International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-9, September 2015

Presenting an assessment model and prioritizing quality indices of maintenance by improving quality function development through Analytical Network Process

Gholamreza Esmaeilian, Maryam Hamedi, Behnam Zandi Lak, Asghar Tahan

***Abstract*— in the present paper, attempt has been made to write a general framework and model for assessment and prioritization of quality indices of maintenance for the manufacturing companies with continuous process such as refineries and petrochemical companies. In this model, important quality indices have been identified in maintenance and ranked and weighed with ANP technique and then technical requirements have been specified and prioritized with QFD technique. Results of the model can increase satisfaction of the customers in addition to increased quality of maintenance in companies and affect duration of maintenance and also affect improvement of maintenance costs.**

***Index Terms*— repair and maintenance, Analytic Network Process, maintenance, quality house.**

I. INTRODUCTION

Maintenance in oil industry plays key role in capacity building of production and transfer process. Maintenance in oil industry is performed based on function of devices and operating conditions and their function without any interruption and disturbance in production process requires accurate, integrated and engineered planning. Maintenance is done to increase efficiency of machinery and equipment based on stability and continuation of production.

In oil industry, considering interdependency of the companies and also importance of production, complexes are not permitted to stop production during year unless with permission of the Ministry of Oil. On this basis, a time interval is given to the company or companies and the companies are obliged to remove defects and problems of their system (the works which cannot be done at normal time) in specified time interval and service their unit and there is a normal state in the complex. This was a simple definition of maintenance.

Subject of maintenance in the industry particularly petrochemical companies and refineries is one of the main concerns of the managers and experts of these companies. All of us have seen occurrence of abundant problems in maintenance during activity in petrochemical industries. Identification and suitable planning of activities and working groups, timely procurement and the required goods, recruitment of skilled manpower , required machinery and tools and other subjects are of the factors which are effective on quality and quantity of maintenance. It can be said that maintenance will be successful when scope of all activities can be determined, organized, managed and finalized well and planned in high level to realize the desired quality goals which is one of the main demands of maintenance customers while performing works desirably and reaching the pre-determined goals

Manuscript received 27, September 2015

Gholam Reza Esmaeilian, Assistant Professor, Department of Industrial Engineering, Payame Noor University, Isfahan, Iran,

Maryam Hamedi, Assistant Professor, Department of Industrial Engineering, Payame Noor University, Isfahan, Iran,

Behnam Zandi lak, MSC Student, Department of Industrial Engineering, Payame Noor University, Assalouyeh, Iran.

Asghar Tahan, MSC Student, Department of Industrial Engineering, Payame Noor University, Assalouyeh, Iran,

II. BACKGROUND

Design of a model which can be a suitable pattern for promotion of quality indices of maintenance is of special importance. Due to high volume of repair activities in overhaul, quality of executive working groups is reduced and attention to identification and promotion of quality indices has been important in overhaul of complexes and refineries.

A research conducted by Isabella M.Lami , Francesca Abstante(2012) presented a common framework with two quality function development and Analytic Network Process (ANP) in Turin, Italy.

Horenbeek, Pintelon, Omega conducted a research in 2014 entitled presentation of a Maintenance Performance Measurement framework with ANP method and they aimed to develop a framework in which goals of maintenance are included in all levels of organization . To help managers select the related components and indices, Analytic Network Process (ANP) and Maintenance Performance Measurement have been used.

Da silva, Gabrita, Matis in another study (2008) who conducted in 2008 emphasized that selection of the most suitable repair model and policies was the best way to reduce repair costs considerably and also optimized key indices of failure, reliability, mean time between defects , mean repair time, access to equipment and studied results in Toneva Plant in Portugal.

In a research in 2010(Rafieian, Alam Tabriz, Roghanian, 2011), the industrial engineers conducted a research on prioritization of strategic measures of the customer-focus organizations with fuzzy ANP-QFD approach and conducted

their case studies on a nongovernmental university. In this paper, they presented a framework based on ANP-QFD combined model in fuzzy conditions to determine and prioritize strategic measures of the university based on attitude of students, weaknesses and strengths and major goals of the university and cost of actions.

A research entitled studying and prioritizing sensitivity of the devices to preventive maintenance with Martel & Zaras model which was conducted by Seyed Ahmad Ahmadi and Nima Mokhtar Zadeh (Ahmadi, 2013) in fall and winter 2013 studied the fire production machining company and aimed to answer this question that what device needs preventive maintenance more than other devices based on the selected indices.

In a paper which was conducted in 2012 by Hossein Rezaee Dolat Abadi, Reza Saleh Zadeh et al. (Rezaee, Saleh Zadeh, 2012) studied cost management by designing product through presentation of a combined model of the target costing methods, QFD and value engineering. Their goal in this paper is to present a model with which role of target costing in management of production costs can be studied. The quality specifications which will fulfill needs of customer should be promoted.

A research conducted in 2009 by Arash Shahin et al., Noori and Amini (Shahin Noori, 2009) wrote a paper entitled prioritization of requirements of Iran Khodro Industrial Group standard for suppliers with clustering and quality function development aiming at presentation of a method for improvement of ranking by the suppliers.

In a research by Bahram Ghadiri , one of the experts of Afrand Resaye Tehran Engineering Company(Ghadiri, 2012) conducted a research in 2012 entitled analytical approach of maintenance strategy in reduction and control of breakdowns. in a paper in 2007 by Seyed Akbar Nili Poor et al. in Malek Ashtar University of Technology (Nili Poor , Bagher Zadeh, Shaabani , 2007) wrote a paper entitled design of applied model for maintenance system balanced assessment . In this paper, they tried to present an applied model of balanced assessment for promotion of performance of maintenance systems of a manufacturing plant and then suitable criteria can be adopted for reporting of system for each of the aspects in the strategy map.

The research which was conducted in December 2011 by Mohsen Moradi (Moradi 2011) implemented quality function development (QFD) for designing the product in fuzzy medium with Analytical Network Process in Kondar Company and this model is presented for prioritizing technical requirements based on their importance in process of design and production . In this model, fuzzy Analytical Network Process has been used to calculate weights of the customers' demands and prioritize technical requirements and complement quality house.

In the research in 2012, Ms. Fatemeh Darzi and MR. Safaee (Darzi, Safaee, 2012) prioritized quality specifications of bank services with a combined approach of QFD and ANP. In this research, a combined framework of function development and quality process and Analytical Network Process has been presented for better understanding of quality demands of customers in the field of bank services.

A research was conducted by Mr. Khobyari in 2012(Khobyari , 2012) about application of Analytical Network Process (ANP) in selection of marketing competitive strategy as a case study in Azar Battery Company and they aimed to select marketing competitive strategy among three strategies of differentiation, focus and leadership in reduction of cost for the said company. Hassan Haleh and Hossein Karimian (Haleh , Karimian , 2010) in 2010 utilized ANP for selection of the most suitable structure for improvement of reliability of system and identified criteria affecting reliability of system in their studies and specified effect of each of them and studied their findings in numerical example and presented results in a paper entitled selection of the most suitable structure for improvement of reliability of system with Analytical Network Process (ANP) in Industrial Engineering Publication.

Achieving a model which can consider different demands altogether and consider and assess the criteria and indices to fulfill main goal of the research i.e. promotion of overhaul quality led the researcher to conduct this research. Undoubtedly, achieving such pattern can create a common language between the repair, exploitation, procurement, stores and financial affairs and try to compile an executive plan for overhaul for other staff units of the companies to convert overhaul of the companies from a compulsory and hard process into an activity with value added. Due to high volume of the repair activities in overhaul, working quality of the executive groups is reduced and on this basis, it is important to pay attention to promotion of the quality indices in overhaul of complexes and refineries.

The Presented proposed model on this basis, it is important to pay attention to promotion of quality indices in overhaul of complexes and refineries.

III. THE PROPOSED MODEL

The main framework of this model has been taken from Wireman model and the terms which can make execution of this model more applicable or the continuous production processes particularly refinery and petrochemical companies. In the following Figure, general scheme of the model has been presented.

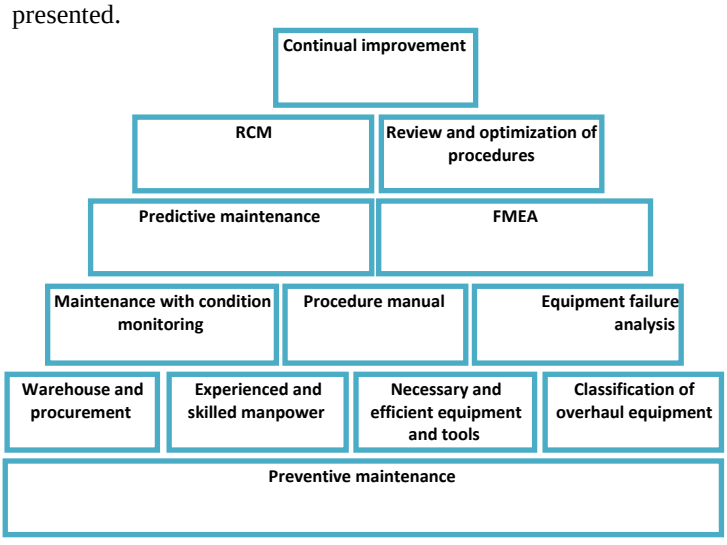

Figure 1- Proposed model for formulation of optimal maintenance strategy

IV. INPUT INTERACTIONS

Quality demands of the customers in overhaul were specified and collected as quality indices with QFD and then technical requirements are specified and defined with quality house. General research process is shown in Figure 2.

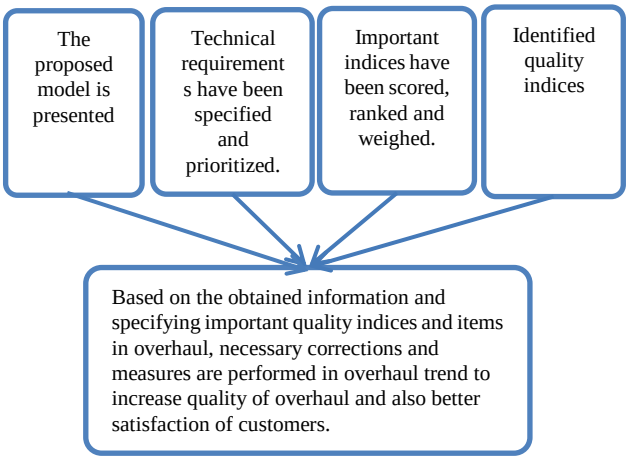

Figure 2- General process of research and construction of model

Considering goal of the first research based on the identified criteria and sub criteria, suitable model for network analysis has been designed in Super Decision software. Based on this model, Analytical Network Process (ANP) will be as follows.

Table 1- main indices and the related sub criteria

Symbol	Sub criteria	Symbol	Criteria
s11	Volume of repair work	c1	Quality of works
s12	Knowledge of manual and efficient procedure		
s13	Inspection and continual supervision		
s14	Specialty of manpower		
s21	Suitable safety equipment and tools	c2	HSE Quality
s22	Safety culture of personnel		
s23	Knowledge and skill of safety personnel		
s24	Specifying all potential events scenarios		
s31	Skill and knowledge level of the supervisors	c3	Human resources quality
s32	Knowledge level of executive factors		
s33	Work motivation		
s34	Organizational discipline		
s41	Welfare equipment	c4	Support quality
s42	Planning and organization		
s43	Suitable and sufficient tools		
s44	Knowledge management		
s51	Stock quality	c5	Spare parts quality
s52	Construction quality		
s53	Quality standards		
s54	After-sales services		

This classification of the main criteria and main sub criteria has been agreed by 30 experts in maintenance. Attempt is made to identify value weight of each of these criteria and sub criteria with ANP technique

V. THE PRIORITY OF MODEL COMPONENTS BY ANP TECHNIQUE

For analysis, the main criteria have been compared based on goal with paired method. For this purpose, the experts view has been used and eigenvector has been calculated with geometrical mean technique and normalization of values. The obtained numbers show importance factor of each of the main criteria. The performed calculations are given in Table 2 and eigenvector is also shown as W_1.

Table 2- Prioritizing main criteria based on goal

Eigenvector	Spare parts quality	Support quality	resources	quality HSE	Quality of works	
0.296	2.110	1.966	1.264	1.898	1.000	Quality of works
0.221	1.834	1.740	1.371	1.000	0.527	quality HSE
0.240	1.996	2.982	1.000	0.729	0.791	Human resources quality
0.133	1.824	1.000	0.335	0.575	0.509	Support quality
0.110	1.000	0.548	0.501	0.545	0.474	Spare parts quality

Based on the above Table, eigenvector of the main criteria will be as W_1.

$$W_1 = \begin{pmatrix} 0.296 \\ 0.221 \\ 0.240 \\ 0.133 \\ 0.110 \end{pmatrix}$$

VI. Final priority of the model indices with ANP technique

To determine the final priority of the main criteria in the model with ANP technique, unbalance initial super matrix, balanced super matrix and finally super matrix should be calculated. Each element of this diagram has been calculated in different stages of paired comparison technique and DEMATEL. Therefore, structure of unbalanced super matrix can be observed by inserting this data in final structure of the model which has been designed with Super Decision software.

Table 3- Final prioritization of the research indices

Rank	Final weight	Symbol	Sub criteria
14	0.0455	S11	Volume of repair work
8	0.0548	S12	Knowledge of manual and efficient procedure
9	0.0537	S13	Inspection and continual supervision
6	0.056	S14	Specialty of manpower
11	0.0506	S21	Suitable safety equipment and tools
7	0.0548	S22	Safety culture of personnel
5	0.0566	S23	Knowledge and skill of safety personnel
17	0.0372	S24	Specifying all potential events scenarios
3	0.0625	S31	Skill and knowledge level of the supervisors
13	0.0471	S32	Knowledge level of executive factors
16	0.0395	S33	Work motivation
19	0.0364	S34	Organizational discipline
2	0.0626	S41	Welfare equipment
1	0.0665	S42	Planning and organization
15	0.0428	S43	Suitable and sufficient tools
18	0.0367	S44	Knowledge management
4	0.0596	S51	Stock quality
12	0.0495	S52	Construction quality
10	0.0533	S53	Quality standards
20	0.0344	S54	After-sales services

VII. Prioritizing technical requirements with QFD technique

To prioritize the most important technical requirements in production based on the identified requirements, QFD technique has been used. Relation matrix of quality house has been used in the first stage. This matrix evaluates each of the technical requirements based on the identified requirements and weight of these criteria has been designed.

Each class of the requirements was ranked with ANP approach. On the other hand, the most important technical requirements include employment of experienced and skilled forces, collection and prioritization of repair works (having efficient manual and procedure, having the necessary equipment and tools, educational need should be met (educational need assessment), payment of wage to personnel and respecting for the personnel etc.

Requirements of the customers which have been prioritized in the second step with ANP technique are inserted in column of QFD matrix shown in table 4.

Table 4- Technical requirements and customers' requirements relation matrix

Purchasing from the reliable and reputable companies with desirable guarantee	Necessary inspection and supervision	Having quality standards	Specified time schedule in overhaul	Holding knowledge management sessions before and after overhaul	Suitable welfare servicing	Having overhaul procedure	Supplying efficient and high quality safety equipment and tools	Having potential events scenarios	Holding scientific educational courses and continual safety theory	Having overhaul organizational chart	payment of wage to personnel and respecting for the personnel etc.	educational need should be met (	having the necessary equipment and tools	collection and prioritization of repair works ا	employment of experienced and skilled forces	technical requirements / requirements of customers
3	3	3	3	1	3	3	3	1	3	1	1	1	9	9	9	Quality of works
3	3	1	3	3	3	1	3	3	1	9	9	9	3	1	1	Quality of human resources
1	1	3	3	3	3	1	9	9	9	3	3	1	3	1	3	Quality HSE
1	1	3	9	9	9	9	1	3	3	1	3	3	3	1	3	Support quality
9	9	9	1	3	1	3	3	1	3	3	3	1	3	1	1	Spare parts quality
2.95	2.95	3.18	3.58	3.20	3.58	2.87	4.06	3.51	3.85	3.58	3.84	3.18	4.78	3.37	4.08	Weight of technical requirements

Based on the obtained results, priority of the technical requirements is as follows:

Table 5- Final priority of technical requirements

Importance	Weight	Technical requirements
2	4.078	Employment of experienced and skilled forces
10	3.371	Collection and prioritization of repair works ا
1	4.778	Having necessary equipment and tools
12	3.182	Educational need of the personnel should be assessed (educational need assessment)
5	3.845	Payment of wage to personnel and respecting for the personnel
6	3.579	Having organizational chart of the overhaul
4	3.848	Having scientific educational courses and continual safety theory
9	3.514	Having potential events scenarios
3	4.062	Supply of the efficient and high quality equipment and tools
15	2.874	Having overhaul procedure
7	3.575	Suitable welfare servicing
11	3.203	Holding knowledge management sessions before and after overhaul
8	3.575	Specified time schedule in overhaul
13	3.182	Having quality standards
14	2.954	Necessary inspection and supervision
14	2.954	Purchasing from reliable and reputable companies with desirable guarantee

VIII. RESULTS

Due to high volume of overhaul activities, quality of the executive working group is reduced and causes dissatisfaction of customers. On this basis, it is important to pay attention to promotion of quality indices in overhaul of the complexes and refineries. This research provided a model for identification, assessment and prioritization of quality indices for repair.

After identification of the important quality criteria and sub criteria, the criteria and sub criteria were prioritized and weighed with ANP and interaction between the main criteria was specified and then the most important technical requirements in overhaul were identified and prioritized based on the main requirements with QFD technique. After weighing each of the criteria, the highest weight was given to quality of works and then quality of human resources was given the highest importance and weight. In the related organization, considering the obtained results in the past repairs, the performed activities had desirable return and results by reinforcing and paying attention to indices of efficient equipment and tools, employing skilled and experienced forces, paying wage to the executive personnel. After studying this field, rate of the performed activities had desirable return and efficiency in customer's satisfaction with quality of overhaul. Overhaul expenses also led to more than 8.5% of benefit for the organization in targeting.

Table 6-Effect of execution of model on the performed overhaul

	Customer's satisfaction with quality of the performed works	The number of performed activities
Before execution of policy	67 %	78 %
After execution of policy	74 %	91 %

ACKNOWLEDGMENT

I thank all those friends and colleagues who have helped me to do this research.

REFERENCES

[1] Ahmadi , Hossein , Garoosi, Nima . Studying priority of vulnerability of devices Haleh Hassan, Karimian , Hossein ; 2010, Selecting the most suitable structure for improving reliability of system with Analytic Network Process(ANP). Industrial engineering and production management international publication. Pp. 24-32-Tehran.

[2] Khoobyari, Hassan, Applying Analytic Network Process (ANP)in selection of marketing competitive strategy. M.A. thesis. Payame Noor University. West Tehran Branch. Fall 2012.

[3] Darzi , Fatemeh, Safaee, Abdolhamid. Prioritizing quality specifications of bank services. International Conference on management. 2012

[4] Rezaee , Hossein , Saleh Zadeh, Reza , Cost management through design of product: Presenting a combined model of target costing methods , QFD , University of Isfahan. Production and operation management. Third period. Serial No. 5. No. 2. Fall and winter 2012. PP. 77-88.

[5] Shahin Arash , Noori, Atefeh. Prioritizing standard requirements of Iran Khodro Industrial group for the suppliers with clustering and QFD. The tenth conference on management. 2009.

[6] Ghadiri, Bahram. An analytical approach to maintenance strategy in reduction and control of breakdown.

[7] Moradi , Mohsen , Implementing Quality Function Development (QFD) for design of product in fuzzy medium . M.S. thesis. December. 2011.

[8] Nili Poor, Akbar, Bagher Zadeh, Mehdi, Designing applied model for balanced assessment of function of maintenance systems. The fifth international conference on management. 2007.

[9] Abastante, Francesca,Isabella,Lami,Quality Function Deployment And Analytic Network Process, Politecnico Di Torino, Turin, Italy, 2012,14-27.

[10] Carlos Manuel Inacio da Silva, Carlos Manuel Pereiva Gabrita and Joao Carlos de Olivera Matias. REVIEW AND CASE STUDIES Proactive reliability Maintenance: a Case Study Concerning Maintenance Service Costs. Journal of Quality in maintenance Engineering, Vol14, No4, 2008 Emerald Group

[11] Rafieian , Hamid , Alam Tabriz, Akbar , Prioritizing Strategic Actions In Customer Oriented Organization With QFD-ANP , 2011.

[12] Van Horenbeek, Adriaan , Pintelon , Liliane ,Omega ,International Journal Of Management Science 42(2014)33-46