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Applying Four-Dimensional Concurrent Engineering Technique to reduce costs: An applied study in the Kufa Cement Factory

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Abstract : The research aims to apply the Four-Dimensional Concurrent Engineering Technique in the Kufa Cement Factory to reduce costs, as they are among the most important strategic cost management techniques in the field of cost accounting and management accounting. The research was conducted on the Kufa Cement Plant data to demonstrate the effect of using the Four-Dimensional Concurrent Engineering Technique to reduce costs.
The research was based on the main hypothesis that (the use of the Four-Dimensional Concurrent Engineering Technique leads to reducing costs in the Kufa Cement Factory in a manner that is consistent with the requirements of the modern manufacturing environment).
The descriptive analytical approach was followed in the theoretical aspect, and in the practical aspect, reliance was placed on the data of the Kufa Cement Plant for the fiscal year (2022), which were obtained from the financial reports, as well as through field experience and personal interviews with the laboratory employees. The research reached a number of conclusions, the most important of which is (that The Four-Dimensional Concurrent Engineering Technique is one of the important technologies that work to reduce costs during the product life cycle, starting from the planning stage all the way to research and development, without compromising the quality of the product.
The research came out with a number of recommendations, including the necessity of moving the Kufa Cement Factory to apply the Four-Dimensional Concurrent Engineering Technique due to the multiple needs and desires of customers and the changing benefits and shapes of the products, as well as their role in reducing costs.
Keywords: Four-Dimensional Concurrent Engineering, Cost reduction, Cement industry.

Introduction: The business environment, in general, and the manufacturing environment, in particular, have been accompanied by many changes that have come to pose challenges and pressures on the economic units operating in this environment, the most prominent of which are scientific and technological development, the information revolution, artificial intelligence, communications, globalization, the change in political, economic and social systems, and the increased intensity of competition between these units, in addition to the change in... The tastes, needs, behaviors of customers, etc., and in order for economic units to be able to face these challenges and pressures and adapt to them, they had to pay attention and focus on the strategic approach to cost management through their contemporary cost and administrative techniques. The most important of these techniques is the simultaneous engineering technique based on synchronization in the processes of designing, manufacturing and assembling the product.
Concurrent engineering is viewed as an organized approach to integrating product design and related operations, including manufacturing and support operations. Thus, it is a business strategy that replaces the traditional product development process with one of the tasks that works in parallel, and it takes the characteristic of accelerating the development process of any product. Therefore, concurrent engineering It is a structured method for integrating the simultaneous design of products and their processes, including both manufacturing and support
The research aims to study one of the contemporary cost and administrative techniques, which is the concurrent engineering technique with its four dimensions of (product design, process design, supply chain design, and product sustainability design) and to demonstrate its role in reducing production costs in Iraqi industrial companies, through application to data for the year. Finance (2022) for the Kufa Cement Plant affiliated with the Southern Cement General Company, one of the industrial companies affiliated with the Iraqi Ministry of Industry and Minerals.

First research: Research methodology

The methodology will be discussed in terms of defining the research problem, the importance of the research, the research objectives, the research hypothesis, the research method and sources of collecting information, and the limits of the research.

problem of research

The research problem can be summarized into the following questions:

Does the Kufa Cement Factory apply the Four-Dimensional Concurrent Engineering Technique in calculating production costs?

Does the Four-Dimensional Concurrent Engineering Technique support and contribute to reducing costs?

The importance of the research

The importance of the research comes from the importance of reducing costs and improving the quality of products and its impact on production processes and the activities of economic units since competition in the market depends on the extent of the ability of the Kufa Cement Factory to produce cement at the lowest possible level of costs and at the same time without affecting the quality of the product and that This can only be done by applying contemporary costing techniques that help reduce costs by eliminating costs that do not add value to the product, and at the same time increasing the effectiveness of activities that add value to the product.

The objectives of the research

The research aims to do the following:

Explaining the cognitive foundations of the Four-Dimensional Concurrent Engineering Technique according to recent studies.

Explain how to reduce costs during the production process using the Four-Dimensional Concurrent Engineering Technique in the Kufa Cement Factory.

The hypotheses of the research

The research is based on a main hypothesis:

(The use of Four-Dimensional Concurrent Engineering Technique leads to reducing costs in the Kufa Cement Factory in a manner that is consistent with the requirements of the modern manufacturing environment)

Research methodology and sources of data collection

To achieve the research objectives, the deductive and inductive approaches were followed. The sources of data collection can be explained according to the deductive and inductive approaches as follows:

The deductive approach :The researcher relied on Arab and foreign books available in offices, Arab and foreign university research, periodicals, dissertations, and dissertations, as well as information published on the international network, the Research Gate, Google Scholar, and other scientific academic sites.

Inductive approach :It consists of field experience and personal interviews with people at various levels of the laboratory, as well as reviewing the accounts and reports related to the laboratory through the application of the Four-Dimensional Concurrent Engineering Technique to reduce costs.

search limits

Time limits: Represented by the data of the Kufa Cement Factory for the year (2022). This factory was chosen for the reasons next :-

The Kufa Cement Factory faces a decrease in profits due to intense competition, as well as selling a product at a lower price, which led to a decrease in profits.

The high percentage of idle capacity due to the significant increase in production costs, especially salaries, wages, and commodity and service supplies, which has led to recurring losses.

Spatial boundaries: The Kufa Cement Factory, located in the Kufa-Barakiya district, was chosen as a field for applying the research

The second topic: The theoretical side

2.1 Theoretical framework of concurrent engineering technology

Concurrent engineering is one of the technologies that came about as a result of environmental changes and developments, especially the intense competition between economic units that generated pressure on these units to achieve clear goals such as reducing unnecessary and unjustified costs and improving the quality of both processes and products, as well as reducing design time and manufacturing and assembly time to deliver the product to... The market and the product’s relationship with the environment, in addition to providing sufficient flexibility in responding to continuous changes in the needs, desires, requirements, tastes, and behaviors of customers, thus helping to achieve competitive advantage and distinction over others (Tayal, 2012: 679). During this study, the concept of concurrent engineering technology, its concept, its importance, four dimensions, and stages of its application will be presented.

2.1.1 Concept of Concurrent Engineering

Researchers disagreed on developing a specific concept for concurrent engineering. There are those who look at it from an administrative or accounting point of view, and there are those who look at it from an engineering and technical point of view. Therefore, these researchers presented three approaches to defining its concept, as concurrent engineering is viewed as an administrative philosophy, or Technology, or a multi-functional work team. These approaches can be clarified according to the opinions of some researchers through the following Schedule:

Schedule (1)

The concept of concurrent engineering, according to the opinions of some researchers

NO.	Entrance	Source	The concept
1	Administrative Philosophy	(Hambail,et,al,2009:9)	It is sometimes called concurrent engineering, integrated engineering, or product life cycle engineering, life cycle engineering, as it is more of a philosophy than a method, and it was initially proposed as a way to reduce product development time. Later, it was noted that applying (CE) leads to reducing costs, achieving savings in product development time, and improving its quality (CTQ) if all design activities are implemented in a parallel manner. However, employing (CE) was not easy, especially with its increasing popularity, which led to Diversifying in its application, the principles that define CE have become more ambiguous and since the CE approach is sometimes costly in the short term, it requires resources and levels of commitment that may not currently be available.
2	Technique	(Al-Zamili, 2017:71)	It is a technology that focuses on a set of tools and methods through which design and development processes can be carried out in parallel or simultaneously by taking advantage of all the information available along the value chain, in addition to the possibility of applying it in manufacturing, assembly and marketing processes through the formation of a multi-functional work team that develops a plan. Creating an event aimed at achieving savings in time and cost while maintaining an acceptable level of quality, in addition to providing sufficient flexibility to respond to any changes in the needs and desires of customers.
3	team work	(Krajewsli,et,2016:570)	A concept that brings together production engineers, process engineers, design engineers, marketers, buyers, quality specialists and distributors and work together to design a product or service and the necessary processes for it, which meets consumer expectations.

Therefore, we can say that concurrent engineering is only one of the tools that work to develop products with high quality, lower cost, and in a shorter time by forming a multi-functional work team that works to achieve goals along the value chain, starting from the research and development stage to the after-sales and customer service stages. , preserving the environment and recycling products, and then there is a need to follow a new integrated process towards designing and providing another initial process in order to overcome difficulties and problems.

2.1.2 The Dimensions of Concurrent Engineering

Many researchers have discussed the simultaneous engineering technique and its dimensions since its appearance, as its simultaneity was limited to only two dimensions, which are after designing the product and after designing the production process. Because of the many benefits that this technology has provided since its inception to economic units, researchers sought to develop this technology by adding... A third dimension to it, which is the supply chain dimension, and the synchronization of this dimension has added a lot to this technology and recently there have been signs of adding a fourth dimension to synchronous engineering, as Al-Falahi (2019) is the first to address adding the dimension of product sustainability to the dimensions of synchronous engineering, as A fourth dimension, which is integrated and works with the other three dimensions (product design, process, and supply chain) in conjunction to achieve competitive advantages for economic units, and the dimensions were as follows:

2.1.2.1 The first dimension: **Product Design**

Product design is strategically important because every business needs a long-term vision or plan. The company's business strategy must support product designs, and be keen on customer participation in product design decisions in order to suit the preferences and needs of the customer group that targets the company's business strategy on the one hand, and to maintain a solid base. Its customers and its position in the market on the other hand (Daoud, 2016:189) The function of product design is to determine its specifications, including strategic and tactical activities through generating ideas for marketing. (Luchs &Swan,2011:330)

The most important aspects of product design that are focused on are (product characteristics, and product cost) and will be discussed below:

***First**: Product characteristics*

(Gubi & Heikkila) state that product characteristics are among the main factors when designing products, (Gubi & Heikkila 2003:8), while (Akinci) stated that economic units can reduce uncertainty about the success of a new product, and reduce risks by making the right decisions in The different stages of the new product design process, and the ability of these units to make the right decisions depends on taking into account the success factors of new product development. One of these important factors is cooperation with customers, especially those who are referred to as major users of the product (the target group for distributing the products of the economic unit). Technological innovations and functional expertise are combined to develop new products that meet customers' constantly changing needs to achieve a competitive advantage over their competitors. (Akinci, 2018:262)

2.1.2.2 The Second Dimension: **Process Design**

Process design requires identifying all activities required to implement production systems in the economic unit, including manufacturing methods, technology, equipment and human resources involved in the manufacturing process. Thus, it is the process through which a framework or form is established for the resources and activities that constitute the product with all its parts and components to satisfy The functional requirements required to transform raw materials into finished products (Kumar & Suresh2009:23), and in light of the simultaneous engineering technique, an attempt is made to determine the activities that can be carried out simultaneously while selecting the required human and material resources, whether they are specific to design processes or manufacturing and assembly processes (2006: 144,.Sapuan,et.al).

2.1.2.3 The third dimension: **supply chain design**

(Hataminezhad)defines the integrated supply chain as an organizational process for integrating suppliers, customers, and internal operating units to improve the overall performance of all partners in the supply chain. He points out that it reduces uncertainty in integrating the supply chain and increases demand control in business operations. In addition, Integrating the supplier and the customer, with a focus on internal integration, leads to product development using interactions such as functional coordination and multi-functional teams, which reflects on improving interaction and cooperation in economic units and confirms that the first principle in today's business world is to create value for customers and that achieving this will not be achieved This is possible only through the economic unit's operations and its supply chain (Hataminezhad, 2019:120).

(Atakulu, et.al) confirms that supply chain management is a necessary concept for manufacturing economic units, as it deals with the coordination and integration of the interactions of cooperating partners to achieve products. Product architecture is important to integrate these interactions as it is usually established in the early stages of product development (Atakulu,et.al,2019:79).

2.1.2.4 Fourth dimension: **product sustainability**

(Gungora & Gupta) state that environmental manufacturing has become a commitment to the environment and society itself and is implemented primarily through government regulations and customers' perspectives on environmental issues (Gungor & Gupta 1999:812). Many researchers have discussed the concept of environmental sustainability and its benefits to the economic unit when applying this concept. (PIL & ROTHENBERG) states that superior environmental performance can translate into broad improvements in organizational results, and this was proven through a study of economic units in the Standard Index, where it was found that efforts to reduce emissions were significantly linked to increased operational performance after one year, and increased Financial performance after two years, in addition to environmental performance leading to excellent financial market results in the form of positive stock returns (PIL & ROTHENBERG 2003:405). Gungora & Gupta indicate that the main objectives of waste management are to reduce waste at the generation source by using appropriate materials, equipment and techniques, and to reuse And recycling waste, and finding better ways to treat waste, by keeping disposal as a less desirable option (Gungora & Gupta1999:836). This dimension focuses on two basic paragraphs, (which are that the product should be environmentally friendly, and the possibility of recycling) as follows

***First** : The product must be environmentally friendly*: Chang & Shen states that the excessive use of natural resources resulting from rapid economic growth has harmed the environment and raised many environmental concerns. To conserve energy and reduce carbon emissions, many countries established ecological regulations to comply with new environmental regulations, so economic units had to adopt environmentally friendly practices (Chang & Shen, 2019:1690).

***Second:** Possibility of recycling*: (Gungor & Gupta) state that recycling is carried out to recover the physical content of used and non-working products, and it is mainly driven by economic and regulatory factors. He points out that environmentally conscious manufacturing units are developing methods to manufacture new products, starting from conceptual design through final delivery and ultimately to final disposal so that environmental standards and requirements are met. Product recovery, on the other hand, aims to reduce the amount of waste sent to landfills by Recovering materials and parts from old products or through recycling and remanufacturing (Gungor & Gupta, 1999:812)

2.1.3 Phases for Implementation of Concurrent Engineering Technique

The stages of implementing concurrent engineering are integrated with different types of stages and concepts in order to implement these stages, and these stages can be explained as follows: (Rihar, et.al 2020:5) (Fateeh, 2017:688).

*2.1.3.1 The first stage: preparation and readiness: **Setup phase***

At this stage, the introduction of the proposed methodology of concurrent engineering into the company requires a suitable climate or starting conditions, which must be achieved in the company itself. The first and most important step for the introduction of the proposed business concept in the company is the decision of the top management that such an approach to product development is part no Integral to the company's business strategy.

2.1.3.2 The second stage: ***Design phase***

At this stage, the idea of an open office is adopted, as is the case in Japanese companies, so that team members can see what others are doing. This stage is considered essential for this technology, as through it actual integration takes place between the concurrent engineering work team, the work environment, and the expertise of specialists in the economic unit.

2.1.3.3 The third stage: ***Post-Design Phase***

It includes documentation of design activities and the outputs of design sessions that translate the alternation between technical requirements, customer requirements, and other information. This stage is considered a continuous improvement of the design process for both the product, the process, and the supply chain. Through this stage, the appropriate design will be determined from the engineering, technical, and cost standpoints. Recommending its application in the next stage, meaning that the design that can achieve the best engineering and technical results, with high quality, best functional performance, and incur the least amount of costs will be tested.

2.1.3.4 The fourth stage: ***Transition to Production Phase***

After the final design has been approved during the previous stage, it is moved to production; that is, in this stage, manufacturing and assembly operations are carried out simultaneously while adhering to the design that was approved to achieve sustainable (CE) goals related to cost, time, flexibility and quality, with a commitment to the process of continuous improvement, which will be reflected in a positive way. Positive on production development processes (Al-Zamili, 2017: 83-84).

The third topic: The applied side

The practical aspect of this research will be conducted in the Kufa cement factory affiliated with the General Company for Southern Cement, one of the industrial companies affiliated with the Iraqi Ministry of Industry and Minerals. This research will refer to a description of the community in which the research is applied, as it includes a definition of the General Company for Southern Cement and its organizational structure. The stages through which production passes Accordingly, the study will be divided into several paragraphs, as follows:

3.1 Introducing the research sample and the nature of its activity

3.1.1 An introductory overview of the Kufa Cement Factory

It is considered one of the largest and largest Iraqi factories and is linked to the General Company for Southern Cement, which is affiliated with the General Company for Iraqi Cement, one of the companies of the Ministry of Industry and Minerals. It is a self-financed, productive economic unit whose ownership is due to the state and enjoys financial and administrative independence. It is located in Najaf Governorate - Kufa District - Karamiya. The factory was established. Kufa Cement from the Danish company F.L.S in 1977 at a cost of (63,233,506) dinars. It consists of four production lines and a design capacity of (1,781,000) tons of cement annually. The design capacity of each line is (1,500) tons per day. The factory operates using the wet method, which is characterized by its lower impacts compared to Dry, and its most important products are Portland cement resistant to sulfuric salts, with a design kiln capacity of (1,728,000) tons of clinker annually. It produces cement according to Iraqi specifications No. 5 of 1984, which made it obtain the Iraqi quality certificate according to Ministerial Order No. (6001) of 8/19/2010 issued. From the Ministry of Planning and Development Cooperation, which relies mainly in issuing its specifications on European specifications, and this product is considered high quality, and this has made the demand for the factory rise continuously, whether from the public sector or the private sector and despite the changes that Iraq witnessed following the events of 9/ 4/2003, most notably the openness of Iraqi markets to global markets and the increased intensity of competition, which negatively affected Iraqi products in terms of demand for them. The production of the Kufa Cement Factory continued, but in fluctuating quantities that did not reach the planned level of production in 2017, which witnessed an increase. Cement production was so great that it exceeded what was planned for that year as a result of the high quality of the product. The following table shows the design capacity, available energy, planned production, and actual production of the factory as follows:

Schedule (2) Designed and available capacity and planned and actual production of the Kufa Cement Factory (2021/2022)

Year	Design energy (ton)	Available energy (ton)	Planned production (ton)	Actual production (ton)	The ratio of actual production volume to		
					design	Available	Scheme
2021	1,781,000	950,000	820,000	661,178	37%	70%	81%
2022	1,781,000	950,000	820,000	729,310	41%	77%	41%

Source: Prepared by researcher based on the reports of the production department

The table above shows that the design capacity is the ability of the Kufa Cement Factory to produce large quantities of cement if it harnesses its potential and production capacity, while the available capacity represents the number of units that can actually be completed according to the provision of the specified numbers of materials, workers and machines, as well as taking into account cases of damage and delay in Production, and planned production is the planning of the process of manufacturing production units in the Kufa Cement Factory, while the actual production is the amount of actual production in the Kufa Cement Factory, as the ratio of actual production to planned production for the year 2021 reached 81%. This percentage is good for the Kufa Cement Factory, but in the year 2022 the percentage increased. Production increased to 89% compared to 2021

3.1.2 Stages of the cement production process in the factory (the place where the research is applied)

The cement industry is considered one of the important industries in all countries, whether developed or developing, as it is directly related to construction work. Cement is used to form strong building materials that are resistant to normal environmental pollutants. The cement industry consists of mixing limestone, ordinary dirt, iron dust, and sand, and mixing all of these materials with water. To form a substance called paste, which is heated at a temperature sufficient to react and produce clinker, and is mixed in the final stages with gypsum to produce resistant cement. There are two methods for producing cement: dry and wet, and the factory uses the wet method, in order to implement cleaner production, and the nature of the resulting waste and emissions must be understood. Regarding the stages of cement production, the cement product goes through several production stages, which are as follows:

1. **The stage of crushing and preparing the raw materials**: The raw materials are prepared, whether by blasting or otherwise, to obtain the raw materials such as limestone, ordinary dirt, and gypsum stone that makeup cement. These materials must be according to certain specifications because they are reflected in the quality and quantity of the product, and then these materials are transported. The materials are transferred to special warehouses to be transferred to the next stage.
2. **The raw materials grinding stage**: In this stage, the raw materials (limestone, dirt, and gypsum stone) are ground with a ratio of (70%) stone and (30%) clay, using special mills for this purpose, and since the factory uses the wet method in manufacturing production Cement: Water is added at a ratio of (3:1) in special huge basins to produce the clay material, which is the output of this stage and is subject to laboratory examination before being transferred to the next stage.
3. **The burning and cooling stage**: This stage includes burning the raw materials (previously ground) in ovens designed for this purpose at a temperature of (1500-1400) Celsius, and gradually includes roasting and heating in order to burn the raw materials to cause the necessary reactions to produce clinker (the semi-finished material). Manufactured), which is in the form of small granules, and then the clinker is cooled and broken to be stored in silos in preparation for the grinding and packing process. The outputs of this stage of clinker are subject to examination in order to ensure that its quality is maintained.
4. **Grinding stage**: This stage includes grinding the clinker material with gypsum at a rate of (3%) to reduce the speed of cement hardening when used. This is done using mills consisting of a metal tube containing a number of steel balls of certain diameters, and thus the product is finished, provided that It undergoes laboratory testing before packing to verify its quality.
5. **Packaging stage**: This stage includes storing the cement in silos, where packing is done in bags designated for this purpose using a packing device. The capacity of each bag should be (50) kg, or it should be transported to cars directly as solid cement without using bags to be marketed.

3.2 Application of Four-Dimensional Concurrent Engineering Technique in the Kufa Cement Factory

This research aims to apply the Four-Dimensional Concurrent Engineering Technique in light of the strategic approach to cost management in the Kufa Cement Plant. Therefore, this research will review the application of the four-dimensional concurrent engineering technique in light of the strategic approach to cost management in the Kufa Cement Plant regarding the data for the fiscal year 2022.

This application requires two main stages, which are as follows:

1) The preparation stage for the study.

2) The stage of applying the Four-Dimensional Concurrent Engineering Technique.

The three stages can be explained through the following paragraphs:

3.2.1 The first stage: **preparing for the study**

The first stage of applying the Four-Dimensional Concurrent Engineering Technique in light of the strategic approach to cost management in the Kufa Cement Plant is the data for the fiscal year 2022, and this stage includes the following steps:

First: Forming a concurrent engineering work team:

The application of CE technicians in the Kufa Cement Factory requires the formation of a multi-functional team of workers in this factory consisting of specialists in the field of management, cost accounting, design engineering, manufacturing and assembly engineering, maintenance engineering, operations management, production management, purchasing and sales. The researcher expressed their opinions on applying these two techniques and achieving interrelation between them.

Second: Preparing the study plan:

The study plan is prepared after identifying the problem that the Kufa Cement Factory suffers from, which is the high costs of the cement product and sagging functionality in addition to the obsolescence and obsolescence of the equipment used in production, in addition to its exposure to intense competition. Therefore, an appropriate business plan must be prepared that is flexible enough to prepare the appropriate ground for Applying simultaneous four-dimensional engineering technology through redesigning the product, taking into account the processes of designing, manufacturing, and assembling the product simultaneously to solve this problem. The plan includes a number of matters, namely: determining the components and functions of the product that the customer desires and that are compatible with his needs and desires, as well as determining the appropriate methods for each of the design, manufacture and assembly of the product, as well as reviewing previous designs and current manufacturing and assembly methods for the product. The work plan must also include Information about the cost and time of operations before realizing this application, and determining the date for implementing the plan after distributing tasks among members of the cross-functional team, and this is done by preparing a specific schedule.

3.2.2 The second stage: **applying the Four-Dimensional Concurrent Engineering Technique Kufa Cement Factory**

During this stage, the four-dimensional concurrent engineering technique will be applied in order to design the product, the production process, the supply chain, and the product's sustainability design according to a set of steps that can be carried out simultaneously. These steps can be clarified through the following four dimensions of the concurrent engineering technique:

The first dimension: after designing the product

After the formation of the synchronous engineering team at the beginning of its work, the design engineers in the team begin to request the functional characteristics, necessary for the design based on the customer's desire, in order to build a design based on these characteristics. Product design is the first dimension of concurrent engineering, and the design department in particular must work to develop new technical design specifications of high efficiency and quality. In order to ensure that the economic unit (the subject of research) remains under investigation and that work continues in the competitive market, in addition to supporting the reality of the national economy and strengthening the industrial sector, in this dimension, the focus is on two main paragraphs, which are the functional characteristics and determining the cost and the idea and specifications for developing the product, and these two will be clarified. The two paragraphs in detail are as follows:

A- *Functional characteristics of the product:*

The successful design of any product is to satisfy customers' wants and needs. Therefore, the main focus of design engineers is on the functional characteristics that will be included in the cement product, enabling the economic unit to survive and continue in the competitive environment. The presence of customers, sales agents and distributors in the concurrent engineering team reduces The time required to obtain these characteristics, and in particular, the researcher asked dealers and agents selling the cement product about the possibility of their presence within the concurrent engineering team, and they liked this idea, especially in the economic units with which they deal. It takes design engineers a long time to obtain these characteristics in order to cover the market with a distinctive product, so it is necessary to have customers who are represented by (importers of the cement product, ordinary customers, or sellers of cement and its derivatives), so the presence of these members in the team will lead to:

- Reducing the cost of obtaining the functional characteristics desired by customers
- Reducing the time it takes to obtain these properties

To know how to reduce the cost of obtaining these characteristics, the economic unit when it pursues the traditional method (the sequential process, or if the design engineers want to know the functional characteristics, they will need to form a team to study and investigate similar products on the market and what their functional characteristics are, costs are also charged These teams, in addition to hindering design engineers from performing their duties within the economic unit, are due to their presence within the research and investigation teams. On the other hand, when customers are among the team, obtaining the customer's desires does not result in any cost compared to the research and investigation teams.

In terms of how to reduce time, the presence of customers within the team reduces the time it takes to obtain the functional characteristics that the customer desires, as the survey team will take time to obtain this information. Under the current paragraph, the researcher conducted a survey questionnaire for (50) customers in order to obtain The most important functional characteristics desired by customers that meet their needs. Through the discussion conducted by the researcher with the design engineers in the economic unit about the time spent developing the product design, it was found that surveying products similar to the cement product in the market takes about 14 days, and determining the most important functional characteristics that meet the desires. Customers, then develop an appropriate design that meets these desires.

Schedule (3)

Unpacking the contents of the questionnaire regarding the importance of customer requirements for the cement product

NO.	Customer requirements	very important (5)	Important (4)	Somewhat important (3)	Not important (2)	Not important at all (1)
1	price	28	15	7	-	-
2	color	-	7	16	27	-
3	Resistant to sulfates and salts	40	9	1	-	-
4	Moisture resistance	33	11	6	-	-
5	Cohesion strength	25	19	6	-	-
6	Bag durability	20	12	10	8	-
7	Availability of agents and distributors	15	18	14	3	-

Source: Prepared by researcher based on the results of the questionnaire (Appendix)

The questionnaire consists of two axes. The first axis covered the main functional characteristics of cement products in the Iraqi markets and their importance to customers. The second axis included the impact of the cost of adding these functional characteristics to the design of the cement product. As for the paragraphs related to the first axis, the researcher collected, through a market survey, a number of technical specifications for different models of cement products produced by different economic units. After reviewing the specifications of products similar to the cement product, it was presented to engineers specialized in the field of the cement industry. In light of those specifications, the questionnaire was formulated to find out the opinions of customers and what requirements the customer desires for the cement product more than others. The following are the requirements of customers:

Schedule (4)

NO.	Customer requirements	weight	Relative importance	Ranking
1	price	221	15.6%	3
2	color	130	9.1%	7
3	Resistant to sulfates and salts	239	16.8%	1
4	Moisture resistance	227	15.9%	2
5	Cohesion strength	219	15.3%	4
6	Bag durability	194	13.6%	6
7	Availability of agents and distributors	195	13.7%	5
	Weighted sum	1,425	100%	

Source: Prepared by researcher based on Schedule data (3)

It is also clear that customers prefer cement that is resistant to sulfates, salts, and humidity, as well as the price, to a significant degree, as these requirements were of the highest relative importance out of the customer's total requirements. The requirement to resist sulphates and salts came in the highest degree among the requirements, with an amount of (16.8%) and was ranked (1).) in meeting the desires of customers, and this indicates that the customer's focus is on the cement product not absorbing salts and being affected by them.

B- *Determine the cost, idea, and specifications for developing the product:*

During this step, the cost, idea, and specifications for developing the cement product will be determined based on the needs and desires of customers and the changes that may occur to them. Accordingly, some additional functions will be introduced to this product, through which the value of the product can be maximized from the point of view. From the perspective of both the factory and the customer, knowing that these functions are consistent with the needs and desires of customers and what the competitive market imposes, and with the help of the opinions of the design engineers and technicians at the Kufa Cement Factory, the following materials were proposed to improve the characteristics of the cement product in question:

1. **Glass powder**: Adding glass powder can affect the hardening property and cohesion of the cement mixture.
2. **Nanoclay**: Adding nanoclay to cement can improve its mechanical properties such as compressive strength, flexural strength and tensile strength.

The first step: product design specifications

The Kufa Cement Factory has a typical production capacity, as it produces one type of cement, which is salt-resistant cement, which consists of (clinker + gypsum). The ratio of lime saturation coefficient is approximately equal to (0.95). Accordingly, it is high-purity gypsum, with the sulfate purity reaching 40%. The application of the simultaneous engineering technique is limited to the salt-resistant cement product. Schedule (5) shows the cost of one unit of the salt-resistant cement product for the year 2022 through the following:

Schedule (5)

NO.	Cost element	Cost per ton / in dinars
	The first element: direct costs	
	First: raw materials and direct materials	
1	limestone	3,403
2	Ordinary dirt	764
3	Iron dust	5,807
4	sand	487
5	Gypsum	231
6	Clinker	8,641
7	Fuel and oils	13,305
	total	32,638
	Second: Direct work	
1	Workers' wages	41,287
	Total direct costs	73,925
	The second element: indirect industrial costs	
1	Water and electricity	5,916
2	Maintenance Services	2,736
3	Renting fixed assets	1,805
4	Spare tools	9,267
5	Extinctions	10,248
	Total indirect industrial costs	29,972
	Total industrial costs per ton for salt-resistant cement	103,897
	The third element: marketing costs	
1	Packing materials	-
2	Advertising, printing and hospitality	35
3	Miscellaneous	887
4	Staff equipment	182
	Total marketing costs	1,104
	Fourth element: administrative costs	
1	Research and consulting services	2
2	Transport, imports and communications	1,924
3	Miscellaneous service expenses	158
4	Transfer expenses	399
5	Other expenses	131
	Total administrative costs	2,614
	The total cost per ton of salt-resistant cement	107,615

Source: Prepared by researcher based on the financial statements for the year 2022 (appendix)

During this step, the needs and desires of customers are translated into engineering and technical specifications that can be measured quantitatively, thus facilitating the process of comparing them with competitors or with the previous model of the product. Depending on the experience of the design engineers at the Kufa Cement Factory, the needs and desires of customers can be translated into a set of engineering and technical specifications, which are as follows:

1. The use of glass powder enhances the hardening property and cohesion of the cement mixture.
2. Using nano-materials (nano-clay) to increase hardening, mechanical durability, flexural strength and tensile strength.
3. The use of nano-silica can enhance its strength and early compression resistance, accelerate the initial and final setting times, reduce its permeability, and improve its resistance to chemical attacks.

Step Two: Basic (Conceptual) Design

To design the product, the cement product consists of a group of components that were previously mentioned, as no changes were made to them in general, and these components are: (clinker + gypsum), and the other components, with a proposal for a group of functions that were indicated in the first step. Among the steps in applying the simultaneous engineering technique, as for the process design, the most important stages of the production processes that this product passes through have been identified through a group of divisions, namely: the quarry, the conveyor, the material mills, the kilns, the cement mills, and the packaging. The production team must take into account synchronization. In manufacturing and assembly operations according to the proposed design in order to help achieve additional savings in both cost and time.

Step Three: Detailed (physical) design

During this step, the cement product is designed in detail, as the focus is on designing the functions and proposals for this product that were proposed in the first step of applying the (CE) technology. The detailed design of the product in question can be clarified through the following:

1. **Design the necessary components to enhance the hardening property and cohesion of the cement mixture**

In order to take into account the economic conditions that the customer is going through and to provide a product at the lowest cost, the design of the cement product will be reconsidered by adding glass powder taken from waste to the salt-resistant cement, meaning that the glass powder will compensate for some of the components present in The current cement, which will be abandoned, is replacing the gypsum used with less expensive bagged gypsum, and also reducing the amount of iron dust by 30%, as well as dispensing with half the purchased quantity of imported clinker, and then an advanced product will be obtained at the lowest costs. The following table shows the cost of raw materials for cement after adding glass powder, noting that the amount of glass powder was 54,000 tons at a cost of 5,000 dinars/ton.

Schedule (6): Cost of raw materials for cement after adding glass powder

NO.	Cost element	
1	limestone	3,403
2	Ordinary dirt	764
3	Iron dust – 30%	4,065
4	sand	487
5	Bagged gypsum (-61 d)	170
6	Clinker (-50%)	4,320
7	Fuel and oils	13,305
8	+Glass powder	5,000
	total	31,514

Regarding the hardening property and consistency of the cement mixture, the researcher used the glass powder used, which is glass waste that is collected, purified from impurities, dried, and ground in a hand tool (mortar). After that, the glass powder is mixed with the cement at a ratio of (0.02) by weight of the cement. This ratio was chosen. Of the glass powder added to prepare the cement mixture, because it is the most positive percentage as it affects the hardening property and cohesion of the cement mixture, as shown in the following Schedule:

Schedule (7)

Additive ratio	0	0.01	0.02	0.03	0.04	0.05
Initial hardening time (min)	108.5	107.5	76.5	101.5	83.5	83.5
Final hardening time (min)	135	125	95	115	110	115

We notice from the table above that the hardening times vary according to the percentage of glass powder added and that the most appropriate ratio, with the shortest hardening times, is at the ratio (0.02), where initial hardening is achieved with a time of (76.5) minutes and a final hardening time of (95), and these are The ratio with the shortest hardening time compared to the ratios mentioned in the table

Therefore, this can achieve the following benefits:

A. **Achieving cost savings of 1,124 dinars/ton (32638-31,514).**
B. **Improving the hardening property and cohesion of the cement mixture**

2. **Design components to increase hardness, mechanical durability, flexural strength, and tensile strength**

For the purpose of achieving the function of increasing hardening, mechanical endurance, flexural strength and tensile strength, the use of nanomaterials (nanoclay) is required. This technology focuses on how to improve the mechanical properties of concrete based on Portland cement with nanomaterials such as nanosilica and graphene for building applications. Adding these nanomaterials to concrete mixtures will give better mechanical properties and resistance to nano applications.

As the strength of concrete improves with nano properties. The compressive strength of Portland cement increases up to 18%, as it is suggested that coating materials based on nanomaterials are better than traditional coatings, and coating materials with self-cleaning properties can be prepared using different metal oxides such as (TiO_2 nanomaterials). The amount of nanomaterials per ton of cement has reached 5 kg, bearing in mind that its actual cost is 1,300 dinars, and this achieves the following:

1. **Increased hardness, mechanical durability, flexural strength and tensile strength**
2. **The use of nanotechnology in concrete enhances its durability, plasticity and flowability.**
3. **There is an increase in the cost by 1,300 dinars per ton**

The second dimension: design of the production process

Designing the production process and synchronizing it with the product design of the industrial economic unit is the essence of every business activity because the management of the economic unit bears the responsibility of focusing on the design of the production process because it can apply a number of strategies that help reduce business risks. In the age of speed and technology, in particular, time is the essential element to keep up with today's intensely competitive environment. This dimension of simultaneous engineering is focused on designing the production process to carry it out simultaneously. The design is done for both manufacturing and assembly so that homogeneous activities can be carried out simultaneously. This requires identifying the most important stages that the manufacturing and assembly of the cement product goes through, and they have been recognized with a set of stages, which are: Quarry, conveyor, material mills, kilns, cement mills, and **packaging**. After that, the design team works on proposing a design for manufacturing and assembly based on the simultaneous performance of homogeneous activities. The production team must carry out manufacturing and assembly operations simultaneously according to the proposed design, It is necessary to adhere to a number of things, which are as follows:

A- Preparing the raw materials represented by extracting and quarrying limestone from the quarries located in Bahr al-Najaf and crushing it through crushers that are the basis of the cement production industry. Also preparing the other components and arranging them in the factory's stores in a way that makes them quickly exit the production lines for manufacturing purposes.

B- The dirt is transported by the contractor and then it is compacted and mixed with water to form the clay material and mix it well with the stone inside the mills in order to facilitate the process of burning it.

C- Burning the raw materials after grinding and mixing simultaneously in a rotary kiln to produce clinker in order to carry out the assembly and manufacturing operations of all parts simultaneously.

D- Inspect and test the product once and for all and transfer it to complete production warehouses.

E- Marketing the product to the customer

From a cost standpoint, the following important question arises: How much savings can be achieved by simultaneously manufacturing and assembling the product under study? Based on the opinions of the design engineers and the manufacturing and assembly engineers in the laboratory, two important matters were reached, which are as follows:

A. Synchronization in manufacturing and assembly processes can lead to significant savings in time and associated costs, as indirect wages, energy costs, spoilage costs in some materials, etc. can be reduced, in addition to achieving the required quality in the production process.

B. Synchronization in manufacturing and assembly processes leads to a reduction in indirect industrial costs by 15%, according to the following Schedule:

Schedule (8) Reducing indirect industrial costs resulting from the synchronization of manufacturing and assembly processes

Data	Details
Indirect industrial costs before application	29,972
Reduction rate	15%
Indirect industrial costs after application	25,476
Amount of reduction	4,496

That is, these costs will become 25,476 dinars/ton (29,972 x 85%) after they were 29,972 dinars/ton. This means that the amount of reduction in these costs will be 4,496 dinars.

The third dimension: supply chain design

The supply chain design dimension is no less important than the first and second dimensions (product design, production process design), and apart from simultaneous engineering, there is a lot of research and studies that emphasize the importance and role of the supply chain.

The importance of the supply chain lies in the great interest of a number of parties, whether they are internal parties, such as (suppliers of raw materials or semi-manufactured parts), which the economic unit needs in the manufacturing process, or external parties, who are represented by (agents and customers). (Wholesalers who will receive finished goods from the economic unit), the presence of suppliers within the simultaneous engineering team facilitates the work of design engineers and the work of members responsible for the production process, which makes it easier for management to make many decisions. The presence of suppliers within the engineering team who have sufficient information about the materials required for the economic unit will also lead to improving the design of new products or adding modifications to the product. This information is considered an input into the design of the product or the production process, which makes it necessary for the factory management to include these parties in the simultaneous engineering dimensions at an early stage, as this will lead to coordination and cooperation between these dimensions, as well as filling the information gap in some parties, which reduces Imbalance between product characteristics and production capacity. The information that suppliers have is of great importance. If, for example, we want to add a certain substance that makes the product more resistant to sulfates, it represents the most important needs of

customers. As indicated by the results of the questionnaire, resistance to sulfates was more important, which means that adding This material is in accordance with the decision of the quality engineers, in addition to that there is no problem in the production process when adding this material. If it becomes clear that this material, through the supplier's information, has high prices, this will be reflected in the cost of the cement product, or that the locations of these materials Far from the location of the manufactured economic unit, which requires additional time, and thus delays the time for products to enter the market and increases the possibility of losing part of the market share of the economic units. If all this information is unavailable during the design process, it may lead to redesigning the product and choosing Other materials. We conclude from this that the presence of a supplier within the concurrent engineering team plays an effective role in arriving at the required design in a timely manner.
A comparison is made between the glass powder component used in the product, in the case of purchasing or recycling solid waste, as follows:

Schedule (9) The cost of the glass used in the product

Details	Quantity	In case of purchase	In case of using glass waste	the difference
Quantity of glass	Tons	54,000	54,000	-
Price of a ton of glass	Iraqi Dinar	45,000	5,000	40,000
Total cost		2,430,000,000	270,000,000	2,160,000,000

It is noted from Schedule ( ) that the cost of purchasing glass material per ton is high, as the researcher believes that if glass waste is used, this will save (2,160,000,000) dinars per economic unit (research sample), in addition to reducing the amount of large environmental pollutants that affect the environment of industrial facilities as a result Accumulation of this waste.
The fourth dimension: designing product sustainability
The design dimension of product sustainability is an important dimension of the concurrent engineering technique, as the members of the concurrent engineering team focus on two basic paragraphs: (**that the product is environmentally friendly, and that it can be recycled**). These two paragraphs will be addressed in the following:
First: The product must be environmentally friendly
A green, environmentally friendly product is any product that is designed and manufactured according to standards designed to protect the environment and reduce the depletion of natural resources while maintaining functional performance characteristics. In addition, the environmentally friendly product is not required to be completely new, but rather there are a number of additions to the regular product to come closer to achieving the desired goal of reducing the materials used and the level of the product's negative impacts on the environment.
This requires adjustments at the level of production stages, as cement companies are currently working on this point, using engineering techniques to re-engineer the cement industry, in addition to adding (solid waste to cement, which leads to a reduction of approximately 900 kg of carbon dioxide gas) Co2) because it contains a high percentage of magnesium oxide (Mgo), and thus the environmental design after addition is called green cement.
A number of pollutants are formed during the manufacturing process in the Kufa Cement Factory. These pollutants have an impact on the community and the environment surrounding the site, which leads to additional costs. Environmental pollutants in the Kufa Cement Factory can be explained through the following:
1. Sediment (solid waste)
Solid waste is formed during the burning stage of clinker production, as a result of the adhesion of the paste to the walls of the kiln, as well as around the steel balls inside the kiln, in the form of fossilized layers. The quantity and cost of solid waste can be clarified according to the following Schedule:

Schedule (10) Quantity and cost of sediments in the Kufa Cement Factory for the year (2022)

Production stage	Amount of sediment (tons)	Cost per ton within this stage (dinar/ton)	Sedimentation cost (dinar)
Burning stage: putty	68,083	30,833	2,099,203,139

Source: Prepared by researcher based on data from the Sedimentation Division
2. Flying dust:
Flying dust is formed at every stage of production, and it occurs in three stages, which are as follows:
A. Grinding raw materials: The percentage of dust was estimated at 6% of the materials entering the mills, for the production of paste. This percentage was determined based on the reports of the Production Division, and that this percentage represents the environmental loss from the total quantity of raw materials.
B. Burning the paste: Dust is produced from the clinker-making process and is estimated to be 2.8 percent of the paste percentage during the burning of the paste. The Sedimentation Division determined the quantity of deposited dust, which amounted to 68,083 tons for the month of December accumulated for the year 2022.

C. Grinding cement material: Dust is produced at a rate of 3.6% of the amount of clinker and gypsum that enters the cement mills at this stage, and this percentage represents environmental losses based on production reports, and these percentages will be calculated as shown in the following Schedule:

Schedule (11): Quantities of volatile dust and deposited dust for the Kufa Cement Factory for the year 2022

NO.	Details	Quantity of tons (expense)	Flying dust percentage %	Quantity of flying dust and deposited dirt (tons)	Cost of flying dust (dinar)	The cost of one ton of flying dust (dinar)
1	The first phase Grinding raw materials:					
	Limestone	885,227	6%	70,109	937,357,330	1,285
	Ordinary dirt	175,639				
	Iron dust	35,574				
	Sand	71,670				
	Total	1,168,486				
2	The second phase: Burning putty:					
	Putty	1,168,110	2.8	32,707	1,008,454,931	1,383
3	The third phase Cement grinding:					
	Clinker	748,456	3.6%	27,912	646,497,744	886
	Gypsum	26,878				
	Total	775,334				
4	Total flying dust			130,728	2,592,310,005	3,554
5	Sediment soil			68,083	2,099,203,139	2,878
	Total flying dust and Sediment soil			198,811	4,601,513,144	6,432

Source: Prepared by researcher based on data from the Production Department, Sedimentation Division, and Environment Division

The previous Schedule represents the environmental costs represented by flying dust resulting from the cement production process in the Kufa Cement Factory, in addition to the dirt deposited during the production process.

The quantity and percentages of both dust and dirt deposited can be clarified in the following Schedule:

Schedule (12) Quantity and percentage of flying dust in the Kufa Cement Factory for the year 2022

Data	Details (tons)
The quantity of flying dust	130,728
Cost of flying dust	2,592,310,005
production quantity	729,310
Production cost	74,783,485,736
The ratio of the quantity of flying dust to the quantity of production	18%
Ratio of the cost of flying dust to the cost of production	3%

Source: Prepared by researcher based on the table (previous)

It is clear from Schedule () that there is an increase in the percentage of volatile dust compared to the volume of production, as the ratio of the amount of volatile dust to the amount of production is (18%). It should be noted that due to the corrosion of the precipitators, and not purchasing new precipitators, the percentage of the amount of volatile dust increased During the production process, which means that the laboratory (research sample) did not reduce the amount of flying dust during the manufacturing process, and also improved its environmental performance.

After completing the process of determining the quantities of volatile dust and sediments, which are among the main pollutants in the laboratory, the pollutants resulting from black oil and oils used in production that cannot be directly determined must be taken into account. The percentage of production volume will be determined in addition to the percentage of environmental wastes that have an environmental impact. As shown in the following equation:

Production ratio = quantity of production/quantity of production and waste

Percentage of environmental waste = quantity of waste (volatile dust and sediments/quantity of production and waste

These equations will be applied in the following table to obtain the results as follows:

Schedule (13) Production and waste ratios in the Kufa Cement Factory for the year (2022)

Data	Details
production quantity (ton)	729,310
Quantity of waste (dust and sediments) (ton)	198,811
Total	928,121
Production ratio	79%
Waste percentage	21%

As is clear from the table above, the percentage of waste in the Kufa Cement Factory is (21%), meaning that the materials used in the cement industry represent (79%) of the total production cost compared to the factory's production quantity. The high environmental cost is due to the lack of application of Modern technologies that help reduce environmental costs and rely on old methods after determining the quantities of volatile dust and sediments for the Kufa Cement Factory. Here comes the role of the simultaneous engineering technique and through the fourth dimension (the dimension of product sustainability), which made its most important basis is for the product to be environmentally friendly. This will indicate a reduction in the amount of these pollutants (flying dust and sediments) through the following equations:

The rate of reducing the quantity of flying dust after applying the Concurrent Engineering Technique = the quantity of dust residue / the quantity of production = 729,310 / 130,728 = 18%
The rate of reducing the quantity of deposits after applying the Concurrent Engineering Technique = the quantity of deposits / the quantity of production = 729,310 / 68,083 = 9%

It is clear from the above equations that the amount of volatile dust will decrease by (18%) for the cement product, while the amount of sediments will decrease by (9%). The amounts of decrease in both volatile dust and sediments for the Kufa Cement Factory will be explained through the following Schedule:

Schedule (14) Quantity of flying dust and sediments in the Kufa Cement Factory before and after implementing the engineering technique

Data	Details
The amount of flying dust before applying the concurrent engineering technique	130,728
The amount of flying dust after applying the synchronous engineering technique	107,197
The quantity of deposits before applying the Concurrent Engineering Technique	68,083
The quantity of deposits after applying the Concurrent Engineering Technique	61,956
The quantity of flying dust and sediments before applying the Concurrent Engineering Technique	198,811
The quantity of flying dust and sediments after applying the Concurrent Engineering Technique	169,153
The rate of reduction of both the quantity of flying dust and sediments after applying the Concurrent Engineering Technique	15%

Prepared by the researcher based on the data of the previous tables

It is clear from Schedule ( ) that applying the Concurrent Engineering Technique to the amounts of volatile dust and sediments will lead to a reduction in the quantity of volatile dust by (15%) and a reduction in the quantity of sediments by (15%). This percentage represents a reduction in environmental costs, which in turn will lead to Reducing environmental pollution and increasing the production of the Kufa Cement Plant compared to the quantity of dust and sediments before applying the Concurrent Engineering Technique. This reduction leads to increased environmental efficiency and improved environmental performance of the Kufa Cement Plant, which means it will lead to reducing pollution, reducing costs, increasing production, increasing the efficiency of the plant, and improving its reputation. Productivity and the environment as well, all this is done by reducing the amount of dust and deposits.

Second: Recycling the product

Glass recycling is the process of collecting and disposing of materials that become waste, then processing them into new products that benefit the environment and society in general. Solid waste is one of the largest environmental problems in the world and a source of environmental pollution, as it contributes significantly to the pollution of environmental elements, including soil, water, and air. Recycling solid waste also helps to avoid some economic unit costs, and the responsibility for redesigning the product falls on the members responsible for designing the sustainability of the product. Therefore, it is important to have these members within the concurrent engineering team, as the producer consumes (1,168,486) tons of raw materials to produce (729,310) tons. Schedule (15) shows the amount of cost that the economic unit can avoid when applied after the sustainability of the product.

Schedule (15)

Details	Quantity/ton	Cost / dinar
Raw materials used before adding glass powder	1,168,486	32,638

Raw materials used after adding glass powder	1,168,486	31,514
Total reduction after adopting recycling		1,124 dinars/ton

Prepared by the researcher based on the financial statements for the year 2022

The amount of reduction in product cost as a result of applying the simultaneous engineering technology for the year 2022 can be clarified based on the previous paragraphs, and through the following: -

Schedule (16)

NO.	Areas of reduction	Actual cost (dinar/ton) (1)	Amount of reduction for the item (dinar/ton) (2)	Cost after reduction for the item (dinar/ton) (2-1) = 3
1	Cost after adding glass powder	32,638	1,124	31,514
2	Cost of flying dust	3,554	640	2,914
3	Sedimentation cost	2,878	259	2,619
	the total	39,070	2,023	37,047

Prepared by the researcher based on the previous tables

In conclusion, reviewing the application of the four-dimensional Concurrent Engineering Technique in the economic unit that is the research sample (Kufa Cement Factory). This can be summarized in a unified report that discloses the competitive advantages achieved for the economic unit as follows :

Schedule (17) A unified report on the competitive advantages achieved from applying Four-Dimensional Concurrent Engineering Technique

Dimensions Of concurrent engineering	Competitive advantages	Financial data					Details
		Amount / dinar	Quantity	percent	time	number	
The first dimension (product design)	Knowing customers' desires	-	-	-	-	-	By conducting a field survey
	Reducing costs for the product	819,744,440	-	-	-	-	Through the use of solid waste
	Increased hardening strength and cohesion	-	-	2%	95-76.5	-	An initial hardening time of 6.57 minutes was achieved and a final hardening time of 95 minutes
The second dimension (Production process design)	Reducing indirect industrial costs	3,278,977,760	-	15%	-	-	By carrying out manufacturing and assembly operations simultaneously
	Improve product quality	-	-	-	-	-	By applying strategies and techniques that raise the level of product quality in less time
The third dimension (supply chain design)	Increase the number of means of transportation	-	-	-	-	21	From 54 to 75 means of transportation
	Increasing the number of factory customers	-	-	-	-	18	Cement products are in high demand by companies
	Reducing the cost of purchasing gypsum	44,487,910	-	-	-	-	By using gypsum plaster instead of regular gypsum
The fourth dimension (product sustainability design)	Reducing the risk of environmental pollution	-	-	-	-	-	By adding (solid waste) to cement, which leads to a reduction of approximately 900 kg of carbon dioxide gas (CO_2).
	Reducing the quantity and cost of dust	14,452,433	640	18%	-	-	
	Reducing the quantity and cost of deposits	188,928,283	259	9%	-	-	
Total		**4,346,590,826**	**-**	**-**	**-**	**-**	

Source: Prepared by researcher based on previous data

3.3 Results of applying Four-Dimensional Concurrent Engineering Technique and its role in reducing costs

After Four-Dimensional Concurrent Engineering Technique was applied in the Kufa Cement Factory based on the data for the fiscal year 2022 in the previous section, the role of this application in reducing costs will be explained in terms of reducing unjustified costs associated with the production stages that do not add value from the point of view of the factory and the customer.

3.3.1 The role of applying Four-Dimensional Concurrent Engineering Technique in reducing costs for the Kufa Cement Factory

After the four-dimensional simultaneous engineering technique was applied in the laboratory (research sample), it became clear that there are a group of effects on the cost of the product that can be explained through the following:

1. The cost of raw materials: It is noted that the cost of engineering characteristics through the first dimension (**product design**) after improvement became (22,983,475,340) dinars for total production and (31,514) dinars per ton after adding glass powder in the first proposal according to table ( ), and this means There is a decrease in cost by (819,744,440) dinars for total production and (1,124) dinars per ton.
2. Direct wages: - There has been no change in direct wages because the number of direct workers is sufficient without any increase and cannot be reduced.
3. Indirect industrial costs: Synchronization in manufacturing and assembly processes through the second dimension (**production process design**) leads to a reduction in indirect industrial costs by 15%, according to the following Schedule :

Schedule (18) Reducing indirect industrial costs resulting from the synchronization of manufacturing and assembly processes

Data	Details	
	per ton	Total cost
Indirect industrial costs before application	29,972	21,858,879,320
Reduction rate	15%	15%
Indirect industrial costs after application	25,476	18,579,901,560
Amount of reduction	4,496	3,278,977,760

That is, these costs will become 25,476 dinars/ton (29,972 x 85%) after they were 29,972 dinars/ton. This means that the amount of reduction in these costs will be 4,496 dinars.

Also, through the fourth dimension (product sustainability design dimension), the cost of flying dust and sediments in the laboratory (research sample) can be reduced, according to the following table:

Schedule (19): The amount of reduction in the cost of flying dust and sediments in the research sample

NO.	Areas of reduction	Actual cost (dinar/ton) (1)	Cost after reduction for the item (dinar/ton) (2)	Cost after Amount of reduction for the item (dinar/ton) (2-1) = 3	Total discount amount (Dinar)
1	Cost of flying dust	3,554	2,914	640	466,615,801
2	Sedimentation cost	2,878	2,619	259	188,928,283
	the total	6,432	5,533	899	655,544,084

The cost of the product can be compared before and after applying the Four-Dimensional Concurrent Engineering Technique through the following Schedule:

Schedule (20) The cost of the product before and after applying the Four-Dimensional Concurrent Engineering Technique in the Kufa Cement Factory

NO.	Details	Before applying Four-Dimensional Concurrent Engineering Technique			After applying Four-Dimensional Concurrent Engineering Technique		
		Total production cost (dinar)	Cost per ton (dinar)	Ratio to total cost (%)	Total production cost (dinar)	Cost per ton (dinar)	Ratio to total cost (%)
1	Direct materials	23,803,219,780	32,638	31%	22,983,475,340	31,514	32%
2	Direct wages	30,111,021,970	41,287	40%	30,111,021,970	41,287	42%
3	Indirect industrial cost	21,858,879,320	29,972	29%	17,924,251,870	24,577	26%
	Total	75,773,121,070	103,897	100%	71,018,749,180	98,277	100%

The fourth topic: Conclusions and recommendations

4.1 Conclusions

1. There is a possibility of applying Four-Dimensional Concurrent Engineering Technique in the Kufa Cement Plant in 2022
2. The Four-Dimensional Concurrent Engineering Technique was applied in the design phase and in the manufacturing and assembly phase of the cement product. Some additional suggestions and functions were introduced for this product, through which its value can be maximized from the perspective of the factory and the customer, knowing that these functions are consistent with the needs and desires. Customers and what the competitive market imposes, and these functions are:: enhancing the hardening property and cohesion of the cement mixture through the use of glass powder, and increasing the hardening, mechanical endurance, flexural strength, and tensile strength through the use of nanometric materials (nanoclay).
3. By applying the four-dimensional simultaneous engineering technique in the Kufa Cement Factory, the total cost of the cement product became (71,018,749,180) dinars, and when compared with the actual cost before application, it is noted that there are cost savings in the amount of (4,754,370,890) dinars, meaning that the reduction rate reached 6.3%. A set of results was achieved that would help the research laboratory reduce costs, and these results are as follows:

A. Through the first dimension (product design), cost savings in the amount of 819,744,440 can be achieved through the use of solid waste within the product characteristics.
B. Through the second dimension (production process design), synchronization in manufacturing and assembly processes leads to a reduction in indirect industrial costs by 15%, or by (3,278,977,760) dinars.
C. Through the third dimension (supply chain design), cost savings can be achieved in the amount of (2,160,000,000) dinars through recycling solid waste instead of purchasing from abroad.
D. Through the fourth dimension (product sustainability design), cost savings (655,544,084) dinars can be achieved by reducing the quantity of flying dust and the quantity of deposits.

4.2 Recommendations

1. The economic unit adopted the strategic approach to cost management through the use of cost and administrative techniques because they are more suitable for the rapid and successive changes accompanying the business environment, and they came in response to these changes, as through these techniques it is possible to provide the financial and non-financial information that management needs to assist in planning processes. Monitoring, decision-making, and evaluation of operational and strategic performance, in addition to accurately measuring the cost of operations, products, and services.
2. Applying concurrent engineering technology because it is an important tool for improving the processes of designing and developing products, whether existing or new, by creating channels of communication and effective exchange of information between all beneficiary parties, and studying the most important problems that accompany the processes of designing, manufacturing and assembling these products, as well as assisting in making decisions. Design with the help of its cross-functional, customer-focused team, in order to achieve savings in both cost and time and thus achieve competitive advantage.
3. The management of the economic unit, the research sample, focuses on the customer by conducting periodic market studies and research. In addition, suppliers and customers are involved in the process of designing and developing products, even indirectly, to produce products that are consistent with customers' needs, desires, and requirements, achieving their satisfaction and then their loyalty.
4. Working to introduce additional improvements to the product by adding other components and functions that are consistent with the needs, desires and requirements of the customer and what the competitive market imposes, so that the value of the product can be maximized from the point of view of both the factory and the customer, and this is done by adopting unique skills and capabilities that are difficult to imitate. Transfer by competitors, even if it is in the short or medium term.
5. The design team presents several design alternatives for the product, compares them based on the engineering and technical specifications in addition to the advantages and cost savings, and chooses the design alternative that achieves the highest engineering and technical specifications and bears the least amount of costs, provided that it is of high quality so that it can help The Kufa Cement Plant is the subject of research in achieving cost savings and achieving a competitive advantage

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