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MAINTENANCE MANAGEMENT AND INNOVATION IN INDUSTRIES: A SURVEY OF MOROCCAN COMPANIES

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GESTÃO DE MANUTENÇÃO E INOVAÇÃO
EM INDÚSTRIAS: UMA SURVEY EM EMPRESAS
MARROQUINAS

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Abstract: The purpose of this paper is to present the maintenance management status in Moroccan companies. The first part is based on the literature; it reviews the main maintenance models. The second part is resulted from a pilot survey about management maintenance in Moroccan companies. The study was performed by conducting a survey within 15 Moroccan companies, questionnaires were submitted to maintenance managers or production managers of those companies. The main objectives of this paper are to study the correlation between success factors of maintenance management in Moroccan companies and to give a global picture about maintenance management level in Moroccan companies.

Keywords: Maintenance Management, Innovation in Maintenance, Statistical Analysis, Success Factors of Maintenance Management, Pilot Surveys, Moroccan Companies.

Resumo: O objetivo deste trabalho é apresentar o status de gerenciamento de manutenção em empresas marroquinas. A primeira parte é baseada na literatura e apresenta os principais modelos de manutenção. A segunda parte é resultado de uma survey piloto sobre a gestão da manutenção em empresas marroquinas. O estudo foi realizado através da realização de uma survey em 15 empresas marroquinas, ou seja, questionários foram submetidos a gestores de manutenção ou gerentes de produção dessas empresas. Os principais objetivos deste estudo é estudar a correlação entre os fatores de sucesso da gestão da manutenção em empresas marroquinas e dar uma visão global sobre o nível de gestão da manutenção nas empresas exploradas.

Palavras-chave: Gerenciamento de Manutenção, Inovação em Manutenção, Análise Estatística, Fatores de Sucesso da Gestão de Manutenção, Pesquisa Piloto, Empresas Marroquinas.

INTRODUCTION

Maintenance has been defined by many authors in literature, those definitions has evolved in time, as during the last half-century, industrial maintenance has improved from a nonissue position in the company into a strategic concern. During this period, the role of maintenance within the organization has drastically been transformed. At first, maintenance was considered as failures that must be repairs, today it is an essential strategic element to achieve business objectives. (Pintelon & Parodi-Herz, 2008).

Although literature review revealed many themes related to maintenance, J.M Simoes (Simões, Gomes, & Yasin, 2011) notes that the area of maintenance performance and management is in need of more future systematic research efforts, also Smith (Smith, 2002) specifies that literature lacks a clear definition of maintenance practices and then, readers are generally confused about the distinction between maintenance practices, actions and tasks.

Such as maintenance is embedded in organizations; it has to respond to each requirement of stakeholders (management, operations, logistics, technology...etc.) which led to a complexity of maintenance tasks. (Pintelon & Parodi-Herz, 2008). As a consequence, maintenance has a relevant role for the industrial companies and then contribute to the growth of the industry sector in every country.

In Morocco, industry contribute in addition to mining about one-third of the annual GDP (Gross Domestic Product). The economic system is characterized by a large opening towards the outside world. The main industries in Morocco are: Phosphates, rock mining and processing, food processing, leather goods, textiles and construction.

In this survey, we have reached most of those industries, local business and subsidiaries, in order to have a clear picture about maintenance management in Moroccan industries. In this paper, results of a pilot survey of Moroccan companies are presented. The results concern the relationships between success factors of maintenance management and a classification of companies depending on the level of maintenance management.

Innovation and maintenance management

Zahra and Covin (Zahra & Covin, 1994) cited that "Innovation is widely considered as the life blood of corporate survival and growth". Anahita Baregheh et Al (Baregheh, Rowley, & Sambrook, 2009) analyses the definition of innovation and considers that is not restricted to business organizations as the US has a Department for Innovation.

In general, innovation is coupled to change and concerns new products or materials, new processes, new services, and new organizational forms (Ettlie & Reza, 1992). In industry, due to technological innovations, manufacturing have evolved from mass production, to the concepts

of lean and predictive manufacturing by bringing transparency to manufacturing asset capabilities (J. Lee & Lapira, 2013).

Innovation in maintenance can be traced from 1930's to 2000 through three generations (Moubray, 1997), this evolution is leading by innovation in processes, services and organizations.

Today, there are new perspectives for maintenance innovation, because “ the role of maintenance function is evolving due to the predictive manufacturing paradigm, the challenges related to asset life cycle management and the opportunities arisen by advances in manufacturing technologies” (Jay Lee, Holgado, Kao, & Macchi, 2014).

Main maintenance methods

Maintenance has evolved from a set of actions executed by operators to maintain equipment (fix it), to a strategic level in companies (proactive maintenance).

A) Corrective Maintenance:

Corrective or curative maintenance is maintenance actions after detecting a fault. It aims to restore the equipment and after the repairs, the incident is saved for analysis, hence its difference from breakdown maintenance, which is only a temporarily repair.

B) Preventive maintenance:

Preventive Maintenance (PM) is maintenance that is regularly performed on a piece of equipment to lessen the likelihood of it failing. Preventive maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.

This method has advantages and some inconvenient as the intrusion into the equipment several times is potentially risky. According to a study done by Corio, MR and Costantini in 1989 (Corio & Costantini, 1989), 56 % of the forced outages occurred within one week after an intrusion type of maintenance

Tsang (Tsang, 1995) mentioned that TD (time directed) will be a waste of resources if:

- Failure rate is a non-increasing function of age
- The cost penalty of a Corrective maintenance (CM) task is not greater than that of a TD task.

C) Condition-based-maintenance

Condition-based-maintenance (CBM) is a predictive maintenance method which is also known as on-condition maintenance or condition-directed maintenance, it's designed to detect the onset of failure. Tsang (Tsang, 1995) .

D) Reliability Centered Maintenance

Reliability Centered Maintenance (RCM) is a structured methodology that originated in the US in 1978 , Tsang (Tsang, 1995) has mentioned seven process in a RCM program:

- 1- System selection and information collection
- 2- System boundary definition

- 3- System description and functional block diagram
- 4- Identification of system functions and functional failures
- 5- Failure mode and effects analysis (FMEA)
- 6- Decision-tree analysis
- 7- Task selection

Due to the satisfactory results of this method in aviation, this method has spread to industry and principally energy production.

E) Total Productive Maintenance:

Total Productive Maintenance (TPM) is a proactive maintenance which evolves for the first time in Japan. The main idea of TPM is based on profound changing about maintenance as it is considered as “Plant Engineering” instead of “Maintenance”.

Most of authors agree that TPM can be applied in every company, even in Small and Medium-sized Enterprises (SME) by following 8 pillar:

- 1st pillar: Autonomous management equipment
- 2nd pillar: Improved case by case
- 3rd pillar: Planned Maintenance
- 4th pillar: Improvement of expertise
- 5th pillar: security, working conditions and environment
- 6th pillar: Quality control
- 7th pillar: Design Master • 8th pillar: TPM in offices.

Kym Fraser (Fraser, 2014) mentioned that TPM is a company-wide equipment maintenance system that organizes all employees from top management to production line workers and can easily support sophisticated production facilities.

METHODOLOGY

Many authors notes that maintenance management depends on different factors: technical, human, and management.

The aim of this survey is to give a picture about maintenance management in Moroccan enterprises. The sample was selected to cover different sectors, size and activities. From 30 questionnaires distributed to enterprises, 15 had completed the questionnaire.

Most questionnaire responders are maintenance managers or production managers. Visits to some enterprises were accomplished especially for the ones which maintenance management level is good.

The table 1 below shows the diversity of the enterprises considered by the survey.

Table 1
Participating enterprises segmented by sector

Companies	Form of companies	Sector of companies	Activities of the company
Company 1	Subsidiary company	Private	Petroleum
Company 2	Local company	Private	Mining and hydrometallurgy sectors
Company 3	Local company	Private	Plastics manufacturing
Company 4	Local company	Semi Public	Mining and hydrometallurgy sectors
Company 5	Local company	Private	Textile
Company 6	Local company	Private	Manufacturing tiles
Company 7	Subsidiary company	Private	Petroleum
Company 8	Local company	Public	Production of electricity
Company 9	Local company	Private	Building material - cement
Company 10	Subsidiary company	Private	Cabling manufacturing
Company 11	Subsidiary company	Private	DNO (Distribution Network Operator)
Company 12	Local company	Private	Mining and hydrometallurgy sectors
Company 13	Subsidiary company	Private	Building material - cement
Company 14	Subsidiary company	Private	Building material - concrete
Company 15	Local company	Semi Public	Operator of ports

Authors, Note: Sample of 15 companies.

The questions designed were based on the list of maintenance management factors described in the literature. Eight success factors were determined:

- 1) Top Management policy
 - Organizational chart in the enterprise where all functions are described;
 - Organizational chart describing maintenance function, structures..etc
 - Maintenance policy is written with description of the objectives and measurement indicators.
- 2) Maintenance approach
 - Preventive maintenance policy exists and is applied;
 - Maintenance actions are classified (preventive action, repair, improving action..Etc)
 - Maintenance operations are recorded and pre-established to be used;
 - Required controls are done systematically.
- 3) Information management and CMMs
 - Documentation (machine file, manuals..etc.) is sufficient;
 - CMMs is used in the enterprise to manage maintenance management.
- 4) Contracting out maintenance

- Part of maintenance is delegated to subcontractors according to specified strategy
- 5) Human resource management
 - Skills management, staff training
 - Respect of social life
 - Direct communication between RH and workers
 - Staff requalification
- 6) Spare part management
 - Management policy for tools , spare parts optimization
- 7) Financial aspect
 - Direct maintenance costs are calculated
 - Analysis of cost maintenance by equipment
- 8) Continuous improvement
 - Regular meetings between maintenance services and Manufacturing / Quality /
 - In case of stop of production , an incident report with an analysis based on the causal chain : (cause , mode, effect) is elaborated
 - Periodic assessment of production losses due to downtime
 - Maintenance services are evolved in purchase of new equipment.
 - A grill of responses for each question submitted was elaborated based on 4 levels:
 - Level 0: Functions didn't exist;
 - Level 1: Functions are partially filled or under implementation
 - Level 2: Functions filled but are not satisfactory;
 - Level 3: Function or Action are filled, operational and satisfactory

RESULTS

To ensure the relationships between the eight factors related to the maintenance management, the correlation studies are performed.

To give a general picture of maintenance management, companies were divided into three categories, (Good, Medium, And Weak).

Analysis of correlation between maintenance success factors

To evaluate relationships between the eight factors related to the maintenance management in companies, the correlation test was adopted after "standardization of responses" issue from the survey. The results obtained are presented in Table 2.

Table 2
Correlation between maintenance management factors

Factors	F1	F2	F3	F4	F5	F6	F7	F8
F1	1,000	0,679	0,105	0,159	0,286	0,273	0,013	0,162
F2	0,679	1,000	0,340	0,024	0,250	0,240	0,014	0,199
F3	0,105	0,340	1,000	0,314	0,153	0,055	0,138	0,448
F4	0,159	0,024	0,314	1,000	0,055	0,155	0,578	0,558
F5	0,286	0,250	0,153	0,055	1,000	0,494	0,101	0,221
F6	0,273	0,240	0,055	0,155	0,494	1,000	0,041	0,599
F7	0,013	0,014	0,138	0,578	0,101	0,041	1,000	0,187
F8	0,162	0,199	0,448	0,558	0,221	0,599	0,187	1,000

Notes: F1: Top management policy, F2: Maintenance approach, F3: Information management and CMMs, F4: Contracting out maintenance, F5: Human resource management, F6: Spare part management, F7: Financial aspect, F8: Continuous improvement.

Authors

According to the results shown in the table 2, we conclude the following points:

- There is a strong correlation between top management policy and maintenance approach, which means that the general management strategy impacts directly the structure of maintenance management and its level in the enterprise. Chinese and Ghirardo (Chinese & Ghirardo, 2010), mentioned that maintenance performance are highly linked with strategies and contexts.
- There is a moderate correlation between the contract out maintenance and the financial aspects;
- There is a moderate correlation between human resource and spare parts management as spare parts management requires technical skills from periodically trained staff and who, in consequence, are motivated to reach goal's fixed by their managers;
- There is a moderate correlation between continuous improvement and information management and CMMs, as generally when information management is available; it helps for statistics which is involved to assure continuous maintenance.
- The results of correlation between maintenance management factors issued from this survey are similar to results elaborated from a pilot survey in UK by C. Cholasuke (Cholasuke, Bhardwa, & Antony, 2004) who shows that two factors : maintenance approach and continuous Table 3: Weak level of maintenance management improvement are highly associated with effective maintenance management.

Status of Moroccan maintenance management practice

In this section, we present the maintenance management status in Moroccan enterprises from results of this pilot survey.

The maintenance management is divided into three levels: Good, Medium, Weak.

A) Weak level of maintenance management

This section concern enterprises where maintenance management isn't implemented or is in the first stage, therefore the maintenance management level isn't satisfactory.

According to the pilot survey, four companies of the fifteen have a weak level of maintenance, which represents 27% of companies. As shown in the table, these companies are characterized by a weak level of top management policy, except for Co.3 where the top management could have recently implemented maintenance management, then the performance due to this couldn't be yet proved and measurable.

Table 3
Weak level of maintenance management

Enterprise Factors	Co.1	Co.2	Co.3	Co.4
Top management policy	78%	67%	100%	0%
Maintenance approach	75%	50%	83%	58%
Information management and CMMs	67%	17%	50%	83%
Contracting out maintenance	33%	83%	50%	100%
Human resource management	100%	67%	67%	67%
Spare part management	33%	67%	33%	33%
Financial aspect	0%	83%	83%	67%
Continuous improvement	33%	56%	22%	100%
Global Score	47%	54%	54%	56%

Authors.

B) Medium level of maintenance management

Medium level of maintenance management concern enterprises essentially enterprises which the implementation of maintenance management didn't reach a mature level, and then the impact of the top management policy is ongoing.

The table 4 shows that six companies have a medium level; it represents 40% of companies concerned by the survey. All those companies have a high score of top management policy, but the score of the other factors in general of maintenance management are not all high.

Table 4
Medium level of maintenance management

Enterprise Factors	Co.5	Co.6	Co.7	Co.8	Co.9	Co.10
Top management policy	78%	56%	100%	100%	89%	100%
Maintenance approach	100%	58%	92%	92%	58%	100%
Information management and CMMs	33%	50%	100%	50%	67%	50%
Contracting out maintenance	83%	67%	83%	83%	83%	33%
Human resource management	67%	67%	33%	67%	100%	100%
Spare part management	67%	100%	33%	67%	67%	100%
Financial aspect	17%	17%	33%	33%	33%	0%
Continuous improvement	67%	100%	78%	67%	67%	89%
Global Score	57%	57%	61%	62%	63%	64%

Authors.

C) Good level of maintenance management

This section concern category of enterprises where maintenance management is implemented in the company and have reached a mature level. According to the results designed in the table 5, there are five companies that have a good level of maintenance management, it represents 33%.

Table 5
Good level of maintenance management

Enterprise Factors	Co.11	Co.12	Co.13	Co.14	Co.15
Top management policy	100%	100%	100%	89%	100%
Maintenance approach	100%	100%	100%	83%	100%
Information management and CMMs	83%	67%	83%	67%	100%
Contracting out maintenance	83%	100%	83%	100%	100%
Human resource management	100%	100%	100%	100%	100%
Spare part management	100%	67%	67%	100%	100%
Financial aspect	17%	83%	100%	100%	83%
Continuous improvement	89%	89%	100%	100%	100%
Global Score	75%	78%	81%	82%	87%

Authors.

All those companies in the table 5 have a high score of both top management policy and maintenance approach, also those companies are improving continually their strategies to guarantee a continuous level of maintenance management. Maintenance function are not persuaded as an independent service but is embedded in organizations (operation, management, quality..etc.).

CONCLUSIONS

Maintenance management are usually modeled by a models cited in the literature (RCM, TPM, CBM), but since the maintenance depends on

human factors which are impacted by cultural factors, it is necessary to have a real picture of maintenance management in each country.

Based on this survey, we can conclude that the main success factors that determine the maintenance management level in companies in Morocco are: Top management policy and maintenance approach in the enterprise.

As a limitation of this survey, it has been the fact that the status of management maintenance in Morocco presented in this paper is issued from a survey conducted essentially in big companies and then those conclusions couldn't be available for SME (Small and Medium Enterprise).

In the future, a survey that concern one sector or a specific size of companies in Morocco can be effected, to give more accurate results in order to obtain an optimized model of maintenance management to be implemented in the companies.

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