Feasibility Study of Implementing Reliability Centered Maintenance in Esfahan Oil Refinery Company

[1]Ghodratollah Aghaei, [2]Arash Shahin, [2]Noushin Ghofrani Isfahani, [3]Naser Mollaverdi Isfahani

[1]Department of Industrial Engineering, Najafabad Branch, Islamic Azad University, Isfahan, Iran
[2]Department of Management, University of Isfahan, Isfahan, Iran
[3]Department of Industrial Engineering, Isfahan University of Technology, Isfahan, Iran
baaghaei@yahoo.com

Abstract: One of the important subjects confronting industrial managers and manufacturing units is to increase production ratio and consequently to increase efficiency of equipments. To increase efficiency ratio of equipments, the failure and disability of equipments should be decreased, which in turn results in increased reliability of equipments and machineries. This will be more important when equipments are utilized in the oil processing company as a vital continuous manufacturing industry of a country like Iran. In this survey the feasibility of implementing maintenance has been investigated based on four dimensions of maintenance management, reliability centered maintenance, project management and change management. The necessary data has been collected and analyzed by a questionnaire filled by maintenance experts of Esfahan Oil Refinery Company (EORC). Findings imply that the major hypothesis of survey has been approved, and among minor hypotheses, one has been rejected indicating that the level of maintenance management factors, reliability centered maintenance, and project management in EORC are higher than medium, while change management is less than medium.
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1. Introduction

The necessity of designing and implementing maintenance systems in factories is one of the today's vital and urgent issues of industries in Iran. On the one hand preserving capitals of the country, and high need of currency for buying equipments and machineries on the other, have necessitates using programmed, rational and on time maintenance of equipments and machineries. The weakness and strength of the department of maintenance directly impacts on productivity and profitability (1).

Maintenance plays an important role in preserving reliability, accessibility, quality of productions, reduction of risk, increase of output and security of equipments. Thus, maintenance and its strategies have special importance in industries. The most important strategies of maintenance include corrective, preventive, and predictive maintenance (2).

Increase of competitiveness causes pressure for improving total business performance. For this reason, in maintenance subject systems like Computerized Maintenance Management System (CMMS), Reliability Centered maintenance (RCM), Total Productive Maintenance (TPM) have been introduced that in general are globalized methods for increasing reliability (3).

Many researchers including Cholasuke et al. (2004), Pintelon et al. (2006), Parida and Kumar (2006) and Reis et al. (2009) have emphasized on the strategic role of effective and efficient maintenance management, and increasing reliability of equipments on gaining competitive advantage, continuous improvement, supporting productive activities, performance improvement, and supporting heavy industries with high capitals by preserving equipments and machineries in secure performance conditions (4,5,6,7).

Mohammadinejad (2003) in his survey entitled "providing a checklist for evaluating Computerized Maintenance Management System (CMMS)" has identified the necessities of software and provided a checklist from these necessities based on which he has investigated and selected the introduced software to organization from prepared checklist (8). In this survey, the module of maintenance on Preventive Maintenance has been emphasized.

Behnia (2011) in his survey entitled "feasibility of implementation of lean maintenance in Esfahan Oil Refinery Company (EORC)" in respect of investigating the feasibility of implementing lean maintenance in organization, has evaluated EORC regarding of indicators of lean maintenance system, and evaluated the weak and strong points of organization and its maintenance system, and introduced the ways of improvement for implementing this maintenance system (9). The variables of this survey are the required dimensions and necessary prerequisites for implementing a lean management system including commitment and

planning, organizing and structure, Total Productive Maintenance, maintenance and training engineering. Ultimately, the findings obtained from survey indicate the point that presently EORC does not have necessary infrastructures for implementing lean maintenance system, and in this respect the most important weak points that are recognized are senior management commitment, maintenance system workflow and correspondence of performing maintenance activities with time scheduling, stock and parts and spare parts control system of store.

Fernandez et al. (2003) in a study entitled "implementation and development of maintenance management system supporting decision" emphasized on the important role of information in today's competitive world that uses information as a tool for supporting decisions (10). In this study, in order to use information effectively, the collected data has been analyzed and entered into decision making grid. Then, each one of the proposed systems of grid boxes has been prioritized by the process of hierarchical analyses.

Almishari and Suliman (2008) have performed a survey entitled "integration of six sigma and other reliability improvement methods in equipments reliability and maintenance applications" having the goal of showing weak points of equipments reliability improvement methods (11). For this purpose, they first investigated the weak points of reliability method based on maintenance and proposed six sigma as improvement ways of these issues, and potential impacts that six sigma have. The results of their activities were to show RCM patterns and their problems by using six sigma; improvement of products and corresponding it with organizational goals and increasing reliability are other results of this survey too.

Yeh et al. (2011) in a survey in order to decrease failure rate of second-hand instruments, have introduced two periodical preventive maintenance policies (12). One of the proposed maintenance policies is based on constant maintenance degree, and another policy is based on age threshold value. To develop proposed policies in this article, Weibull age distribution has been used. The proposed policies in this article have been compared by a numerical example, that regarding the obtained results, the results of the two proposed approaches are very similar.

Considering the mentioned points and the importance of implementation of RCM to improve efficiency ratio of equipments, and also the importance of EORC in oil industry of the country, in this survey the feasibility of implementation of RCM based on four variables of maintenance management, RCM, project management, and change management is investigated.

In the following, the literature and concepts of survey are first investigated, and then survey methodology is explained; afterwards the collected data and survey's findings are analyzed, and finally discussion and conclusions of the survey are presented.

2. Maintenance management

Maintenance means preserving existing physical instruments in factory. Effective maintenance strategy provides this assurance that instead of high costs, maximum life duration is obtained from manufacturing equipments, installations, tools, and possibilities. Anyway maintenance cannot result in increasing life duration but can preserve equipments performance for the factory (13).

In general, management is a process that realizes the goals of one organization. Considering this definition, maintenance management includes important activities like targeting strategy determination, organizing, planning, standardization, resource control, supervising performance of programs, creating motivation and commitment in staff, creating safe competition, and providing an environment full of understanding, empathy and cooperation, so that the maintenance organization can access the determined goals. Today, administration is not synonym of management, and is regarded as a more restricted activity in organizing and formations and methods (14). Since 1930, the changes process and evolution in maintenance can be divided into three basic periods (15) of Breakdown Maintenance; Total Productive Maintenance (TPM); and RCM.

Introducing maintenance based on reliability as a comprehensive method is for decision making in accurate use of existing maintenance systems. RCM is a process that first of all determines what action should be performed in order for the life of any physical capital to be continued, and secondly fulfill expectations that users have from equipments.

3. Reliability Centered Maiantenance (RCM)

Reliability means long and failure free performance of a product. Long periods of performance, without failure result in increase of capability, reduction of needed human resources for performing operations, and ultimately reduction of costs.

Improving reliability results in increase of costs but causes improvement of availability, reduction of unemployment, and reduction of repeated failure costs, and increases revenue ratio, because instruments continue their actions for a more period of time without failure. Accurate calculation of

reliability can be related to death and losses (reduction of failure ratio to the time), accidental failure (constant failure ratio), or burnout (increase of failure ratio to the time), (16).

In order to perform RCM, the following questions should be investigated and answered by using an organized framework about existing equipments and their working conditions (17):

1. Performances: What are the executive standards and performances of equipments?
2. Failures of performance: Which performance aspect(s) of one instrument fails?
3. Different kinds of failure: What are the types of performance failure?
4. Impacts of failure: What would happen when each failure occurs?

The above four questions can be stated as Failure Modes and Effects Analysis (FMEA).

5. Failure consequences and results: In what respect does each failure have importance?
6. Preventive operation: What actions should be performed in order to prevent failure?
7. Inefficiency of operation: Provided that no preventive operation exists, what measures should be performed in order to prevent and omit failures?

Two last questions can be stated as analyses of operation.

In order to perform and develop RCM in a factory, three stages exist. Success in any stage will follow success in the next stage; these stages are (18):

i) beginning the work, training and gaining primary successes;
ii) performing and developing forward-looking maintenance and beginning proactive maintenance; and
iii) evaluating performed stages of RCM.

4. Project management

Project management or project control is a process to preserve the route of project in order to access a justified economical balance among three factors of cost, time, and quality during performing project that get help from its special tool and techniques for doing this important action. In fact, controlling accurate and perfect performance of compiled program is for project, so as when getting out of program, by distinguishing reasons and plan, and the most economical activity, the project can be returned into nearest possible situation in its primary and major route. Controlling project utilizes three factors in this route (19) as determining real situation of project; comparing real situation with program; and considering corrective measure.

But the history of project management in modern world returns to the first years of 1900's when Henri Gant by developing innovative bar chart was the beginner of next fast movement during 1950's and 1960's in military and aerospace projects of America and afterwards England. Although the popular name of Henri Gant as the father of techniques of planning and project control has been recorded in history, the years of 1950's and 1960's are recognized as the beginning years of growth and development of project management in contemporary world. These years are the beginning and development of many methods and knowledge related to nine project management that in the next years have been applied in projects by various operational softwares (20).

The reflection of economical calculation of life cycle of project cost is important for investor or the product of project. Although management of project cost is generally related solely to the cost of necessary resources for completing related activities, the impact of decisions during project on the cost of product of project should be observed. As an example, reduction of endeavor in planning stage might be shown on the cost of project as ascending and increasing in customer's performance. The concepts of life cycle investment of product of project can be resulted from wide discussions about the importance of customer orientation and customer satisfaction in project management (21).

One real structure of project life cycle including phases of investigating feasibility, programming, planning, performing, transferring, and launching have been offered in project management standards. Project investment phases include preparing, performing and operation, while the phases related to the deliverable items of project include selling, marketing, and after sale services (22). Anyway, focusing solely on project performance makes it possible to understand the point that technical and operational application of items that will be delivered to the customer at the end of project is an important parameter that leads to profit investment. The levels are divided into three groups of operational, tactical, and strategic. Terner and Pain have used the operational, tactical, and strategic phrase as applied levels in conceptual project management in a different way (22).

5. Change management

The importance of positive change and evolution is not hidden for anyone, because it is the necessity of future. Successful organizations in today's world are those organizations that perform change and evolution inside their organizational framework. It is not hidden from anyone that the foundation of each organization is based on meeting requirements, and since human beings and

organization's requirements continuously change or tend to new demand, therefore the necessity of evolution in organizations is always perceived and the necessary feeling to manage these evolutions shows itself more than before (23).

The important point is that since successfulness of an organization depends on its dynamicity and evolution should always be accepted for dynamicity to be developed, thus those organizations and people are successful that the ratio of their planned evolutions are more than their accidental evolutions, meaning that they try to take initiative and do not have to perform according to other's wishes and desires (24).

Steps or actions that have been recommended to be taken in order to make evolution in today's organizations have common and different points, but one of the best models in this respect is a combination of John Tager and Peter Dracker viewpoints that will be referred to the following:

1. Providing the atmosphere and feeling for necessity and immediacy of change
2. Forming powerful coalition for change leadership
3. Targeting strategic points
4. Notifying common vision to the entire organization
5. Granting power to people for moving towards common vision
6. Change planning
7. Combining logical progresses and creating more evolutions
8. Institutionalizing the obtained innovations and evolution

6. Research methodology

Choosing survey method depends on survey's nature, goals, and subject, and also its executive facilities. On this basis, in this part it is tried to present survey type, tool for collecting data, statistical population, statistical sample, and way of determination of sample volume, survey variables, and finally total process of survey. This survey in respect of investigating existing information is typically descriptive, and in respect of goal is application based. The statistical population includes all of the maintenance staff, experts, and professionals of EORC. Data collection tool has been questionnaire that is distributed by simple random method, and finally 40 of them have been completed and returned. In this survey, initially by collecting library resources, the variables of implementing RCM have been determined. On this basis, four maintenance management, RCM, project management, and change management that have been considered more in the literature are investigated and studied. In the next stage, to investigate surveyed indicators, a questionnaire with 23 closed questions (using Lickert's five-choice spectrum) is developed for collecting data and SPSS software is used for data analysis; the descriptive statistics methods including average and standard deviation that have been used to compare and investigate data collected by questionnaire. Inferential statistics methods including correlation test and one sample t have also been used. Survey independent variables include four dimensions that have been named, and dependent variable is implementation of RCM in EORC.

Literature review provides the basis for investigating the following hypotheses:

1. Implementation of RCM is feasible in EORC;
2. Factors of maintenance management system of EORC are higher than medium level;
3. Factors of RCM in EORC are higher than medium level;
4. Factors of project management in EORC are higher than medium level; and
5. Factors of change management in EORC are higher than medium level.

The first hypothesis is the major hypothesis of survey, and hypotheses 2 to 5 are minor hypothesis of survey.

In this survey, in order to investigate and confirm the accuracy of stated hypotheses, a statistical population should be chosen, and after collecting necessary data and information by the designed questionnaire, the validity and accuracy of hypotheses should be tested. Thus, for this purpose, the staff and experts of maintenance department of EORC are asked to fulfill the questionnaires.

EORC has begun its activity in the field of refining crude oil and producing petroleum products since 1979, and now produces about 33% of petroleum products of country requirements. This company in a region with a total area of 340 hectares, and having an area of 5.144 hectares of green space, is located in the north west of Isfahan. The production capacity of this refinery is now 375 thousand barrel per day. This company was subjected to article 44 of the constitution on 2007, and by offering its shares in stock market has been assigned to private sector, and because of competitiveness in private sector and the necessity of profitability for survival and using production capacity of refinery, the need of implementing RCM in EORC has become more important.

7. Findings

In this section, the sample features regarding demographic variables are investigated. Demographic variables of this survey include gender, marital status,

age, level of education, and duration of activity in organization.

First of all, Cronbach's Alpha coefficient for major variables has been calculated, the results of which have been presented in Table 2. As it is obvious in the table, reliability values are satisfactory, and since the questionnaire has been standard, there has been no need to confirm the validity of content. The formal validity of questionnaire has also been investigated based on five university and industry experts' viewpoints.

The results of data correlation test are illustrated in Table 3. As it is clear this correlation has been tested at 99% level, and as the results show, the correlation of questions of questionnaire are significantly high.

Table (1): Demographic features of survey participants

Demographic Variables	Frequency	Percent
Gender		
Woman	5	12.5%
Man	35	87.5%
Marital Status		
Single	8	20%
Married	32	80%
Education		
Diploma	0	0
Associate Degree	1	2.5%
Bachelor	18	45%
Master and higher	21	52.5%
Age		
Less than 33	12	30%
33- 39	13	32.5%
39- 45	9	22.5%
Higher than 45	6	15%
Duration of activity		
Less than 7 years	12	30%
7 to 13 years	19	47.5%
13 to 19 years	5	12.5%
More than 19 years	4	10%

Table (2): Cronbach's alpha coefficient calculated by SPSS software for each category of questions

Category title	Cronbach's alpha coefficient
RCM	0.0912
Maintenance Management	0.83
Project Management	0.885
Change Management	0.898

Table (3): Correlation ratio of major categories of questionnaire

	Maintenance Management	RCM	Project Management	Change Management
Maintenance Management	1	0.736**	0.783**	0.797**
RCM	0.736**	1	0.836**	0.882**
Project Management	0.783**	0.863**	1	0.895**
Change Management	0.797**	0.882**	0.895**	1

**: Correlation significant at 99% level

Table 4 shows the acceptance and rejection of hypotheses. This test has been evaluated at 95% confidence level. As it is shown in the table, only the last hypothesis is not accepted. Theses hypotheses are tested at 5% significant level, and the only significant indicator of hypothesis is related to change management meaning that this hypothesis is not accepted and the level of change management factors in EORC is not higher than the medium level.

Table 4: The Test Results of Acceptance or Rejection of Survey Hypotheses

Hypothesis	t value = 2.5				95% reliability level	
	t	Freedom Degree	Significant Indicator	Mean Difference	Minimum	Maximum
Major Hypothesis	2.353	39	0.024	0.31629	0.0444	0.5882
Maintenance	2.919	39	0.06	0.40625	0.1248	0.6877
RCM	2.278	39	0.028	0.36250	0.0407	0.6843
Project Management	2.691	39	0.010	0.37857	0.0940	0.6632
Change Management	0.856	39	0.397	0.11786	-0.1606	0.3963

In order to test the impact of demographic variables on survey major variables, variance analyses test and t test have been used. Based on these tests, demographic variables ratio impacting on major variables have been identified. Based on these tests, gender, and marital status influence RCM. Other demographic variables do not influence major variables.

8. Discussion and conclusions

As shown in table 4, the major hypothesis of survey has been accepted indicating the feasibility of implementing Reliability Centered Maintenance (RCM) in Esfahan Oil Refinery Company (EORC). Among minor hypotheses, only the last one has not been accepted, that means the level of change management factors in Isfahan Refinery is at medium or lower, and in order to improve it, effective

measures should be taken and performed. Other infrastructures of RCM are at appropriate level.

Behnia, (2011) in his survey entitled "Feasibility of implementation of lean maintenance in Isfahan Oil Refinery Company" reached to this result that because of lack of appropriate infrastructures the feasibility of implementing lean maintenance in EORC does not exist, and for this purpose the organization needs a comprehensive plan for maintenance, work study of lean system, and such infrastructures (9), while in this survey regarding the point that only change management factors level is lower than medium level, implementation of Reliability RCM is relatively possible. Yeh et al., (2011) in their survey in order to decrease cease and failure of instruments, have proposed two Preventive Maintenance policies that ultimately reached to similar results (12); while the aim of this survey was to study the feasibility of RCM in order to increase equipments efficiency and reliability. Fernandez et al., (2003) in their survey emphasized more on the role of information for increasing equipments reliability (10), while this survey tried to study the possibility of implementing RCM based on dimensions of maintenance management, reliability centered maintenance, project management and change management.

Generally, the obtained results of this survey are as follows:

i) feasibility of implementing RCM in EORC;
ii) change management level is lower than medium EORC;
iii) the educational level in EORC influences understanding ratio of maintenance management situation; and
iv) gender and marital status influence RCM.

Regarding the findings, the following suggestions can be offered:

i) implementing RCM in EORC;
ii) training managerial concepts such as change management and general points of management to the staff of maintenance;
iii) holding in-service training courses or providing facilities for staff with the aim of upgrading their level of education;
iv) encouraging in-service training courses and providing facilities to staff with the aim of upgrading their level of education; and
v) employing creative people with new thoughts and ideas for creating change in maintenance department of EORC.

Similar to other investigations, this survey has limitations, some of which are address a follows:

i) the obtained results of this survey are usable only in EORC and cannot be generalized to other organizations; In this survey, the implementation of maintenance based on four dimensions of maintenance management was investigated, and the obtained results are limited to the four factors;
ii) feasibility of implementing RCM was only assessed from viewpoints of experts of maintenance department and other requirements of implementing a new system were not studied; and
iii) economic criteria were not studied in this feasibility study.

Based on the above limitations, some suggestions are provided for future stusied. In future studies it is suggested to investigate the role of other organizational factors such as costs, staff motivation, and job satisfaction in implementing RCM system. Feasibility study of implementing other maintenance systems in EORC can also be performed together with comparing their results with the obtained findings of this survey. Furthermore, it is suggested to investigate possibility of implementing RCM from viewpoints of other staff of organization in addition to the staff's viewpoints of the maintenance department.

Authors

Ghodratollah Aghaei
Master Student of Industrial Engineering – System and Productivity Management, Department of Industrial Engineering, Najafabad Branch, Islamic Azad University, Isfahan, Iran
baaghaei@yahoo.com

Arash Shahin
Associate Professor, Department of Management, University of Isfahan, Isfahan, Iran
arashshahin@hotmail.com

Noushin Ghofrani Isfahani
Master of Industrial Management, University of Isfahan, Isfahan, Iran
n.ghofrani65@yahoo.com

Naser Mollaverdi Isfahani
Assistant Professor, Department of Industrial Engineering, Isfahan University of Technology, Isfahan, Iran
naserm@cc.iut.ac.ir

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