Using Fuzzy Quality Function Deployment In Sustainable Product Design :Case Study In The Kufa Cement Factory

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ABSTRACT: The research aims to apply the fuzzy quality function dissemination tool to the cement product in the Kufa cement plant, and objectively determine the dimensions of sustainable design as it focuses on meeting the requirements of customers related to sustainability. Choosing the Kufa Cement Factory as a community for the study, and evaluating the extent of the laboratory's commitment to the aspects of sustainability, and the research problem was represented by a main question that (what is the role of spreading the ambiguous quality function in achieving the dimensions of sustainable design), and the research sample was represented by (150) customers dealing with the factory and (153) of the workers in the laboratory, and the research used the method of the scientific method (case study), and the data was collected by relying on the questionnaire tool, and the results of the research confirmed that the application of the quality house in the foggy form contributed to providing more detailed information about the product and the environmentally harmful waste. By adopting the dimensions of sustainable design, it serves as a feasibility study during planning for product improvement.
Keywords - Deployment Of The Fuzzy Quality Function, Sustainable Design

I. INTRODUCTION

Sustainable development has become a major concern all over the world, due to the increasing depletion of natural resources and the increase in environmental waste, as the concept of sustainability emphasizes the development of environmentally friendly products and processes that are compatible with the economic and social aspects, and the research problem has emerged that the researcher noticed during field visits to the laboratory and personal interviews with Managers and experts in the factory that the factory still relies on old technology in most production lines, which leads to the occurrence of environmental pollutants during production, and the deployment of the ambiguous quality function allows dealing with the uncertainties associated with the inputs during the analysis of the customer's voice into engineering specifications, and sustainable design is A term used to describe the use of sustainability principles in the design and development of products, and the deployment of the fuzzy quality function can be applied in two stages. In the first stage, customer requirements are set with the dimensions of sustainable design and the priority is set for the latter, and in the second stage, sustainability

parameters are set using the dimensions of sustainability and the latter is given priority Fuzzy Quality Function Deployment is a powerful tool for figuring out requirements The customer accordingly designs new products and services, it is also useful to modify the features and designs of existing products according to the changing requirements of customers.

RESEARCH METHODOLOGY

1-THE RESEARCH PROBLEM

Contemporary manufacturing organizations recognize sustainability as an important concept for survival, as the concept of sustainable product design has become a major concern for organizations around the world due to the increasing depletion of natural resources and the increase in environmental waste. With the uncertainties associated with transforming the customer's voice into engineering specifications and contributing significantly to sustainable product design, which addresses the limitations of traditional quality function deployment (QFD) in sustainable product design that lacks comprehensiveness and assumes certainty in decision-making, so this research came to address a case of weakness or The inability of organizations to design a sustainable product by diagnosing the dimensions of sustainable design that have the most impact in achieving success in designing a sustainable product that represents a competitive advantage for the laboratory (the research site). The lab still relies on the classic method of applying sustainability standards through education and billboards, without a real working mechanism to adopt it. Sustainability understandings, and this is what this research attempts to address by answering the following question (what is the role of spreading the fuzzy quality function in achieving sustainable design dimensions) and accordingly the research problem centers on raising the following questions:-

1-Is it possible to adopt the fuzzy quality function deployment in the process of meeting customer requirements towards sustainability in the Kufa Cement Factory, the research community?

2-Is there a clear perception of the fuzzy quality function deployment in the laboratory, the research community?

3-Are there attempts in the laboratory and the research community to adopt sustainable design?

4-Is it possible to determine the requirements of customers, and the dimensions of sustainable design in the laboratory, the research community?

2-THE RESEARCH IMPORTANCE

The importance of the research stems from the importance of spreading the fuzzy quality function and the dimensions of sustainable

design, as well as the importance of improving the quality of products and enhancing customer value, which contributes to diagnosing the effects of these variables on the sustainability of organizations, so the research derives its importance from the importance of its variables as well as the following:-

1-The importance of the research is gained by touching on a vital topic that helps the organization (Kufa Cement Factory) under discussion to promote sustainable development in its various operations and activities.

2-The fuzzy quality function deployment is one of the administrative techniques that work on developing new product requirements, its benefits are reliable, and it is a customer-driven process.

3- The use of fuzzy quality function deployment and sustainable design is very necessary in product design, as it is a comprehensive concept that provides a means of translating customer requirements into appropriate technical requirements at each stage of product development or production, ie planning, product design, evaluation of prototypes, development of the production process, marketing and sales .

4-Adopting the concept of sustainable design helps to increase organizations' commitment to sustainability standards and enhance their ability to improve the quality of their products.

5-The process of combining the two techniques of spreading the fuzzy quality function and sustainable design contributes to choosing the best customer requirements, in a way that achieves the organization's goal in achieving high profits and quality in work performance and promoting sustainable development.

3-RESEARCH OBJECTIVES

Through what was presented in the problem and the importance of the research, the current research seeks to achieve a set of the following goals- :

1-Identifying the reality and the possibility of using the Fuzzy Quality Function Deployment Tool (FQFD) by the Kufa Cement Factory.

2-Contribute to enabling the laboratory of the research community to achieve the requirements of sustainable design for its products by transforming the basic customer requirements that have been identified into requirements and characteristics and determining their technical precedence to ensure focus on them in order to meet the customer's requirements.

3-Determining the important customer requirements, and the sustainable design dimensions of the cement product.

4- Determining the priorities of the dimensions of sustainability that affect the sustainable design of the cement product according to the basic requirements of customers

4- The study population and sample

A-Study community

The study was applied in Kufa Cement Factory and this is due to several reasons-:

1 - The production of cement results in environmental harm, as the raw material is dust that is swept from the ground and burned using heavy fuels that produce various gases.

2- Dusts resulting from industrial processes and the environmental pollutants they leave behind.

3 - The possibility of applying the study because the plant does not contain complex operations, as well as the need for the plant to improve the value of its product of resistant cement in terms of increasing quality.

B-Study sample

The study was applied to a sample of clients (contracting companies and construction works) and workers of different levels and occupational specializations (manager, expert, engineer, technicians, administrators) in the Kufa Cement Factory. (153) questionnaires were retrieved as in the table(), in addition to (183) questionnaires submitted to the lab customers, and (150) questionnaires were retrieved

5-THE RESEARCH MODEL AND ITS HYPOTHESES

A- RESEARCH MODEL

Figure (1) The hypothesis of the research

B -HYPOTHESES

Fuzzy Quality Function Deployment and sustainable design dimensions contribute to satisfying customer requirements.

Fifth: the statistical methods used in the study

The researcher used the dimensions and equations of the Fuzzy Quality Function Deployment Tool and the Sustainable Design, which included the following-:

1-Standard weight for calculating the relative importance of the basic customer requirements and the dimensions of sustainable design.

2-Fuzzy weight: - The scale (Vinodh et al., 2016) was adopted to give fuzzy weights to basic customer requirements and sustainable design dimensions.

3-Quality House Matrix by applying the Quality Function Deployment Tool to transform customer requirements into technical characteristics that are included in sustainable design.

4-Quality House Matrix by applying the dimensions of sustainable design to technical characteristics.
5- Simple Pearson correlation coefficient: - It is used for the purpose of determining the correlation between matrices.]

Theoretical framework for research

First: Fuzzy Quality Function Deployment

In 1965 Zadeh proposed fuzzy logic and developed the fuzzy AHP hierarchy theory to deal with situations in which absolute numbers and weights ranging from absolute true to absolute false cannot be assigned (Tas, 2009:2). From (1965) onwards, many applications of fuzzy logic were developed which led to important industrial achievements as in (1987), the first fuzzy-logic subway system in Japan based on the logic of control system. These projects were seen as a great success, as industries and universities took an interest in developing new systems based on fuzzy logic. For example, fuzzy logic theory is used in automobile systems and other vehicle systems, such as automatic transmissions and cruise control. It is also used in air conditioners, digital cameras, washing machines and other household appliances and many other uses (Al Fazari, 2008:81**).**

(Zhou, 1998) introduced a fuzzy logic and optimization model for implementing QFD Quality Function Deployment, and a new method for determining optimal objectives in the QFD process.

(Vinodh & Chintha, 2011: 345). Kahraman et al., 2006) suggested an integrated framework for product design based on fuzzy QFD and fuzzy optimization model Lee & Lin, 2011:28).

Sohn and Choi, 2001) applied Fuzzy-QFD Quality Function Deployment to the supply chain and developed a fuzzy multi-criteria decision-making method for selecting a design with the optimum combination of reliability and customer satisfaction, and how to deploy the Quality Master House to improve the logistics process efficiently and effectively Haq & Boddu, 2015 :4)). Nowadays, FQFD has been used as a powerful tool in product design and development and decision-making from supplier selection to environmental design product development. Compared to traditional QFD, the use of FQFD has become essential for organizations (Abdolshah & Moradi, 2013:1). (Sagnak et al., 2017:231) states that uncertainties are experienced in the decision-making process due to the subjective method of human judgments. And the concepts of fuzzy logic were applied to (QFD) to become (FQFD). Most of the FQFD studies focused on quantitative methods to build a matrix of quality house based on the requirements of customers, where the most used techniques are based on the criteria of decision analysis methods, and they indicated that there are factors other than the house of quality. Quality is relevant to product development, and they called metaheuristic methods "a promising approach to solving complex problems for FQFD (Abdolshah & Moradi, 2013:3).

A number of scholars have applied fuzzy group theory to QFD and developed several fuzzy FQFD approaches. For example, Khoo and Hoo, 1996 proposed the concept of fuzzy FQFD and fuzzy language variants to make it more reasonable, besides, they also considered the correlations between customer requirements CRs and ECs (Liu, 2011:4). (Doğan et al. .,2020:290) The first stage of the FQFD is the establishment of the Quality House, similar to that in QFD, during the establishment of the Quality House, expert opinions are used to determine the requirements of customers, performance and technical requirements of the organization (organization, port, product, service, etc.) and its competitors, because expressing these opinions through linguistic variables creates uncertainty, and fuzzy numbers are used to eliminate uncertainty and reach definite conclusions.

Second: Applications of fuzzy quality function deployment

Although QFD has many applications and traditional QFD has been deployed in many organizations, the most important applications of FQFD are supply chain management, product design applications and other applications (Abdolshah & Moradi, 2013:7).

1-Supply chain management: A research paper on supplier selection (Bevilacqua., 2006:8) suggested a new method that translated HOQ as a problem for a large company to produce delivery dimensions, and a new method of emergency management was proposed for third party logistics (3PL).), risk management was also considered.

2- Product Design: Due to legal constraints and public pressures, many companies were making products consistent with environmental concerns, many of these products were produced and sent to market, but most of them were rejected by customers and could not gain market share because they took Only taking into account the environmental conditions and neglecting the needs of customers, so some studies focused on this matter to solve it by considering both the environment and customer requirements using FQFD (I. H. Kuo et al., 2009:6109).

3- Other applications:- (Jia,2011:447& (Bai) suggested a method for developing a manufacturing strategy using QFD. This method consists of 11 steps and used QFD as a transfer tool to link competitive factors with manufacturing decision groups (such as structural and infrastructure decision groups) and a key tool in different stages. From the development of the manufacturing strategy, and integrated fuzzy group theory with HOQ to deal with the ambiguity of the inputs to the decision-making process, (Slack et al., 2004: 105) is defined as the exploitation of certain characteristics of the manufacturing function to achieve competitive advantages, and the content of the manufacturing strategy refers to specific decisions and actions that determine the role of Manufacturing, its goals and activities; to make specific content decisions

Third:- The benefits of spreading the fuzzy quality function

There are many benefits to spreading the fuzzy quality function (FQFD), including (Vinodh et al., 2017: 2)

1-The fuzzy quality function deployment (FQFD) fulfills the requirements of sustainable manufacturing.

2-It helps in improving business performance while meeting customer requirements.

3- It opens a wide opportunity for application in sustainable development of products.

Fourth: The concept of sustainable design

To understand the meaning of design for sustainability, we need to understand the meaning of the word sustainability. The word sustainable was used for the first time in relation to its current use as sustainable development. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Clark et al. ,2009:409). And sustainability is the level of human consumption and activity, which can continue in the foreseeable future, so that the systems that provide goods and services to humans continue indefinitely (Deutz, 2010:231).

(Duarte, 2010:2 Gil&) pointed out that any definition of sustainability must include dynamic efficiency, must consist of complete welfare (equality between generations) and must represent the consumption of market and non-market goods and services. Sustainable design is an evolving environmental design concept that includes the social and economic elements of production, as it integrates the three pillars of sustainability: community, profit, land, and how to meet customer needs in a more holistic and sustainable way (Mercure et al., 2016:103). Organizations that integrate sustainable design into long-term product innovation strategies seek to mitigate negative environmental, social, and economic impacts along the product supply chain and throughout its life cycle (Cidik et al., 2014:2). Sustainable design is about making sure what we use and how we use it today, does not have negative impacts on the ability of current and future generations to live prosperously on this planet. It is also about ensuring that we meet our needs in ways that are socially just, environmentally positive and economically viable. Design (Boik,2021:726).

These radical changes can pose significant challenges, but there are encouraging developments that expand the knowledge base to develop sustainable products. These newly designed products and services provide increased functionality, ease of use, longer life, ease of disassembly or recycling, and lower environmental impacts. To save the organization's funds and improve the sources of materials and production that can positively impact communities (Jabbarzadeh et al., 2018:5946). (Fatima et al., 2018:2) indicated that sustainability provides added value through better quality and lower price, which are the driving forces for most customer decisions.

Fifthly, the importance of sustainable design

Sustainable design has generally been a reaction to global environmental crises, with an emphasis on resource efficiency. While efficiency is important, growth in goods and services consistently outweighs efficiency gains. As a result, the full impact of sustainable design has been to simply slow the rapidly increasing impacts (Ahmad et al. al.,2019:337). When applying sustainability to the design, it makes clear to the organization the impacts that the product will have over its entire life cycle, enabling the organization to ensure that all efforts are made to produce a product that fits the system that will exist within it. in a sustainable manner (Cidik et al., 2014:2). The importance of sustainable design lies in completely removing the negative environmental impact through skilled and sensitive design, and the manifestations of sustainable design require renewable resources and innovation to affect the environment to a minimum and connect society with the natural environment (Jabbarzadeh et al., 2018: 5946).

Design decisions in organizations are made on a daily basis, affecting sustainable development or providing for the needs of future generations of life on Earth (Bergmann, 2018:2). Sustainability and design are closely related, meaning that our future is designed, and the term design is used to refer to the practices applied in making goods and services, as well as business strategy and innovation, all of which inform sustainability (Mercure et al., 2016:103). Sustainability can be considered a property of continuity, meaning that what is sustainable can continue into the future (Ahmad et al., 2019:337). To achieve the goal of sustainable design, several goals must be achieved, and these goals are design for cost-effectiveness, optimum use of materials, energy efficiency, product dismantling, recycling, repair and reuse of products, remanufacturing, and continuous improvements (Feria & Amado, 2019: 136).

Sustainable design includes guiding principles that ensure a long product life cycle, emotional satisfaction and personalization, as sustainable design focuses on incorporating systematic changes in design thinking to promote sustainable patterns in production and consumption. By considering the environmental, social and economic aspects (Dondi et al., 2020: 2).

The use of environmentally friendly materials or green materials is one of the most important strategies in sustainable design, as the use of green materials in product development reduces the environmental impact through the possibility of reusing, recycling and degrading naturally at the end of its lifespan (Olabanji, 2020:3). Green materials are often derived from plants which offer the advantage of unlimited resources and renewable energy compared to traditional engineering materials such as non-renewable minerals and depleted resources (Serrao et al.,2021:2976). The properties of green materials when applied to products and processes significantly reduce carbon footprint and high energy consumption throughout the entire product life cycle (Ahac,2021:537).

Sustainability requires the conservation of resources, minimization of the depletion of non-renewable resources, and the use of sustainable practices to

manage renewable resources. There can be no product development or economic activity of any kind without the available resources. Thus, efficient designs conserve resources while minimizing impacts from material extraction and activities. Relevant, depletion of non-renewable resources and excessive use of renewable resources reduce their availability for future generations (Poon,2021:210).

Sixth: Dimensions of sustainable design

1-Preserving resources for future generations

This dimension focuses on two factors, the first is reducing environmental impacts and recycling, as reducing environmental impacts is an important environmental dimension for sustainability or recycling will ensure the extraction of maximum use of resources, while the second factor is reducing the use of resources, reducing the use of resources will enable the needs of Future generations (Vinodh et al., 2017:4). (Ozga et al., 2020:4) indicated that the end of use is the time point at which the product goes out of service by reaching the end of its operational life or for any other reasons, and the service life of the product may be a very short or long-term period

2-Functional work environment

This dimension focuses on ease of use, maintainability / serviceability and scalability, as it must be ensured if the developed product is easy to use, as it has a significant impact on the durability of the product and maintenance works to extend the life of the product, thus ensuring the sustainability characteristics of the product, and products are designed with features modularity to enable scalability (Bereketli et al., 2009:214). Functionality is a key aspect of a product where scalability, modularity, and maintainability contribute to product preservation. Manufacturability deals with assembly, transportation, and packaging as new legislation comes into force. Recyclability/remanufacturing is a massively broad component. Organizations should focus heavily on reducing waste and conserving resources (Neykov et al., 2021:462).

3-Economic efficiency

This dimension focuses on the potential financial benefits and the reduction of waste, as the potential benefits include both profits and grants provided by legal authorities to adapt the culture of sustainability, and the product development process must be simplified with minimal waste to increase productivity (Niranjali et al., 2009: 252). Economic efficiency is a term that refers to the optimal use of resources, with the aim of maximizing production of goods and services, and therefore that any economic system is more efficient compared to another system if it is able to provide more goods and services to society without using more resources (Neykov et al. al.,2021:462).

4-Environmental aspects

The adverse effects of air quality on the regional atmosphere and the global environment are an important factor affecting the sustainability of the product. Effluents must be treated before they are released into water bodies. The

enrichment of water with nutrients is a serious concern for sustainability, and the harmful effects of the industrial process on human health are among the most important Sustainability factors (Bereketli et al., 2009: 214).

5-Economy in the use of resources

The cost of installation, training, material use, and energy efficiency/energy consumption are among the most important factors affecting sustainability, as product installation and support must be simplified to improve the cost involved. Vinodh et al., 2017:4)

6-Social Impact

This dimension focuses on operational safety and ethical responsibility, as safety is the factor of the organizational level that ensures a safe working environment for the workforce and avoids any safety risks. Ethical responsibility is a major social dimension that pushes the organization towards being more socially responsible by creating recovery options and policies Appropriate product pricing (Niranjali et al., 2009:252).

7-Optimization and Distribution

This dimension focuses on three factors. The first is reusable packaging. Packaging has a significant impact on sustainability, and it is very important at the organizational level to manage the reuse of packaging. It is important to ensure a reasonable proportion of packaging materials are recyclable (Niranjali et al., 2009:252). The second factor is the mode of energy-saving transport, and this factor depends on both the input and output flows, as appropriate policies for efficient transport must be developed, and the third factor refers to less energy consumption, as the amount of energy consumed during product development must be significantly reduced by choosing Renewable alternatives (Vinodh et al., 2017:4).

8-Physical Characteristics

This dimension focuses on the weight of the product, the size of the product and the number of parts, as the weight of the product is an important factor in the design of the product, and the effect of the size of the product is reflected on storage, packaging and transportation, in addition to the fact that the number of parts in the product has a vital impact on disassembly (Bereketli et al., 2009 :214).

RESEARCH DESIGN

1. The Research sample

First: - Determining customer requirements and their importance

For the purpose of reviewing the opinions of customers, the researcher distributed (150) survey forms shown in Appendix (1), which included (10) paragraphs of them related to the requirements of customers, as they were distributed to contracting companies and construction companies that deal directly with the laboratory, the study community, and after using the five-point Likert scale. In determining the degree of importance of each opinion, as shown in Table (1):-

Table (1) weighted sum and weighted arithmetic mean of customer requirements

weighted mean	Weighted total	Not Very important (1)	not important (2)	somewhat(3)	important (4)	very important (5)	Customer requirements	ت
3.893	584	12		41	36	61	Product weight	1
4.200	630			34	52	64	Hardening time	2
4.373	656			28	38	84	Hardening strength	3
4.327	649		7	18	44	81	Product color after hardening	4
3.953	593		17	34	38	61	The product is moisture and salt resistant	5
4.293	644			29	48	73	Product shelf life	6
4.320	648			31	40	79	The product is free from hazardous materials	7
3.807	571	18		35	37	60	Environmentally safe	8
4.313	647			33	37	80	Ease of transportation and storage of the product	9
4.193	629		14	22	35	79	Quality packaging bags	10
	6251						Total	

Second: The dimensions of sustainable design and its importance

The researcher distributed (153) survey forms illustrated in Appendix (2) to the workers in the laboratory (under study), which included (25) paragraphs, including technical and engineering requirements related to the dimensions of sustainable design, as the aim of these opinions was to identify the most important dimensions necessary to achieve The sustainable design, as it was distributed to the workers in the laboratory, the study community, and after using the five-point Likert scale in determining the degree of importance of each opinion, as shown in Table (2):-

Table (2) the weighted sum and the weighted arithmetic mean of the dimensions of sustainable design

Weighted mean	Weighted total	Not Very important (1)	Not important (2)	Somewhat (3)	Important (4)	Very important (5)	Dimensions of sustainable design	ت
							Preserving Resources For Future Generations	
4.007	613		18	27	44	64	Environmental awareness is an important dimension of sustainability	1
4.248	650	4		23	53	73	The design takes into account the elements of recycling in order to make the best use of the available resources	2
4.268	653			32	48	73	The best use of the available resources contributes to securing the future needs of the laboratory	3
							Functional work environment	
3.797	581	7	12	31	58	45	The design takes into account the ease of use of the developed product	4
4.033	617		9	42	37	65	The design takes into account the durability of the product	5
4.085	625	4		36	52	61	The design ensures the product's sustainable properties such as maintenance to extend the life of the product	6
3.941	603		15	37	43	58	Product design keeps pace with typical features and modern trends in product development	7

							Economic efficiency	
4.124	631	3	2	39	38	71	Design fits with a culture of sustainability to realize potential benefits from legal authorities (such as profits and grants)	8
3.961	606		10	42	45	56	We work to make the product development process simplified with minimal waste to increase productivity	9
							Environmental aspects	
3.843	588		14	48	39	52	The product design takes into account the harmful effects on the air and the atmosphere to preserve the environment from pollution	10
3.882	594	9	7	31	52	54	The design of the product takes into account liquid waste and facilitates its disposal	11
3.869	592		22	29	49	53	The product design takes into account the potential effects of the product on human health	12
							Economy in the use of resources	
3.739	572		24	36	49	44	Simplicity of product design reduces costs	13
3.928	601	3	12	36	44	58	Material type, cost and quantity are proportional to the sustainable design of the product	14
3.706	567	18		37	52	46	Rationalize the use of energy consumed by the product during its life	15
							Social impact	
4.065	622		8	41	37	67	safety element is taken into account in the design to ensure a safe working environment for employees and avoid risks	16
4.346	665			24	52	77	it takes into account social responsibility as a major social dimension that drives the factory management towards creating take-back options and appropriate product pricing policies	17
4.163	637			39	50	64	Takes Into Account Ethical Responsibility In Product Design And Pricing	18
							Optimization and distribution	
3.824	585		24	32	44	53	packaging has a significant impact on sustainability, and it is very important at an organizational level to manage the reuse of packaging	19
4.098	627			48	42	63	the management of the plant is concerned with ensuring a reasonable proportion of recyclable packaging materials	20
3.908	598	14	5	24	48	62	the plant management develops appropriate policies for efficient transportation	21
4.105	628			43	51	59	we significantly reduce the amount of energy consumed during product development by choosing renewable energy alternatives	22
							Physical properties	
3.758	575		22	43	38	50	The design takes into account the weight of the product, which facilitates storage and packaging	23
4.092	626			48	43	62	The components of the product have a vital effect in its development	24
4.078	624		11	32	44	67	Product size affects storage, packaging and transportation	25
	15280						Total	

Third: Obtaining weights using triple fuzzy numbers

1- Customers' requirements

The linguistic variables are determined according to the appropriate scale to convert the linguistic variables into the triple fuzzy numbers in order to be able to deal with them mathematically.

Table (3) Customer Requirements According To The Triple Fuzzy Function

fuzzy weight	Symbol		Standard Weight	**Customer requirements**	ت
(0, 0, 0.3)	PI	584	584	Product weight	1
(0.5, 0.7, 1)	I	630	630	Hardening time	2
(0.7, 1, 1)	VI	656	656	Hardening strength	3
(0.7, 1, 1)	VI	649	649	Product color after hardening	4
(0, 0.3, 0.5)	FI	593	593	The product is moisture and salt resistant	5
(0.5, 0.7, 1)	I	644	644	Product shelf life	6
(0.7, 1, 1)	VI	648	648	The product is free from hazardous materials	7
(0, 0, 0.3)	PI	571	571	Environmentally safe	8
(0.5, 0.7, 1)	I	647	647	Ease of transportation and storage of the product	9
(0, 0.3, 0.5)	FI	629	629	Quality packaging bags	10

2-Dimensions of sustainable design

Linguistic variables are determined according to the appropriate scale for converting linguistic variables into triple fuzzy numbers with regard to the dimensions of sustainable design in order to be able to deal with them mathematically.

Table (4) Dimensions of sustainable design according to the triple blur function

fuzzy weight	Symbol	Standard Weight	**Dimensions of sustainable design**	ت
			Preserving Resources For Future Generations	
(0.3, 0.5, 0.7)	M	613	Environmental awareness is an important dimension of sustainability	1
(0.7, 1, 1)	S	650	The design takes into account the elements of recycling in order to make the best use of the available resources	2

(0.7, 1, 1)	S	653	The best use of the available resources contributes to securing the future needs of the laboratory	3
			Functional work environment	
(0, 0, 0.3)	W	581	The design takes into account the ease of use of the developed product	4
(0.3, 0.5, 0.7)	M	617	The design takes into account the durability of the product	5
(0.3, 0.5, 0.7)	M	625	The design ensures the product's sustainable properties such as maintenance to extend the life of the product	6
(0.3, 0.5, 0.7)	M	603	Product design keeps pace with typical features and modern trends in product development	7
			Economic efficiency	
(0.7, 1, 1)	S	631	Design fits with a culture of sustainability to realize potential benefits from legal authorities (such as profits and grants)	8
(0.3, 0.5, 0.7)	M	606	We work to make the product development process simplified with minimal waste to increase productivity	9
			Environmental aspects	
(0, 0, 0.3)	W	588	The product design takes into account the harmful effects on the air and the atmosphere to preserve the environment from pollution	10
(0, 0, 0.3)	W	594	The design of the product takes into account liquid waste and facilitates its disposal	11
(0, 0, 0.3)	W	592	The product design takes into account the potential effects of the product on human health	12
			Economy in the use of resources	
(0, 0, 0.3)	W	572	Simplicity of product design reduces costs	13
(0.3, 0.5, 0.7)	M	601	Material type, cost and quantity are proportional to the sustainable design of the product	14
(0, 0, 0.3)	W	567	Rationalize the use of energy consumed by the product during its life	15
			Social impact	
(0.3, 0.5, 0.7)	M	622	safety element is taken into account in the design to ensure a safe working environment for employees and avoid risks	16
(0.7, 1, 1)	S	665	it takes into account social responsibility as a major social dimension that drives the factory management towards creating take-back options	17

			and appropriate product pricing policies	
(0.7, 1, 1)	S	637	Takes Into Account Ethical Responsibility In Product Design And Pricing	18
			Optimization and distribution	
(0, 0, 0.3)	W	585	packaging has a significant impact on sustainability, and it is very important at an organizational level to manage the reuse of packaging	19
(0.7, 1, 1)	S	627	the management of the plant is concerned with ensuring a reasonable proportion of recyclable packaging materials	20
(0, 0, 0.3)	W	598	the plant management develops appropriate policies for efficient transportation	21
(0.7, 1, 1)	S	628	we significantly reduce the amount of energy consumed during product development by choosing renewable energy alternatives	22
			Physical properties	
(0, 0, 0.3)	W	575	The design takes into account the weight of the product, which facilitates storage and packaging	23
(0.7, 1, 1)	S	626	The components of the product have a vital effect in its development	24
(0.3, 0.5, 0.7)	M	624	Product size affects storage, packaging and transportation	25

3-Building a quality foggy house between customer requirements and sustainable design dimensions

Figure (2) shows the quality house for customers' requirements versus the dimensions of sustainable design, the first stage after completing its requirements.

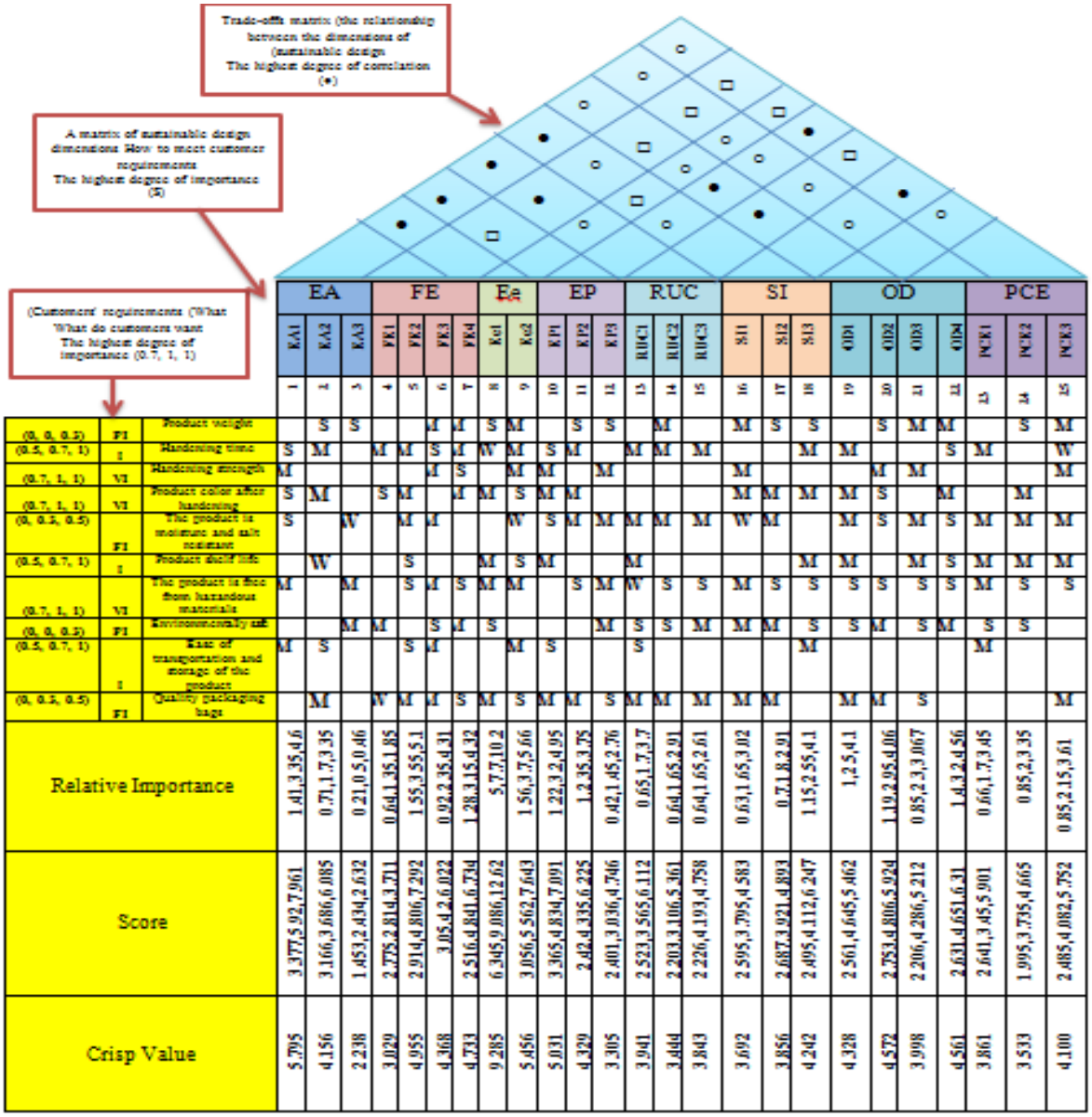

Figure (2) The fuzzy quality house matrix between customer requirements and sustainable design dimensions

The results of Figure (2) indicate the following:

A - Regarding the importance

1-The paragraph (product design keeps pace with typical features and modern trends in product development) got the highest relative importance by (1.28,3.15,4.32), as the shape of the product is one of the most important elements of design and the most affected by the variables that occur and relate to the design process in any of its fields And to ensure that it keeps pace with modern trends.

2-The paragraph (the plant management is concerned with ensuring a reasonable percentage of recyclable packaging materials) ranked second with a rate of (1.19,2.95,4.06), which facilitates achieving sustainability goals for manufacturers by providing packaging solutions in light of advanced concepts that preserve the environment, and allow More sustainable product packaging.

3-The paragraph (design works to ensure the sustainability characteristics of the product such as maintenance to extend the life of the product) ranked third with a rate of (0.92,2.35,4.31), as all organizations seek to search for the necessary steps to extend the life of the product in a way that ensures sustainability.

B- Concerning the final result

1-The paragraph (design commensurate with the culture of sustainability to achieve potential benefits by legal authorities such as profits and grants) got the highest result of (6.345, 9.086, 12.621), sustainable design contributes to compliance with the principles of sustainability that most official bodies and public and private organizations seek to achieve.

2-The paragraph (product design takes into account the harmful effects on the air and the atmosphere to preserve the environment from pollution) got the second highest result with a score of (3.365,4.834,7.091), as the cement industry is classified among the heavy and dangerous industries that many international systems fear. The environment is one of the environmental and health risks that result from air pollution, especially when it is near residential areas.

3-The paragraph (the design takes into account the elements of recycling in order to achieve the best investment of the available resources) got the third highest result with a rate of (3.166, 3.686,6.085), as many countries have taken measures to recycle waste, and recycling waste has many benefits. It protects natural resources, reduces waste, creates new job opportunities, and makes the place look more beautiful.

C - Regarding the target value

The quality house can be linked to the dimensions of sustainable design by considering the target value of the design by transferring customer information to the management in the laboratory (under study), and in this way it is possible to develop a design in which all parties in the supply chain (customers, management) can be developed to involve them in the design and production of the product.

Finally, the study provided insights for practicing managers about the application of the methodology of spreading the ambiguous quality function for the sustainable development of Kufa Cement Factory products. Hence, following the methodology will lead to customer satisfaction, and support the approach developed by managers to deal with their resources effectively.

Also, the deployment of the quality foggy function is an excellent approach that would enable the organization to become a sustainable organization to meet the requirements of the customers, as the success of the deployment of the foggy quality function depends to a large extent on the quality of the customer's voice, that is, the customer's requirements and evaluation of their importance, on the other hand, the design dimensions depend The sustainable quality function that enables any organization to meet those requirements, and the deployment of the foggy quality function is applied to an integrated cycle of the administrative, marketing and engineering program where the management effects include the

commitment of senior management, the formation of a cross-functional team, the full participation of the workforce and the readiness for sustainable improvements, and these effects are considered as factors Fundamental enablers to inculcate sustainable characteristics in the organization.

Conclusions and Recommendations

First: conclusions

1-Although the factory has a way to hear the customer's voice through a customer complaints form, it does not use any means to include the customer's voice in the production process to meet his requirements.

2-The fuzzy quality function deployment tool helped to identify customer needs and rank their priorities according to the degree of their satisfaction with the product.

3-Some of the customer's requirements constituted high impact points on the purchase of the cement product if some improvements were made to it (hardening strength, product color after hardening, and the product being free of hazardous substances.(

4-The application of the House of Quality in a blurry manner contributed to providing more detailed information about the product and waste harmful to the environment by adopting the dimensions of sustainable design, which is a feasibility study during planning to improve the product.

5-The dimensions of sustainable design were most closely related to the customer requirements that the laboratory should provide in the product, which topped the first three ranks: (taking into account social responsibility as a major social dimension that pushes the factory management towards creating options for recovery and appropriate product pricing policies) and (contributing to the better use of resources Available to secure the future needs of the plant) and (the design takes into consideration the elements of recycling in order to achieve the best investment of the available resources), as these requirements are basic in environmental performance, because of their active role in causing the chemical reactions necessary for the production of cement that are reflected on Cement product quality.

6-The results of the study I showed that there was a slight decrease in the factory's tendency to use environmentally friendly machines and hardware, and this indicates a decrease or lack of orientation to social responsibility in preserving environmental pollution, so it requires the factory management to abide by the social, legal, and ethical responsibility that is imposed on all organizations Protect the environment because it belongs to everyone. The results of the Research resulted in the existence of a correlation relationship between the two variables of the Research (quality deployment Matrix Technique, and quality customer relationship quality), and this indicates that the construction of the Research title and its hypotheses are healthy and logical, and thus the possibility of reaching possible solutions to the problem of the Research. The study recommends that in order to obtain the full potential of

quality deployment matrix Technique It is necessary that the management of the factory, the study community, possess sufficient awareness of its role in protecting the environment, and not harm it, and that it have effective programs to achieve sustainable production and the benefits that accrue to the factory and the environment, based on its legal and moral responsibility.

Second: Recommendations

1-Using the Quality Function Dissemination Tool and applying the Quality House enables the laboratory to analyze the extent of its need for each and every standard of customer requirements, no matter how many standards are, because of its ease and ability to translate customers' needs.

2-Keeping abreast of the development in production lines that take into account the sustainable product in similar laboratories all over the world, as well as striving to twin with them with the aim of continuous improvement.

3-Collecting data about customers, the voice of the customer by conducting interviews and surveying the opinions of customers, in order to accurately determine the real requirements of the customer and his apparent and hidden expectations for the factory product, and then disseminate them during the product design and development process by adopting the quality function deployment technique.

4-Diagnosing areas of weakness and strength in the performance level of the factory product compared to its competitors, which helps reduce competitive gaps by making these market and technical competitive comparisons, especially with regard to sustainability.

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