Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 4 Issue 7, July - 2017

An Analytical Model for the Implantation of the Maintenance Strategy in the Industrial Organization

M.ER-RATBY [1], M.MABROUKI [2]

University Sultan Moulay Slimane, Faculty of science and technology, Industrial Engineering Laboratory

Beni Mellal, Morocco

Emails: [1] mohamed.erratby@gmail.com ,[2] mus_mabrouki@yahoo.com

***Abstract*— During the last years industrial maintenance has evolved from a non-issue into a strategic concern. Perhaps there are few other management disciplines that underwent so many changes over the last half-century. During this period, the role of maintenance within the organisation has drastically been transformed. At first maintenance was nothing more than a mere inevitable part of production, now it is an essential strategic element to accomplish business objectives. Without a doubt, the maintenance function is better perceived and valued in organizations. One could considered that maintenance management is no longer viewed as an underdog function; now it is considered as an internal or external partner for success.**

In view of the unwieldy competition many organisations seek to survive by producing more, with fewer resources, in shorter periods of time. To enable these serious needs, physical assets take a central role. However, installations have become highly automated and technologically very complex and, consequently, maintenance management had to become more complex having to cope with higher technical and business expectations.

This article covers directly or indirectly both maintenance engineering and the proposed model of the maintenance strategy to develop a simple and cost-effective approachaimed to formulate and implement maintenance strategies for the manufacturing industry.

***Keywords*— Maintenance, Management, Production.**

I. INTRODUCTION

Today's manufacturing organizations are required to operate as open operational systems. In such systems, advanced operational manufacturing technologies are blended with modern information systems to integrate and coordinate operational resources, processes, and activities in order to generate a stream of value-added operations aimed at capturing a competitive advantage. With the increasing complexity, scope, and organizational role of operational advanced manufacturing technologies, the maintenance of these technologies is becoming very important to the ability of the organization to compete.

In the last few decades, manufacturing organizations were forced to shift their business models from closed systems orientations, to more open system orientations. Today's manufacturing organizations are required to operate as open operational systems. In such systems, advanced operational manufacturing technologies are blended with modern information and communication technologies to integrate and coordinate operational resources, processes, and activities in order to generate a stream of value-added operations aimed at capturing and sustaining a competitive advantage. With the increasing complexity, scope, and organizational role of operational advanced manufacturing technologies, the maintenance of these technologies is becoming very critical to the ability of the organization to compete. In this context, operations management, especially maintenance management is taking on a broader organizational strategic role.

II. MAINTENANCE IN CONTEXT

To discuss the context in which maintenance management is embedded, one may raise the question what is maintenance as such? Most authors in maintenance management literature, one way or another, agree on defining maintenance as the "set of activities required to keep physical assets in the desired operating condition or to restore them to this condition". While this defines what maintenance is about, it may suggest that maintenance is simple, which it is not, as will be confirmed by any maintenance practitioner. Hence "maintenance management" is needed to ingrain maintenance practice in a complex and dynamic context. From a pragmatic view, the key objective of maintenance

management is “total asset life cycle optimization”. In other words, maximizing the availability and reliability of the assets and equipment to produce the desired quantity of products, with the required quality specifications, in a timely manner. Obviously, this objective must be attained in a cost-effective way and in accordance with environmental and safety regulations. Figure 1 clearly shows that maintenance is embedded in a given business context to which it has to contribute. What is more, it shows that the maintenance function needs to cope with multiple forces and requirements within and outside the walls of the organization. Beyond any doubt, the tasks of maintenance are complex, enclosing a blend of management, technology, operations and logistics support elements.

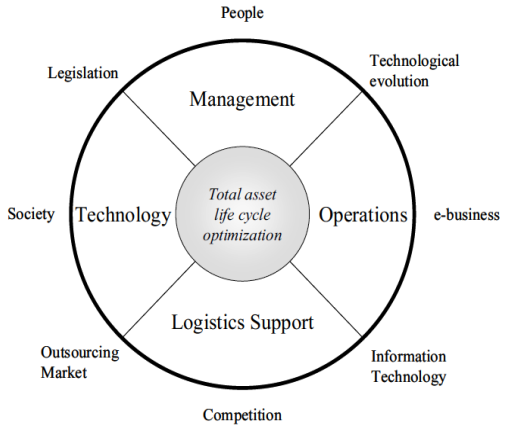

Figure 1: Maintenance in context

- Role of maintenance organization

Too many maintenance functions continue to pride themselves on how fast they can react to a catastrophic failure or production interruption rather than on their ability to prevent these interruptions. Although few production engineers will admit their continued adherence to this breakdown mentality, most equipment continues to operate in this mode.

- Maintenance mission

Contrary to popular opinion, the role of maintenance is not to “fix” breakdown in record time; rather, it is to prevent all losses that are caused by equipment or systemrelated problems. The mission of the maintenance department in a world class organization is to achieve and sustain the following:

• Optimum availability

• Optimum operating conditions

• Maximum utilisation of maintenance resources

• Optimum equipment life

• Minimum spares inventory

• Ability to react quickly

- Three Types of Maintenance

There are three main types of maintenance and three major divisions of preventive

Maintenance, as illustrated in Figure 2:

• Maintenance improvement

• Corrective maintenance

• Preventive maintenance

• Reactive

• Condition monitoring

• Scheduled

- Maintenance Improvement

Picture these divisions as the five fingers on your hand. Maintenance improvement efforts to reduce or eliminate the need for maintenance are like the thumb, the first and most valuable digit. We are often so involved in maintaining that we forget to plan and eliminate the need at its source. Reliability engineering efforts should emphasize elimination of failures that require maintenance. This is an opportunity to pre-act instead of react.

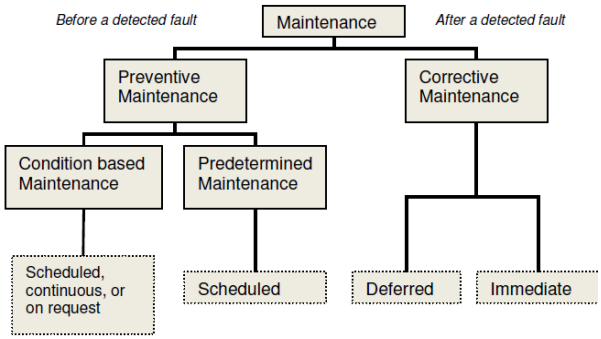

Figure 2: overview of different maintenance

- Evaluation of the maintenance organization

One means to quantify the maintenance philosophy in your plant is to analyse the maintenance tasks that have occurred over the past two to three years. Attention should be given to the indices that define management philosophy. One of the best indices of management attitude and the effectiveness of the maintenance function is the number of production interruptions caused by maintenance related problems. If production delays represent more than 30 percent of total production hours, reactive or breakdown response is the dominant management philosophy. To be competitive in today’s market, delays caused by maintenance related problems should represent less than 1 percent of the total production hours.

Another indicator of management effectiveness is the amount of maintenance overtime required to maintain the plant. In a breakdown maintenance

environment, overtime costs are a major, negative cost. If your maintenance department's overtime represents more than 10 percent of the total labor budget, you definitely qualify as a breakdown operation. Some overtime is, and always will be, required. Special projects and the 1 percent of delays caused by machine failures will force some expenditure of overtime premiums, but these abnormal costs should be a small percentage of the total labor costs.

Labor usage is another key to management effectiveness. Evaluate the percentage of maintenance labor, compared to total available labor hours that are expended on the actual repairs and maintenance prevention tasks. In reactive maintenance management, the percentage will be less than 50 percent. A well-managed maintenance organization should maintain consistent labor usage above 90 percent. In other words, at least 90 percent of the available maintenance labor hours should be effectively used to improve the reliability of critical plant systems not spent waiting for something to break.

III. THE STRATEGY OF MAINTENANCE

This section describes the basic theories on strategies, starting whit definitions of the term and continuing whit strategy formulation and function strategies .the last parts of the section describe theories on maintenance strategies and how formulate them.

[Mintzberg et al. 1999] state that there is no single definition for the term strategy. However, they choose to use the following definition in their book: "A strategy is the pattern or plan that integrates an organization's major goals, policies and action sequences into a cohesive whole. A well-formulated strategy helps to marshal and allocate an organization's resources into a unique and viable posture based on its relative internal competencies and shortcomings, anticipated changes in the environment and contingent moves by intelligent opponents [Mintzberg et al. 1999, p.5].

[Mintzberg et al 1999] describe four basic dimensions of formal strategies:
- Effective formal strategies contain there essential elements goals the be achieved, poliсcies for guiding or limiting actions, and the major action sequences that accomplish the defined goals within the limit sets.
- Effective strategies develop around a few key concepts and thrusts, which give them cohesion, balance and focus.
- Strategy deals not only with the unpredictable but also with the unknowable.
- All complex organization should have a number of hierarchically supporting strategies.thes strategies must be more or less complete in themselves [Further, Mintzberg et al. 1999] present the following criteria for effective strategies:
- Clear decisive objectives
- Maintaining the initiative
- Concentration
- Flexibility
- Coordinated and committed leadership
- Surprise
- Security

[Hill 2000] defines four levels of strategy present within a firm's context and its environment:

-Industrial level strategy
-concerns issues of an industrial sector, or reflecting the level and nature of government intervention.
-Corporate level strategy
-concerns the market sectors in which a company competes and to what degree the company prioritizes its resources to each sector.
- Business level strategy
-concerns the identification of the markets in which each of the businesses compete and the dimensions of competition involved.
-Functional level strategy
-concerns investment and the development of the necessary capabilities in order to fulfill the business level strategy.

[Porter 2004] states that competitive strategy is a combination of the goals for which the firm is striving and the means by which it tries to get there (see Figure3).

Figure 3: The wheel of competitive strategy (Porter, 2004).

Maintenance strategy is not well-defined in literature. Some authors define it as the choice between corrective, preventive and condition based maintenance. [Swanson 2001] distinguishes between three different types of maintenance strategies; Reactive (CM), Proactive (PM and PdM), and Aggressive (TPM).
Based on a model by [Visser 1998],Tsang identifies four strategic dimensions of maintenance [Tsang, 2002]:
- Service-delivery options: the choice between in-house capability and outsourced service.
- Organization of the maintenance function and the way maintenance tasks are structured.

- Maintenance methodology: the selection of maintenance policies.
- Design of the infrastructure that supports maintenance.

Maintenance strategies are needed because plant and building performance influences quality, costs, and customer needs, and thereby has a direct input to the bottom line." [Wilson, 1999, p.i]

[Pinjala et al. 2006] discuss the relationship between business and maintenance strategies. They define maintenance strategy as a "coherent, unifying and integrative pattern of decisions in different maintenance strategy elements in congruence with manufacturing, corporate and business level strategies; determines and reveals the organizational purpose; defines the nature of economic and non-economic contributions it intends to make to the organization as a whole." [Pinjala et al. 2006, p.216]. Like [Tsang 2002, Pinjala et al. 2006] find that there is a set of strategic decision elements that have to be dealt with when designing maintenance strategy. However, where [Tsang 2002] identifies four strategic dimensions, [Pinjala et al. 2006] suggest ten decision elements. They are as follows:
Structural decision elements:
- Maintenance capacity, Maintenance facilities, Maintenance technology, Vertical integration Infrastructure decision elements, Maintenance organization, Maintenance policy and concepts, Maintenance planning and control systems, Human resources, Maintenance modifications

In their paper, [Pinjala et al. (2006)] show indications of a relationship between business and maintenance strategies.

IV. THE PROPOSED MODEL OF THE MAINTENANCE STRATEGY

This section presents the models proposed implementation of the maintenance strategy.After presenting some definitions of maintenance and the different types; we place in the following maintenance in relation to the production process.

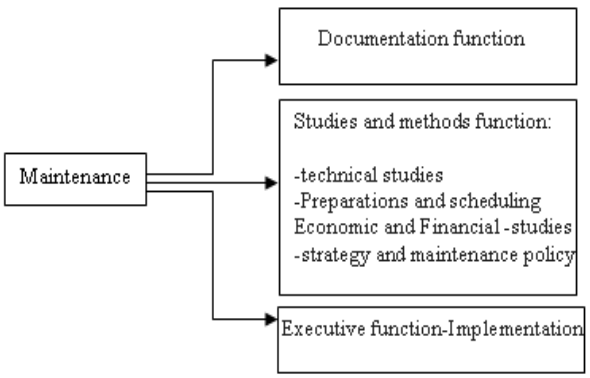

Figure 4: Functions and tasks associated with maintenance

Thus, we present the functions and tasks associated with maintenance. We identify three functions associated with the maintenance management (Figure 4). These tasks associated with each of these functions, although different in their descriptions, are complementary in their purposes
The first function is to optimize all tasks based on criteria in the context of the formulation of the maintenance policy. This part consists of four main tasks.

-The first task on the technical study is to:
• seek improvements in the production system that can provide the desired added value
• Participate in the design of new work taking into account the service aspect of the production apparatus
• participate in the analysis of occupational accidents to try to remedy this by providing safety information in the first place, and actions of corrective and preventive maintenance in a second.

-The second task relating to the preparation and scheduling, comprises:
• establish the instruction sheets to perform the interventions
• create documentation for all kinds of intervention
• Establish schedules preventive interventions and supply (the stock management policy is dependent on that of the company)
• receive and classify documents related to the intervention.

The third task, on economic and financial study, several steps such as:
• manage supplies to optimize the management of raw materials in the production process;
• Analyses maintenance costs, failure and operation, which will have a direct impact on the maintenance policy chosen by the manufacturing company and also on the cost of production
• participate in the drafting of specifications to reflect the maintainability and reliability of the systems to be controlled;
• managing and monitoring the performance of work, so update the historical part of the technical file of machinery.

For the executive function, implementation, extensive experience in the equipment of modern enterprises and a thorough knowledge of different technologies are needed.

The main tasks to fulfill this function are:
• install machinery and equipment (receipt, control, etc.)
• educate staff on how to use the equipment and to upgrade
• apply hygiene rules, safety and working conditions
• manage the scheduling and response maintenance and the diagnosis of equipment failure

• coordinate the interventions of maintenance and restart the equipment after the intervention
• Manage hardware resources (spare parts, tools, etc.).

The maintenance system and located clarifies, limit and identify the responsibilities and expectations of that system. However, this is a necessary but not sufficient condition for successful implementation of a maintenance system in a company. We present the following other conditions of success

a) The maintenance management system

the maintenance management system has been demonstrated in several books [Monchy [108] Lyon [96] Nakajima [113, 114] , Lavina , [86] Liptrot and Palarchio [93] Madu [97] Pintelon and al. , [120] Pricket [124] and Jardine et al. [74]] Indeed, a maintenance management system suited to the manufacturing business needs can help it remain competitive both nationally and internationally. To illustrate the system, we will proceed in two stages. In the first, we highlight the consequences of the implementation of maintenance of the business management system. During the second stage, we will try to establish the link between the results reported in the first stage and the criteria of competitiveness of a manufacturing company.

A maintenance management system operates properly has a different impact levels: infrastructure, resources (human and material), management (spare parts, inventory, etc.) and safety (Figure 5). This is what we will detail in the following.

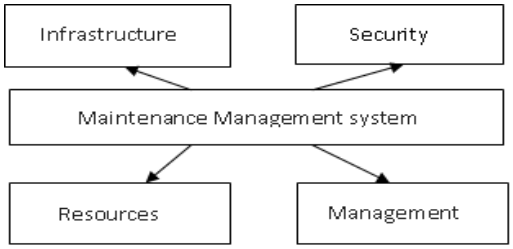

Figure 5: the impact of the maintenance management system.

b) Presentation of the proposed system of maintenance management

The framework of the maintenance management system that we present in Figures 6, 7 also has four important steps as each other.
The first step is the receipt of material and documentation. The second concerns the choice of type of maintenance to be made according to your settings . From the type of service selected (conditional preventive , routine , corrective or ameliorative) , we specify the steps of the maintenance process such as planning interventions , fault detection procedures, implementation and monitoring of the intervention (third step). The last step is the implementation and monitoring of maintenance.

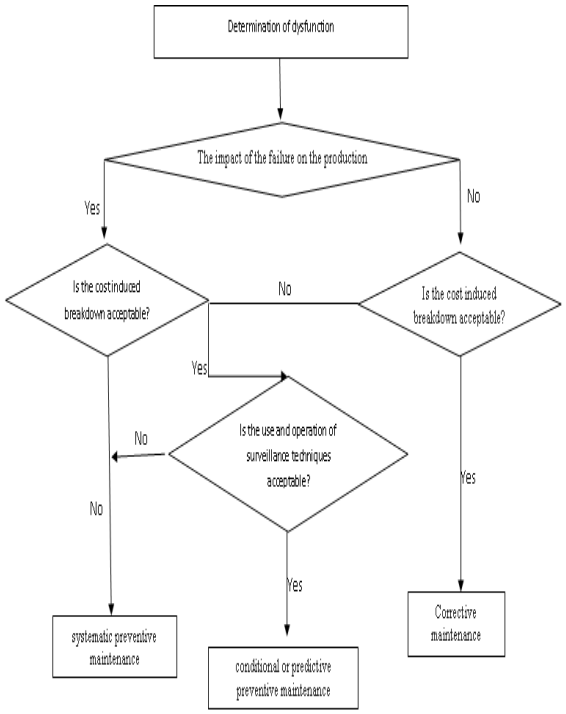

Figure 6: the impact of the maintenance management system.

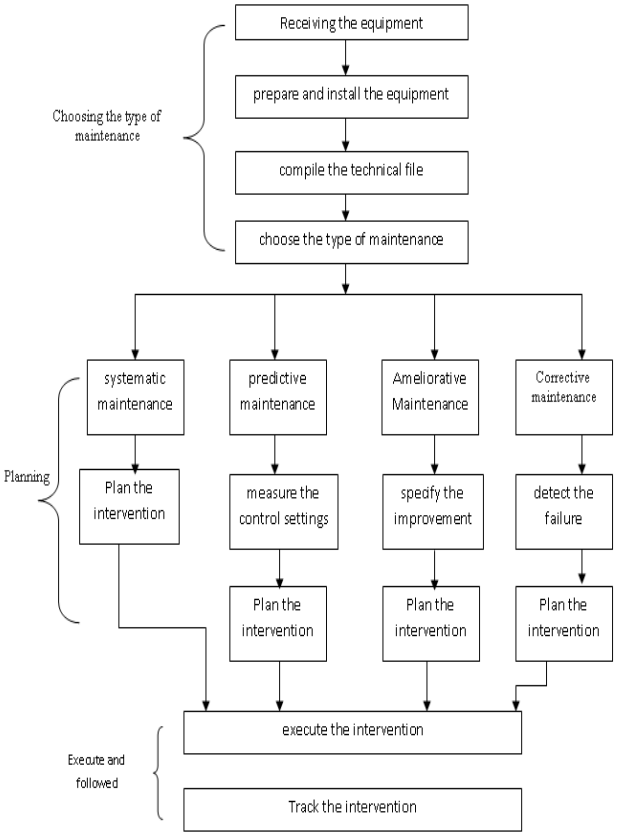

Figure 7: the maintenance management system

V. MAINTENANCE ANALYTICAL MODEL

Maintenance is an integral part of any production system, plays an important role in ensuring the operability of the company and significantly influences its productivity. Appropriately chosen maintenance strategy contributes to the fact that

customers receive their products in the required time and required quality, which is involved in maintaining business competitiveness. It is therefore obvious that the level of maintenance management can significantly influence the success of business. It is for this reason that the choice of the maintenance system strategy in the industrial society makes it possible to improve the economic efficiency of the maintenance system. To fulfill this task, the following objectives have been identified:

1. Proposal of the methodology for selecting the appropriate maintenance strategy
2. Design of the decision support model for selecting of the appropriate maintenance
Strategy (Maintenance Analytical Module)
3. Characteristics of the links between the model and other information systems and
Sources
4. Evaluation of the maintenance efficiency

VI. SURVEY OF THE MAINTENANCE MANAGEMENT LEVEL IN INDUSTRIAL ENTERPRISES IN MOROCCO

Determining the level of maintenance management in morocco engineering enterprises was the main objective of the survey. I chose an electronic questionnaire in combination with structural interviews to meet this objective. The questionnaire consists of five main parts, which represent key characterization areas of maintenance management level.

1. Definition of the role of maintenance in the enterprise
2. Maintenance strategy
3. Causes of failure
4. Use of IT tools in the management and maintenance planning
5. Costs associated with maintenance

1. Results of the survey

Most respondents define their maintenance strategy as a combination of reactive and preventive approach. They differ only in the relation between these parts. The average share of machines on which preventive maintenance is carried out is approximately 80%. This share is lower for companies with fewer machines and younger machines.

The results show that many of the failures can be directly influenced by maintenance (normal wear, lack of lubrication or cleaning, poor maintenance). Only 20% of respondents have specialized GMAO systems in place.

Most of the time, direct maintenance costs are closely monitored and calculated, the level of allocation costs is insufficient for an appropriate choice of maintenance

Strategy. But maintenance managers often do not have enough information to choose an appropriate maintenance strategy.

2. Maintenance Analytical Model

Methodology for selecting the appropriate maintenance strategy:

This part of the paper deals with a brief description of the methodology for selecting of the appropriate maintenance strategy for defined system of machines. The methodology focuses primarily on the economic benefits of implemented strategies and is primarily based on the Reliability Centred Maintenance (RCM) approach.

The main goal of the methodology is to prepare and provide information needed for the selection of the maintenance strategy for individual system element (machine), which effectively uses resources allocated to the maintenance and has maximum benefits for the whole system. Using the developed MAM decision support model.

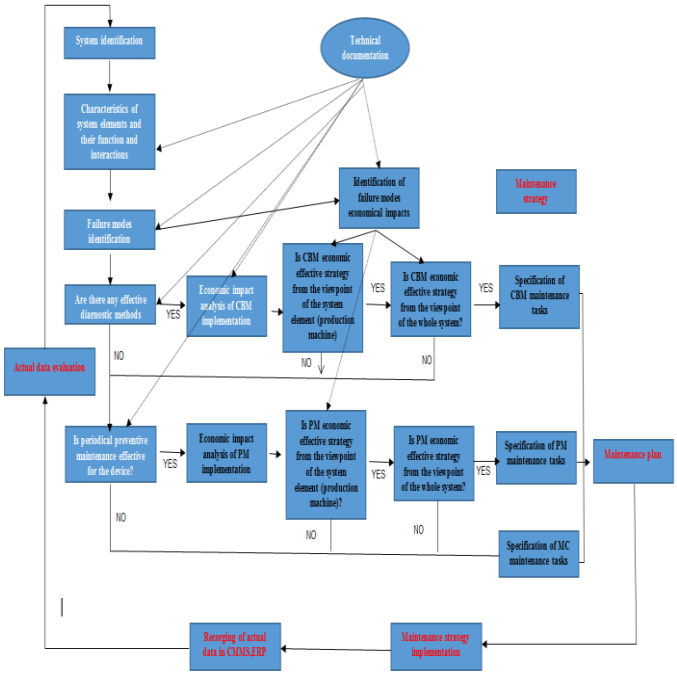

Figure 8: Maintenance Analytical Model Process map of the methodology for selecting appropriate maintenance strategy

VII. 3. CONCLUSION

Maintenance concept optimization has professionalized. Corrective and precautionary actions are combined in different policies, from reactive to preventive and from predictive to proactive policies. A sound insight into the pros and cons of each of these policies is available in practice and research supports the selection and optimization of these policies. These policies are no longer ad hoc and lose elements within maintenance management but policies are also embedded in maintenance concepts, focusing on reliability and productivity. These concepts ensure consistent decision making for all equipment and at the same time allow for individualized installation maintenance concepts. Decision tools are available to support this process.

Top management nowadays, at least in most companies, recognizes the importance of maintenance as an element of their business strategy. Expectations for maintenance are no longer formulated as “keep things running”, but are based upon the overall business strategy. This strategy can be based on flexibility, quality and low cost. The maintenance organization, with its structural and infrastructural elements, is built accordingly.

This article deals with brief description of three main outputs of Strategy of maintenance system in industrial company. At first it describes survey of the maintenance management level in industrial enterprises that was used for definition of current state, needs of target companies and together with research of information sources for identification of potential ways of development in field of maintenance management.

References

[1] Anderson, R.T., Neri, L., (1990) : Reliability Centred Maintenance: Management and Engineering Method Elsevier Applied Sciences, London
[2] Blanchard, B.S., (1992): Logistics Engineering and Management, Prentice Hall, Englewood Cliffs, New Jersey
[3] Cho, I.D, Parlar, M., (1991): A survey on maintenance models for multi-unit systems. European Journal of Operational Research, 51:1–23
[4] Coetzee, J.L., (2002): An Optimized Instrument for Designing a Maintenance Plan: A Sequel to RCM. PhD thesis, University of Pretoria, South-Africa
[5] Dekker, R., (1996): Applications of maintenance optimisation models: A review and analysis. Reliability Engineering and System Safety, 52(3):229–240
[6] Lantz, A., (1993):Intervjumetodik (In Swedish), Studentlitteratur, Lund, Sweden.
[7] Ljungberg, Ö. (1998): “Measurement of Overall Equipment Effectiveness as a Base for TPM Activities”, International Journal of Operations & Production Management, Vol. 18, No 5, pp. 495-507.
[8] Merriam, S. B., (1988):Fallstudien som forskningsmetod (In Swedish), Studentlitteratur, Lund, Sweden.
[9] Mintzberg, H., Quinn, J. B. and Ghoshal, S., (1999): The Strategy Process, Revised European Edition, Prentice Hall, London, UK.
[10] Moubray, J. (1997): Reliability-centered Maintenance, Second Edition, Industrial Press Inc, New York.
[11] Salonen, A.]:Maintenance Strategy – An Enabler for Improved Competitiveness, in the proceedings of 18th International Conference of Flexible Automation & Intelligent Manufacturing – FAIM 2008, Skövde, Sweden.
[12] Salonen, A.]: Strategic Factors for Maintenance in Manufacturing Industry, in the proceedings of 21st International Congress and Exhibition COMADEM – 2008: Prague, The Czech Republic
[13] b.s.dhillon: Engineering maintenance a modern approach
[14] an introduction to predictive maintenance
[15] Ghosh, D., Roy, S., 2009 “Maintenance optimization using probabilistic cost-benefit analysis”, Journal of Loss Prevention in the Process Industries, 22(4):403-407.
[16] Oke, S.A. (2005): “An analytical model for the optimization of maintenance profitability”, International Journal of Productivity and Performance Management, Vol. 54 No. 2, pp. 113-36.
[17] Parida, A. (2007): “Study and analysis of maintenance performance indicators (MPIs) for LKAB”, Journal of Quality in Maintenance Engineering, Vol. 13 No. 4, pp. 325-37.
[18] Parida, A. and Chattopadhyay, G. (2007): “Development of a multi-criteria hierarchical framework for maintenance performance measurement (MPM)”, Journal of Quality inMaintenance Engineering, Vol. 13 No. 3, pp. 241-58.
[19] Pascual, R., Del Castillo, G., Louit, D. and Knights, P. (2009): “Business-oriented prioritization:a novelgraphical technique”, Reliability Engineering & System Safety, Vol. 94 No. 8, pp. 1308-13.
[20] Pintelon, L., Pinjala, S.K. and Vereecke, A. (2006): “Evaluating the effectiveness of maintenance strategies”, Journal of Quality in Maintenance Engineering, Vol. 12 No. 1, pp. 7 20.
[21] Pramod, V.R., Devadasan, S.R., Muthu, S., Jagathyraj, V.P. and Moorthy, G.D. (2006): “Integrating TPM and QDF for improving quality in maintenance engineering”, Journal of Quality in

Maintenance Engineering, Vol. 12 No. 2, pp. 150-71.

[22] Pun, K.-F., Chin, K.-S., Chow, M.-F. and Lau, H.C.W. (2002:"An effectiveness-centred approach to maintenance management. A case study", Journal of Quality in Maintenance Engineering, Vol. 8 No. 4, pp. 346-68.

[23] Robinson, N. (1982): "Making maintenance work", Industrial Management & Data Systems, Vol. 82 No. 56, pp. 6-7.

[24] Pun, K.-F., Chin, K.-S., Chow, M.-F. and Lau, H.C.W. (2002):

[25] Žilka M., Úroveň managementu údržby v průmyslových podnicích v ČR, In: Trendy a inovatívne prístupy v podnikových procesoch 2012, Košice, TU Košice, 2012, ISBN 978-80-553-1126-5.

[26] Žilka,, M., Survey of the maintenance management level in industral enterprises in Czech Republic,

[27] In: MAINTENANCE 2012. Zenica: University of Zenica, 2012, vol. 1, 136-142, ISSN 1986-583X.

[28] Moore R., Selecting the right manufacturing improvement tools: What tool? When?, Burlington: Butterworth-Heinemann, 2007, xxii, 390 s., ISBN 07-506-7916-6.