A Study of Barriers and Success Keys to The Implementation of Computerized Maintenance Management System in an Organization: Case Study in Fan Avaran Petrochemical Company

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Abstract: At same time with industrial revolution and the using of machines, maintenance became a part of the game to because managers wanted to improve the yield. Proper maintenance of equipment and devices reduces the cost of product malfunction or stop production.That's why maintenance managers and employers turned to new strategies. At first because equipment were not mechanized, maintenance was not a focal point. But gradually as equipment became more and more mechanized and also rising if the new competitive markets and the importance of time in a quality product without a breakdown, a need appeared for the maintenance strategy. Maintenance management is all about proactively analyzing the data, the reasons of the breakdown, inconsistencies, finding the root of the problems and defining adjustment behaviors. Computerized Maintenance Management System also, should be implanted with the same strategy. Key factors to the implantation of Computerized Maintenance Management System are commitment from the senior partners, employees' resistance, employees' training, structural design, the ability of the producers for adjusting and error correction, the support of the structure of organization, technical features and information about the equipment, and the co-ordination with the CMMS team and other sections of the organization. Some organizations face difficulties due to lack of information about some of the factors mentioned here. Therefore in this study we are about to study some of these factors for CMMS implantation in Fan Avaran Petroleum Company. First a questionnaire was designed and after the approval of its creditability by some of the professors and experts, to measure the creditability those questionnaires were distributed among a sample of 30 employees of that company. Reliability was measured by Cronbach's alpha as it was 0.83 for this questionnaire. 8 hypotheses were tested by T-test in SPSS software 19, 6 of which were approved and the two hypotheses about employees' resistance and co-ordination with the CMMS team were rejected. Also some suggestions were developed.

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1-Introduction

Maintenance was a part of humans' life from the day heinvented his first device. Nowadays with the improvements of the technology, moving towards automation and using machines for human has speeded up; hence maintenance has gotten more seriously than ever. Maintenance refers to keeping equipment in an acceptable level of performance or getting broke equipment to the production cycle. The desired result of this action is for the equipment to keep their preparedness, performance, and continuity for a specific situation. In this direction a wide range of engineering stuff like maintenance can be designed using expert systems.

This era is the era of IT and communication technology. IT has become a phenomena and an inevitable part of our lives. Quick access, in-time access and proper access have made the technologies form the past to go away and be replaced by the new ones. IT is also special to maintenance and has a lot of functions in it. One of the fields influenced by IT is maintenance. Nowadays regarding the advances of technology which led to advanced information systems organizations felt a necessity for computerizing and mechanizing information systems.

2-1- A history of different kinds of maintenance

The rising rate of investments on machines on one hand and automation on the hand, made managers think of a rational way to optimize the usefulness

period of the machines to also elongate the economic cycle. From 1930 until now the evolution period of the maintenance has been divided to three periods:

2-1-1-First period of evaluation

Researches shows that the first period of evaluation happened in the years before world war the second. At those days equipment were not mechanized as they are today so preventive maintenance wasn't really a problem in sudden breakdowns. In other words, preventing errors was not really a concept in managers' minds. In addition, all the equipment had a simple design therefore maintenance and repairing was simple by the same degree. In summary maintenance was not really systematic and it just happened in the case of a breakdown.

2-1-2-The second evaluation period

Everything underwent a huge change so quickly. The demands in the world war for different products got higher and higher due to the pressures of the war and human resources were not enough to comply. This led to mechanization in 1950. This era could be named as the inception of automation. With this growth in using mechanized equipment the matter of breakdowns became so important and after a while increasing the breakdowns shadowed on the quality and quantity of products and owners of the factories started to get unsatisfied and start to look for a way to deal with this problem. In this path preventive maintenance was suggested in the US as a good way.

1960s can be named as the era of expanding maintenance in the industries. Introducing maintenance without needing to repair, reliability engineering and repairable engineering 1962 were the results of the researches in this decade which were so important to evaluation of efficient maintenance. Introduction of the total productive maintenance or TPM in 1970s by Japan could be the last achievement of the second period. It is basically preventive maintenance used by the Americans which was adjusted to comply with the needs of the Japanese industry. Responsibility and orientation innovation in this system is that operators are responsible for their machines. In efficient maintenance the results of economic and commercial activities were amazingly optimized and made the workplace a happy, efficient, safe, place which optimizes the relationship of the human and the equipment.

2-1-3-The third evaluation period

Increasing the efficiency of the machines, quality improvements and reducing costs of maintenance and preventing the environmental damages were the factors causing the changes in maintenance:

1. Introducing the maintenance system based on machine operating conditions and promote the use of CM techniques such as vibration analysis, temperature measurement and ...
2. Introducing and applying various methods of analysis of machinery failures
3. Equipment designed with a greater emphasis on reliability and capacity building
4. Fundamental change in organizational thinking towards participation in working groups
5. The introduction of an effective maintenance system
6. Presentation of maintenance and repair as a comprehensive approach for reliability-based maintenance decision in the proper use, maintenance and repair of existing systems.RCM is a process which first determines the job that needs to be done for the continuity of all the physical capital and secondly guarantees and takes to action what users need.

2-2-Kinds of maintenance and its strategies

In a result of the changes in the strategies of business and also the dominant paradigms on the production and some other factors like the trend of other nations towards information society, different maintenance and repair strategies emerged.

2-2-1-Breakdown and breakdown-based maintenance (BM)

The first maintenance system in which there is no planning for the future breakdowns and technicians are always ready to deal with a situation and repair the equipment. (Mkemai, 2011)

2-2-2-Emergency maintenance (EM)

This system consists of the unplanned activities that happen during a breakdown. In the other words this is a series of maintenance and repair on broke machines.

In EM after a request from staff, repairs commence to set back the machine to the desired quality and quantity. In this type of maintenance what is most important is to find the location of the broken part and to separate it. If the maintenance part is organized well enough it could immediately find the location where the error happened and repair it.

If the activities of maintenance are put in the plans to be used in the case of a breakdown it is and adjustment type of maintenance. But in EM the breakdown has happened and there is no time to plan for it. This system could be the same as BM, the only difference is that in BM, maintenance is basically independent and nothing happens beside it but in EM systems maintenance is a part of the installed equipment. (Oscar, Ashraf, Labib, Walmsley, Petty, 2003).

2-2-3-Preventive maintenance (PM)

PM happens with regular intervals and regarding some specific norms to reduce error probability and breakdown. (EN 13 303- 2001). All the plans in this system are Time-oriented. The machine or the part which is broke can be replaced or renewed depending on the state of the machine. The rate of a breakdown

for a machine is the probability ofa breakdown in a certain period. (Coetzee, 2004).

The most important maintenance system which is the economic one too is PM which seeks the following objectives:

- Perform corrective actions planned for equipment caused the crash with before minor problems take them.
- Conservation of the measures and standards of performance of the machines.
- Minimizing maintenance costs.
- Avoid excessive equipment wear and tear.

Regarding the objectives PM can be defined as:

It is a systematic planned method which refers to the scheduling the observances, services, and replacements of the parts on a regular period to prevent their breakdown. Points and sections which are supposed to be investigated and also the schedule for these investigations are planned in advance and also the processes which are to be done are described in there. All the recording, analyses of recordings to improve and maintain maintenance plans are necessary.

2-2-4-Predictive maintenance

PDM happens on a regular basis or according to the consumed units and regardless of past situations. (EN 13 306- 2001)

To successfully implant PDM, the breakdown rate of the machine makes it necessary to elongate the use-time of the machine. So, decisions concerning the maintenance periods are to be made on the basis of use-time of the machine, age, frequency of use and also the distance passed. (Coetzee, 2004).

PDM is the name for the whole activities which are conducted to measure the technical status of the machine parts (the level of erosion) during the use and according to the results the type and the time of the activities are chosen.

PDM is conducted in accordance with the parts of the machine and so the other name for this type of maintenance is Condition Based Maintenance.

PDM activities include:

1. Technical inspection by human senses: technical inspection conducted by maintenance experts using human senses (like inspection for abnormal noise or heat).

2. Erosion measurement by the human using tools: technical inspection for erosion using tools like vibration, temperature gauge, oil analyzer. In this method, the inspector regularly inspects the machines during a work time and compares the results to measure the range of performance for each machine. The decisions concerning continuing or stopping the performance is to be made on the basis of these results. In this method no extra maintenance activity is to be done and hence it is also called economic maintenance.

3. Continuous inspect and measure: nowadays using continuous control method by designers is commonly accepted. Air filters are equipped with a sensor to measure the right time to change the filters. There are heat sensors for bearings to measure the exact time for lubrication and this time is announced to the operators.

2-2-5- Corrective maintenance:

CM is a name for the repairs we do after finding the error to make the machine ready to go back to the cycle (EN 13 303- 2001). This is highly costly because repairs are done immediately and without any planning (Kumar& et al, 2010). CM doesn't include predicting the time of a breakdown. Depending on the task the machine is doing, corrections could be immediate or delayed. CM is a strategy for maintenance which is commonly used when predicting a breakdown is hard.

2-2-6-Proactive maintenance:

Proactive maintenance is the name for the whole series of the activities which are meant to improve the status of the machines, reducing the need to do maintenance and removing the causes of errors. In total proactive maintenance which is codified by the maintenance engineers association of Japan maintenance prevention is used for proactive maintenance.

The most important analysis methods used in proactive maintenance are:

RCA : Root Cause Analysis

MFMEA : Machine Failure Mode and Effects Analysis

Its activities include:

1. Select or change the use of machinery and equipment are based on experiences and personnel records, notes, production notes.

2. Redesigned to eliminate the causes of failure of machine components.

3. Review the design, installation and operation of equipment. (Haji Shirmohamadi 1377).

The policy in this system is "don't fix it, improve it"

2-3- Literature background

Sandy Dunn 1997 has implied the advantages of CMMS as: 1. CMMS system implementation, increases the equipment availability time 2. CMMS system implementation, increases labor efficiency 3.CMMS system implementation, reduces maintenance costs 4. CMMS system implementation, leads to a better stock control 5. CMMS system implementation, reduces bureaucracy.

David Berger 2009 conducted a study about implantation of CMMS, and suggested that the barriers to implant CMMS are: 1. Lack of management support for the implementation of CMMS systems 2. Employee resistance in the CMMS system3.Poor planning for the implementation of

automated systems 4.Lack of appropriate training software and its capabilities to employees.

KeyvanAhrar 1388 counts inability of the software producers to correct errors of the system and also lack of software and computer infrastructure as the barriers to implant CMMS.

M Reza Maher 1386 suggests that lack of information and also technical features of the machines are the barriers to implant CMMS.

KeyvanAhrar 1390 conducted a study entitled: a model to analyze and assess CMMS using phasic logic in Fan Avaran Petroleum Company. In this thesis a model is presented for the analysis of CMMS's engine and it studies the use of phasic networks to better analyze potential errors. In this thesis in addition to completely studying the phasic logic and CMMS, a new method is presented for error detection in pumps, which uses phasic networks for information outputs.

S.EhsanS.Marvasti and MohamadPourhosseinali 1387 also studied the maintenance needs of a mechanized system in study entitled "the definition of CMMS for Cement Factories".

HedayatolahKalantari has used T-test and likert's 5 scale range to assess HSE and HSE-MS in Arvandan Oil and Gas Company and finally using friedman test he showed that factors affecting the HSE don't have the same degree of influence and then he prioritize the factors.

2-4-CMMS

The growing price of the raw material and human resources and also the hard competition between the producers, shows the necessity of a good maintenance system. Regarding the fact that nearly 40% of the costs in productions is for maintenance, anything that can increase efficiency on that matter with no doubt reduces the costs and as a results increases competitiveness.

CMMS or computerized Maintenance Management System is a system on the basis of one or more software which depending on the view of owners leads to improvements for the system and makes the personnel, equipment and material more intelligent. In most of the industries regarding the huge load of maintenance activities and the number of equipment and machines manual adjustments are difficult; so using software can deal with this problem. Besides some statistical analyses (including maintenance efficiency assessment factors) can only be done by computer software.

CMMS is a computer repair management system which presents a series of computer programs and files designed to deliver information economically to the user to manage the huge load of repair information, stock control and purchase. These systems also can be an effective tool for human resources management. (cato,mobley,2002).

2-4-1- The importance and usage of CMMS

The increase in the information load in maintenance units and the necessity of analysis of information to make proper decisions shows the necessity of mechanizing more than ever. For instance the possibility of using Pareto Diagrams and the need to filter information and analyzing the costs for the future are the most important reasons why automation is important. Of other advantages of mechanized maintenance we could name the ability to analyze the costs in any period, defining virtual equipment, defining the lowest stock level and Order point for spare parts. About the virtual equipment the advantage of this system is that it can control the maintenance-related activities. (Keyvan Aharar, Ebrahimipur, Vahdat 1390).

2-4-2- The advantages of CMMS:

The advantages are reporting ability about the performance in specified periods so that we can see the sections which are not functioning well and analyze the factors involving in that. Also we could store technical features of the machines in a file as well as parts' schemes. Association with the stock file and operating under the network as well as the ability of controlling managers and limiting the authorities are other advantages of this system.

Of other advantages of this system we are to name the possibility of categorizing the errors, reasons of errors and delay reasons in activities and so there is the possibility of analyzing statistics. Also we can find errors during the breakdown which is interesting because most of the times the problem causing the failure is a small part. In this study there is model for analyzing CMMS's data.

3- Methodology

This study could be categorized regarding many different norms and basis. The most useful one is on the basis of objective and methods: objective basis. Every research is a systematic activity which expands sciences or describes and finds solutions for a problem. Therefore, regarding the fact that any research is started with a goal, so on the basis of the objective researches are categorized in 5 categories namely; basic, practical, research and development, assessment, scientific. Basics are the ones which don't have any commercial goal and it is tried in that to expand general or technical sciences. The practical use of these kind is not important. (Ormazdin1386).

In this study in accordance with hypotheses for each of key factors in implanting CMMS a questionnaire was designed and desirability level was set first for each question then for the whole questionnaire. The mean was calculated summing the means and dividing it by the number of the means. Regarding the fact that likert's 5 scale was used the basis was set to be 5, which was found by summing the numbers 1 to 9 and

then dividing them by 5. So the median was (no idea) is set to be level of meaningfulness.
After setting the basis, regarding that level of reliability is 95%, accepted error is 5% or in other words P-value=0.05.

3-1- Hypotheses:

First hypothesis: management supports CMMS.
Second hypothesis: staff resist against CMMS.
Third hypothesis: staff are trained enough to use CMMS.
Fourth hypothesis: there are infrastructures needed for the implementation of CMMS.
Fifth hypothesis: the technical information and features which are necessary for implantation of CMMS are available.
Sixth hypothesis: the software producer is able to support and debug the system.
Seventh hypothesis: organizational structures support CMMS.
Eighth hypothesis: CMMS team and other parts of the organization are well coordinated.

3-2- Population and the sample

One of the questions that researchers seeks to answer is that whether the whole population should be tested or a chosen sample which is chosen on the basis of some rule can give us the result which is applicable to the whole population. The population in this study includes all the staff in Fan Avaran Petroleum Company who are 170 people.

the size of the sample

In this study due to many reasons like time saving, cost reducing and lack of access to the whole population, sampling was used. This study aims at the barriers and key factors for CMMS implantation in Fan Avaran Petroleum Company. According to the Morgan's table below, out of the 170 people, 120 were chosen as the sample randomly and they were given the questionnaires and finally questionnaires were completed, and analyzed for further assessments.

3-3- Creditability assessments:

Reliability

One of the most important measuring tools in this study in which the most important one is the questionnaire, is its reliability. Reliability shows the stability and consistency of the concept in question and helps an assessment have a good measurement. How the concept in question shows the same results in the same situation. There are so many different ways to assess reliability. The most common one is cronbach's alpha.
Cronbach's alpha is considered weak under 0.6, acceptable above 0.7, and good above 0.8. However as it gets close to 1 the reliability grows better and better. (Danaifar 1383 p489-490). The cronbach's alpha was measured using SPSS software.

Table(1): Reliability Statistics

Cronbach's Alpha	N of Items
.831	40

As you can see in the table above, cronbach's alpha is 0.830 which is above 0.7 and as a result the questionnaire is reliable.

4- The method of data analysis

One sample T test:

To generalize the results of a sample to the whole population, one sample t test was used by comparing with a constant number in SPSS software. As mentioned before, 5 is the test value in this study and the means of the answers to each question are used as variable index to compare with the test value and to be used in analysis. Using this test, the data form the 2; agreed and disagreed groups, score of them is above and under 5 respectively were analyzed and hypotheses were tested. This means if the mean of a question is above 5 the hypothesis is approved otherwise it's rejected.

4-1- First hypothesis: management supports CMMS.

Statistical hypotheses
$H_0: \mu >= 5$
$H_1: \mu < 5$
(Just for the record claim is put in H0)

Table (2): One-Sample t test for Hypothesis1

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis1	120	6.4842	1.09022	.09952

When our statistical hypothesis is on-way ($\mu >= 5$ $\mu < 5$), hypotheses are answered to using the t test value and the mean of the index in question. As you can see in the statistical hypotheses whereas the test is on-way test, comparing the mean index in hypothesis no. 1 with the test value we could say that H0 is approved by 95% of reliability.

$H_0: \mu >= 5$
$6.4842 >= 5$

4-2- Second hypothesis: staff resist against CMMS.

Statistical hypotheses
$H_0: \mu >= 5$
$H_1: \mu < 5$

Table (3): One-Sample t test for Hypothesis2

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis2	120	6.4842	1.09022	.09952

As you can see in the table, comparing the mean index in hypothesis no. 2 with the test value we could say that H0 is rejected by 95% of reliability.
H_0: μ>=5
3.9067<=5

4-3- Third hypothesis: staff are trained enough to use CMMS.
Statistical hypotheses
H_0: μ>=5
H_1: μ<5

Table (4): One-Sample t test for Hypothesis3

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis3	120	5.253	1.17215	.10700

As you can see in the table, comparing the mean index in hypothesis no. 3 with the test value we could say that H0 is approved by 95% of reliability.
H_0: μ_farzie3>=5
5.2533>=5

4-4- Fourth hypothesis: there are infrastructures needed for the implementation of CMMS.
Statistical hypotheses
H_0: μ>=5
H_1: μ<5

Table (5): One-Sample t test for Hypothesis4

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis4	120	6.016	1.21159	.11060

As you can see in the table, comparing the mean index in hypothesis no. 4 with the test value we could say that H0 is approved by 95% of reliability.
H_0: μ>=5
6.0167>=5

4-5- Fifth hypothesis: the technical information and features which are necessary for implantation of CMMS are available.
Statistical hypotheses
H_0: μ>=5
H_1: μ<5

Table (6): One-Sample t test for Hypothesis5

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis5	120	5.976	1.19472	.10906

As you can see in the table, comparing the mean index in hypothesis no. 5 with the test value we could say that H0 is approved by 95% of reliability.
H_0: μ>=5
5.9767>=5

4-6- Sixth hypothesis: the software producer is able to support and debug the system.
Statistical hypotheses
H_0: μ>=5
H_1: μ<5

Table (7): One-Sample t test for Hypothesis6

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis6	120	5.803	1.19887	.10944

As you can see in the table, comparing the mean index in hypothesis no. 6 with the test value we could say that H0 is approved by 95% of reliability.
H_0: μ>=5
5.8033>=5

4-7- Seventh hypothesis: organizational structures support CMMS.
Statistical hypotheses
H_0: μ>=5
H_1: μ<5

Table (8): One-Sample t test for Hypothesis7

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis7	120	5.432	.98648	.09005

As you can see in the table, comparing the mean index in hypothesis no. 7 with the test value we could say that H0 is approved by 95% of reliability.
$H_0 : \mu_{farzie7} >= 5$
5.4325>=5

4-8- Eighth hypothesis: CMMS team and other parts of the organization are
Well-coordinated.
Statistical hypotheses
H_0: μ_farzie8>=5
H_1: μ_farzie8<5

Table (9): One-Sample t test for Hypothesis8

Test Value =5				
	N	Mean	Std. Deviation	Std. Error Mean
Hypothesis8	120	4.790	.89662	.08185

As you can see in the table, comparing the mean index in hypothesis no. 8 with the test value we could say that H0 is rejected by 95% of reliability.

H_0 : μ >=5

4.7900<=5

5- Results and suggestions

The hypothesis of the study

In this part we present the findings of our study to reject or approve the main and secondary hypotheses.

First hypothesis: management supports CMMS.

According to the findings of the study in chapter four, comparing the mean (6.48) and the test value 5 we conclude that first hypothesis is approved or in other words management supports CMMS.

Second hypothesis: staff resist against CMMS.

According to the findings of the study in chapter 4, comparing the mean (3.90) and the test value 5 we conclude that second hypothesis is rejected or in other words staff don't resist against CMMS implantation.

Third hypothesis: staff are trained enough to use CMMS.

According to the findings of the study in chapter four, comparing the mean (5.25) and the test value 5 we conclude that third hypothesis is approved or in other words staff are trained enough to use CMMS.

Fourth hypothesis: there are infrastructures needed for the implementation of CMMS.

According to the findings of the study in chapter four, comparing the mean (6.01) and the test value 5 we conclude that fourth hypothesis is approved or in other words there are infrastructures to support CMMS.

Fifth hypothesis: the technical information and features which are necessary for implantation of CMMS are available.

According to the findings of the study in chapter four, comparing the mean (5.97) and the test value 5 we conclude that fifth hypothesis is approved or in other words technical information and features needed to implant the CMMS exist.

Sixth hypothesis: the software producer is able to support and debug the system.

According to the findings of the study in chapter four, comparing the mean (5.80) and the test value 5 we conclude that sixth hypothesis is approved or in other words the software producer is able to correct and debug errors in the system.

Seventh hypothesis: organizational structures support CMMS.

According to the findings of the study in chapter four, comparing the mean (5.43) and the test value 5 we conclude that seventh hypothesis is approved or in other words organizational structure supports the CMMS implantation.

Eighth hypothesis: CMMS team and other parts of the organization are well coordinated.

According to the findings of the study in chapter four, comparing the mean (4.79) and the test value 5 we conclude that eighth hypothesis is rejected or in other words CMMS team and other parts of the company aren't well-coordinated.

According to the results of the study, the key factors in CMMS implantation in Fan Avaran Company include: management support, infrastructures, the technical information and features about the equipment, the ability of the software producer, the organizational structure's support, trained staff, the coordination between CMMS team and other parts of the company and the lack of resistance form the staff. In this case all the infrastructures are ready except the coordination between CMMS team and other parts of the organization. So we suggest in a fore step toward a successful implantation of CMMS in that company, related authorities and CMMS department staff should hold meetings and consult each other in order to solve the problem and coordinate CMMS team and other sections.

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