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RESEARCH NOTE

Assessment of Improvement of Preventive Maintenance (PM) Systems Related to the Civil Projects Using Concepts of Value Engineering (VE)

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A B S T R A C T

The purpose of this paper is to use the concepts of value engineering (VE) in evaluating the improvement caused by preventive maintenance (PM) systems in civil projects. A real case is used to show how we can implement the proposed method. VE is the systematic application of recognized techniques by multi-disciplined teams.It identifies the function of a product or service, establishes a worth for that function, generates alternatives through the use of creative thinking, and provides the needed functions and reliably at the lowest overall cost.In evaluation phase of PM system, the expenses of the systemand satisfaction rate of submitted service quality by PM system of workshop (by questionnaires) has been investigated. Then, in the identification and survey phase, principle of operation in PM system were identified (by fast charts).Consequently, ideas and suggestion for improvement weresubmitted by attending the VE workshops and brain storming meetings. Accepted suggestions were implemented by priority. After implementation of VE phase, the system was again evaluated withregardto the expenses deduction and keeping or increasing the quality of services' giving in. Performing value engineering caused saving in incurred cost and development the quality of PM system related to the civil projects.

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1. INTRODUCTION

Each year a great amount of effort and financial resources are invested in large civil and industrial projects. Whereas, in average, executing these projects considered nationally or provinciallyyield more than 50% tardiness deviating from due datethe customers have specified.

Continual increase incost and long delays of these projects have obliged us to omit thoseparts having no role in increasing quality and considered as unnecessary

parts in practice. As a whole, the most important aim of the project management is to perform the project with least cost and at defined due date as well as observing defined quality level. To this end, one important activityis to consider the weight of cost of machinery and equipment in the total cost of a civil engineering project (10 to 40 percent). Value engineering is a technique that helps decrease the maintenance cost of the machinery and equipment as the main part of a civil engineering project. This is accomplished by collecting the ideas, attributing the score or values to them and choosing the best idea at the end.

In other words, this approach omits or reforms any unnecessary cost without losing the main structural

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functions.At least, performing VE yields between 10 to 35 saving in project budget as a whole.

1. 1. Subject Plan   Bearing in mind that the completion of civil projects and their exploitation (adopted to scheduling of plan) are very important issues. On time, supplying and readiness to use equipment and machines is necessary and inevitable matter to progress of projects. In this regard, one of the critical factors is the effectiveness and capability of the PM system.

The most important goal of project management is performing the project with minimal cost at predefined time. Considering the weight of machinery and cost of equipment in the balance sheet of civil cost (10 to 40 percent) makesusing a potent approach named value engineering for reducing the repair and maintenance cost and keeping or improving the quality inevitable[1]. The mechanism of this approach is collecting the ideas, ranking them, and finally choosing the best idea.

The following difficulties and cases obliged us to use and exploit VE techniques to analyze and improve the repair and maintenance system of the shop floor.

- Long term breakdowns of equipment and machineries
- High cost of the PM system of the shop floor.
- Low efficiency of manpowerrelated to thePM department of shop floor.
- Unsatisfactory of project performing system (customer) and low service quality

The main aim of this research is to survey the improvement of repair and maintenance systems of civil projects using VE related to the following cases:

- Decreasing cost of the PM system related to its shop floor as well as quality improvement of services performed by the PM system
- Performing PM activity in short term time, decreasing the breakdown time of machines.
- Increasing capability ratio of machineries and manpower efficiency

1. 2. Value Engineering (VE)   VE is a process to attain the best output in such a way that quality, immune and incurred flexibility respect to the each monetary unit are improved.

Analyzing value in the form of specific technical approach, after World War II has been investigated. With respect to the milestones in history of VE following cases can be considered.

- In 1947, Lawrence Miles devised a phase-to-phase methodology linking final production and its cost. He named this methodology as value analyzing.
- In 1959, VE society of United States was established.
- In 1996, Public rules 104-106 obliged the practical organizations depending upon the American Federal Government to establish and preserve effective methods of VE for projects whose values are greater than $1,000,000.
- In 2000, instruction of work referral and coalescence contract with VE servers was reported.
- However, there exist numerous works using value engineering techniques to optimal management. For further study, please refer to references [2] and [3]. To scrutinize the recent research works considering value engineering technique the reader can refer to references [4-10].

1. 3. VE phases   Performing VE project involves eight phases. Selection phase (selecting the project under study and developing VE team), and surveying phase (obtaining related information, analyzing performance, identifying the best opportunity to save cost during the life of the project), presentation phase (determination and identification of maximum number of replacement approaches), assessment phase (assessment of suggested approaches and selecting the best alternative), extension and development phase (collecting real and practical data related to each approach), presentation phase (presentation of value engineering suggestions to impose it atthe final plan), practical and auditing phase (to perform and analyze the obtained result of executing approved proposals).

1. 4. PM Systems   During two previous decades remarkable changes related to the PM of machines have occurred. A large number of elitists believe that changes related to the PM systems have been greater than the other engineering systems. Given that, majority of machines of civil projects have basic roles.

Thus, technicalorientation to the category of maintenance and arranging, it can be regarded as appropriate approach to make profit and save cost of execution civil projects in managerial plans of projects. One of the main reasons for prolonging the execution time of projects is failing to maintain machineries. This matter causes failure and breakdown of machines

resulting the failure in completing jobs in predefined due dates.

Therefore, it must be tried to establish systems to PM issue, to increase the quality of offered services by the PM system, to authorize the elitists and experts according to the recommendation of work constructor. In this way, we accomplish more capability and availability of machines and tools to perform civil projects faster, keeping the acceptable quality.

In spite of the common idea, the role of PM team is removing the causes of failure and not the repairingtask following breakdown. The mission of PM team is attaining and keeping the optimum availability of machines and equipment.

1. 5. Service Management   Bearing in mind that one of the most important subjects is service quality and customer satisfaction at their best degree. Thus, taking into account the service management issue must be regarded as priority in PM system.

Therefore, considering issues related to the service managementmust be regarded as priorities of PM system. According to the classifications existing in standards of service management, the quality indexes of service representation can be categorized in 4P as follows:

- **Product:** involving standards and cases promised to the customers of PM system.
- **Processes:** involving cases related to the procedures and methods of work enforcement.
- **Presentation:**appearance of work places, style of personnel, drawing of symbol of related firm (Logo), packaging of product.
- **Manpower skills:** involving cases related to the personnel behavior with respect to the customers.

Background: VE issues in the form of academic theses have been surveyed and studied since 1998 in Iran. Although, according to the researches done in this current study (involving valid sites and related universities and etc.) up to now VE technique has not been used to improve PM systems of civil engineering.

Although, in the PM system area, different methods such as six sigma have been used to improve these kinds of systems. in addition, VE technique has been used in different areas, but up to now, coalition of these two issues, the matter of this research paper, has not been surveyed before.

Questions and Assumptions: Questions and assumptions of this research paper are as follows:

Question 1: Does the use of value engineering concepts cause a decrease in the PM costs in civil projects?

Question 2: Does the use of value engineering concepts cause to increase thequality of PM services in civil projects?

Question 3: Does using value engineering concepts cause to decrease of the times of machinery breakdowns in civil projects?

Assumption 1: Using value engineering concepts causes to decrease of PM costs in civil projects.

Assumption 2: Using value engineering concepts causes to increase of quality of PM services in civil projects.

Assumption 3: Using value engineering concepts causes to decrease the times of machinery breakdowns in civil projects.

2. RESEARCH APPROACH

The most important challenges in the PM system are customer satisfaction [on (Quality Improvement) and decreasing its cost. One of the best existing techniques is VE considered in this research paper. Using this method, the improvement of the PM system of the largest dam constructor workshop inIran has been investigated.

In this research, a tri-phase approach has been used. In the first phase, the main emphasis is on accumulating literature and subjects related to VE concepts to improve the PM system specifically related to civil engineering. Assessment indexes of PM system (cost and quality) in combination with VE have been identified in this phase.

In the second phase, using the accumulated subjects obtained from the first phase and research requirements, was planned and distributed among personnel. The main aim of using questionnaire was identifying the degree of satisfaction of the customers of the PM system of workshop (users of machineries and equipment, executing system of workshop).

Afterward, costs of the PM system of workshop based on headings of costs were identified and calculated. In this phase, using Function Analysis System Technique (FAST) diagrams, the performance of the PM system was identified and analyzedmeticulously. Subsequently, by holding VE

workshop and brainstorming sessions, numerous ideas and suggestions to improve PM performances were presented. Then, these ideas and suggestions were analyzed and prioritized to execute one by one. Finally, the accepted ideas were executed. To assure the effectiveness of VE, the PM system was analyzedwith respect to the two indexes, namely, cost reduction and service improvement. In the third phase, using the results of this research, the possibility of implementing VE technique to improve the PM systems of civil engineering was identified. Figure 1 schematically illustrates these three phases.

2. 1. Costs of the PM System   There exist different categories associated with the PM costs. To specify PM

costs in the project considered in this research with respect to the accomplished surveys and studies, following headings wereconsidered. These headings in the view of involving all costs have width attribute and were regarded as outline for collecting and calculating of costs of PM system.

1.   Costs of manpower
2.   Costs of materials and parts
3.   Costs of breakdowns of machines
4.   Costs of production and jobs lost
5.   Costs of manpower idle times
6.   Clerical costs
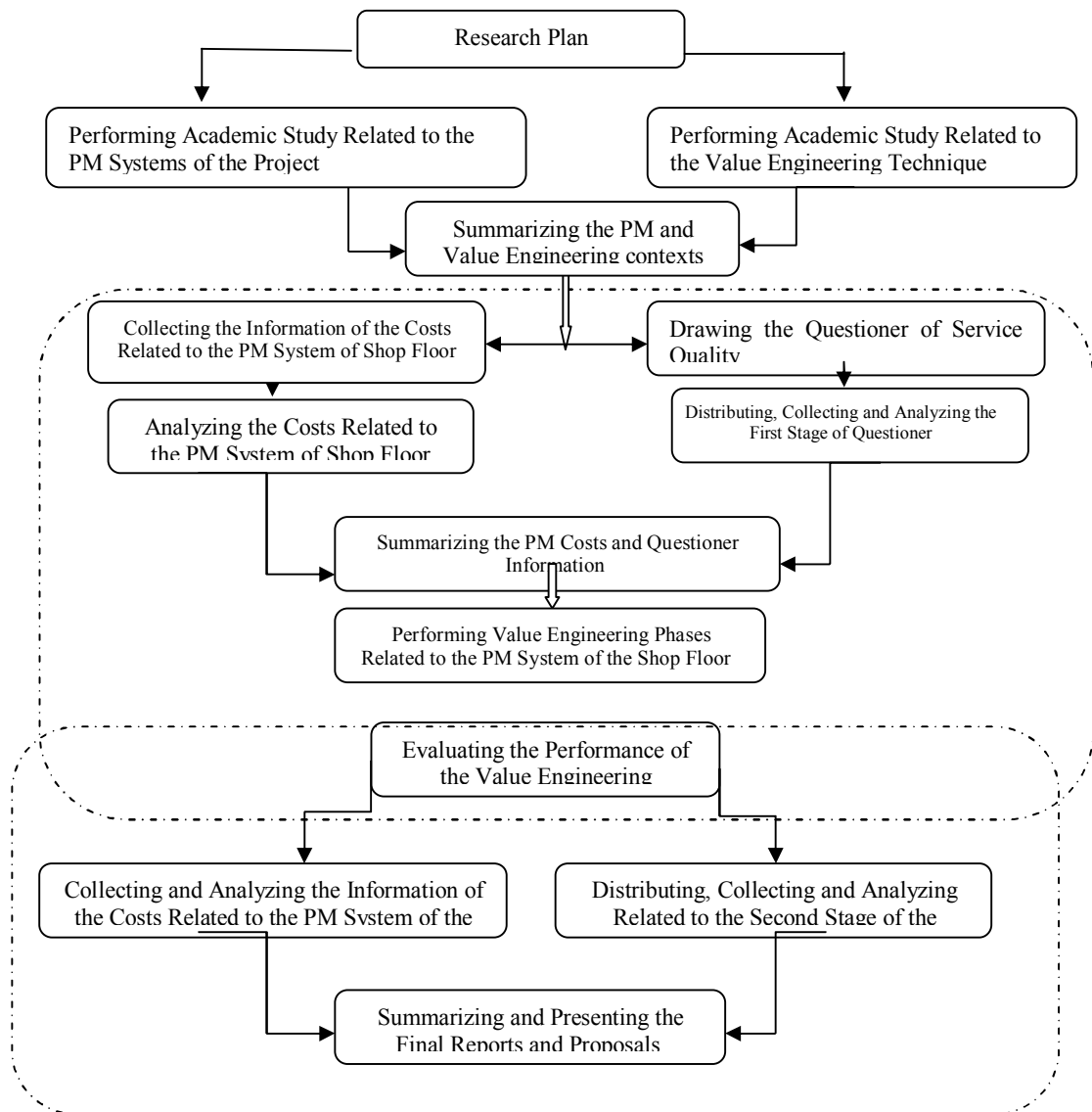   Sub-contractional cost [11].

Figure 1. Research Structure

2. 2. Service Quality   In the direction of specifying customer satisfaction, PM system of workshop prepared and planned a questionnaire (After and before of executing VE method). In the first phase of planning this questionnaire, important quality indexes of service performance must be identified.

In this relates, a large number of studies and researches were done. Some indexes such as processing time, up to date service exhibition, appropriate behaviour respect to the customers, availability, preciseness of service exhibition, amount of responsiveness and etc were identified.

Bearing in mind that the PM system is a service system inherently, 4P theory one of the modern, novel and comprehensive theories having nearrelationship with the considered cases in this research was chosen as the basis of arranging the questionnaire. Quality questionnaire of this research involving 25 questions was planned, codified and classified based on the four indexes of the service quality.

3. STATISTICAL COMMUNITY OF RESEARCH

The target community of this research considering executive system involves 500 persons. From this community, 150 persons were chosen. (Statistical community using randomness sampling method)

3. 1. Execution of VE Method   After specifying the headings of PM cost and drawing quality questionnaire, VE steps related to the PM system were executed. In this respect, the VE team was identified. Then, using performance analysis technique and holding brainstorming sessions, numerous ideas and plans were executed and verified based on the cost and quality indexes at last.

These plans and ideas are given below:

1. Improving fuel system of workshop and machines using FOWA system.
2. Planning and executing PM inclusive software and storage coding system.
3. Establishment of PM and CM systems in workshop.
4. Holding tutorial courses for PM Personnel and users of machines.
5. Preparing required equipment to facilitate machine operators' work(Ergonomic).
6. To update required equipment and machines of PM system.

7. Establishment of total planning and control system in PM unit of workshop

4. RESEARCH OUTCOMES:

4. 1. Analyzing the Costs of the PM System With respect to the categorization and calculation methods of costs of the PM system, these costs were computed before and after of execution of the VE method. The results are provided in Table 1.

With respect to the total calculated cost of the PM system, the appropriate effect of VE in improving the PM system and the most important of its index meaning cost decreasingcome out. As seen in this table, total costs of PM system have decreased 20.49% after executing VE technique.

It is worth mentioning that despite the other cost headings; using VE technique increases clerical cost partially.

The reason is the cost ofpurchasing software systems and some equipment and machineries required to perform some improving methods. According to the recorded numerical outcome, using VE incursup to 13.04%. rise in clerical and logistic costs

Capital purchasing performed through VE project suggestions (Involving purchasing of software and required necessities of PM system) and its cost are regarded asdepreciation in this issueand accounted after considering VE as well.

4. 2. Quality Analysis   To analyze results of the questionnaire, each answer is verified individually (25 questions) based on the four quality indexes (products, methods, processes, service presentation, manpower skills, etc.). These answers and questions were analyzed before and after performing VE project. The method considered is as follows: at first, the average score assigned to each question considering all of the respondents (150 persons) was calculated. Then, considering this categorization (0-20%=0-1, 20-40%=1-2, 40-60%=2-3, 60-80%=3-4, 80-100%=4-5) satisfaction rate of performing system related to theeach question was calculated.

In addition, the rate of customers' satisfaction was calculated for each quality index. As shown in Table 2, after performing VE, the rate of satisfaction related to the service quality provided by PM system of work shop has improved.

TABLE 1. Costs of PM system (before and after the execution of VE method)

Heading of Costs	Before VE execution (Rials)	After VE execution (Rials)	Amount of Decreasing (Rials)	Percent of Decreasing (%)
Costs of Manpower	1,131,000,000	1,100,550,000	30,450,000	2.77
Costs of materials and parts	28,919,994,048	25,449,550,762	3,470,393,286	13.64
Costs of breakdowns of machines	48,626,700,000	39,213,900,000	9,412,800,000	24.00
Costs of production and jobs lost	72,940,050,000	58,820,850,000	14,119,200,000	24.00
Costs of manpower idle times	8,752,806,000	7,764,352,200	988,453,800	12.73
Clerical costs	1,281,761,789	1,474,026,057	192,264,268	13.04
Subcontractional Costs	16,917,641,473	14,379,995,252	2,537,646,221	17.65
Total	178,569,903,310	148,203,224,272	30,336,679,038	20.49

Rials 32000 = US $ 1.0

TABLE 2. Results of performed analysis based on the questioner related to the service quality

Index	Question no.	Average of Degrees before VE Execution	Satisfaction Percent before VE Execution	Average of Index Degrees before VE Execution	Satisfaction Percent of Index before VE Execution	Average of Degrees after VE Execution	Satisfaction Percent after VE Execution	Average of Index Degrees after VE Execution	Satisfaction Percent of Index after VE Execution
Product	1	2.01	40.13			3.99	79.87		
	2	1.96	39.20			4.04	80.80		
	3	2.05	40.93	2.00	39.93	3.95	79.07	4.00	80.07
	4	1.99	39.87			4.01	80.13		
	5	1.93	38.67			4.07	81.33		
	6	2.04	40.80			3.96	79.20		
Procedures & Methods	7	2.05	40.93			3.95	79.07		
	8	1.99	39.73			4.01	80.27		
	9	1.91	38.13			4.09	81.87		
	10	2.07	41.47	2.01	40.21	3.93	78.53	3.99	79.79
	11	2.00	40.00			4.00	80.00		
	12	2.00	40.00			4.00	80.00		
	13	2.06	41.20			3.94	78.80		
Service Presentation	14	2.00	40.00			4.00	80.00		
	15	2.04	40.80			3.96	79.20		
	16	1.99	39.73			4.01	80.27		
	17	2.07	41.33	2.00	39.92	3.93	78.67	4.00	4.00
	18	1.93	38.53			4.07	81.47		
	19	2.03	40.67			3.97	79.33		
	20	1.96	38.40			4.08	81.60		
Manpower Skills	21	1.93	38.53			4.07	81.47		
	22	2.07	41.47			3.93	78.53		
	23	1.96	39.20	1.97	39.49	4.04	80.80	4.03	4.03
	24	1.97	39.33			4.03	80.67		
	25	1.95	38.93			4.05	81.07		

The results show that the main aim of this research meaning analyzing the improvement of PM system related to the civil projects using VE technique was met. The other results are as follows:

1. Decreasing the breakdown time of machines.

2. Satisfaction of execution system related to shop floor on service presentation.

3. Increasing the efficiency of PM manpower.

4. Extraordinary Decrease of Annual costs related to the PM system of workshop.

5. Finally, increasing the speed related to thecompletion of executive works in workshop to improve the machines and equipment availability in workshop.

Bearing in mind that in this research both value engineering technique and PM system were discussed. Thus, it is suggested that other researchers introduce an

executive model to perform VE for improving PM system in civil area by means of the results of this research, considering PM system models and VE techniques accurately.

5. REFRENCES

1. Jardine, A.K. and Tsang, A.H., "Maintenance, replacement, and reliability: Theory and applications, CRC press, (2013).

2. Martinez, V. and Bititci, U.S., "Aligning value propositions in supply chains", *International Journal of Value Chain Management*, Vol. 1, No. 1, (2006), 6-18.

3. Qudrat-Ullah, H. and Kane, V.L., "Value cycle model: Managing value through stakeholder management", *International Journal of Value Chain Management*, Vol. 4, No. 1, (2010), 153-169.

4. Behncke, F.G.H., Maisenbacher, S. and Maurer, M., "Extended model for integrated value engineering", *Procedia Computer Science*, Vol. 28, (2014), 781-788.

5. Zhong, S., Zhou, J. and Chen, Y., "Determination of target values of engineering characteristics in QFD using a fuzzy chance-constrained modelling approach", *Neurocomputing*, Vol. 142, (2014), 125-135.

6. Lester, A., ""Value management", Project Management, Planning And Control (sixth edition), chapter. 35, (2014).

7. Marzouk, M., "Electre III model for value engineering applications", *Automation in Construction*, Vol. 20, No. 5, (2011), 596-600.

8. Shu, H., Duanmu, L., Zhang, C. and Zhu, Y., "Study on the decision-making of district cooling and heating systems by means of value engineering", *Renewable Energy*, Vol. 35, No. 9, (2010), 1929-1939.

9. Houshmand, M. and Jamshidnezhad, B., "A lean manufacturing roadmap for an automotive body assembly line within axiomatic design framework", *International Journal of Engineering Transactions*, Vol. 17, No. 1, (2003), 51-72.

10. Yahyaei, M., Bashiri, M. and Garmeyi, Y., "Multicriteria logistic hub location by network segmentation under criteria weights uncertainty", *International Journal of Engineering*, Vol. 27, No. 8, (2014), 1205-1214.

11. Narayan, V., "Effective maintenance management: Risk and reliability strategies for optimizing performance author: Vee narayan, publish", (2004).

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چکیده

در این مقاله روش استفاده از مفاهیم مهندسی ارزش برای ارزیابی بهبود سیستمهای نگهداری و تعمیرات پروژه‌های عمرانی ارائه شده است. در این راستا، یکی از پروژه‌های بزرگ سدسازی کشور به عنوان مطالعه موردی مورد بررسی قرار گرفته است.تکنیک مهندسی ارزش برپایه شناسایی عملکردهای اصلی هر سیستم مورد بررسی، ارزیابی عملکردها و اقدام در جهت افزایش ارزش عملکردها که در نهایت منجر به ارتقاء ارزش سیستم مورد بررسی می‌گردد، قرار دارد.در مرحله ارزیابی سیستم نت (نگهداری و تعمیرات)، هزینه‌های سیستم و میزان رضایتمندی از کیفیت خدمات ارائه شده توسط سیستم نت کارگاه مورد بررسی قرار گرفت. سپس در فازهای شناخت و بررسی مهندسی ارزش عملکردهای اصلی سیستم نت شناسایی شد، پیشنهاداتی برای بهبود سیستم نت کارگاه ارائه گردید و پیشنهادات پذیرفته شده به ترتیب اولویت به اجراء گذاشته شد .پس از فاز اجرای مهندسی ارزش، سیستم مجدداً از نظر کاهش هزینه و حفظ و ارتقاء کیفیت ارائه خدمات مورد ارزیابی قرار گرفت و نتیجه ارزیابی نشان داد اجرای مهندسی ارزش باعث کاهش هزینه‌ها و ارتقاء کیفیت سیستم نت پروژه‌های عمرانی می‌شود.

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