International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

December 2022 | Issue 53 | Volume 14 | Number 4 | Pages 247-252

DEVELOPMENT OF PRODUCTS AND CONSTRUCTION IN VALUE ENGINEERING

M. Abdulkareem S. Naimi

Department of Civil Engineering, Altinbas University, Istanbul, Turkey
203724169@ogr.altinbas.edu.tr, sepanta.naimi@altinbas.edu.tr

Abstract- Record levels of competition have been reached in a number of industries, most notably the automotive sector, as a direct result of rising levels of product globalization. As a consequence of this, businesses are consistently looking for innovative approaches to acquire a competitive advantage over their rivals. Producing goods that consumers place a high value on is critical to the continued success of any company over the long run. By gaining an understanding of the myriad of factors that contribute to these costs, one can cut a variety of non-value-added charges. When it comes to increasing the value of a product, it is necessary to utilize function analysis strategies in an effective manner. Value engineering is a method that is structured, function-based, and does not compromise the quality or reliability of the product in any way. Its primary goal is to locate and eradicate unnecessary expenditures. The implementation of this method fosters creative thinking, new innovations, entrepreneurial endeavors, and long-term financial success. When it comes to the development of new products, businesses operating in a wide range of sectors stand to gain significant competitive advantages by making early use of this strategic instrument.

Keywords: Value Engineering, FAST, Job Plan, Value Analysis, Construction.

1. INTRODUCTION

An ever-increasing trend toward globalization is fueling fierce competition in numerous product development domains, such as the automotive industry [1]. As trade barriers and transaction costs come down, more and more companies are joining the market, making it more difficult to gain a competitive advantage. An organization has limited options in today's challenging environment. To deal with the increasing global competitive pressure, corporations might seek trade and regulatory protection, acquire capabilities that will help them compete, or abandon the market, segment, or industry." Value Engineering [2] is a powerful tool that can be utilized in product development and design to help a company compete. Long-term success in any industry hinges on providing customers with high-quality products (or services) that are also cost-effective. We'll look at the history, benefits, and steps of Value Engineering, as well as some real-world examples. The Function Analysis System Technique (FAST) and the sources of needless product expense will be examined [3][4].

2. A SHORT LEGACY

The fundamental ideas and guiding principles of value engineering are not novel in any way. It is possible to trace the organized method all the way back to the Second World War. As a result of a lack of available materials, General Electric Company was driven to locate cheaper alternatives to essential commodities in order to maintain profitability. Lawrence D. Miles, a staff engineer at General Electric, is credited with developing the first value analysis methodology in the year 1947. In 1954, the United States Navy Bureau of Ships came up with the concept of value engineering as a way to reduce wasteful expenditures during the design phase of a project. The globalized social order Nearly half a century has been devoted by SAVE International to the development and dissemination of the value methodology [5]. Annual conferences on value engineering are held by SAVE all over the world in 35 different nations, including the commercial sector. These conferences are meant to foster the growth of value engineering. There is a wide variety of fields of study available, including but not limited to the following: construction, transportation, healthcare, manufacturing, environmental, and government. There are a number of potential origins for a product's or process's incurring excessive costs. Every company, location, and set of circumstances is one of a kind. It is crucial to have a solid understanding of these sources in order to make the most of the value engineering process [6].

2.1. Unnecessary Expenditures Can be Caused by any of the Following

A. The absence of a concept
B. Not having enough information to make informed decisions
C. Thinking the same way every day (mental impediments, innate aversion to change)
D. The truth about common misunderstandings
E. The presence of unfavorable viewpoints

F. There is a lack of time
G. Changes in technology (uninformed of the present status of technology or current capabilities)
H. Out-of-date specs
I. Human relations are in disarray (Faulty communication is also included)
J. Failure to grasp the true meaning of "excellent value"

2.2. In the Value Engineering Process, Another Group of Cost Drivers is the Seven Types of Waste

A. Excessive quantity and/or pace of manufacturing.
B. Inspection and repair are required.
C. There is no new value in the movement of material or information
D. Processing is a waste of time and effort.
E. Oversupply is a term used to describe the surplus of anything.
F. When a human or a machine is left to wait.
G. Human or machine movement that does not offer any value to the process.

3. VALUE ENGINEERING

Using a systematic, function-based approach, Value Engineering seeks out and eliminates wasteful expenditures. It's a multidisciplinary approach to systematic problem solving. As a proven management tool, value engineering has no design limitations. FAST [7], for example, is a function-based analysis method that can be used to improve designs or processes. In addition, it can be utilized to reduce the total cost of ownership. The following are a few areas that can be improved using Value Engineering, whereas farther down, qualities that are not reflective of Value Engineering are outlined.

3.1. Value Engineering is:

a) Reliability
b) Maintainability
c) Manufacturability
d) The importance of human considerations
e) Availability of the necessary components
f) Cycle Counts
g) Qualities
h) Loss of weight
i) Logistic
j) Performances
k) Packaged

3.2. What Value Engineering does not Include:

a) A Cost-Cutting or Cost-Reduction Method
b) A Review of the Design
c) Cost vs. Performance Tradeoff
d) It's Only Useful for Design Engineering
e) Only Used During the Conceptual Design Phase
f) Administrative tasks necessitate a different approach
g) Always a Part of Every Design

4. GOAL OF VALUE ENGINEERING

It is the goal of Value Engineering to discover and remove excessive expenditures without sacrificing the quality and reliability of the design [8]. Companies today are constantly seeking for strategies to boost profitability and develop a long-term business model in an increasingly competitive global marketplace. As an added benefit, Value Engineering promotes the development of new ideas as well as the use of cutting-edge technologies. The optimal moment to use Value Engineering principles is at the beginning of a project or program [9].

When an idea or a modification can be adopted earlier, less money is spent on it, hence avoidable costs are reduced (or value is maximized). Retesting, documentation revisions, and tooling modifications can all be avoided if Value Engineering is used in the Concept Design or Preliminary Design Phases as indicated in Figure 1. "Opportunity Curve" [10] depicts another example of this notion in the following figure. A program's potential for savings or improvements is greatest at the beginning of its implementation but diminishes considerably as it progresses. The "Top Down" approach to Value Engineering is used during the Concept Phase [11], whereas the "Bottom Up" approach is used during the Design Refinement Phase [12].

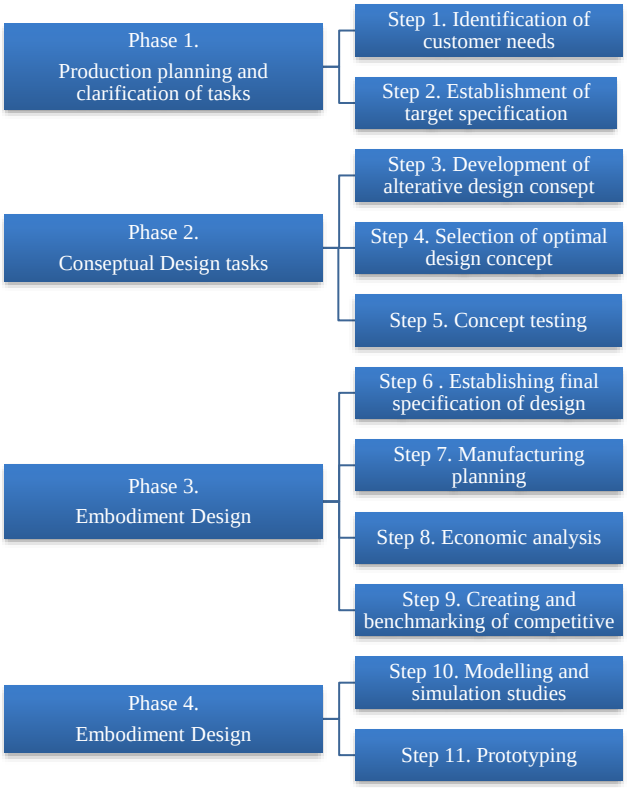

Figure 1. Phase of concept design [11]

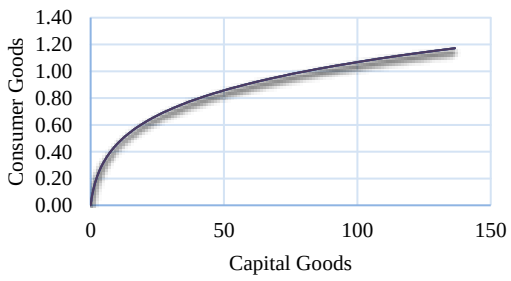

Figure 1. Opportunity curve [11]

5. JOB PLAN PROCESS

The 'Job Plan' that is utilized in Value Engineering is a strategy that is methodical and step-by-step in nature [13]. During his time at General Electric, Lawrence D. Miles developed the first version of the Job Plan, which consisted of the following six steps: gathering information, analyzing functions, speculating and coming up with ideas, developing the idea, and finally presenting it. Lawrence D. Miles is credited with the invention of the Job Plan [13]. It's possible that there are a lot of different takes on this subject depending on the industry or the application. Before beginning work on the Job Plan, it is important to make sure that team members have been thoughtfully chosen to represent a diverse variety of experiences. If everyone in the team participates in the process, and the team strives to be diverse, then the team will be able to produce the highest quality responses possible. This method of leadership encourages optimistic thinking as well as a sense of personal ownership and buy-in from followers [14]. Figure 3 provides a visual representation of one possible organizational structure for a Value Engineering team. For the purpose of this study, a comprehensive "Job Plan" for value engineering that consists of eight steps is detailed [15].

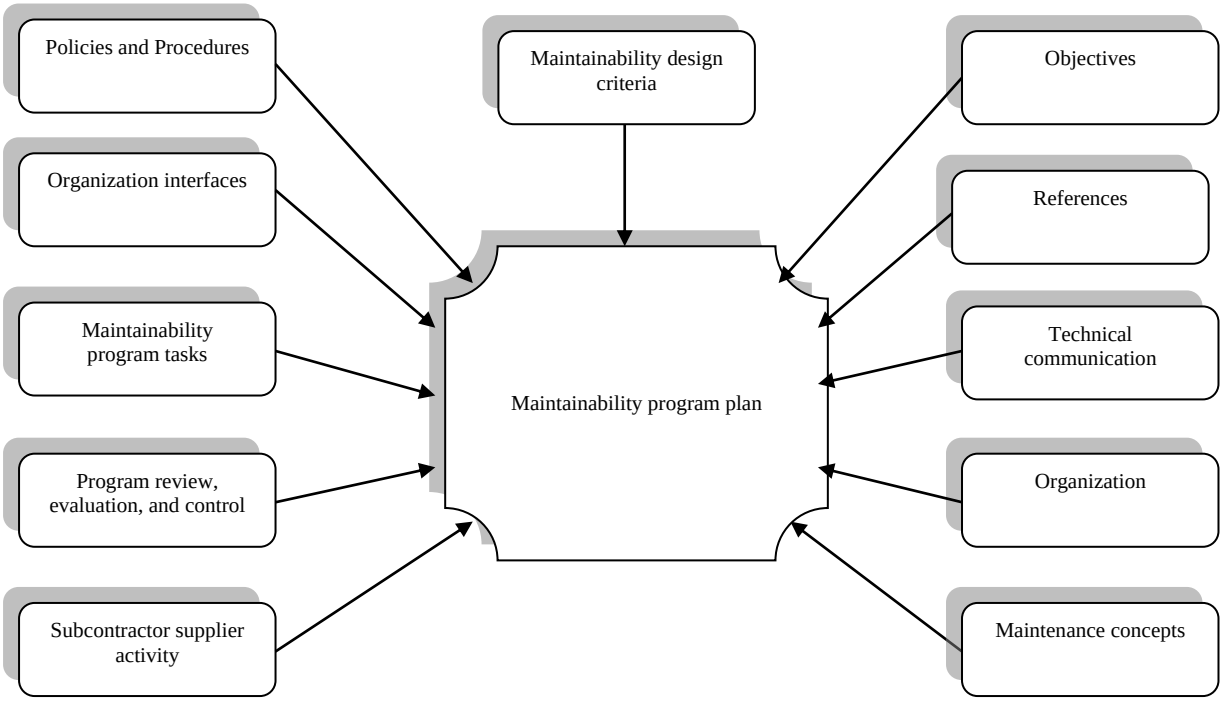

Figure 3. The phase of conceptual design [15]

A. The first thing that needs to be done by management is to decide if Value Engineering will be applied to a product, a process, or a project. The projects that are selected are often those that are the costliest or those that are "just not worth the money necessary to achieve." It's possible that there are others that are challenging or low on the priority list, but they don't fit within the budgetary constraints [16].

B. There are a lot of questions that are asked, and answers to those questions are given. & How does it work? Have you any idea? in order to achieve what purpose? What would a reasonable price be for it? Where can I find out how much it costs? The function, the cost areas, and the links between cost and value are all identified. It is helpful for teams to prioritize their analysis by referring to Pareto's Principle, which argues that 20% of something contributes to 80% of its worth [17].

C. Participating in think-tank sessions is a productive way to come up with prospective alternatives to the approach that is currently being taken. As a consequence of this, the group generates a large number of potential answers in the form of two-word phrases that combine a noun and a verb.

D. When ranking the possibilities generated by the Speculation stage, selection mechanisms such as weighted decision matrices are utilized. There are positives and negatives associated with every option. In the end, the option that strikes optimal balance between quality, cost, and delivery time will be selected [18].

E. In order to provide the best alternative, we employ sketches, schematics, specifications, cost estimates, and confirmation of test findings. It is decided upon how to carry out the plan in minute detail.

F. The participants in the decision-making process are provided with a presentation of the solution [19].

G. It will not be possible to fully appreciate the worth of the initiative until it has been put into action.

H. Audits involve carrying out an assessment of the true worth of the activity being checked.

During the course of the inquiry phase, it is essential to pose a great number of very detailed questions in order to acquire a comprehensive understanding of the function [20]. The following list of questions is a useful resource for gathering information throughout the early stages of the Value Engineering process, as it consists of:

A. It is feasible to get rid of it without having any effect on the functionality or dependability of the system.
B. Is the price too high in relation to what it has to offer?
C. Does it go beyond what is expected of a reasonable person?
D. Is there anything in here that serves no use at all?
E. Is there a more efficient approach to doing the task?
F. If it were practicable, a method of production that used fewer resources would be utilized.
G. Are there any restrictions on what kinds of objects, whether they be common or specialized ones, can be put to use?
H. Is it conceivable to switch to a production process that requires fewer resources?
I. What kind of instruments are going to be utilized?
J. Is the price higher than what would be considered a reasonable sum for labor, overhead, material, and profit?
K. How can I acquire it at a lower price without compromising the level of quality?
L. Exists a market for this feature that is willing to pay less for it?
M. Is the price of the item anything that influences your decision about whether or not to buy it?

6. METHODOLOGY OF THE FAST PROGRAM

Analysis of functions is at the heart of the Value Engineering process. The Functional Analysis System Technique, more commonly known as FAST, Figure 4 [21], is a method that fosters creative thinking and problem-solving by centering analysis on functions. It helps interdisciplinary teams communicate more effectively while also providing a visual representation of the functions those teams do and the links between them.

Based on the questions "How" and "Why," one might create a visual representation of how the various functions of a project, product, process, or service are interconnected. Using the Function Analysis System Technique, you can think about a problem objectively and clearly establish the scope of your project.

Participants are able to recognize all of the needed functions thanks to the arrangement of the functions into a FAST diagram. It is possible to utilize the FAST diagram to determine whether and to show how a suggested solution meets the project's needs, as well as to identify unneeded or duplicate functions [22].

How and why functions can be further developed [23]:
A) Asking 'how is the function achieved' can help you build on the "How" approach. Using an active verb and a measurable noun, form the answer in the box to the right.
B) The "Why" path (right to left) can be tested by asking 'why is this function being performed?'
C) If the logic doesn't work, look for any omissions or duplicates, or re-arrange the routines.
D) When a function is performed, ask, "what else is done or caused by the function?" to identify related functions.
E) What is completed is described by higher-order functions (those to the left on the FAST Diagram), whilst the methods used to accomplish it are described by lower-order functions (those to the right on the FAST Diagram).
F) Functions that occur simultaneously or as a result of each other are not measured by a clock.

The method known as FAST may be broken down into six primary steps [4]:
A. In the first stage of the process, a list of the intended outcomes and requirements of the client are developed using a structure consisting of one verb and one noun each. First, establish what the fundamental role is.
B. It's common practice to utilize post-it notes to call attention to goods and services that are a good fit for a certain aim. These goods and services cater to the system needs that have been specified.
C. In the third stage, a list of all of the functions and processes in verb-noun format that would fulfill or produce each product or service from the previous phase is developed. This list is developed for each product or service in the previous step. The following stage is to generate all functions, regardless of their relationship to one another, including primary, secondary, support, aesthetic, and higher order functions.
D. From the phase that came before, choose the 'How' functions that you believe to be the most significant to the task that is now being worked on. The question that needs to be answered is "HOW can this vital duty be carried out?" Each time an answer is given, a fresh post-it note is generated. In this stage, you will check over the post-it's from the previous stage to see whether any of them answer the HOW question.
E. In Step 5, a response is provided to the "How" question, and a post-it note is then placed directly to the right. When arranging the functions on the same level, the CRITICAL PATH function is either positioned above or below the other functions. It is important to make the line going through the vital passage thicker.
F. At this stage (step 6), functions for the critical path are being written and tested. You can assess whether you are on the crucial route by answering the HOW question to the right and the WHY question to the left.

7. VALUE ANALYSIS AND ANALYSIS OF VALUE

One of the most common questions people have about businesses is why they require more than one strategy to increase their value [24, 25]. There is an old proverb that reads, "If the only tool you have is a hammer, every problem appears like a nail." The following instruments may be applied in order to enhance the quality of anything, a process, or a project, respectively:

- Concurrent Engineering
- Design for Assembly (DFA)
- Design for Manufacturing (DFM)
- Design for Six Sigma (DFSS)
- Failure Modes Effects Analysis (FMEA)
- The Seven Wastes
- Value Analysis / Teardown

It is not necessary to employ Value Engineering as a standalone strategy or methodology in order to achieve one's goals. Instead [26], it should be utilized in concert with a number of different strategic instruments in order to construct an all-encompassing strategy for continuous improvement [27]. The diagram that follows demonstrates how Value Engineering can be included into the overall business strategy of a corporation.

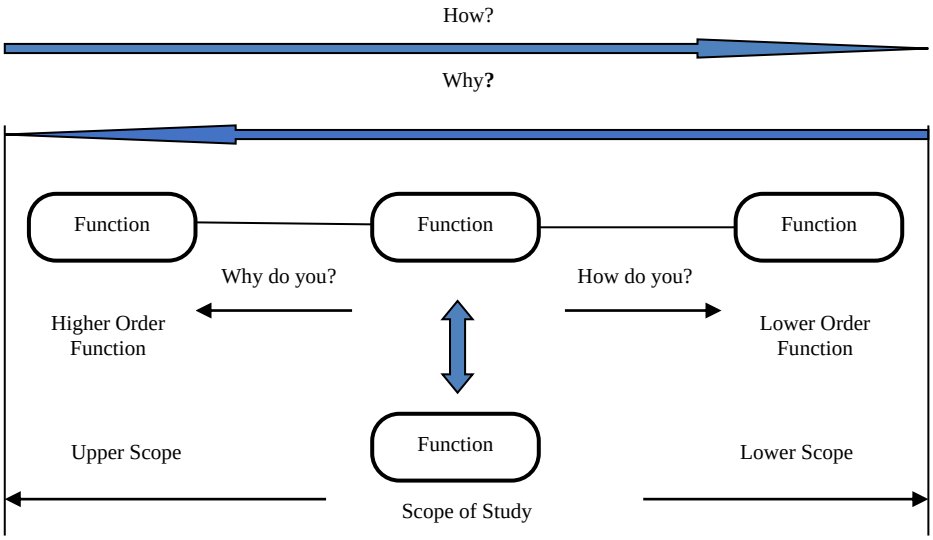

Figure 2. FAST diagram [21]

8. CASE STUDIES

There are an infinite number of instances in which value engineering made it possible to cut costs that were not necessary [28]. In certain instances, designs have supplied a function that calls for an operation in the manufacturing process that is relatively expensive. Value Engineering is a technique that aims to accomplish a given function in the most efficient and economical manner feasible. In the following example, punched-out holes rather than more expensive formed louvers on a fan cover achieve the essential purpose of providing air movement, resulting in a savings of $68,000 in total.

In some instances, the initial design has led to the incorporation of new components or the development of new capabilities beyond what was originally envisioned. Value Engineering was able to accomplish the primary function (attach fan to shaft) while at the same time realizing a total cost savings of $33,000 by getting rid of four unnecessary elements and secondary functions in the final sample.

9. CONCLUSIONS

Value Engineering is a powerful tool that can reduce costs while maintaining high quality and dependability criteria. Utilizing it early on in the product development cycle will yield the best results. Utilizing a heterogeneous set of prevalent support technologies enables one to improve value while simultaneously lowering expenses. If you really understand how things function, you are the only one who can bring good value to the table. Delivering the highest possible value to the customer is essential to one's success in virtually every sector of the economy. There are a lot of places where items or processes have unnecessary costs, and those are all places that could be exploited in order to give the competition a run for their money. In today's global marketplace, where there is more competition and new technologies, it is getting increasingly difficult for firms to turn a profit. To summarize, is the application of Value Engineering absolutely necessary for the continued profitability and success of a business over the long term?

REFERENCES

[1] S.R. Golroudbary, I. Makarava, E. Repo, A. Kraslawski, P. Luukka, "Magnesium Life Cycle in Automotive Industry", Procedia CIRP, Vol. 105, pp. 589-594, 2022.

[2] V. Gowrishankar, "Value Engineering in Residential House Construction", Int. Journal of Civil Engineering and Technology, Vol. 6, No. 6, pp. 46-52, 2022.

[3] J.R. Wixson, "2 Function Analysis and Decomposition using Function Analysis Systems Technique", INCOSE Int. Symp., Vol. 9, No. 1, pp. 800-805, 1999.

[4] A. Pokhriyal, "Value Analysis Using Function Analysis System Technique (FAST)", Int. J. Eng. Appl. Sci. Technol., Vol. 5, No. 1, pp. 664-665, 2020.

[5] C. Carpenter, "Value Methodology Identifies Energy-Saving Challenges and Opportunities", Journal of Petroleum Technology, Issue 12, Vol. 72, pp. 46-47, December 2020.

[6] I.H. Hashim, H. Helal, A. Maaty, "Quantifying of Highways Safety Impacts during the Value Engineering Process", International Journal of Scientific and Engineering Research, Vol. 10, Issue 7, 2019.

[7] P. Westfall Lake, G.N. McBride, "FAST Tracking Techniques", Shiftw. Saf. Perform., pp. 103-139, 2020.

[8] R.H. Voelker, "Value Engineering and the Design/Build Process", Manag. Complexities Real Estate Dev., pp. 44-45, 2022.

[9] J. Chu, J. Zhu, H. Li, W. Cuan, L. Qiao, Q. Qiao, "Applications of Value Engineering Principle in Polypropylene Production", Huagong Xiandai/Modern Chem. Ind., Vol. 21, No. 11, pp. 44-46, 2001.

[10] K. Emami, T. Emami, "Value Engineering: Opportunities and Challenges", Irrig. Drain., Vol. 69, No. 2, pp. 307-313, 2020.

[11] M.A. Levin, T.T. Kalal, J. Rodin, "Design Concept Phase", Improv. Prod. Reliab. Softw. Qual., pp. 257-271, 2019.

[12] D. Alwerfalli, A. Ali, "An Overview of Value Engineering in Product Development and Design", IIE Annu. Conf. Proc., No. December, pp. 1-7, 2021.

[13] N. Sharp, "Job planning", Bmj, Vol. 328, No. 7442, pp. s130-s130, 2004.
[14] L.C. Dominguez, D. Dolmans, W. de Grave, J. Donkers, "Transformational Leadership Encourages Residents' Job Crafting in Surgical Training: A Mixed-Methods Study of Residents' Perceptions", Research Square, 2020.
[15] J. Loar, "Revisions and Value Engineering", Sound Syst. Des. Prim., pp. 563-565, 2019.
[16] M.D. Guillamon, "Budgetary Constraints", Glob. Encycl. Public Adm. Public Policy, Gov., pp. 1-8, 2016.
[17] K. Kvam, R. Lie, D. Bakkelund, "Legacy System Exorcism by Pareto's Principle", Companion to the 20th Annual ACM SIGPLAN Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), pp. 250-256, 2005.
[18] S. Brunthaler, "Speculative Staging for Interpreter Optimization", arXiv, 1310.2300v1, October 2013.
[19] K. Koziol Nadolna, K. Beyer, "Determinants of the Decision-Making Process in Organizations", Procedia Comput. Sci., Vol. 192, pp. 2375-2384, 2021.
[20] V.G. Shevchenko, I. Belskaya, "Range of Phase Integral Values for Asteroids", European Planetary Science Congress, Vol. 11, pp. 776-777, Riga, Latvia, 2017.
[21] J.R. Wixson, "Function Analysis and Decomposition Using Function Analysis Systems Technique", International Council on Systems Engineering Annual Conference (INCOSE), Vol. 9, pp. 6-10, June 1999.
[22] T. Kretz, M. Kaufman, M. Schreckenberg, "Counterflow Extension for the FAST-Model", Computing Research Repository, Vol. 8, pp. 555-560, 2008.
[23] F. Othman, M.S. Sadeghian, M. Heydari, "Direct and Indirect Effects of Drought using the Function Analysis Systems Technique (FAST) Diagram", International Conference on Environment, Vol. 12, pp. 123-130, December 2012.
[24] D. Armentrout, "Engineering Productivity Management and Performance Measurement", Journal of Management in Engineering, Vol. 2, Issue 3, pp. 141-148, 1986.
[25] S.Q. Cao, C.C. Tang, H.Y. Wu, X. Liu, "Value Analysis Determines when and how to Strive", Adv. Psychol. Sci., Vol. 30, No. 4, pp. 877-879, 2022.
[26] J. El Boudali, K. Mansouri, M. Qbadou, "Towards A Connected, Efficient and Sustainable Supply Chain Integrating the Risk Factor", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 48, Vol. 13, No. 3, pp. 42-47, September 2021.
[27] A.I. Khudiyeva, M.Z. Yusifov, "Reconstruction of Structural Elements Damaged Under Influence of Pressure and Wave on Stationary Sea Platforms", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 50, Vol. 14, No. 1, pp. 64-70, March 2022.
[28] J.N. Aslanov, K.S. Mammadov, "Design and Performance Analysis of Improved Valve Construction being used in Oil and Gas Industry", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 51, Vol. 14, No. 2, pp. 98-103, June 2022.

BIOGRAPHIES

Mohammed Abdulkareem was born in Baghdad, Iraq, on August 30, 1995. He received the B.Sc. degree from Civil Engineer Department, Al-Israa University, Amman, Jordan in 2017.

Sepanta Naimi was born in Esfahan, Iran on July 1, 1977. He received the B.Sc. and M.Sc. degrees in Mechanical Engineering in 2001 and 2004, respectively. He received the PhD. degree in Civil Engineering in 2013. He worked as a Mechanical Engineering for Iran Khodro Ltd, Esfahan, Iran in 2001-2004. He worked at various offices and brunches in Iran. He was Research Assistant and Lecturer at Mechanical Engineering, Civil Engineering, General Education Departments, and Institute of Graduate Studies and Research, Eastern Mediterranean University, North Cyprus. He has been appointed as an Assistant Professor in Department of Civil Engineering, Istanbul Aydin University, Istanbul, Turkey in 2013. Then, he has been appointed as an Associate Professor since 2019. He was the Vice-Chair of the Civil Engineering Department between 2019 and 2021. He is working at Altinbas University as a Head of Department since 2021. He is specialized in steel structures in civil engineering and die-cast forming in mechanical engineering also he is active in research. He has supervised over 25 postgraduate students and he is currently supervising over 20 postgraduate students. He acts as a reviewer for some journals listed in SCI and SCI-Expanded. His research interests include the behavior of steel-framed structures, the influence of steel beam column connections on frame response, RBW connections, sustainability issues in structural engineering, building maintenance and repair, and die-casting.