The Applicability of Total Productive Maintenance for Healthcare Facilities: an Implementation Methodology

Tamer H. Haddad
Instructor
Industrial Engineering Department, P.O.Box 7
An-Najah National University
Nablus, West Bank, 97200, Palestine

Dr. Ayham A.M. Jaaron
Assistant Professor in Industrial Engineering
Industrial Engineering Department, P.O.Box 7
An-Najah National University
Nablus, West Bank, 97200, Palestine

Abstract

This paper presents a novel methodology for 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 in-depth interviews coupled with observations and documents collection. 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.

1. 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 (Gosavi, 2006). TPM is a maintenance program which involves a newly defined concept for maintaining plants, equipment and facilities (Venkatesh, 2003), 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 (Bohoris et al., 1995). Also TPM can be defined as a program for fundamental improvement of the maintenance functions in an organization, which involves its entire human resources (Wang, 2006). 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 (Riis et al.,1997).

According to Ljunberg (1998), 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 (Eti & Ogaji, 2006). 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 (Ahuja & Khamba, 2008). 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 (Basu, 2001; Gosavi, 2006). 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.

2. 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 (Jaaron & Backhouse, 2011), and TPM tools improve the effectiveness of the transformation processes (i.e. dealing with the reasons why things do not go to plan (McCarthy & Rich, 2004). 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 (Ahuja & Khamba, 2008), 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 (Yamashina, 2000; Ollila & Malmipuro, 1999; Cua et al., 2001).

3. Tpm Practices and Pillars

The core practices and activities of implementing TPM are usually called pillars (Gosavi, 2006). The naming and the number of pillars may differ slightly (Patra et al., 2005). According to Ahuja and Khamba (2008), 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 (Patra et al., 2005; Ireland & Dale, 2001; Rodrigues & Hatakeyama, 2006). 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 (Jeong & Phillips, 2001). The overall goal of TPM is to raise the overall equipment effectiveness (Huang et al., 2002; Juric et al., 2006), or in a most simple form, it aims to increase OEE of facilities by operating and maintaining machinery at an optimum level (Prickett, 1999), where OEE is a function of availability, performance, and quality rate (Blanchard, 1997).

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 (Robbins, 2008). 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 (Eti & Ogaji, 2006). It can be used as an indicator of the reliability of the production system (Ahuja & Khamba, 2008).

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 (2001), 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.

4. Research Site

The present research was conducted at one of the leading hospitals in Jordan. The hospital is considered to be one of the distinct landmarks in the region, due to its healthcare services capabilities. As a general hospital, it provides various clinical and referral healthcare services to other healthcare sectors in Jordan in a framework of mutual agreements and contracts, in addition to being a teaching hospital where university level 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.

5. 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" (Creswell, 2004) 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 (Creswell, 2004), 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 quite 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" (Tashakkori & Teddlie, 1998). 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 (Taylor & Bogdan, 1984) were employed to identify the main themes constituting the interviewee replies. The full process of analysis followed in this research is illustrated in the following three stages:

1- As a first step, the research objective and interviewees stories are studied in order to shed the light on general leading theoretical topics available. These theoretical topics, also called coding schemes (Minichiello et al., 1990), were then used to list a set of words or topics that represent a general meaning of what has been said in the interviews, this is known as the coding framework of interviews analysis (Attride-Stirling, 2001). To illustrate this approach for the current situation the research objective was identified as being "how to implement lean thinking in call centres embraced by manufacturing organizations?". The codes used were the problems found, project needs, choice, options, strategy and action applied. The benefit of creating such a coding framework is the generation of a list of words which can be linked into common categories during analysis (Minichiello et al., 1990).

2- The second step involved reading again through the transcripts of interviews and coding the content. The interviews transcripts were divided into meaningful fragments to facilitate dealing with the data. Every fragment or text segment was then given a word or a code that represent the meaning perceived and belongs to the pre-defined coding framework.

3- The final step involved revising the divided transcripts to find codes with common basic themes. This was done by careful reading of the coded fragments, which enabled the identification of underlying structures. This has allowed for clustering basic themes around more central themes that was used later for interpretations.

6. Previous 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 (Robbins, 2008). Most operational failures resulted from breakdowns in the supply of material and information (Tucker, 2004). Therefore, it is noteworthy to identify the whole process of maintaining any device from the breakdown call until putting the device back to its work before the implementation of TPM principals. The results from the in-depth interviews have identified the main stages of the maintenance process before the TPM implementation. These stages are shown in the process flow chart of 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 percent for medical devices branch which means that if they accomplished about 80 percent 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.

7. Proposed Tpm Implementation Methodology

The results achieved from in-depth interviews, observations, 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:

7.1 Seiri – Sort out: almost all the interviewees in this study have discussed the importance of technicians to organize their working place so that the most frequent used tool should be put in the front line. Interviewees insisted that this step was employed to facilitate the gradual introduction of TPM to the maintenance department. It was stated that previous experience will help technicians in categorizing their tools so they can use them directly without losing time while trying to find them.

7.2 Seiton – Organize: there was a strong feeling among interviewees that technicians should organize their tools in order that each tool has just one place and labels can be used. This was thought to lead technicians quickly to the required tool. The same is true for other employees.

7.3 Seiso – Shine the Workplace: interviewees stated that a thorough cleaning of the workplace was regularly done in order to remove any burrs or wastes from a previous maintenance activities, then a daily follow up cleaning procedure is necessary to sustain the improvement of the current state.

7.4 Seiketsu – Standardization: interviewees highlighted the necessity of this stage in standardizing 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 for the next maintenance activity.

7.5 Shitsuke – Self Discipline: Interviewees stated that 5S should be considered as a way of life and should bring about self discipline among the employees of the hospital. Interviewees explained that this can be achieved by the utilization of their workers capabilities to the utmost by treating them as human beings. In the maintenance manager own words: "the hospital has built up a system of respect for human". This respect stems from three different strategies followed in hospital:

- Elimination of waste movement by workers: workers were taught to show their skills and diligence when it is vital to add value for maintenance activities. They were encouraged to move materials and use processes only when a new maintenance call is received that needs that particular process to move forward.
- workers' safety importance: maintenance workers were very committed and enthusiastic about their job. Thus, they will do almost anything to keep the work running. However, in situations where an extra role or behavior could be dangerous or causes further troubles, maintenance department management put on a tremendous effort to eliminate the sources of obstruction and obstacles in the processes flow, not only as a cost reduction measure, but also as a workers' safety measure.

- Active participation of workers: maintenance department management has shown great consideration for respecting human values and capabilities. This was due to management belief that respecting human abilities and capabilities is where the competitive success lies. Workers were allowed to make decisions they found necessary for the work, such as replacing parts when a problem happens, make work changes, and make any improvement initiative to remove any waste found in the maintenance processes.

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.

8. Discussion

TPM implementation in hospitals is a new management paradigm, it is considered a dramatic change as compared to the nature and concepts of traditional maintenance system currently used in majority of healthcare departments. However, this dramatic change requires a top management commitment and support. The proposed maintenance methodology suggests an increase in employees' responsibilities from using medical device to maintaining them. This needs a complete coordination with hospital's top management and largely depends on employee involvement concept which represents a success factor of TPM implementation. The offerings of the TPM structure has contributed to the development of employees' sense of job ownership and promoted feeling of belonging and value to the work place. This is because TPM provides the opportunity for employees to fulfill their personal ambitions; desire of achievement, autonomy, and a sense of control on what they have. Furthermore, it was revealed that TPM is related to the employer ability to empower employees to make work decisions at their own level to provide a quick service, with this in place employees can develop a feeling of personal importance to the organization (van Emmrik & Sanders, 2005).

Constructive management' relationships with employees has a particular importance in creating a supporting culture in the work place rather than a monitoring culture that could destroy employees morale (Seddon, 2008). This inevitably creates a rewarding working experience for employees. All considered, the implementation of TPM principles, employ open channels of communication with other departments in the hospital as well as among employees themselves. Decentralizing decision making processes to be at employees' level was a result of this open communication strategy. Employees could access the information necessary for them to process maintenance demands and thus allow them to provide effective solutions without the need for maintenance requester to call again. Handling maintenance demands this way allowed employees to process more requests and increased value productivity in an efficient way without a cut in service, and eventually enhanced their self-esteem of ability to act and personal achievement.

During the process of analyzing the most frequent causes for failing devices in the hospital before the TPM implementation, employees described errors as redundant due to the lack of devices' care and preventive maintenance activities. Proposed TPM system gives a high priority to improve employees' abilities to accomplish small maintenance activities and upkeep their devices. Majority of these activities lies in the AM pillar which is a major concept in the TPM. However, hospitals, like KAUH, are considered a large organization, following its maintenance working performance and medical devices' availability requires more than one performance indicator. Some of these indicators should be related to the maintenance department itself and the others should be related to different hospital's departments. The proposed performance indicators measure the ability of maintenance staff to fulfill all coming maintenance claims within a specific period of time, the frequency of failures, where they come from, how every department deals with its devices, and the employees satisfaction in implementing TPM activities.

The presented methodology, for implementing and evaluating TPM, in this paper can be a useful tool for guiding other healthcare facilities to improve their maintenance operations. It is designed so that other healthcare facilities may use it to evaluate TPM implementation in their own unique settings.

9. Conclusions

The fundamental objective of this paper has been to presents a novel methodology for the implementation of the Total Productive Maintenance (TPM) program in the healthcare industry. The analysis of the results achieved in this case study clearly satisfies the research aim posed at the beginning of this research paper by suggesting the development of TPM implementation methodology using the 5S modeling technique. Further, a clear strategy has emerged between the use of TPM approach for designing maintenance activities and the value adding to the healthcare department that embraces it. It has been explored that TPM principles is likely to create a dramatic change in the philosophy of work as compared to the traditional maintenance principles found in majority of healthcare maintenance departments. Employees under the new system are no longer restricted to repetitive job handling procedures or target achieving dilemma, they are empowered to do the job in the best way they see is vital to satisfy customer needs. Hence, employees have opportunities to develop their working skills by handling a wide range of challenging demands on daily basis. This suggests that the ability of employees to control the work and to decide about the way they handle and receive information is a key factor of improving productivity and service quality.

10. References

Ahuja, I.P.S., & Khamba, J.S. (2008). Assessment of contributions of successful TPM initiatives towards competitive manufacturing. Journal of Quality in Maintenance Engineering, 14 (4), 356-374.

Attride-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. Qualitative Research, 1(3), 385-405.

Basu, R. (2001). Six sigma to fit sigma. IIE Solutions, 33 (7), 28-33.

Blanchard, B. (1997). An enhanced approach for implementing total productive maintenance in the manufacturing environment. Journal of Quality in Maintenance Engineering, 3 (2), 69-80.

Bohoris, G.A., Vamvalis C., Tracey, W., & Ignatiadou, K. (1995). TPM implementation in Land-Rover with the assistance of a CMMS. Journal of Quality in Maintenance Engineering, 1 (4), 3-16.

Creswell, J.W. (2004). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. (2nd ed.). Ohio: Pearson Education.

Cua, K.O., McKone, K.E. & Schroeder, R.G. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. Journal of Operations Management, 19 (6), 675-694.

Eti, M.C., Ogaji, S.O.T. (2006). Development and implementation of preventive-maintenance practices in Nigerian industries. Applied Energy, 83, 1163-1179.

Gosavi, A. (2006). Arisk-sensitive approach to total productive maintenance. Automatica, 42, 1321-1330.

Hartmann, E. H., & Charles, H. L. (2001). Total productive maintenance. In: K.B. Zandin, Maynard's Industrial Engineering Handbook. (5th ed.). New York: McGraw-Hill.

Huang, S.H., Dismukes, J.P., Shi, J. & Su, Q. (2002). Manufacturing system modeling for productivity improvement. Journal of Manufacturing Systems, 21 (4), 249-260.

Ireland, F., & Dale, B.G. (2001). A study of total productive maintenance implementation. Journal of Quality in Maintenance Engineering, 7 (3), 183-191.

Jaaron, A., & Backhouse, C. (2011). Value-Adding to Public Services through the Adoption of Lean Thinking. International Journal of Service Science, Management, Engineering, and Technology, 2(3), 33-50.

Juric, Z., Sanchez, A.I. & Goti, A. (2006). Money-based overall equipment effectiveness. Hydrocarbon Processing, 85 (5), 43-45.

Jeong, K., and Phillips, D.T. (2001). Operational efficiency and effectiveness measurement. International Journal of Operations and Production Management, 21 (11), 1404-1416.

Ljungberg, O. (1998). Measurement of overall equipment effectiveness as a basis for TPM activities. International Journal of Operations and Production Management, 18 (5), 495-507.

McCarthy, D., & Rich, N. (2004). Lean TPM: A blueprint for Change. (1st ed.). Burlington: Elsevier Ltd.

Minichiello, V., Aroni, R., Timewell, E. & Alexander, L. (1990). In-Depth Interviewing: Researching People. Melbourne: Longman Cheshire.

Ollila, A., & Malmipuro, M. (1999). Maintenance has a role in quality. The TQM Magazine, 11 (1), 17-21.

Patra, N.K., Tripathy, J.K., & Choudhary, B.K. (2005). Implementing the office total productive maintenance ("Office TPM") program: a library case study. Library Review, 54 (7), 415-424.

Prickett, P.W. (1999). An integrated approach to autonomous maintenance management. Integrated Manufacturing Systems, 10 (4), 233-242.

Riis, J., Luxhoj, J., & Thorsteinsson, U. (1997). A situational maintenance model. International Journal of Quality and Reliability Management, 14 (4), 349-366.

Rodrigues, M. & Hatakeyama, K. (2006). Analysis of the fall of TPM in companies. Journal of Materials Processing Technology, 179 (1-3), 276-279.

Robbins, R. (2008). Overall Equipment Effectiveness. Control Engineering, 55 (1), 64.

Seddon, J. (2008). Systems Thinking in the Public Sector. Axminster: Triarchy Press.

Tashakkori, A., & Teddlie, C. (1998). Mixed methodology: Combining qualitative and quantitative approaches (Applied Social Research Methods, No. 46). Thousand Oaks: Sage.

Taylor S.J., Bogdan R. (1984). Introduction to Qualitative Research Methods: The Search for Meaning. New York: John Wiley & Sons.

Tucker, A.L. (2004). The impact of operational failures on hospital nurses and their patients. Journal of Operations Management, 22 (2), 151-169.

van Emmrik, I.J.H. & Sanders, K. (2005). Mismatch in working hours and affective commitment: differential relationships for distinct employee groups, Journal of Managerial Psychology, 20(8), 712-726.

Venkatesh, J. (2003). An introduction to total productive maintenance. [online] Available at: http://plantmaintenance.com/article/tpm_intro.shtml (July 1, 2011).

Wang, F. (2006). Evaluating the efficiency of implementing total productive maintenance. Total Quality Management, 17 (5), 655-667.

Yamashina, H. (2000). Challenge to world-class manufacturing. International Journal of Quality and Reliability Management, 17 (2), 132-143.

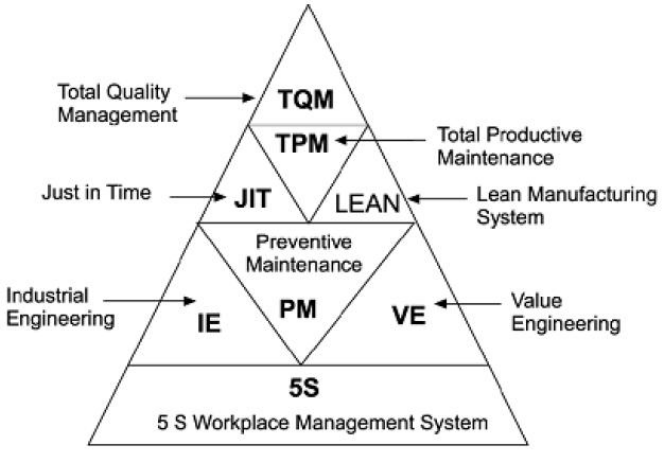

Figure 1: Relationship between TPM and lean manufacturing philosophy.

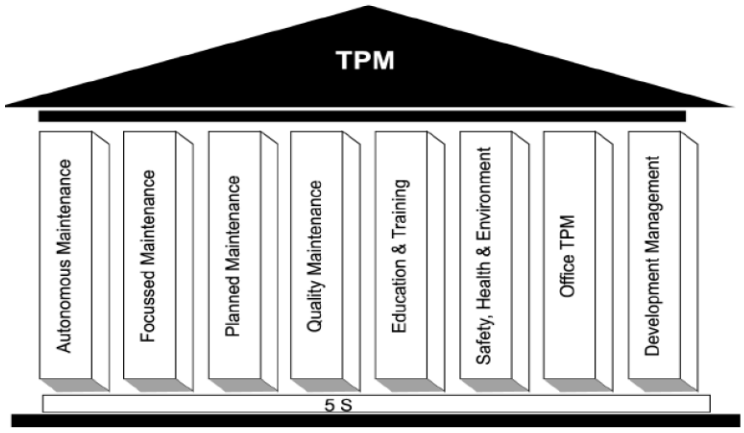

Figure 2: The eight pillars approach for TPM implementation

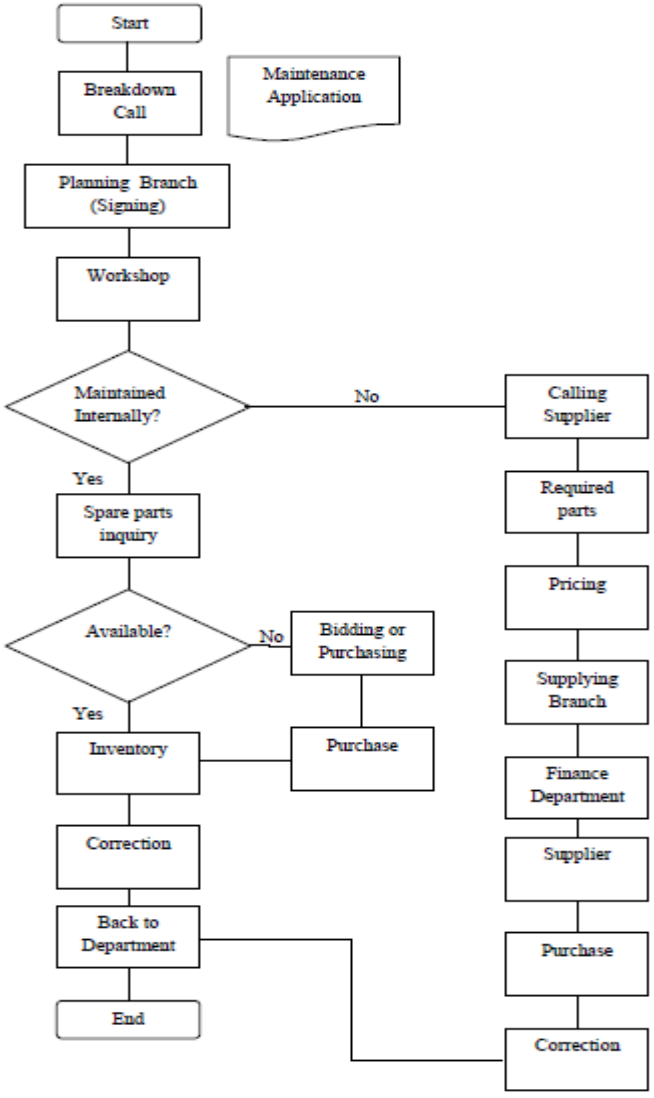

Figure 3. Previous medical devices maintenance procedure.

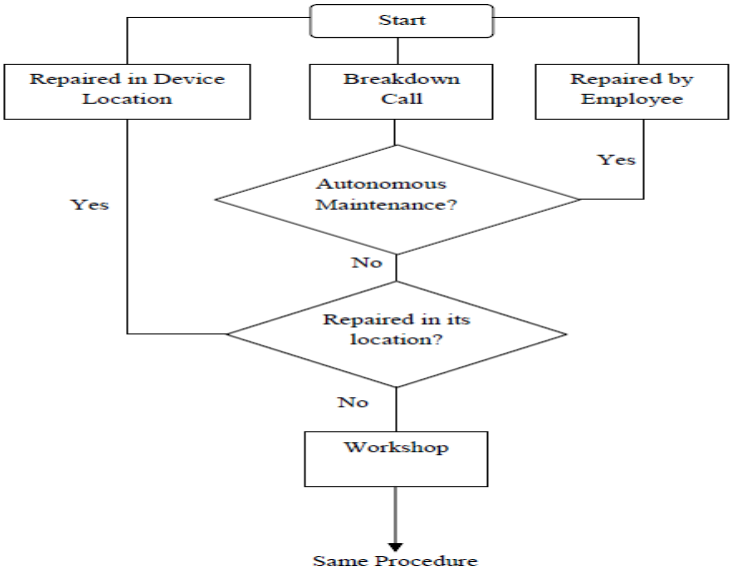

Figure 4. Medical devices maintenance process flow after TPM implementation.