

## **LEAN TPM FOR HEALTHCARE FACILITIES: AN IMPLEMENTATION METHODOLOGY**

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### **ABSTRACT**

This paper presents a study that aims to investigate the implementation of the Total Productive Maintenance (TPM) program in the healthcare industry. The study was carried out at a major hospital in Jordan using semi-structured interviews coupled with documents collection and analysis. A TPM implementation methodology has been developed for increasing medical devices utilization and decreasing their failures. The developed employees' working system and new responsibilities were explained through Autonomous Maintenance (AM), Preventive Maintenance (PM), and 5S Modeling, with a suggestion for additional working performance indicators. This paper is one of a few studies that investigate the applicability of manufacturing maintenance systems in other settings and that they can generate significant operational benefits.

**Keywords:** Total Productive Maintenance; Healthcare; maintenance system; implementation methodology; lean TPM; maintenance operations.

### **INTRODUCTION**

The concept of Total Productive Maintenance (TPM) has been introduced and developed by Japanese in 1971. This came in response to the maintenance and support problems in commercial factory. TPM is defined as a productive maintenance carried out by all employees through small group activities. TPM is a maintenance program which involves a newly defined concept for maintaining plants, equipment and facilities [1], knowing that failures will cause additional costs, TPM aims to increase the ability of existing equipment in a given situation reducing in that way the need for further capital investment [2]. Also TPM can be defined as a program for fundamental improvement of the maintenance functions in an organization, which involves its entire human resources [3]. TPM philosophy requires the development of a preventative maintenance program for the life-cycle of the equipment and the involvement of operators in maintaining the equipment in order to maximize its overall efficiency and effectiveness [4]. According to Ljunberg [5], TPM is based on three major concepts; maximizing equipment effectiveness, autonomous maintenance by operators, and small group activities. TPM approach is widely used in different industrial sectors due to the significant change in business environments over the last two decades. The changes in the current business environment are characterized by intense competition on the supply side, increased pressures to reduce costs, and heightened volatility in customer requirements on the demand side [6]. The change in the market increased the level of global competitiveness between organizations and everyone wants to satisfy customers more than others. The global marketplace has witnessed an increased pressure for reduced operating costs with improved performance in industrial sectors including healthcare [7]. Hence, the aim of this paper is to present an implementation methodology for the TPM in healthcare facilities that can reduce maintenance cost and improve operational efficiency.

## TPM AND LEAN CONCEPTS

TPM is a methodology originating from Japan to support its lean manufacturing system. Lean thinking tools improve the design efficiency of transformation processes providing the potential to deliver greater customer value with less effort and TPM tools improve the effectiveness of the transformation processes (i.e. dealing with the reasons why things do not go to plan [8]. TPM is a common element to lean drive as it is a tool to reduce and remove the variation to decrease the frequency of equipments' failures, another tools and lean systems that need a stable working system such as Just-in-Time (JIT) and TQM can be applied, so that TPM is the corner stone activity for most of the lean manufacturing philosophies and can effectively contributes towards success of lean manufacturing [6] and this relationship is shown in Figure 1. The relationship between TPM and other tools was approved by defining TPM as an innovative approach to plant maintenance that is complementary to TQM, JIT, Total Employee Involvement (TEI), Continuous Performance Improvement (CPI), and other world-class manufacturing strategies [9][10][11].

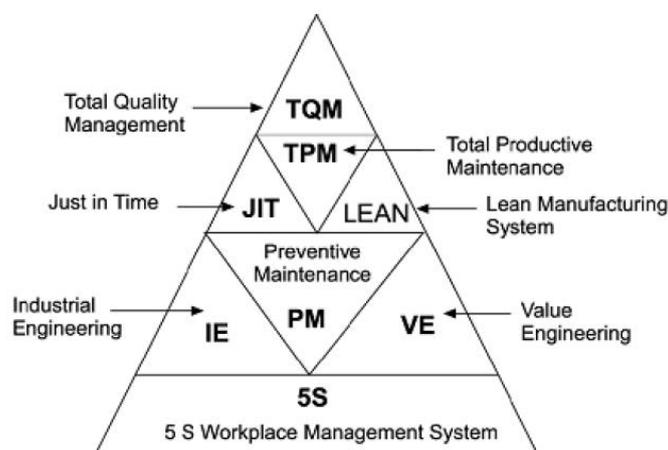


Figure 1: Relationship between TPM and lean manufacturing philosophy.

## TPM PRACTICES AND PILLARS

The core practices and activities of implementing TPM are usually called pillars. The naming and the number of pillars may differ slightly [12]. According to Ahuja and Khamba [6], Japan Institute of Plant Maintenance (JIPM), suggested and promoted the eight pillar implementation plan that substantial increase labor productivity through controlled maintenance, reduction in maintenance costs, and reduced production stoppages and downtimes. Figure 2 shows the eight pillars that comprise an implementation plan of TPM including: Autonomous Maintenance, Focused Maintenance, Planned maintenance, Quality Maintenance, Education and Training, Office TPM, Development Management and Safety, Health and Environment [12][13][14]. The basic measure associated with total productive maintenance (TPM) is the Overall Equipment Efficiency (OEE). OEE highlights the actual 'Hidden Capacity' of the organization. TPM employs OEE as a quantitative metric for measuring the performance of a productive system. OEE is the core metric for measuring the success of TPM implementation Program [15]. The overall goal of TPM is to raise the overall equipment effectiveness [16][17] or in a most simple form, it aims to increase OEE of facilities by operating and maintaining machinery at an

optimum level [18], where OEE is a function of availability, performance, and quality rate [19]. Availability is measured as a proportion of time the equipment or the machine is actually available out of time that should be available, performance represents and influenced by the number of produced items in a given period of time, and quality rate represents the percentage of good parts out of total produced [20]. OEE is not always feasible for all types of organizations due to the huge difference in the working systems and sources of losses between the service and manufacturing sectors. This metric offers a starting-point for developing quantitative variables for relating maintenance measurement to corporate strategy. It can be used as an indicator of the reliability of the production system [6].

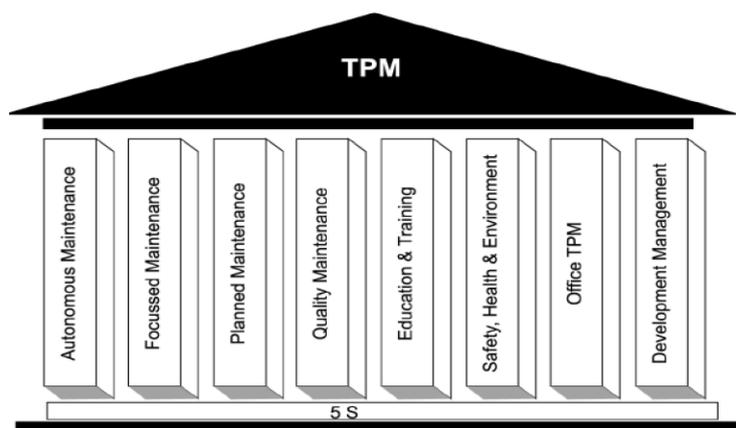


Figure 2: The eight pillars approach for TPM implementation

Due to the fact that devices and equipments are the largest assets in any organization, equipment management is thus required to focus and enhance a companywide approach to improving equipment productivity. Hartmann and Charles [21], defined this approach as a process of focusing efforts to improve the elements of equipment utilization, equipment performance, and equipment availability. This approach is key to moving a company through the installation of TPM.

## **RESEARCH SITE**

The present research was conducted at King Abdullah University Hospital (KAUH). It is considered to be one of the distinct landmarks in Jordan and the region as a whole, due to its design and health care services capabilities. As a general hospital, KAUH provides various clinical and referral healthcare services to other health care sectors in Jordan in a framework of mutual agreements and contracts, in addition to being a teaching hospital where university health science students receive their education and training courses. The hospital's maintenance department provides maintenance activities to the whole buildings of the hospital and it is divided into four branches. Medical Devices Branch is the one responsible for maintaining all medical devices used in the hospital by implementing corrective maintenance and some preventive maintenance activities to make sure that all spare parts needed are available and can be used directly to keep the devices in its highest performance levels. Civil Activities Branch is responsible for correcting and maintaining all civil buildings and roads in addition to the furniture and monitoring every activity relating to them. Mechanical Branch concentrates its activities on operating the mechanical devices in the hospital such as hot and cold water pumps, water filtering

and sanitation, monitoring the air conditioning systems, and medical gases systems. Electrical Branch is responsible for operating and maintaining the electrical networks, externally and internally, hospital generators and transformers, and monitoring the network work and any other systems or devices connected to it. In the research presented here, the work will be concentrated on the medical devices branch and to investigate how TPM can be implemented to reduce medical devices' failures and generate benefits.

## **RESEARCH METHODOLOGY**

The data was primarily collected through in-depth interviews conducted within the premises of KAUH, followed by observations and documents gathering. Prior to the commencement of interviews a number of visits have been established with the "gatekeeper" [22] to develop a sense of trust as well as to explain the purpose of research. An "interview protocol" has been prepared as a backup to help in structuring the interviews and taking accurate notes [22], it consisted of interviewer and interviewee name and position, time and date of the interview, list of questions to be asked and a space where the notes on each question is to be written. A suitable quiet place was arranged by the "gatekeeper" to conduct the interviews. Thirteen interviews in total were conducted in research site, eleven were front-line employees from the maintenance department, and two senior managers in the maintenance department. The eleven front-line employees were interviewed about their working duties before and after the project as a part of a comparison study to explore the changes happened at the workplace. The remaining interviewees were interviewed about the introduction process of TPM and the benefits achieved so far at all levels. The purpose of the study and the estimated interview time and how the information of the interview will be treated were all explained to participants before starting the interview. The interviews started with a very broad questions about participants roles, responsibilities and general working issues and gradually were narrowing down to a more focused issues which are the main concern of the research work, allowing for the employment of the "funnel interview" [23]. To ensure the elimination of the sense of anxiety and discomfort, every interviewee was asked whether he is comfortable with brief note taking and the use of audio tape to record the conversation, with which all interviewees have agreed. After completing the interview, interviewees were thanked for their participation, a confirmation for the information confidentiality was reassured. Further, the participants were told that a report about the study will be provided for the research site to ensure that results are accessible to every individual concerned. "Thematic analysis" methods [24] were employed to identify the main themes constituting the interviewee replies.

## **CURRENT MEDICAL DEVICES MAINTENANCE WORK**

Operational failures in healthcare can obstruct employees, delay patient care, waste hospital resources, put patient at risk, as well as decrease productivity and quality of care [20]. Most operational failures resulted from breakdowns in the supply of material and information [25] and so, before proceeding to the breakdowns and its causes, it is worth to identify the whole process of maintaining any device from the breakdown call until putting the device back to its work. And this work procedure is shown clearly in the following process flow chart, as given in Figure 3. As a part of implementing TQM in the hospital, the medical maintenance department use the term: Percent of Maintenance Calls Achieved as a measure of repairing and working performance. This indicator is usually calculated for each month to follow its success trend for future improvement decisions. Each maintenance branch has a reference value to represent the minimum percent of maintenance claims that should

be completed for every month; this value is determined by the hospital's management depending on the difficulty of work between the four branches of maintenance (civil, electrical, mechanical, and medical). For example, the reference value is chosen to be 80% for medical devices branch which means that if they accomplished about 80% of the claims for any month, it is considered a very good work depending in their own internal evaluation. Note that the total reports or claims comes to the work shop are considered for each month alone, so that any backlog comes from previous month is not taken into consideration to the next month, where as backlog means number of failures claims received at the end of one month and repaired during the next month.

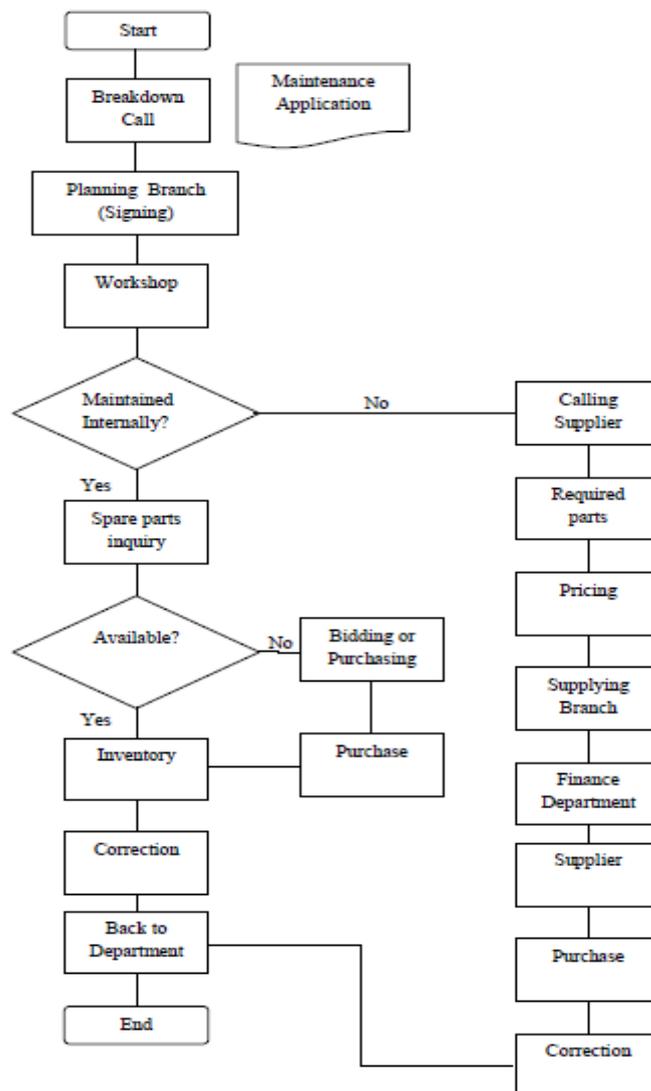


Figure 3. Current medical devices maintenance procedure.

## PROPOSED TPM IMPLEMENTATION METHODOLOGY

The results achieved from interviews and documents collected suggest the development of TPM implementation methodology using the 5S modeling technique. 5S is an approach to keep the working areas in the different

departments and in the maintenance workshop in an organized condition to have effective workplace, simple working environment and less waste. The methodology is constructed around the following five pillars:

- 1) **Seiri – Sort out:** The technicians should consider and organizing his working place so that the most frequent used tool should be put in the front line. Previous experience will help him in categorizing his tools so they can use them directly without losing time in searching about them. This also can be applicable in the departments in the autonomous maintenance activities needs many tools.
- 2) **Seiton – Organize:** Here the technician should organize his tools in order that each tool has just one place and marks can be used. This will lead him directly to the required tool quickly. The same is true for other employees.
- 3) **Seiso – Shine the Workplace:** A thorough cleaning of the workplace should be done in order to remove any burrs or wastes from a previous maintenance activities then a daily follow up cleaning is necessary to sustain the improvement or the current state.
- 4) **Seiketsu – Standardization:** It is necessary to standardize the previous three stages in order not to repeat them again. The technician and the user can develop a daily checklist to ensure that the workplace is still clean and all the required tools or devices are put in their correct places.
- 5) **Shitsuke – Self Discipline:** Considering 5S as a way of life and bring about self discipline among the employees of the hospital.

Figure 4 is a representation of the new medical devices maintenance process flow after the implementation of TPM. It takes into account the role of Autonomous Maintenance and its Employees Responsibilities' Extension as a major concept of TPM in addition to the ability to repair some failed devices in its places instead of transmitting every device to the workshop. Previously, any small failure in any device requires maintenance staff activities but in the developed process described below there is a necessity to involve the employees in the care and maintenance of devices they are responsible for.

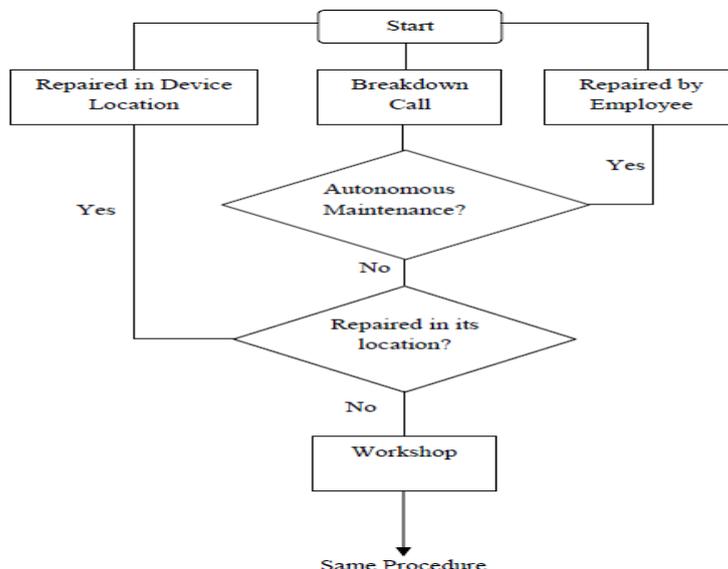


Figure 4. Medical devices maintenance process flow after TPM implementation.

## DISCUSSIONS AND CONCLUSIONS

TPM implementation in hospitals is a new management paradigm and change in the nature and concepts of traditional maintenance system currently used and this big change requires a top management commitment and full understanding of it. The proposed maintenance system suggests an increase in employees' responsibilities from using medical device to maintain them. This needs a complete coordination with hospital's top management and lies into overall employee involvement concept which represents a success factor of TPM implementation. During analyzing the most frequent failing devices in the hospital and their causes, employees related errors are redundant due to the lack of devices' care and preventive maintenance activities. Proposed TPM system gives a high priority to develop employees to be able to take care of small maintenance activities tasks and to upkeep their devices. All of these activities come in AM pillar which is a major concept in this research. The developed methodology for implementing and evaluating TPM can be useful for guiding other healthcare facilities to improve their operations. It is designed so that other healthcare facilities may use it to implement and evaluate TPM implementations in their own unique settings. For the other facilities that have lack of data are records, it is also useful to use the proposed computerized data collection system to follow their performance with some modifications depending on their sizes, number of departments, medical devices, employees and so on.

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