notification and desgn change request. Work plans were then given schedules to be processed as a work order. The defective component would then be isolated from the system as repairs were being carried out.

Once a defective component is isolated, work permit will be issued. All concerned will be given permit to work so that they could carry on with their tasks. After

work is completed, a normalization function test is conducted to verify if the system component returns back to its normal operating conditions. And the proces is then repeated.

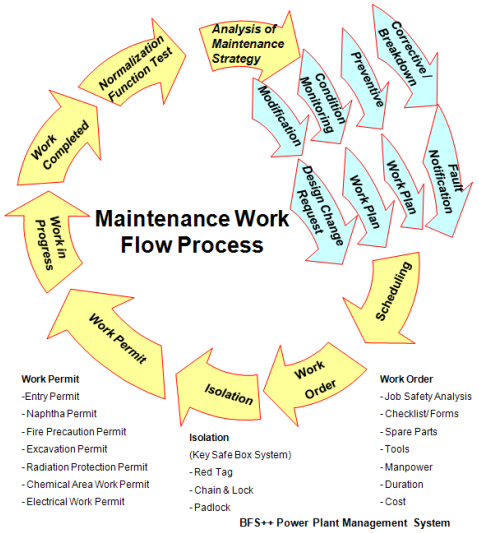

Fig.2 Maintenance Work Flow Process

Spare parts and consumables are prepared prior to start of work. Stores can view which work are scheduled for the next day. Stock issues are effectively managed by status controls and stocks replenishment is handled by Auto Order system. The spare parts management module ensured provision, and an appropriate storage for an optimized spare parts inventory.

Benchmarking is a process used to evaluate various aspects of the performance in relation to best practice, as compared to their peers. This allows organizations to develop plans on how to adopt such best practices, usually with the aim of increasing some aspect of performance. The key performance indicators used for benchmarking includes availability, reliability, percentage of each type of work order, condition monitoring work order, breakdown work order, preventive maintenance work order, corrective maintenance work order, number of generated fault notification, and number of open fault notification.

4.2 Evaluation of the Maintenance Program

The existing maintenance program was evaluated in terms of maintenance organization, maintenance activities, spare parts and procurement, management assessment and program review and record keeping.

4.2.1 Maintenance Organization

Plant personnel who comprise the organization must be knowledgeable and with competence in performing the work. To perform the necessary maintenance procedure in a power generating station, maintenance personnel must be trained thoroughly in all operating schemes and equipment capabilities.

The management's support and recognition with regard to the maintenance organization had an appreciable outcome as shown in a composite mean of 4.55. It was evident that the management is always looking forward in aiming good quality service by interacting with other trade and work groups such as the operations, engineering and technical support as posited in highest mean of 4.75. This observation conforms to the statement of Joshi [7] which cited that maintenance is a coordinated integration of the operation, maintenance engineering support, training and administrative areas of any process in order to increase the efficiency, reliability and safety of the process.

However, the management was not good enough in providing all maintenance personnel with specific training in plant systems commensurate with their responsibilities in the organization as could be noted in lowest weighted mean of 4.38. The finding affirms the idea of Layog [8] that the training of maintenance personnel, their qualifications and responsibilities to the organization must be considered in assessing the performance of the substation maintenance program.

4.2.2 Maintenance Activities

One of the most important elements of a maintenance program is to perform the necessary maintenance work on the mechanical equipment. Data on study shows the extent of practice of performing maintenance activities of the O&M management to the Combined Cycle Power Station as perceived by the respondents.

Performance of the necessary maintenance work on mechanical equipment had a composite mean of 4.44 which means that the respondents perceived that these activities needed further sustenance. This bears similarity with Bridges [9] findings that maintenance program optimization is to provide assurance that the right work is being performed on both the right time and intervals. Further, he stressed that a right work is one which conforms to the standard practice and labels or lay-outs.

4.2.3 Spare Parts and Procurement

Maintenance personnel of the power generation units must be familiar with the spare parts and be acquainted with their use, its process of procurement and securing together with the tool requirements.

It was agreed that the management followed the standard practices on spare parts and procurement as revealed in composite mean of 4.33. The maintenance organization followed the existing processes and procedures to procure, receive, store, secure and issue spare parts, tools and materials as expressed in weighted mean of 4.69. The respondents believed that the system of procurement of spare parts should be continued and careful inspection should be done before acquiring spare parts.

4.2.4 Management Assessment and Program Review

To reduce the number of avoidable breakdowns is the objective of any maintenance program. Breakdowns add tremendously to the operating cost of the equipment and may result in an unprofitable operation. The study reveals the extent of practice of performing management assessment and program review, in order to reduce breakdowns, of the O&M management to the Combined Cycle Power Station as perceived by the respondents.

The respondents agreed that the management conducted an assessment and program review. This had a composite mean of 4.29. The respondents perceived that the maintenance program deficiencies may be corrected and improved through feedbacks taken from the assessment to ensure that the maintenance strategy is effective, meets its objectives and has been implemented in accordance with applicable industry codes and standards. This finding supports Koller's [10] idea that maintenance work must be a continual process to optimize maintenance programs for the duration of the plant life management. He pointed out that maintenance techniques have to be dynamic but their in-service effect to the equipment should be assessed to achieve optimum balance.

4.2.5 Record Keeping

In a maintenance program, complete records of the maintenance activities done to the mechanical equipment must be kept and treated confidential. Study shows the extent of practice of keeping complete records.

The respondents perceived that the practices of keeping complete records should be persistently implemented as depicted by a composite mean of 4.25. The respondents agreed that these maintenance reports be kept so as to monitor changes in the performance of components/systems being maintained.

4.3 Benchmarking with Similar Companies

Benchmarking is a process used to evaluate various aspects of performance in relation to best practice, as compared to their peers. This allows organizations to develop plans on how to adopt such best practices, usually with the aim of increasing some aspects of performance. Benchmarking has been recognized across industry as a key tool for assessing what is possible in terms of performance. For decades, generating companies have been comparing their plant's performance against other plants in order to set realistic goals, identify opportunities for improvement, give advance warning of threats, set appropriate incentives, trade knowledge and experiences with their peers and quantify and manage performance risks, an increasingly vital action in an increasingly competitive business environment.

Benchmarking is a powerful management tool because it opens organizations to new methods, ideas and tools to improve bottom-line results. It helps crack through resistance to change by demonstrating how different processes and approaches can realistically yield improved results.

Benchmarking in terms of the different key performance parameters such as availability, reliability, efficiency and percentage of breakdown maintenance was conducted on the O&M Company with its peers. The results of the benchmarking served as tool for further improvement of its operating performance.

Table 3 Key Performance Indicators

KPI (%)	O&M Company	Peer Company
Availability	90-96	90-93
Reliability	94-99	36-61
Efficiency	96-99	50-53
Percentage of Breakdown Maintenance	0.1-0.4	2.7-5.4

4.3.1 Availability

Availability is a performance criterion for repairable systems that accounts for both the

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 3, No. 5, December 2015

reliability and maintainability properties of a component or system. It is defined as the probability that the system is operating properly when it is requested for use. Thus, availability is the probability that a system is not failed or undergoing a repair action when it needs to be used. Data in Table 3 shows that for the O&M Company, availability ranges from 90-96 percent indicating that the machine components maintained by the industry do not fail or undergo repair when requested for use. The same conclusion can be mentioned on availability of the peer company. Percent availability of which is 90-93 percent, with O&M Company having a higher three percent availability.

4.3.2 Reliability

Reliability does not imply validity. That is, a reliable measure is measuring something consistently, but not necessarily what it is supposed to be measuring. In this study, the O&M's reliability ranges from 94-99 percent as shown in Table 3, whereas for its peer company it may be taken from 100 percent less the capacity factor. The capacity factor for its peer company ranges from 39-64 percent, thus reliability would be 36-61 percent.

4.3.3 Efficiency

Efficiency is a measure of how much more work must be put into a machine than you get out of the machine. In the real world, the efficiency of a machine will always be less than 100 percent. From Table 3, the peer's efficiency ranges from 50-53 percent which is far behind that of the O&M Company. The efficiency for the O&M Company may be computed from the net dependable capacity. It ranges from 96-99 percent corresponding to the 1458-1496 MW output power.

4.3.4 Percentage of breakdown maintenance

Percentage of breakdown maintenance is the ratio of the number of breakdown hours to the sum of the breakdown hours and the preventive maintenance hours. It is the ratio of the forced outages in relation to the total maintenance hours expressed in percentage. Breakdown maintenance of the O&M Company ranges from 0.1-0.4 percent as illustrated in Table 3. These values were lower in comparison with its peer company which has values of the forced outage ranging from 2.7-5.4 percent.

4.4 Enhancement Activities Based on the Results of the Evaluation

The existing maintenance practices are generally effective and evident but still needs enhancements. It is envisioned that the proposed enhancement activities are designed to be of great help in strengthening the company's maintenance program.

Table 4 Enhancement Activities

Areas of Concern	Enhancement Activities
Maintenance Organization	Annual Personnel Development Seminar
	Proper Equipment Tagging
	Comprehensive BOSH Trainings
Maintenance Activities	Specialist Trainings
	Expatriate's Immersion
	Develop a Procedural Implementation
	Spare Parts Identification Program
Spare Parts and Procurement	Defective Equipment Tagging Check
	Data Storage Program
	Program Assessment Survey
Management Assessment and Program Review	Monthly Maintenance Evaluation
	Re-engineering the Maintenance Program
	SSC's Repair Data
Record Keeping	Data Keeping Seminar
	Proper Record Turn-over Development Seminar

CONCLUSIONS AND RECOMMENDATION

The O&M company follows the standard practices in each element of the maintenance program in the evaluation The extent of implementation is generally effective and evident yet still needs enhancements.

Benchmarking is done to compare the operating conditions of the power generating station with its peers. Key performance indicators such as availability, reliability, efficiency and percentage of breakdown maintenance are used by the mechanical maintenance division to evaluate its effectiveness.

Proposed enhancement activities based on the evaluation of the maintenance program include reengineering maintenance program activities for improvement of existing practices to ensure better service delivery to its consumers.

It is recommended that the management of the O&M Company should review the proposed enhancement activities before implementation. A parallel study on this concern should be conducted in different companies, colleges and universities as tool towards productivity and effectiveness.

REFERENCES

[1] Roemer, M. J. (2009). A Key to Successful Condition Based Maintenance Program: A Supplement to Mechanical Engineering Magazine, December, (2009).

[2] Kirschen, G. (2000). Building up an O&M Company in the Philippines, Modern Power Systems.

[3] "What is a CMMS?" retrieved from www.maintenanceassistant.com/cmms/

[4] "Computerized Maintenance Management System" retrieved from energy.gov/sites/prod/.

[5] Wiersma, W. (1995). Research Method in Education, Allyn & Bacon, Boston, (1995).

[6] Garcia, G. D. (2010). Developing Competencies in Research and Thesis Writing, Books Atbp. Publishing Corp.

[7] Joshi, M.M. (2001). Quality Assured Maintenance Management for Coal Handling Plant

[8] Layog, C. F. M. et al. (2009). An Assessment of the Implementation of the Substation Maintenance Program of Ibaan Electric & Engineering Corporation

[9] Bridges, M. (2003). A Method for Determining the Critical Systems, Components for Maintenance Optimization, USA.

[10] Koller, D. (2003). Work Optimization: A Fashion or a Useful Tool, United Kingdom: Process Alignment Services