Maintenance management system for upstream operations in oil and gas industry: a case study

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Abstract: This paper explores the plant maintenance management system that has been used by a giant oil and gas company in Malaysia. The system also called as PETRONAS maintenance management system (PMMS) used to manage the upstream operations for more than 100 plants of the case study company. Moreover, from the observations, focus group discussion with PMMS personnel and application through simulation (SAP R/3), this paper reviews the step-by-step approach and the elements that required for the PMMS. The findings show that the PMMS integrates the overall business strategy in upstream operations that consist of asset management, work management and performance management. In addition, PMMS’s roles are: to help operations personnel organise and plan their daily activities, to improve productivity and reduce equipment downtime, and to help operations management analyse the facilities and create performance and to provide and maintain the operational effectiveness of the facilities.

Keywords: maintenance; oil and gas industry; upstream operations.

1 Introduction

Many companies already regard maintenance management as a vital part of production activities. Excellent maintenance management may reflect well on various sectors of a company, and even boost companies to the extent that, through planned maintenance, they will obtain a competitive advantage.

This paper presents the results of an investigation on the application of a computerised maintenance management system (CMMS) called PMMS in Petronas Nasional Berhad (PETRONAS), Malaysia that used to manage the upstream operations for more than 100 plants. The PMMS is also known as ‘PETRONAS maintenance management system’ and is a CMMS, which is supported by the system application production (SAP R/3). The SAP system is an integrated suite of order entry, scheduling, manufacturing, inventory and financial software. In addition, it integrates enterprise resources planning (ERP) system that consists of several modules, namely plant maintenance (PM), finance (FI), human resources (HR) and material management (MM), which is supported by many functions in the day-to-day operations.

To organise this paper, Section 1 explains the overview of maintenance management system for capturing the key issues. Section 2 provides the literature review. Section 3 classifies the research methodology. Section 4 briefs the case study at a selected oil and
gas organisation. Section 5 explores the PMMS. Section 6 discusses the findings and the knowledge earned, and this paper ends with some useful conclusions and thoughts for future research.

2 Literature review

Maintenance is a combination of all technical, administrative and managerial actions during the life cycle of an item intended to keep it in or restore it to a state in which it can perform the required function (Komonen, 2002). Previously, maintenance has been supposed as an expense account with performance measures developed to track direct costs or surrogates such as the headcount of tradesmen and the total duration of forced outages during a specified period. Fortunately, this perception is changing (Kutucuoglu et al., 2001; Tsang, 1998). Nowadays, maintenance is acknowledged as a major contributor to the performance and profitability of business organisations (Arts et al., 1998; Tsang et al., 1999). Maintenance managers, therefore, explore every opportunity to improve on profitability and performance as well as achieve cost savings for the organisation (Al-Najjar and Alsyouf, 2004). In addition, poor maintenance management contributes to a significant financial cost (Aoudia et al., 2008).

The maintenance organisation is confronted with a wide range of challenges that include quality improvement, reduced lead times, set-up time and cost reductions, capacity expansion, managing complex technology and innovation, improving the reliability of systems and related environmental issues (De Groote, 1995) and must have a proper plan (Reis et al., 2009). However, trends suggest that many maintenance organisations are adopting total productive maintenance (TPM) that aims at the total participation of plant personnel in maintenance decisions and cost savings (Ahuja and Khamba, 2008; Blanchard, 1997). The challenges of intense international competition and market globalisation have placed enormous pressure on maintenance system to improve efficiency and reduce operational costs. These challenges have forced maintenance managers to adopt tools, methods and concepts that could stimulate performance growth and minimise errors, and to utilise resources effectively towards making the organisation a ‘world-class manufacturing’ or a ‘high-performance manufacturing’ plant.

Industrial maintenance has two essential objectives, which are a high availability of production equipment and low maintenance costs (Komonen, 2002). However, a strong factor militating against the achievement of these objectives is the nature and intensity of equipment failures in plants. Since system failure can lead to costly stoppages of an organisation’s operation, which may result in low human, material and equipment utilisation, the occurrence of failure must, therefore, be reduced or eliminated. An organisation can have its customers build confidence in it by having uninterrupted flow in operations. Thus, maintenance ensures system sustenance by avoiding factors that can bother effective productivity, such as machine breakdown and its several attendant consequences.

Maintenance management process can be divided into two parts: the definition of strategy and the strategy implementation (Márquez et al., 2009). To carry out effective maintenance activities, the team players must be dedicated, committed, unflagging and focused on achieving good maintenance practices. Not only are engineers and technicians involved, but also every other employee, especially those involved in production and
having physical contact with equipment. Thus, maintenance is not only important for these reasons, but also for its successful implementation, which leads to maximum capacity utilisation, improved product quality, customer satisfaction, adequate equipment lifespan, among other benefits. Equipment does not have to finally breakdown before maintenance is carried out. Implementing a good maintenance policy prevents system failures and leads to high productivity (Vineyard et al., 2000).

To perform effectively, the maintenance manager normally should be well versed in performance measurement (Kutucuoglu et al., 2001; Pintelon and Van Puyvelde, 1997). Measures such as productivity, efficiency, effectiveness, quality, quality of working life, innovation and profitability should be regularly used to assess the performance of the system and that of the subsystem within the maintenance function (Bamber et al., 2003; Ljungberg, 1998). There exist several methods for maintenance performance (Blanchard, 1997; Maggard and Rhyne, 1992). Besides, Karim et al. (2009) reviewed that maintenance management is effectively conducted using computer. However, Chinese and Ghirardo (2010) found that some maintenance strategy gives little impact on performance.

Moreover, Labib (2004) stated that the CMMS is now a central component of many companies’ maintenance departments, and it offers support on a variety of levels in the organisational hierarchy. Indeed, a CMMS is a means of achieving world-class maintenance, as it offers a platform for decision analysis, and thereby acts as a guide to management (Kaus, 2009; Labib, 1998). Using computer, the process can be facilitated not only during planning phase, but also during the execution and review process (Pokharel and Jiao, 2008).

CMMS is a computer-based software programmes used to control work activities and resources, as well as to monitor and report work execution. CMMS is a tool for data capture and data analysis. The major features of CMMS include the processing of maintenance data to give in useful information on which management decisions are based. This information can be analysed or evaluated with respect to previous results such that performance over a period of time can be assessed. Managers will, therefore, find it convenient in making use of the available data to plan for present and future goals. There is also the advantage of printing out this information in hard copy at any desired period. Other useful information, such as work done in the maintenance department and its total costs (TC), lists of jobs worked on during a period and inventory taking can be presented in a manner that will greatly ease both the technical and administrative tasks of maintenance. Through networking of the systems, information can be passed efficiently between the maintenance department and the organisation’s management.

The CMMS can be used to analyse budgets, downtime, supplies, screening of applicants, etc. The database programmes in CMMS systems contain structured data on workers’ names, job titles, daily, weekly or yearly schedules, etc. The data processed on CMMS can be stored permanently or retrieved much faster for future use or modifications. Also, CMMS can be used in maintenance planning and scheduling, coordinating people and controlling resources and costs of maintenance functions. It can also be used in such areas as the analysis of a week’s activity and budget proposals.
3 Research methods

An intensive case study was conducted in July 2008, and one of the authors recently had undergone industrial attachment and spent almost six months, focusing on productivity improvement activities at the case study company. Observation, focus group discussion and simulation application were used to collect the primary data that related to PMMS applications. The observation was focused on the upstream operations and PMMS, meanwhile the focus group discussion was conducted among the maintenance control system (MCS) engineers. In addition, the discussion was conducted not only to dwell on the past implementation, but also to focus on the future plans and developments via telephone and internet conference. Then, to validate the PMMS, simulation of SAP software (SAP R/3) was performed with Master Data Team of Peninsular Malaysia operations (PMO)/PETRONAS Carigali Sdn Bhd (PCSB). Secondary data were obtained from PCSB SAP R/3 MCS guide, Carigali maintenance management guide (CMMG), Carigali inspection and maintenance guide (CIMG) and PETRONAS electronic performance support site (EPPS).

4 Case study

The case study was conducted at PCSB. For history, on 11 May 1978, this Malaysian company, PCSB a wholly owned subsidiary of PETRONAS was born as its exploration and production arm. PCSB’s domestic operations are divided into three regions, which are PMO, Sarawak operations and Sabah operations. Effective 1 April 2002, these regional operations were put under PCSB’s division called Domestic and South East Asia Division (DOMSEA).

This paper only focuses on PMO. PMO started its operation in April 1984 (the first production of division in PCSB) with the commencement of gas production from the Duyong field. Its main office is located at PETRONAS Office Complex in Kerteh about 110 km south of Kuala Terengganu. PMO is supported by Kemaman supply base (KSB) in terms of warehousing and logistics activities, Kerteh Helibase for helicopter services, onshore gas terminal (OGT) at Paka for gas receiving facilities and Terengganu Crude Oil Terminal at Paka for crude receiving facilities. Nowadays, PMO operates 16 producing fields, namely Duyong, Dulang, Bekok, Kepong, Tiong, Tinggi, Pulai, Malong, Sotong, Anding, Resak, etc.

There are a total of 33 platforms, two floating storage and offloading facilities, two floating production, storage and offloading facility and one OGT. There are 20,936 equipments under PCSB’s maintenance.

5 PMMS

PCSB operates a number of complexes onshore and offshore installations, most of which are in the remote locations. The management and supervision of operational activities involve a flow of data, which can be most easily managed when consistent, meaningful information is readily available to all parties. This depends on the ready access to all information to design, construction, manufacturer, spare parts, skilled manpower resources and operating or maintenance histories. The PMMS, which is supported by
SAP R/3, is implemented to achieve the management of such data. PMMS covers asset management, work management and performance management.

5.1 Asset management system

In PMMS, asset management is important to ensure that a complete maintenance master data are captured in the system, including plant asset structure, tag no, equipment master, bill of material (BOM), maintenance plans and data consistency in master data. Asset management covers two areas – plant asset structure (PAS) and planned preventive maintenance plan (PPM). The first requirement for supported maintenance system is to represent its operational systems and their detailed structure.

5.1.1 Plant asset structure

The plant asset structure allows the user to control system management according to functional location or process-oriented criteria and to manage the individual inventory maintenance resources. This will enable the planning, execution and analysis of the maintenance works through the system. Figure 1 shows the example of a PAS for PSCB.

The procedure of PAS is categorised by level. Levels 1 until 3 are the selection process of the asset, investing the asset, making proper assessment of risks and developing proper strategies to save the assets from exposure to risks. Level 4 is a process for the execution of the PM system. At PETRONAS, there are two different production platforms, which are oil or associated gas platform and gas or non-associated gas platform. The main processes on the platforms are: oil production, gas production, gas dehydration and gas compression.

Figure 1  An example of plant asset structure based on PCSB level

![Plant Asset Structure Diagram](image-url)
Level 5 is a functional location for technical system. It is used to capture information related to location, process or group of functions. Functional location shall be used to structure or represent a plant relationship, between organisational set-up, process and maintenance functions. Under functional location, there is a functional location boundary. The boundary is termed as a grouping of main and supporting equipment that provides one main function for delivering intended output from a maintenance perspective.

Level 6 is equipment master, which is a uniquely identifiable physical asset upon which all notifications and work order can be carried out, where costs and history can be recorded. When an equipment master is dismantled and installed from one functional location to another, its equipment master historical data remain attached.

Level 7 refers to the BOM. BOM is the term used to describe the raw materials, sub-assemblies, intermediate assemblies, sub-components, components, parts and the quantities of each needed to manufacture an end item (final product). BOM structures are included in system structuring in the overall structuring of individual operational systems.

5.1.2 Planned preventive maintenance plan

Preventive maintenance is the generic term for planned inspections, preventive maintenance work and planned repairs. In the PMMS, preventive maintenance plans are created to automatically generate preventive maintenance orders when the preventive maintenance work is due. The business objectives of preventive maintenance are: to provide an effective planning of preventive maintenance schedule and to ensure good resource management that are performed on a recurring basis; to provide effective implementation of scheduled preventive maintenance that will increase integrity and reliability of equipment and reduce unplanned breakdown of equipment and to reduce maintenance costs by reducing uneconomic maintenance or overhaul schedules, wear and tear and human-induced failures due to unnecessary equipment dismantling.

In the preventive maintenance plans, the following important details are specified:

- **Maintenance strategy and functional location**: specifies the time interval when the preventive maintenance work is done. Once the preventive maintenance plan is finalised, maintenance strategies can be generated.

- **Object list**: specifies all the equipment, where the preventive maintenance is to be carried out.

- **General task list (GTL)**: a grouping on task list for work order. GTL used to describe the steps or operations of the preventive maintenance activities to be carried out. Spare parts, materials and tools may also be specified in the task list. The relevant order type that can be performed on the GTL are PPM, predictive maintenance and plant statutory inspection.

- **Work centre**: indicates which group in the maintenance department is responsible to carry out this job. Three functions in the work centre are for costing, scheduling and capacity planning. Work centre includes over two groups, which are maintenance planner group that means the supervisor is responsible to carry out the plan of the job and maintenance work centre that means the group in the maintenance department is responsible to carry out this job.
5.2 Work management

Work management is a documented and tested step-by-step method that aims to ensure the efficient work order, and is processed by standardised maintenance business processes across all operation units. Moreover, it ensures that the implementation of proper control and various steps in work order process to minimise the amount of lost time during maintenance order planning with updated and complete master data. Work management generally includes detailed information on topics, such as organising a work, setting and implementing work order and choosing employees to execute the work. The following explains the six main stages of work management.

5.2.1 Work identification

Work identification is used to complete and screen details in notification. To complete the work identification, users must use the correct notification type by determining whether it is an ad hoc or planned maintenance and is functional to create notifications; use the correct equipment tag or functional location and do not use generic equipment tag; indicate the correct priority level; attach the relevant document if required, and screen the notification before converting to order. It requires to establish the nature of work carried out on the equipment so that maintenance can identify improvement areas in maintenance plan for the equipment, if necessary, to ensure that full equipment history is recorded in the system for future maintenance work, to help planner to better respond to the urgency of the work request, to breakdown time period enables management to analyse reliability of the equipment and effectiveness of maintenance planning, and to attach document is critical in providing graphical view of the work scope or equipment condition.

5.2.2 Pre-planning

Pre-planning and planning is used to plan and approve the maintenance order that contains activity type, depicting detailed job to be performed. This information is crucial for maintenance work reporting.

5.2.3 Planning

The purpose of planning is to ensure prudent and cost-effective maintenance work practices. The estimated and planned cost shall assist planner to improve maintenance work planning and serve as reference in future planning. GTLs for common maintenance can be adopted to specify operations of an order; determine resources required to perform job (internal and external manpower, spare parts, etc.). Based on planned or estimated costs, orders will be sent for technical approval before being released for execution.

5.2.4 Scheduling

Scheduling is used after necessary planning has been conducted. Scheduling process involves activities to check availability of resources to perform the job. Subsequent to ensuring the materials availability, the planner will start to schedule or set the working date for the job. The order will be released once it is scheduled.
5.2.5 Work execution

Print maintenance order, material issue slip and object list (if required). Monitor user status of order, e.g. if there are operational, material, manpower constraint or if the work carried out is only a temporary repair, etc., or select and specify the relevant status on the maintenance order. Monitor estimated, planned and actual cost of order. Perform partial, full or collective time confirmation for the order.

5.2.6 Reporting and feedback

Complete technical reporting in the system which includes maintenance report, specifications of damage and cause codes, confirmation on measurement/counter reading, if any, and specification of malfunction end date if the notification involves a breakdown. Set system status to TECO technically complete to indicate the end of maintenance work.

5.3 Performance measurement

Performance management is a data from all the maintenance work that was carried out. It will be extracted from the SAP system and stored in the SAP business warehouse (BW) and Carigali maintenance management performance system (CMMPS) for analysis and reporting. Performance management aims to enable the users to generate accurate reports to analyse the efficiency and effectiveness of their maintenance work. It is also to provide operations unit with a feedback mechanism to track their progress towards best practice.

5.3.1 SAP BW reporting

As an integrated system, SAP BW is a reporting and analysis tool, and a part of a collection of solutions from SAP business suites. SAP BW gives management the advantage of a multiperspective view of their business, which helps in making strategic business decisions. Under the hood, the BW engine is able to extract information from various sources, making it a flexible data processing system capable of being integrated with SAP as well as non-SAP applications. The benefits of BW are as follows:

1. SAP BW extracts data from SAP R/3 and stores it in a separate server, making data retrieval speed much faster
2. SAP R/3 system performance is not compromised by running of reports or data gathering
3. SAP BW is able to extract data from non-SAP systems and integrate with SAP data to give more comprehensive, multidimensional information
4. BW organises reports by customised roles, e.g. plant manager, maintenance planner, operations engineers, etc., to reports of interest
5. business explorer is a very powerful and yet user-friendly data analysis tool. It gives you all the capabilities of Microsoft Excel and more.

There are five BW reports, which are work identification, planning and scheduling, maintenance execution, feedback and reporting and cost management. Expert users are suggested to use Excel apart from the BEx analyser functions, and can utilise all Excel
functions. The report structure is divided into three items, which are report title, filter cells and result area.

5.3.2 CMMPS

CMMPS is a front-end application tool developed to generate the reports as specified by the CMMG in the form of 21 key performance indicators (KPIs). In addition to that, the system generates for more performance indicators pertaining to the average processing efficiency of work orders.

The following are the items used for KPI:

- KPI 1: standard non-productive man-hours
- KPI 2: total real available man-hours
- KPI 3: man-hours utilisation
- KPI 4: total non-productive man-hours
- KPI 5: percentage of proactive work created
- KPI 6: equipment availability, reliability and utilisation
- KPI 7: REM completion
- KPI 8: work order status details
- KPI 9: overdue maintenance order
- KPI 10: total man-hours % distribution
- KPI 11: maintenance overtime hours
- KPI 12: production loss shutdown
- KPI 13: maintenance mix costs
- KPI 14: unit maintenance costs
- KPI 15: turbomachinery run-hours per start (RPS)
- KPI 16: PPM scheduled compliance
- KPI 17: inspection scheduled compliance
- KPI 18: percentage of completed order by type
- KPI 19: repetitive work
- KPI 20: planning effectiveness percentage
- KPI 21: planned or unplanned orders percentage.

6 Discussion and conclusion

The findings show that asset management, work management and performance management are the core factors for PMMS. Asset management is a multiusers,
Maintenance management system for upstream operations

Maintenance management system for upstream operations

multioffices, web-based centralised database management system. The system aims to assist organisation to better manage the allocation, distribution and productive use of its assets. The system facilitates the management of assets with the objective of capturing information on assets, and tracking of the assets through the entire asset’s life cycle of asset registration, assignment or allocation, transfer, stock checking, maintenance and eventually disposal or reported lost. Asset management contains the plant asset structure and PPM plan. Plant asset structure represents the place at which a maintenance task is performed. It is a type of data object used in SAP to represent the functional part that an object can be installed, as opposed to the installed equipment, which represents the technical side. After that, PPM plan will be created to automatically generate maintenance orders when the maintenance task is performed.

Furthermore, work management facilitates the management of construction, maintenance and operations work request by automating and streamlining the processes required to initiate, track, design, estimate, schedule, construct and close work request. By tracking and analysing information, and distributing it across the enterprise, these systems enable the PMO to increase the efficiency, accuracy and speed of the entire work cycle. In PMMS, work management consist work identification, pre-planning, planning, scheduling, work execution and reporting and feedback. It is a work order creation and tracking system design for asset PMO, custodian or contractors to manage work orders for their infrastructure.

Performance management is the systematic process of monitoring the results of activities, and collecting and analysing performance information to track progress towards planning results. Performance management uses performance information to inform and programme decision-making and resource allocation. The main objective is to communicate results achieved or not attained, to advance organisational learning. In PMMS, performance management consists of sap BW and CMMPS. It consists of the task of gauging, tracking and sustaining PMO’s employee progress through the analysis and reporting. The analysis and reporting will be extracted from SAP system, and it is viewed from the BW Explorer.

On the basis of the simulation from the results, the SAP R/3 is used to evaluate all approaches. SAP R/3 is arranged into distinct functional modules, covering the typical functions in PCSB. The most widely used modules at PCSB are HR, procurement, inventory and PM. Each module handles specific business tasks on its own, but it is linked to the others where applicable.

To sum up, on the one hand, PMMS can result in major benefits in terms of money and time. But it requires a great deal of thinking and effort. Besides, PMMS has improved the monitoring system for maintenance management. On the other hand, PMMS provides awareness for the importance of the maintenance in PCSB, which involves all parties. Therefore, in order to develop future research in this area, the following research questions should be evaluated:

- Are there any spaces to improve the current PMMS?
- How the PMMS can improve the listed KPIs progressively?
- What happens to the PMMS if there are lots of broken-down machines?
- What are the critical success factors that influenced the application of PMMS totally?
What are the common problems faced by PCSB to sustain the application of PMMS? Are the PMMS applicable for other industrial background?

The authors of this paper intend to extend such research questions in the future publications. The authors believe that the above-mentioned research solution may prove useful in helping to re-architecture the PMMS as an effective approach towards the successful PM management system.

References


