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KNOWLEDGE MANAGEMENT FOR MAINTENANCE ACTIVITIES IN THE MANUFACTURING SECTOR

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ABSTRACT

Maintenance is an indispensable part of the business process and plays an important role in an organisation's success and survival. The main purpose of maintenance is to ensure equipment functions at its original optimal level. Thus, the knowledge and skills of operators are crucial and in demand. This paper presents a knowledge management of maintenance activities transfer method. Knowledge management is a process that a company cannot avoid, because it is a step in providing the necessary information for business performance measurements. Based on the example of a knowledge management system for a consultant company, we propose a knowledge repository or warehouse for maintenance activities that consists of four elements: best practice, databases, discussion forums and assessment tools. Each element has its own role and contribution towards better maintenance activities. Therefore, knowledge management has a deep relationship with performance evaluation or measurement.

***Keywords**:* Maintenance, knowledge management, performance measurement.

INTRODUCTION

In the early 1900s, maintenance was considered a necessary evil. When equipment broke down it was fixed without consideration of the cost or time consumed etc. The general attitude towards maintenance at that time was, "it costs what it costs". However, with the advent of technological change, maintenance can now be planned and controlled and can optimise the production processes. Today, maintenance is considered as an indispensable part of the business process. The efficiency and effectiveness of the maintenance system plays an important role in an organisation's success and survival According to Nakajima and Shirase (1992), there are two types of production maintenance: planned and unplanned. Planned maintenance is generally classified as preventive and corrective maintenance, whilst breakdown maintenance is considered as unplanned. Preventive maintenance can be further subdivided into fixed maintenance and predictive maintenance. Figure 1 shows the different types of maintenance. If planned maintenance works efficiently, it will lead to a reduction of unplanned maintenance.

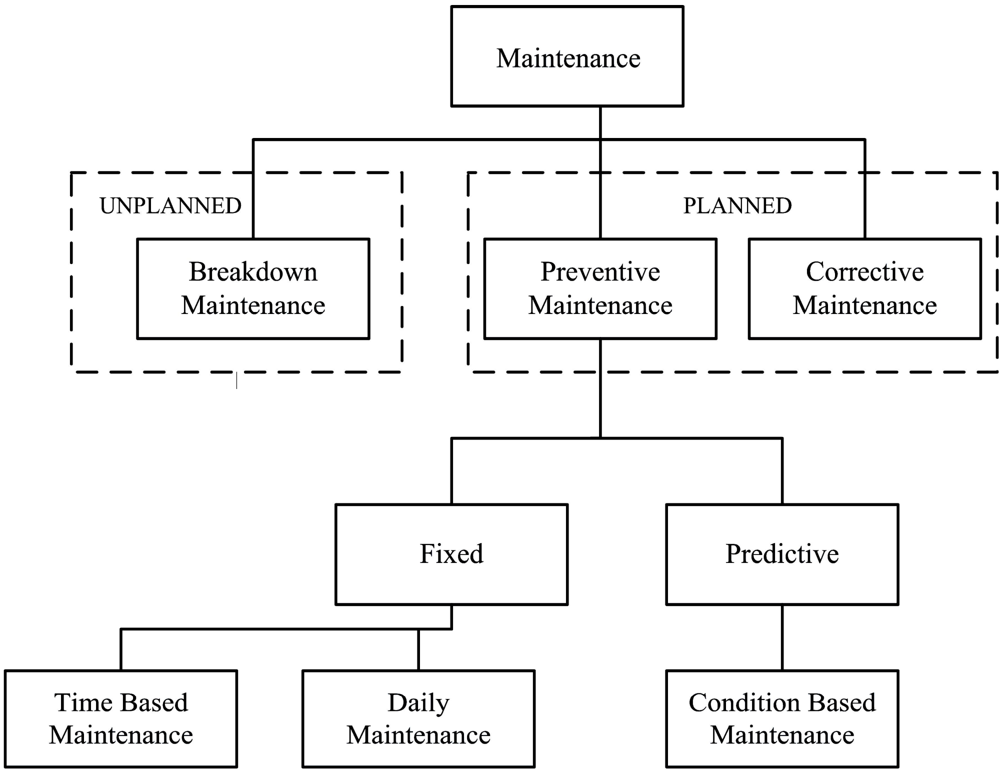

Figure 1. Types of maintenance.

Preventive maintenance maintains the "healthy" condition of equipment by performing daily routine actions (normally referred to as daily maintenance), such as: cleaning, refuelling, checking to prevent deterioration, periodic inspection and equipment diagnosis to measure deterioration and maintenance and repair to restore deterioration at an early stage. Because fixed maintenance requires periodic maintenance before a breakdown occurs, maintenance expense is costly. There are two types of fixed maintenance: time-based maintenance (TBM) and the overhaul type maintenance called inspection and repair (IR). Predictive maintenance foresees the life of an important part by checking and diagnosis and therefore, maintenance costs and trouble losses are less with this method when compared with others. One method of predictive maintenance is condition-based maintenance (CBM). This type of maintenance uses condition diagnosis technology (CDT) to observe the deterioration in the condition of equipment and then foresee its life span. Therefore, a suitable period and method for the maintenance can be decided upon. A system to monitor the condition of equipment online, for example, makes maintenance technology and manpower more necessary in CBM compared with TBM.

Breakdown maintenance can be considered as unplanned maintenance because it results in the repair or exchange of parts after a sudden breakdown or malfunction of the equipment. Breakdown maintenance has a significant influence on the production process, because of the time during which the equipment is stopped and the time consumed to restore the equipment back to normal. Corrective maintenance aims to improve the reliability, maintainability and safety of equipment. Improving bad parts of equipment to reduce deterioration and breakdown, increasing the meantime between failure (MTBF) and reducing the meantime to repair (MTTR) of equipment, are all typical actions in corrective maintenance. These actions are performed on equipment with a short fixed maintenance cycle, a high incidence of breakdown maintenance and high breakdown expense. The main purpose of maintenance is to ensure equipment functions to its original optimal level and this can be accomplished by eliminating losses that affect the equipment. Simultaneously, this also leads to a reduction of production costs. Specifically, seven major losses that can impede equipment efficiency are:

1. Breakdown losses
2. Set-up and adjustment losses
3. Cutting tool losses
4. Start-up losses
5. Minor stoppage (“choko-tei”) and idling losses
6. Speed losses
7. Scrap and rework losses

Breakdown losses are time losses when the function of equipment suddenly stops and these account for the majority of equipment loss (Nakajima and Shirase, 1992).

Total productive maintenance (TPM) is widely known worldwide as a maintenance management technique. This technique taken from the U.S. style of preventive maintenance (PM) was reconfigured by adding some elements of Japanese management style. TPM activities are performed based on a structure called "TPM 8 pillars", which include:

1. Individual improvement
2. Autonomous maintenance
3. Planned maintenance
4. Development management
5. Education and training
6. Office TPM
7. Quality maintenance
8. Safety, health and environment

Among the TPM 8 pillars, companies, especially small and medium-sized enterprises, put more effort into autonomous maintenance in addition to 5S. Autonomous maintenance has seven phases or steps of activity, as listed below:

1. Performing an initial cleaning
2. Eliminating sources of contamination and inaccessible areas
3. Creation of cleaning and routine maintenance standards (checklist)
4. Conducting "standards and inspection" training
5. Carrying out an autonomous equipment inspection
6. Organisation and standardisation of the workplace
7. Continuous improvement of policies, standards and equipment

The higher steps demand more knowledge and skill on the part of the operator and therefore, learning methods and knowledge transfer methods from an expert or a specialist must be facilitated. This paper describes the knowledge management for maintenance activities in the manufacturing sector, by benchmarking the knowledge management of a consultant company and proposes a knowledge repository or warehouse for maintenance activities leading to knowledge-based maintenance.

KNOWLEDGE MANAGEMENT

According to Beesley and Cooper (2008), data and information are objects that can be stored, traded and classified as tangible assets but knowledge is an intangible asset that develops from certain mental activities undertaken by an individual. However, knowledge is valuable only when used and therefore, knowledge must be transferred and shared. Knowledge transfer and knowledge sharing are among the essential components of knowledge management. It is context-dependent and must be targeted towards the needs of a specific organisation. It is not just a process of managing knowledge assets but of also making knowledge more available and applicable at all levels of the organisation (Hasan and Al-hawari, 2003). Knowledge management makes companies more competitive by improving decision-making processes and productivity (Schreiber et al., 1998). The practice of knowledge management is not limited to large organisations but is also applicable to small and medium-sized enterprises (SMEs). However, SMEs often experience erosion of knowledge in many forms; the most obvious is the departure of a key employee, whether it is via retirement or leaving to work for a competitor's firm. According to Wickert and Herschel (2001), smaller firms can employ many techniques for retaining knowledge. These techniques include training, maintaining a repository of "lessons learned", mentoring, knowledge databases and best-practice sharing.

Knowledge Management in Maintenance

Knowledge management should have elements, such as several databases, including information of best practices, on-line information exchange, an assessment tool and a platform from which to learn and consult. (AAKMG, 2001) These elements are also applicable to the knowledge management of maintenance. To facilitate its sharing among employees, it is necessary to store knowledge, such as best-practice information, maintenance methods, assessment methods, trouble symptoms and countermeasures in some medium or a knowledge warehouse. Figure 2 shows the outline of a knowledge warehouse, which consist of best practices, discussion forums, databases and assessment tools. Knowledge can come from three sources: external sources, internal sources (employees) and assessment exercises.

The best-practice element includes the company's achievements, such as maintenance performance evaluations, case studies, advice and the time spent on maintenance (Takehashi and Fukushima, 2000). In addition, it is important to share discussions among communities, maintenance activities and bulletin-board systems. Discussion forums are a form of communication used to transfer, communicate and exchange knowledge. Discussion forums can serve as a consulting platform that can be used as a medium where beginners can learn technology and obtain advice from an expert.

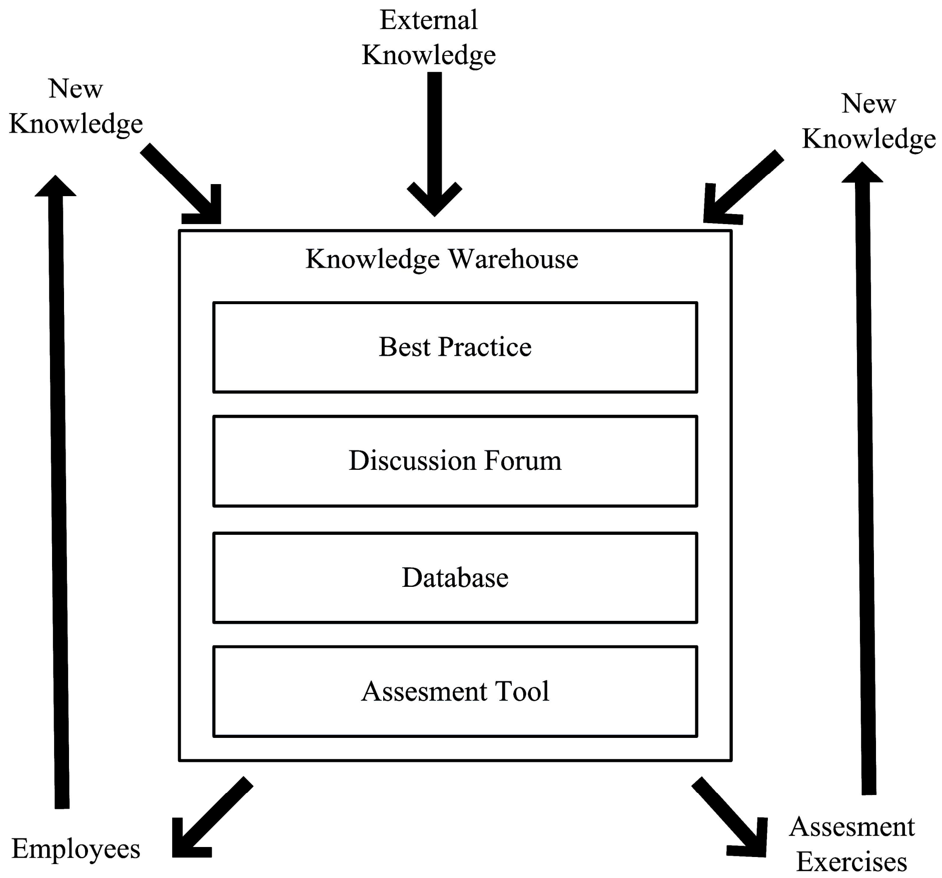

Figure 2. Outline of knowledge warehouse.

One of the assessment methods is performance evaluation. Many performance evaluation techniques have been developed to meet the requirements of business processes. Among them are key performance indicator (KPI), data envelopment analysis (DEA) and game theory. KPI shows a performance of a specific practice, for example; the maintenance costs per product are measured quantitatively with respect to the specific situation within the process. Wireman (2005) suggested ways of developing performance indicators for maintenance management that work at every level, from top management to the bottom level of an organisation. Appendix 1 lists the performance indicators for maintenance. The performance indicators are divided into ten categories, namely: production, cost, quality, delivery, safety, health and environment, morale, time, man, machine and training. These are the typically outputs of TPM and inputs for a production system.

DEA is widely used as a performance evaluation technique in various fields, such as banks, hospitals and universities. DEA is a technique of analysing the efficiency of the business unit using linear programming. The units, called decision-making units (DMUs), refer to the collection of private firms, non-profit organisations, departments, administrative units and groups with the same (or similar) goals, functions, standards and market segments. Instead of using the conventional one input to one output, DEA evaluates multiple inputs and multiple outputs of the system, based on what gives the greatest efficiency value.

Shapley Value, a game theory, is an idea of fair distribution to each player of the profit obtained by collaboration among players. This theory can determine how important each player is for the whole strategy. DEA evaluates the efficiency of the activity while Shapley Value evaluates the result of the activity. Mansor et al. (2008) proposed a framework to benchmark maintenance performance using data envelopment analysis, as shown in Figure 3. This framework requires data acquisition from a data repository before the rest of the processes can be conducted. This framework describes the importance of the space needed to store knowledge because every day new knowledge is created. Knowledge warehouses can avoid important information from becoming useless. The goals of an organisation can be clearly set using proper performance evaluation or measurement standards; this will help an organisation to clarify the problems, which can then be improved. A good balance of progress can be maintained if we are able to set the performance evaluation standard while performing knowledge management processes. Performance evaluation is performed using knowledge stored through knowledge management. The result or new knowledge obtained through this exercise, is then stored back into the repository. This process is repeated to create a continuous knowledge cycle.

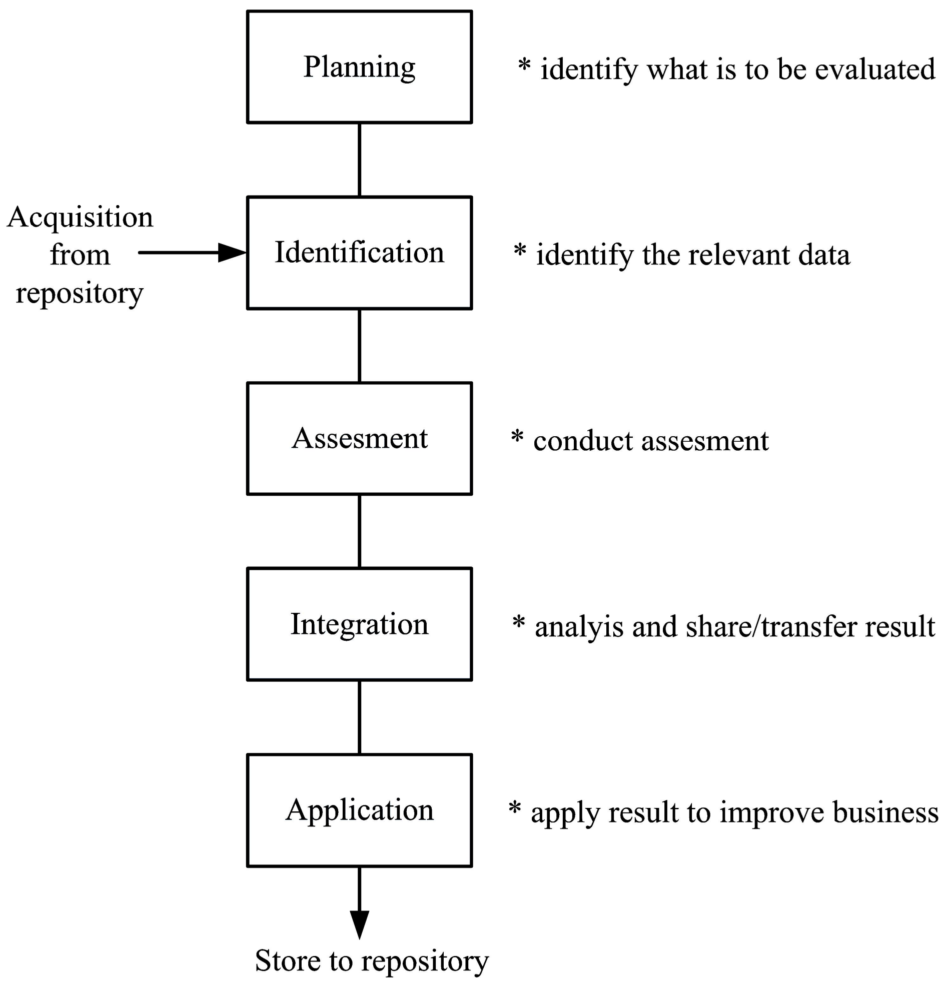

Figure 3. Framework of maintenance performance benchmarking using DEA (Source: Mansor et al., 2008)

Managers use performance measurement to monitor key issues in business. These measures provide the most relevant information of the company, showing managers how the business is performing. Performance measurement not only monitors the business performance according to the business objectives but also assesses the performance in comparison with similar companies through the use benchmarking (Del-Rey-Chamorro et al., 2003). Tsang et al. (2006) suggested that the following four categories of maintenance data are needed in data management:

1. Failures/replacement data (failure mode/suspension, date and time of failure)
2. Inspection data (covariates, data and time of inspection)
3. Maintenance action data (maintenance action, start and finish date and time of maintenance action)
4. Installation data (date and time of installation)

Maintenance can be observed from various viewpoints. For example, maintenance in terms of cost from accountants, budget performance from top management, techniques from engineers and equipment availability and support responsiveness from production. Maintenance managers often have access to many data but seldom receive the information they need (Garg and Deshmukh, 2006). Therefore, a knowledge warehouse will provide the maintenance manager with the opportunity to share the knowledge from other departments. Nagarur and Kaewplang (1999) developed a maintenance decision support system, which comprises several databases that store detailed knowledge about equipment, inventory, line, workstation, machine, fault, tool, manpower, work order, plan, performance indices and schedule databases. Such databases are necessary not only for a decision support system but also for new employees in order to gain new information about equipment, as well as the maintenance system.

CONCLUSIONS

Knowledge management is a process that cannot be avoided for a company, because it is a step in providing the necessary information for business performance measurement. In order to acquire accurate results of performance measurement, accurate information becomes an important factor. In our work, we have discussed the necessary elements that should be included in a knowledge repository or warehouse for maintenance, where one of the key elements is an assessment tool. This is an important factor because knowledge management has a deep relationship with performance evaluation and measurement. Therefore, knowledge management for maintenance activities strongly indicates a paradigm shift from conventional maintenance to knowledge-based maintenance or “K-Maintenance”. Maintenance is more than just the fixing of a broken-down piece of equipment because this event also brings serious effects for production efficiency. Maintenance based on knowledge contributes to time and cost savings. Better efficiency of maintenance activities can be achieved by taking advantage of the available maintenance knowledge. Thus, knowledge warehouses for maintenance activities are an appropriate tool or medium for knowledge utilisation. Transferring information or knowledge from employees to a knowledge warehouse is also a preliminary process in the whole processes. However, in general, technicians or direct maintenance personnel have no time to participate in documentation or computing. In this sense, the transfer of their knowledge to the knowledge warehouse is often a missing piece. In future work, we would like to further investigate this missing portion of maintenance knowledge.

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APPENDIX 1

Production

1. Availability
2. Breakdown Reduction Rate
3. Man-hours Spent On Emergency Jobs
4. Number of Downtime
5. Number of Minor Stoppage (Choko-tei)
6. Total Man-hours Worked
7. Overall Equipment Effectiveness
8. Performance Rate
9. Total Work Order
10. Total Amount of Produce Produced
11. Total Number of Breakdowns
12. Number of Equipment Failures
13. Number of Preventive Work Orders
14. Mean Time Between Failure (MTBF)
15. Mean Time To Repair (MTTR)
16. Number of Corrective Order
17. Number of Emergency Order

Machine

1. Number of Machines/Equipment

Training

1. Total Training hours
2. Total Technical Training Hours

Cost

1. Amount of Cost down/Cost Reduction
2. Amount of Money for Inventory
3. Amount of Money for Quality Losses
4. Kaizen Cost
5. Cost of Idle Production/Operation
6. Cost of Late Delivery
7. Overtime Cost
8. Downtime Cost
9. Downtime or Lost Production Costs Per Hour
10. Initial Cost of The Equipment
11. Lost Efficiency Cost
12. Maintenance Labour Costs On Work Order
13. Maintenance Material Costs On Work Order
14. Replacement Cost For The Equipment
15. Direct Maintenance Cost
16. Total Maintenance Material Cost
17. Utility Cost
18. Unplanned Maintenance Cost
19. Planned Maintenance Cost
20. Total Maintenance Cost
21. Breakdown Maintenance Cost
22. Preventive Maintenance Cost
23. Operational Expenditure
24. Capital Expenditure
25. Total Manufacturing Cost
26. Manufacturing Cost per Unit

Quality

1. Customer Return Rate
2. Number of Customer Claims/Complaints
3. Number of Rejected Products
4. Quality Rate

Delivery

1. Inventory Days
2. On Time Delivery To Customer

Safety, Health & Environment

1. Number of Accidents
2. Amount of Waste Disposed
3. Number of Environment Accidents
4. Recycle Rate

Morale

1. Number of Employee Suggestions
2. Operator Skill
3. Number of Absences/Absence rate

Time

1. Downtime Losses (time)
2. Operating Time
3. Planned Downtime
4. Downtime Caused by Breakdowns
5. Hours Worked As Overtime
6. Total Downtime Hours
7. Total Hours Worked
8. Total Maintenance Hours
9. Total Breakdown Hours
10. Time Taken For All Repair Works
11. Time Spent on Maintenance
12. Number of working days (per week/month/year)
13. Total Working Time
14. Planned Downtime
15. Loading Time
16. Operating Time
17. Design Cycle Time

Man

1. Number of Direct Maintenance Employees
2. Number of Indirect Maintenance Employees
3. Number of Employees