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The Selection of Investment Projects in production line by an Integrated AHP-QFD approach: A Case study

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Abstract

Most of the organizations and manufacturing and industrial companies look for new technologies and new methods of marketing and sale. The determined strategic goals in these companies and organizations showed that today, based on correct planning and decision making and by innovative approach we should take a step into competitive and global markets. Today, the successful organizations are the ones that by true perception of technology and investment method, enter the competitive market. One of the most important challenges of managers in industry is identification and selection of investment projects, decision making in this regard is faced with some problems. The present study to achieve a correct decision making in order to fulfill the satisfaction of the company management applied uniformed model based on AHP-QFD. In this model, at first the indices of customer needs are weighted and prioritized by AHP method. In the next step, technical needs are extracted and central matrix of house of quality is formed based on QFD model. By scaling method 1 to 5, correlation of customer needs and technical needs are scored. Then, by AHP method, pair wise comparison of the alternatives is done for each technical need. The final stage of this study framework is calculation of the extracted result of AHP-QFD to score the alternatives and rank the alternatives based on their importance.

Keywords: Decision making, production line, technology, analytic hierarchy process, quality function deployment.

Introduction

In the current competitive and challenging world, the organizations should be prepared to accept any change in industrial and manufacturing activities. One of the important tools to be conformed to these changes is technology. As technology plays an important role in the success of commercial processes of all organizations namely manufacturing and industrial organizations, to achieve profitability and growth, the challenging question is decision making about selection and using the best type of technology and this is the main concern of the industries managers.

The present study aimed to select the investment projects in production line technology and the managers need more reliability coefficient and prevention of any risk to the investment. Based on the limitations and problems in the economic field of the country, most of the organizations and industrial-manufacturing companies are inclined to invest on new technologies. Based on the definitions, technology is a set of hardware and software that should be combined suitably with each other to make goods or services production possible. The technology components are including: Equipment, machineries and tools, Human skill and experience, Data, knowledge, techniques, methods and processes, Organization and management

The proposed model of the study is the investigation of the investment goals of a company working in equipment production of oil, gas and petrochemical industry to achieve its production goals, in order that competition is increased in market. To do this, to achieve the good condition consistent with the strategic goals of the company, non-economic models as decision making with multiple criteria and house of quality matrix were applied as decision making instrument to select the best alternative. The proposed methodology is using AHP-QFD combined model to solve non-economic problem. The mentioned method is used to select the two projects of investment (technological) in the required company to achieve great share of sale market in accordance with the required goals. At first, the required projects of the investors were evaluated from its qualitative aspect by combined model of Analytical Hierarchy Process (AHP) and QFD (Quality Function Deployment). AHP-QFD analysis is done on a set of technical-specialized needs and investor needs as production capacity, after sale services, energy saving, price and etc. The needs of investor and technical - specialized needs should be met via providing questionnaire and interview with the experts or involved technical and engineering groups in the organization. The results determine the required criteria of house of quality and relationship matrix between the technical indices and investor indices (customer). Then, by the results of matrices relationship and underlying math equations on ranking the indices and investigation of consistency rate of variables in each of the aspects, the technology with the highest score was selected and investment was started.

Although in various scientific researches, using AHP alone could make different decisions in manufacturing industries; no extensive study is conducted by the mentioned combined model as an instrument to select a special technology in manufacturing industries. Thus, the result of proposed model is a strong potential for decision making process in all investment projects of production line. The economic methods analysis alone can make the decision maker doubtful about final decisions. Thus, in the present study, selecting the product line technology for investment by the mentioned combined model was studied from two economic and non-economic aspects and it is expected that the required result is generalized to all projects of production line investment.

Review of Literature

QFD: In 1970s, qualify function deployment (QFD) was utilized in Japan but until 1980, no country like west didn't start it as a technique and since then, applied it as an instrument for decision making goals. QFD was successfully applied in most of the Japanese organizations to improve the processes and creating competitive advantage. Today, some companies apply QFD successfully and show it as a strong instrument in operational and strategic decisions in business. QFD provides a concept of translating the customers need to suitable technical needs for each stage of development and product production (e.g. market strategies, planning, design and product engineering, evaluation of a sample of product, product process development, sale production)[1]. Today, there are some firms in the world applying QFD technology by assuming the production of the products with marketing capability in accordance with the taste of the customers and are made for production specialized teams[2].

Some researchers as Sullivan[1], Hauser and Clausing[3], Zairi and and Youssef[4] discussed about QFD benefits. These advantages are summarized as followings as they were referred by the researchers in the literature[5]. QFD can do the followings: Help to balance customer requirements and what the company is capable to do for production. Work group is improved among the engineers in various sectors. Customer satisfaction is increased (This is done by using the customers' needs in assumptions and using them in product development). Time is reduced for market. It is caused that the employees provide adequate documents as they perceive the importance of information. Effective communication between various parts of the company is improved.

QFD applications: The main applications of QFD were in shipyard and Electronic industries[6]. Although QFD applications originally refer to some industries as Automobile, electronic and software, it was applied rapidly in other industries as government, banks, medical systems, education and research. Now, it covers all the industries in the world. QFD is continued to be a general instrument and it is called as "one of the useful methods in total quality management"[4].

QFD is a structured method to search the customers and perceiving their needs and guarantees meeting their demands. QFD is the most important developed management instrument to guarantee quality in products, improved or new services. Griffin and Hauser[2] believed that there are more than 100 main companies applying QFD in USA. To find the companies intended to use QFD technique in their decision making process, we should refer to annual symposium issues of America regarding QFD. QFD is applied in various grounds to determine the customer needs, developing the priorities, formula making of annual policies, strategies and marketing[7] and environmental decision making.

QFD, AHP: Saaty[8] presented a new technique called Analytic Hierarchy Process (AHP) that is applied highly in various fields of decision making and multiple criteria decision making in the past 20 years. AHP is based on pair wise comparison judgment. Based on hierarchy, the comparison judgments can be applied in pair wise comparisons to determine the relative importance of alternatives. Thus, the judgment is done based on the best existing information by assuming the inputs of decision makers, their knowledge and attitude about the issue and their experiences.

Partovi[9] applied the combined AHP–QFD approach to aid the project selection. Then, some methods were proposed by Wang et al.[10]. Partovi[9] used the AHP to quantify the strength of the relationships between customer requirements and design specifications. Using QFD as concepts of customer voice transfer in design and product presented a new comprehensive hierarchy framework for QFD planning process and zero-one goal programming was presented to select customer requirements by Han et al[11].

Decision making model helps to determine a set of design needs being faced effectively with the customer needs to limited resources and other organizational limitations. Köksal and Eğitman[12] applied the combined AHP–QFD approach to improve the education quality of industry engineering sector of Middle East technical university. AHP was used for relative importance of weightings of beneficiaries' requirements. Alternatives were education design requirements and were prioritized based on AHP weights to the relationship between educational requirements and beneficiaries' requirements. Finally, the educational requirements were targeted by high scores. Chuang[13] applied the combined AHP–QFD approach to deal with the facility location problem. Bhattacharya et al.[14] used the combined AHP–QFD approach to aid the selection of Robot. At first, in QFD matrix, customer requirements (e.g. economical goods for transportation and life expectancy) and technical needs (driving system and robot weight) were determined. Then, to obtain the importance of technical need weights, two inputs were required including the relationship between customer needs and technical needs and relative importance of customer weights being extracted from AHP method. Then, AHP method was used again to evaluate the relative importance of the weights of each Robot based on technical needs. Finally, the Robot with the highest score was selected. Hanumaiah et al.[15] presented the combined AHP–QFD approach to deal with the rapid tooling process selection. The AHP was adopted to determine the relative importance weightings of the tooling or customer requirements while considering constraints, such as material, geometric features, die material, and production quantity. Das et al.[16] developed an AHP-QFD framework for designing a tourism product, which takes care of the touristic needs of tourists.

Chen et al.[17] in their study presented a key model for knowledge management system by AHP-QFD combined model for semi-conductor industry in Taiwan. Lin et al.[18] evaluated the relative overall importance of customer requirements and design characteristics by AHP-QFD combined method. De Felice and Petrillo[19] presented a new methodological method to define the customer needs among the employees by AHP-QFD model. The model was based on QFD and applied AHP method to determine and rank the relative importance of the judgment weights defined for customer needs and operational features.

Anirban Ganguly[20] applied combined method to select a technology in pharmacology industry. He selected two technologies in pharmacology industry and by economic and non-economic methods of AHP-QFD and risk management, selected the required technology. Bakhshi et al.[21] in their study presented a uniform fuzzy AHP-QFD model to select software project.

Proposed Methodology

As it was said, the present study aimed to develop a decision making method based on uniform model of AHP-QFD. figure-1 shows selection process in decision making. The benefits of the proposed methods are as: Customer needs and technical needs are considered in a uniform model. People judgment is used to achieve final decision to select capital project.

AHP-QFD problem solving is done on a set of customer needs and technical needs provided based on the results of questionnaires and various meetings were held with the experts. Then, the analysis of effect of the results of problem solving is done by proposed approach to select investment (technology) projects. Finally, the analysis of the results of the selection of the best investment projects (technology) is done and the best decision making alternative is selected.

Results and Discussion

Case study: As it was said, this study was focused on a decision making process regarding investment to select the production line technology in a production company. The studied company is one of the branches of Eagle Burgmann in Germany producing fluid mechanical systems in the world. The mentioned company as Burgmann pars company designer and producer of pumps and compressors seal systems in Iran was founded based on purchasing technical knowledge from Burgmann Company in Germany in 2002. This company started its specialized activity by localizing design and fluid mechanical production of pumps and compressors in oil and gas and petrochemical projects by emphasis on localized technical knowledge and its personnel specialization and based on the need of import of this important part in oil and gas and petrochemical industry could fulfill a part of design and production capacity and attempted to completely transfer technical and localized knowledge of production. This company by 100 human resources, a production factory, two maintenance centers and three sale agencies did their activities. One of the visions of the company is achieving first rank in pump making and oil, gas and petrochemical engineering in Iran to design and produce the projects of seal systems of pumps and compressors and based on the design capability and fluid mechanical production in Iran, considered achieving the budget 400 billion Rial by 2020 in its plan.

Based on the products of the company and the number of competitors, there is high competition between the exiting competitors now. Thus, to remain in competition market to achieve the company vision, purchasing technical knowledge from parent company and taking specialized courses of design, maintenance, engineering and sale, should have update technical and technological capability. The customers are inclined to reduce the price and increase their demands for the products, thus, the condition should be prepared that by low costs and risk and high technology, and they can provide suitable and high quality products with good price to stay in the competition market. After the investigation of the condition of existing technologies and systems in the factory, some items as high delivery time, low production capability, unsuitable financial flow, material wastage, high energy consumption and reworking are observed. Thus, investment to buy milling and lathe machines was on the priority for the company. After investigation of the strengths, weaknesses, opportunities and threats and company strategies, decision making on selecting the investment project was defined and by the proposed model that was presented in the third chapter, at first the required data were collected and problem solution was done based on proposed algorithm to take suitable decision making as:

Appling the proposed methodology: As it was said, the main purpose of the study is selecting the investment project in production line. Thus, the goal is reducing delivery time, creating high production capability, creating suitable financial flow, reduction of material wastage, reduction of high energy consumption and eliminating the re-working. To fulfill these goals, the company purchased milling and lathe machines in industry and two various CNC machines as three-axis and five-axis were selected. The main purpose of the study was selecting and decision making about one of the systems and investment to purchase it. If we call 2 three-axis CNC machines technology A and 4 five-axis CNC machines astechnology B in production line of Burgmann pars company, the main purpose of the study is selecting A or B technology in production line of Burgmann pars company.

The alternatives of decision making problem in this project are two types of various A,B technologies in production line and technology A includes 2 three-axis CNC machines and technology B includes 4 five-axis CNC machines.

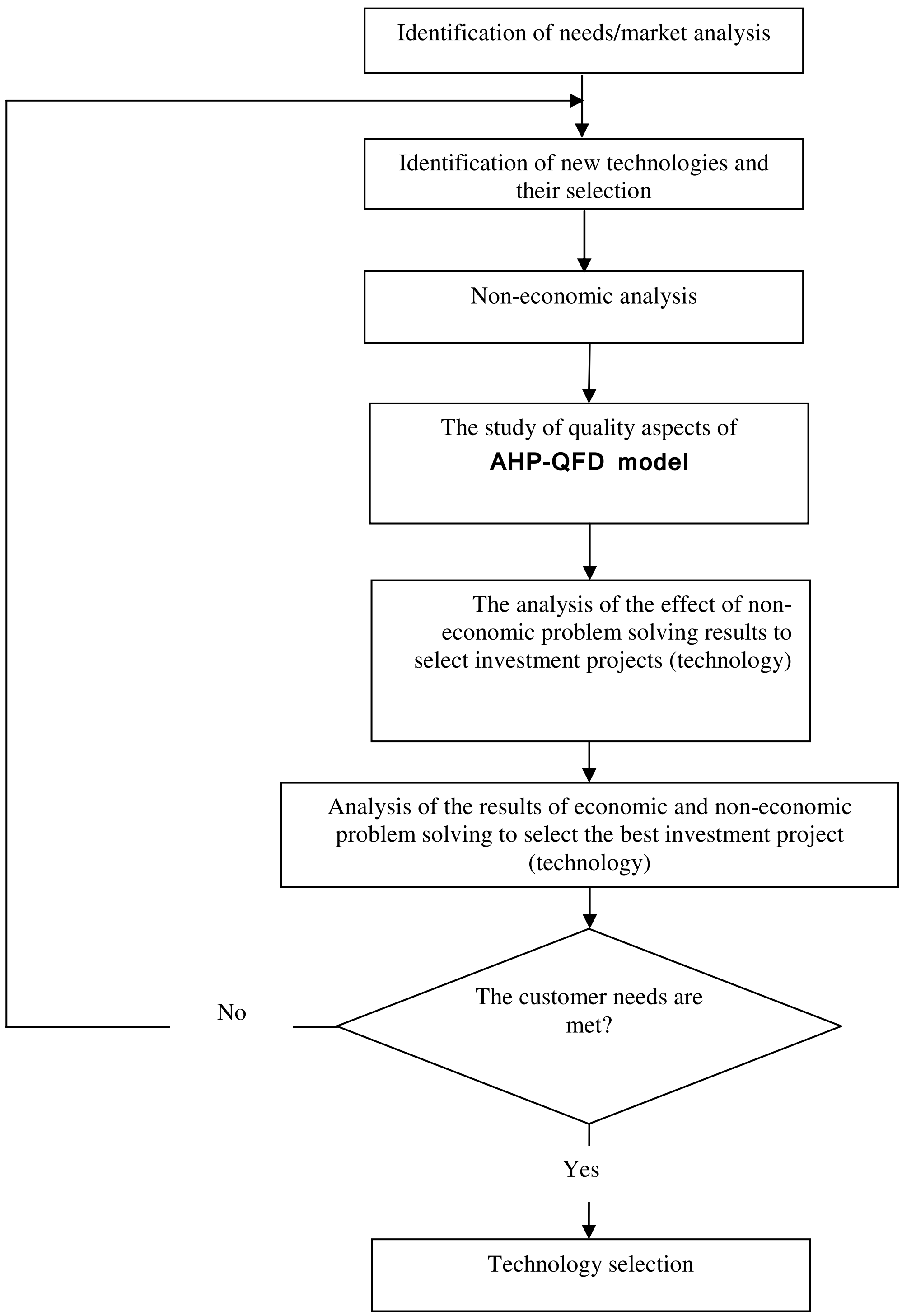

Figure-1
The proposed methodology

Customer requirements were determined via questionnaire and interview, observation and data analysis. At first, 12 indices as customer requirements were determined. Then, 6 questionnaires were given to the experts of company and the required indices were prioritized and if they had any new recommendation about the indices, they can present their comments. After receiving the experts' comments and prioritization of indices, 5 final indices were selected as: Energy consumption, Proper Product Price, after sale services, Product accuracy, Production capacity.

Figure-2 shows hierarchy structure of the customers' requirements.

The technical indices are determined with the aim of fulfilling the customer requirements via questionnaire, interview, observation and survey of the experts. To do this, the indices should be measured and have direct relation with the customer requirements.

Thus, at first the raw expectations of the customer are turned into benefits, and then its features are determined based on benefits. This analysis helps us to translate customer voice to engineers' voice. Thus, the indices were determined for the customer need and 18 indices were selected in accordance with the questionnaire. Then, the relations of production processes and its effects on technical indices were investigated. By distributing the questionnaire among 6 company experts and by investigating the comments, among 18 technical indices of the machines, finally 6 technical indices with the highest score in the results of survey were extracted as followings:

Power of Engine Spindle, Rate of Spindle Speed, Accuracy of Axes Movement, Diameter of Lathing table, Smooth Surface, Number of Tart Tools.

To prioritize the customer needs and technical indices, AHP and Expert Choice software were applied. Table-1 and 2 show the pair wise comparison matrices used in AHP method.

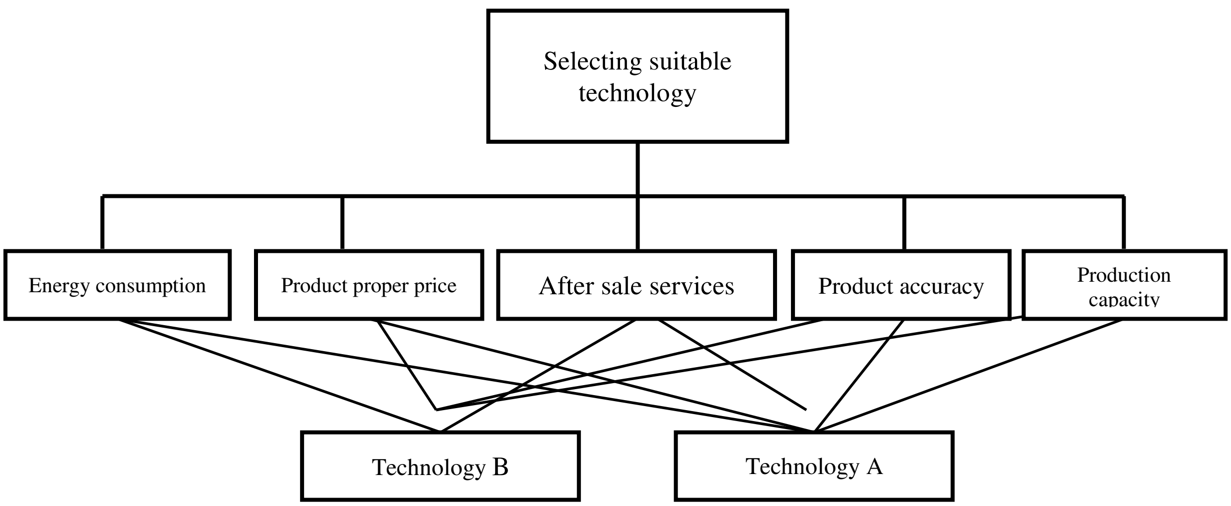

Figure-2
The hierachical structure of customer needs

Table-1
Pair wise comparison of customer requirements indices

Index	**Energy consumption**	**Product proper price**	**After sale services**	**Product accuracy**	**Production capacity**
Energy consumption	1	3	3	1/5	**1/4**
Product proper price	-	1	1/3	1/8	**1/5**
After sale services	-	-	1	1/7	**1/6**
Product accuracy	-	-	-	1	**3**
Production capacity	-	-	-	-	**1**

Table-2
Prioritization of customer requirements based on extracted weights

Customer requirements index	Extracted weights	Score
Energy consumption	0.112	3
Product proper price	0.041	5
After sale services	0.064	4
Product accuracy	0.503	1
Production capacity	0.279	2
Total	1	**-**

After determining the importance of the customer indices weights and formation of central house of quality matrix, the correlation between technical indices of customer indices is extracted based on scoring scale 1 to 5 after receiving the comments of experts based on questionnaire in accordance with Table-4 and technical indices weight is calculated by the following formula:

$$W_j = \sum_{i=1}^{n} X_{ij} * Y_i$$

Where: W_j=Relative importance of jth technical need, X_{ij}=Correlation between the ith customer need and jth technical need, Y_i=Prioritized weights of customer requirements, Then, importance degree rank of technical needs obtained by the above equation is normalized.

The next stage in study problem solving is prioritization of two alternatives, technology A and technology B. Based on the tables provided of technical requirements of the questionnaire and receiving the experts comments, a pair wise comparison was done between the technical indices. To achieve this issue, six pair wise comparison matrices as tables-4 to 9 were considered and after receiving the comments and entering the information of the tables in Expert Choice, the results were achieved.

Table-3
QFD matrix to extract relative importance of technical needs

Technical requirments / Customer requirments	Power of Engine Spindle	Rate of Spindle Speed	Number of Tart Tools	Accuracy of Axes Movement	Smooth Surface	Diameter of Lathing Table	Prioritized weights of customer requirements
Energy consumption	4	3	1	4	4	3	0.112
Product proper price	5	4	3	3	4	5	0.041
After sale services	4	3	4	4	1	3	0.064
Product accuracy	5	5	1	5	2	4	0.503
Production capacity	4	3	1	1	1	4	0.279
W_i (Importance rank of technical indices	4.54	4.044	1.273	3.621	1.961	3.861	-
W_i (Normalized) K_j	0.235	0.21	0.066	0.188	0.102	0.2	-

Table-4
Pair wise comparison of technologies to power of engine spindle

Alternatives	Technology A	Technology B	Normalized weight value
Technology A	1	1/7	0.125
Technology B	7	1	0.875
Total	8	1.142	1

Table-5
Pair wise comparison of technologies to rate of spindle speed

Alternatives	Technology A	Technology B	Normalized weight value
Technology A	1	1/6	0.143
Technology B	6	1	0.857
Total	7	1.167	1

Table-6
Pair wise comparison of technologies to Diameter of Lathing Table

Alternatives	Technology A	Technology B	Normalized weight value
Technology A	1	1/7	0.125
Technology B	7	1	0.875
Total	8	1.142	1

Table-7
Pair wise comparison of technologies to Accuracy of Axes Movement

Alternatives	Technology A	Technology B	Normalized weight value
Technology A	1	1/5	0.167
Technology B	5	1	0.833
Total	6	1.2	1

Table-8
Pair wise comparison of technologies to Smooth Surface

Alternatives	Technology A	Technology B	Normalized weight value
Technology A	1	1/3	0.25
Technology B	3	1	0.75
Total	4	1.333	1

Table-9
Pair wise comparison of technologies to Number of Tart Tools

Alternatives	Technology A	Technology B	Normalized weight value
Technology A	1	1/5	0.167
Technology B	5	1	0.833
Total	6	1.2	1

The final stage of the proposed methodology is including the calculation of the final value of AHP-QFD model and their prioritization based on importance. The final value is extracted as the following formula:

$$A_j = \sum_{j=1}^{n} k_j * b_{ij}$$

Where: A_j=Total score of alternatives, k_j=Normalized weights of technical requirements, b_{ij}=The value of jth alternative to ith technical need.

Thus, technology with the highest final value is selected as the most preferred alternative based on uniform model of AHP-QFD, after selecting the final value of the alternatives based on the above formula, the final result is presented based on table-10.

Table-10
The calculaiton of final value of the alternatives

Technical requirements	Prioritized weights of technical requirements	Extracted weights of alternatives to technical indices	
		Technology A	Technology B
Power of Engine Spindle	0.235	0.125	0.875
Rate of Spindle Speed	0.21	0.143	0.857
Diameter of Lathing Table	0.2	0.125	0.875
Accuracy of Axes Movement	0.188	0.167	0.833
Smooth Surface	0.102	0.25	0.75
Number of Tart Tools	0.066	0.167	0.833
Final score	1	0.152	0.848

Table-10 shows the final value of Technologies A,B. At is seen, final score of technology B is considerably more than final score of Technology A. Thus, by uniform model of AHP-QFD, it can be said that tecnology B is considered as the best decsion making alternative for the company decsion makers.

Conclusion

During the various years, correct selection of investment projects is a challenging result for the roganizations. There were always some examples that due to an untrue selection led into the organization bankruptcy. The presented model in the study can solve this problem. This study investigated the process of selecting an investment project by developing a decsion making model. In addition, two decsion making methods as QFD and AHP were integrated for final decsion of the model. This model can be applied by decsion makers of an organization to compare the projects, processes and tecnologies to select the best alternative amogn them. Also, it helps the decsion makers to have a correct evaluation of new and existing tecnologies as a part of their selection process. Using the proposed model of the study created strong planning capabiity in facing with the great problems and complexities in selecting the investment projects and its solution is also facilitated.

The case study in this research is focused on two competative tecnologies in production line process of an industrial company. Thus, the top managers of all industrial production organizations can apply the proposed model to evaluate and select their development process. Regarding the manufacturing companies in oil and gas industry, their main focus is on various non-economic factors. This method can be considered as an applied instrument for managers of manufacturing companies in oil and gas industries. Although the extracted indices in the study are presented in accordance with the studied organization, other similar companies can extract these indices or improved indices in accordance with their needs and characteristics.

References

1. Sullivan L.P., Quality Function Deployment, *Quality Progress,* **19(6),** 39-50 **(1986)**
2. Griffin A. and Hauser J.R., Patterns of Communications Among Marketing, Engineering and Manufacturing : A comparison between two new product teams, *Management Science,* **38(3),** 360-73 **(1992)**
3. Hauser J.R. and Clausing D., The House of Quality, *Harvard Business Review,* **66**, 63-73 **(1998)**
4. Zairi M. and Youssef M.A., Quality Function Deployment: A Main Pillar for Successful Total Quality Management and Product Development, *International Journal of Quality and Reliability Management,* **12(6),** 9-23 **(1995)**
5. Zare Mehrjerdi Y, Quality Function Deployment and its Extensions, *International Journal of Quality and Reliability Management,* **27(6),** 616-640 **(2010)**
6. Akao Y., New product development and quality assurance: Quality deployment system, *Standardization and Quality Control*, **25(4),** 7-14 **(1972)**
7. Kochhar A.K. and Eguia F.J., A Quality Function Deployment Approach to Perfomance Measurement and Benchmarking in Manufacturing control Systems, in Morel, G., and Vernadat, F.B. (Eds), Information Control in Manufacturing (INCOM_98): Advances in Industrial Engineering: Proceedings of the 9th IFAC Symposium, June 24-26, Nancy-Metz, 2, Elsevier, Kidlington, 815-20 **(1998)**

8. Saaty T., The Analytic Hierarchy Process, McGraw-Hill, New York, NY, **(1980)**

9. Partovi F.Y., A Quality Function Deployment Approach to Strategic Capital Budgeting, *The Engineering Economist,* **44(3),** 239-260 **(1999)**

10. Wang J. Fuzzy, Outranking Approach to Prioritiza Design Requirement in Quality Function Deployment, *International Journal of Production Research,* **37(4),** 899-916 **(1999)**

11. Han S.B., Chen S.K., Ebrahimpour M., and Sodhi M.S.A., Conceptual QFD planning model, *International Journal of Quality and Reliability Management*, **18(8),** 796-812 **(2001)**

12. Koksal G. and Egitman A., Planning and Design of Industrial Engineering Education Quality, *Computers and Industrial Engineering,* **35(3-4)**, 639-642 **(1998)**

13. Chuang P.T., Combining the Analytic Hierarchy Process and Quality Function Deployment for a Location Decision from a Requirement Perspective, *International Journal of Advanced Manufacturing Technology,* **18(11),** 842-849 **(2001)**

14. Bhattacharya A., Sarkar B. and Mukherjee S.K., Integrating AHP with QFD for Robot Selection Under Requirement Perspective, *International Journal of Production Research,* **43(17**), 3671-3685 **(2005)**

15. Hanumaiah N., Ravi B. and Mukherjee N.P., Rapid Hard Tooling Process Selection Using QFD-AHP Methodology, *Journal of Manufacturing Technology Management*, **17(3),** 332-350 **(2006)**

16. Das D. and Mukherjee K., Development of an AHP-QFD Framework for Designing a Tourism Product, *International Journal of Services and Operations Management,* **4(3),** 321-344 **(2007)**

17. Chen S.C., Yang C.C. and Lin W.T., Construction of key model for knowledge management system using AHP-QFD for semiconductor industry in Taiwan, *Journal of Manufacturing Technology Management,* **18(5),** 576-598 **(2007)**

18. Lin M.C., Wang C.C., Chen M.S. and Chang A.C., Using AHP and TOPSIS Approches in Customer-Driven Product Design Process, *Computer in Industry,* **59(1),** 17-31 (**2008)**

19. De Felice F. and Petrillo A., A Multiple Choice Decision Analysis : An Integrated QFD-AHP Model for the Assessment of Customer Needs, *International Journal of Engineering, Science and Technology,* **2(9),** 25-38 **(2010)**

20. Anirban G, A Decision Making Model for the Selection of Capital Projects". Castle Point on Hudson, PHD Dissertation, Faculty of the Stevens Institute of Technology, Hudson, **(2009)**

21. Bakhshi T., Sarkar B. and Kumar Sanyal S., A Novel Integrated AHP-QFD Model for Software Project Selection Under Fuzziness, *International Journal of Computer Application,* **54(7**), 36-43 **(2012)**