The Role of Developed Concurrent Engineering on Enhancing a Competitive Capability for Manufacturing Firms

Karrar Abdulellah Azeez
University of Kufa, School of Administration and Economics: Accounting, Iraq.
E-mail: karara.alkhaldy@uokufa.edu.iq

Husam Saleem Najaf AL-tayar
University of Kufa, School of Administration and Economics: Accounting, Iraq.
E-mail: hussams.najaf@uokufa.edu.iq

Received November 30, 2020; Accepted December 30, 2020
ISSN: 1735-188X
DOI: 10.14704/WEB/V18SI03/WEB18043

Abstract

This paper focused on the Concurrent Engineering which is a powerful model for product development and many firms need to remain in the competition market. It has an important role for the product development process via reduced a manufacturing time, higher product quality, lower cost in the manufacturing process and meeting customer requirements, which are key factors to determine the success. The paper shows the role played by the development of Concurrent engineering through its four dimensions after adding the fourth dimension called product sustainability design, which is complementary to other dimensions and is no less important, especially after environmental manufacturing has become a commitment to the environment and society itself. The four dimensions integrated for enhancing the competitiveness of firms. Results showed two aspects. Firstly, presented the role of concurrent engineering developed through its four dimensions in developing concurrent products, while the second aspect shows the contribution of each of the four dimensions of concurrent engineering to enhance competitiveness through its indicators. Findings revealed that the four-dimensional concurrent engineering contributes, through all its dimensions, to achieving rapid access to sustainable products that meet the desires of customers with low costs, which in turn was reflected in enhancing the competitiveness of firms.

Keywords

Concurrent Engineering, Environmental Sustainability, Product Design, Competitiveness.

Introduction

Business strategies change rapidly with the needs of the highly competitive market, as industries face more difficult challenges daily, as there is a need to shorten the product life

cycle to meet customer requirements and keep it competitive in the markets (Sandip& et al., 2013). Manufacturing firms have to search for ways to improve production, and customers have a high taste for new products, and this requires a lot of manufacturing firms to work, because they will have to improve their quality, and produce many different products at one time, in order to be able to meet the tastes of customers (Bansal & et al., 2016). Starting is with a new product that has the high expectations of customer satisfaction to meet complexing and formidable challenges for companies in the current business environment. Firms must be able to act and respond quickly to response the dynamic market requirements. Moreover, companies must be environment friendly process and able to significantly reduce their time in the manufacturing system, due to the short product life span. Therefore, concurrent engineering (CE) has emerged as a means of providing rapid solutions to product design and development process for environmental sustainability (Ramana& et al., 2015).

There is no interesting for adopt concurrent engineering (CE) which is the market of the future to develop new products. companies must review their product development cycle and processes to be able to complete various tasks concurrently(Ramana 2012).(CE) analyzes the requirements of the stakeholders (customers) in a functional analysis and analyzes the execution structure at the same time, in relation to the product and its life cycle processes, and from the analysis the requirements and characteristics of the product are captured, after which it organizes its life cycle processes and the relationship between them is determined (Loureiro & et al., 2010). (CE) are best suited for manufacturing high-quality products by companies that highlight benefits such as shorter product introduction time, improved design quality, reduced design iterations and shorter production time (Ramana 2012).Concurrent engineering(CE) has become the main approach to product design and development, partly due to the rapid development of science and technology, adding that the main purposes of (CE) principles which create products with a short design process, lower costs and higher quality for environmental sustainability (Qamara & et al., 2016).

Concurrent engineering focuses on the design stage and gets things done correctly in the first place to avoid rework, redesign, and future problems in other stages of the production process (Dahmas &et al., 2019). The concept of three-dimensional Concurrent engineering was discussed by several researchers among them (Fine& et al., 2005). Concurrent three dimensional engineering (3DCE) is a robust new product development (NPD) paradigm supported by concurrent engineering, where the traditional focus on appropriate congruence between product and process is reinforced by an additional study of supply chain configuration (Ilhami & Masruroh, 2018).

In this context, This paper tries to clarify the role of adding the fourth dimension of improved concurrent engineering, represented by the dimension of product sustainability, after three dimensions of concurrent engineering have been discussed by many researchers, and this paper measures the contribution of the fourth dimension (after product sustainability) in combination with the other three dimensions. Quick access to sustainable design that meets customers' desires, which in turn is reflected in enhancing the competitiveness of industrial economic units. This paper is organized as follows. In the second section, we present previous studies and develop hypotheses. In the third section, a research methodology is presented. As for the fourth section, it includes results, discussion and conclusion.

Previous Studies and Hypothesis Development

Many researchers discussed the synchronous engineering technique and its dimensions since its emergence, as it was limited to synchronizing it to two dimensions only, which is after product design and after designing the production process, and because of the many benefits that this technology has provided since its inception to economic units, researchers sought to develop this technology by adding Its third dimension, which is after the supply chain, and this synchronization has added a lot to this technology, and recently there have been signs of adding a fourth dimension to concurrent engineering, as Al-Falahi (2019) is the first to suggest adding the product sustainability dimension to the synchronous engineering dimension, as a dimension. Fourth, it integrates and works with the other three dimensions (product design, process, and supply chain) concurrently to achieve competitive advantages for economic units. Adding environmental sustainability to concurrent engineering is an important fourth dimension to help economic units working to address sustainable development to put themselves at the forefront of the wave of innovation. By implementing the increasing social and regulatory requirements faced by economic units to act in an environmentally conscious manner on a global scale, the environmental impact is rapidly becoming a factor equal to the cost, functionality and value during the product development process (Mombeshora & et al., 2014).The increased growth of laws related to environmental issues, increases in waste disposal costs, decreased availability of raw materials, and changes in customer preferences lead to a significant increase in interest in industries that take into account environmental considerations (Pil & Rothenberg, 2003).

The Cost and Developed Concurrent Engineering

The total cost must be taken into account when determining which parts will be part of the product, and how they will be joined together, i.e. when designing products (Gubi & Heikkilä, 2003). The cost factor is perhaps the most influencing product or service in many industries today, as cost reduction is essential to survival. Customers expect higher quality at a consistently low cost. It is therefore not surprising that cost-cutting initiatives are necessary in the current highly competitive market. As cost has become an important factor for success (Rush& Rajkumar, 2000). The costs associated with the product are identified early in the development process (Anumba & et al., 2000). As the design stage determines and often affects the total cost of the product, in addition to that, (80%) of the production cost can be allocated to the product in the design stage, and the treatment of life-cycle problems must perform in advance in the design stage and ensure that the design is appropriate, which Leads to cost savings (Maulanaa & et al., 2016).

The Most Important Factors for Product Development

The feasibility of the product: the ability to manufacture is one of the constraints that must be taken into account in the field of manufacturing (the production process), for achieving this goal requires a mixture of individuals, knowledge and experience, meaning (one must know what aspects can be embedded in machines and computers, and what communications are required to ensure interaction (Anumba & et al., 2000). It emphasizes that product and process must be closely coordinated to achieve matching cost requirements (Kumar, 2017).

Product quality: The increase in globalization, rapid improvements in information technology, and the increasing quality requirements of customers have increased pressure on economic units to maintain their competitive edge (Atakulu & et al., 2019), the increase in product quality represents the main competitive advantage of the economic unit applied to concurrent engineering, in terms of manufacturing high quality products. Quality can be seen as exceeding customer needs and providing superior value to the economic unit. This is because production problems are identified and solved in the early stages, thus eliminating unrealistic designs and defects (Chikwendu, 2017).

Environmental sustainability: (The article was based on the importance of this factor in adding the fourth dimension to simultaneous geometry) Ecological industrialization has become a commitment to the environment and society itself, and is implemented mainly through government regulations and the customer's perspective on environmental issues (Gungor & Gupta, 1999). Many researchers discussed the concept of environmental

sustainability, and its benefits for economic unity when applying this concept, as superior environmental performance can translate into broad improvements in organizational results (Pil& Rothenberg, 2003).The main goals of waste management are, to reduce waste at the source of generation by using appropriate materials, equipment and technologies, reuse and recycle waste, and find better ways to treat waste, by keeping disposal as a less desirable option (Gungor & Gupta, 1999). This dimension focuses on two basic paragraphs, namely (that the product is environmentally friendly, and possibility of recycling).

Environmentally friendly product: 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 have put in place environmental regulations to comply with new environmental regulations, so companies have had to adopt environmentally friendly practices (Chang & Shen, 2019).

Recyclability: Recycling is undertaken to recover the physical content of used and non-functional products, it is mainly driven by economic and regulatory factors. He notes that environmentally conscious manufacturing units develop ways to manufacture new products from conceptual design to 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 or outdated products through recycling and recycling (Gungor & Gupta,1999). Environmentally friendly technologies are needed. To achieve this, an organization's effort is needed to develop and diffuse environmentally friendly technologies. Ultimately, the motivation for exorbitant environmental improvements could be the expectation of increased profits due to more goodwill towards the producer and the overall economic unit(Nielsen& Wenzel2002).

Concurrent product development: CE philosophy has been well implemented in product development (Sapuan & Mansor 2014). Accordingly, the research hypothesis can be formulated, "The developed concurrent engineering affects the competitiveness."

Materials and Methods

The Sample: The study was conducted in the Evaporative Coolers Production Laboratory of the Iraqi General Company for Chemical and Plastic Industries, and the company’s data for April 2019 was used to conduct the study.

The Procedures: Several procedures have been taken to develop designs through the developed concurrent engineering technology.

Primary product design: After the formation of the concurrent engineering team and at the beginning of its work, designers within the team begin to request the functional characteristics that the customer desires in order to build the design or designs based on these characteristics. A questionnaire (50) for customers to obtain the most important functional characteristics that customers want and meet their needs, and from During the discussion that the researcher had with the design engineers of the economic unit about the period that takes to develop product design in the economic unit, it was found that it takes approximately (15) days to scan similar products represented in the evaporative coolers in the market, to identify the most important functional characteristics that meet Customers' desires.

The second design: this model will relied upon to develop it more and make it compatible with the rest of the customer's requirements. The new design: increasing the volume of the water basin, adding a filter to prevent the entry of mud, increasing the speed of the cryogenic engine, adding a temperature and humidity measuring device, reducing electrical energy consumption, as it was mentioned that the economic unit has developed its product recently, through the addition of the control device Remotely, as well as changing the colors of some of the front parts of the cooler, which makes it more attractive, but it did not take all the customer's requirements into account, so in this model some parts will be added to the design that are necessary for the customer as indicated by the survey results.

Detailed design: The last step that falls on the responsibility of design engineers is to develop a detailed design for the chosen design model, after obtaining the needs and desires of customers, the task of design engineers is to convert these needs into engineering and technical specifications. The concurrent engineering tools in this step play a major role in Assist in reaching the required design, as CE tools (such as CAD) are applied.

Designing the production process: The design of the production process and its synchronization with the design of the product in the industrial economic units is at the core of every commercial activity, as it is the responsibility of the economic units management to focus on designing the production process as it enables the implementation of many strategies that help reduce business risks, especially In an era of speed and technology, when time is an essential element to keep pace with today's highly competitive environment.

Supply Chain Design: The supply chain design dimension is no less important than the first and second dimensions (product design, production process design), and far from concurrent engineering, there are a lot of research and studies that emphasize the importance of the supply chain and the important role it plays, especially when integrated with design Product when developed. The supply chain consists of two sides, the first is the suppliers who supply the economic unit with the raw materials or semi-finished parts that the unit needs in the manufacturing process, while the other side is the wholesalers who will be supplied with the finished goods by the economic unit.

Product sustainability design: The focus is made by the members responsible for the sustainability of the product, within the members of the concurrent engineering team, on two basic paragraphs (that the product is environmentally friendly, the possibility of recycling): The excessive use of these plastics is associated with generating a large amount of waste, which poses a serious threat to the environment. Several methods are used to dispose of it including burning, filling land, reusing it and converting it into value-added products (Ahmad & et al., 2015).

Results and Discussion

After identifying what functional characteristics the customer wants from the first step, design engineers need in this step to know the specifications of the product to be developed and the cost of producing this product, in order to add the non-existent functional characteristics that the customer wants. The economic unit produces the evaporative cooler product based on two models of design, as there are some differences between the two designs, where the first design model contains a mechanical switch, in addition to the external plastic structure of the cooler is in one color, while the second model contains a remote switch It contains some colors in some parts of the front side of the cooler. (6700) units of the two models were produced at a rate of (3500) at a cost of (83917.3 dinars / unit) for the product of the first model and (3200) and at a cost (87431 dinars / unit) for the product of the second model, at total costs. For the two models, it amounts to (573492490) dinars. After converting the needs to engineering specifications, product specifications were presented according to the customers' desire in Table (1).

Table 1 The product specifications according to customers' desire

Number	Specifications	the weight	Specifications Relative importance
1	The introduction of an anti-humidity system that helps reduce humidity inside the room.	97	8
2	Increase the number of coolant engine speeds.	64	6
3	Add color to some parts of the external cooler to increase its attractiveness	53	5
4	There are three outlets instead of one outlet for air intake.	86	7
5	Volume cryogenic evaporative	63	5
6	Reducing the amount of electrical energy required to operate.	96	8
7	It is considered necessary to increase the volume capacity of the water tank.	80	7
8	Use a light alarm before running out of water from the cryogenic basin.	88	8
9	The presence of a temperature and humidity meter inside the room.	66	6
10	The cold air was pushed into the room through the (SARS) instead of the fan	54	5
11	Using a plastic material that is difficult to break.	96	8
12	If there is a water-raising device number 2 instead of 1.	53	5
13	Adding a system that enables the coolant to work even when the power is cut for a limited period by supplying it with rechargeable batteries.	60	5
14	The presence of places to keep ice to increase the coolness of the air.	59	5
15	Adopting the mechanical trigger instead of the remote key	58	5
16	Addition of filterma to prevent the entry of clays into the coolant and thus prevent deposits inside the cooler.	87	8
Total		1160	100

The second model was developed because it contains specifications that meet the needs of the customer more than the first model, and the table below shows the functional characteristics (specifications) contained in this model as follows: -

Table 2 Functional characteristics contained within product of second model

N	Specifications	
First: the external structure		
1	There are three air inlets	
2	The volume of the water tank has a capacity of (75) liters.	
3	A hard-to-break material is used.	
4	Contains colored parts in The front side of the cooler to increase its attractiveness.	
The total cost of the external structure		25918
Second: the electric motors with the control unit		
1	Main cooler motor contains (3) speeds	18000
2	Water pump device (1)	2880
3	Mator air distributor, count (1)	2040
4	Electrical connection wires	846
5	Remote operation device (contains light alarm to run out of water)	4200
Total cost of electric motors with control unit		27966
Third: cardboard sheets that humidify the air		
A complete set of (3) pieces		6600
Total		6600
Fourth: Other form details		
The rest of the model details do not contain specifications that amount to other costs		26947
Total unit cost		87431

Based on the financial statements for April 2019

The new design of the product: The results of the questionnaire indicated in paragraph (7) that it is important to enlarge the size of the cryogenic basin to increase the water holding capacity, and the ratio indicates that (66%) consider this important, so the volume of the water basin will be increased from (75) liters to (100 liters, as indicated by the results of paragraph (2) of the questionnaire, because (40%) of customers consider it important to increase the number of coolant engine speeds, and (48%) consider this important, but somewhat, as indicated in paragraph (6) of the questionnaire. Till that (94%) of the customers consider it important to reduce the electrical energy consumption needed by the chiller, so the number of cryogenic engine speeds will be increased from (3) to (4) speeds, taking into account that its electric energy consumption is less.

Paragraph (9) of the questionnaire, and as a proportion (40%) of customers consider it important to add a device to know the temperature and humidity inside the room, and that (52%) consider this to be somewhat important, so this device will be added to the refrigerant design, as well as Paragraph (16) of the questionnaire indicates that 78% of customers consider it important to add a filter to filter the water before it enters the cooler. For you a water filter will be added to the cryogenic design as well. Increasing the volume of the water basin from (75) liters to (100) liters requires an increase in the amount of the mixture of plastic material required for the basin of propylene standard and recycled in certain proportions, and the table 3, shows the specifications of the second design model and its costs after adding and modifying some parts as follows: -

Table 3 Specifications of the second design model after modifying

N	Specifications	
First: the external structure		
1	There are three air inlets	
2	The volume of the water tank has a capacity of (75) liters.	
3	A hard-to-break material is used.	
4	Contains colored parts in The front side of the cooler to increase its attractiveness.	
The total cost of the external structure		25918
Costs resulting from modifying and adding some parts to the external structure		
1	Increasing the water tank volume capacity from (75) liters to (100) liters Damn costs increase by an amount	1227
2	Adding a filter to prevent the clays from entering the cooler results in an increase in costs by a factor	1620
3	Adding a temperature and humidity meter results in an increase in costs of by	1810
The total cost of the external structure after modifying and adding some parts		30575
The total cost of the external structure after modifying and adding some parts		
1	A main refrigerated motor contains (3) speeds, the cost of which is (18,000) dinars, which has been replaced by a refrigerated motor that contains (4) speeds, whose cost is (20,100) dinars, and it has little consumption of electricity	20100
2	Water pump device (1)	2880
3	Mator air distributor, count (1)	2040
4	Electrical connection wires	846
5	Remote operation device (contains light alarm to run out of water)	4200
The total cost of the electric motors with the control unit after replacing the main chiller		30066
Third: cardboard sheets that humidify the air		
A complete set of (3) pieces		6600
Total		6600
Fourth: Other form details		
The rest of the model details do not contain specifications that amount to other costs		26947
Total unit cost after modifying and adding some parts		94188

The requirements have been converted into engineering specifications. The table 4, shows the detailed design of the specifications that will be included in the model developed by the design engineers in cooperation with all members of the concurrent engineering team as follows:

Table 4 The detailed design of the specifications of developed product

N	Specifications
First: the external structure	
1	There are three air inlets
2	The volume of the water tank has a capacity of (100) liters
3	A hard-to-break material is used, as Standard propylene is used in a large proportion
4	Contains colored parts on the front of the cooler to increase its attractiveness
5	Filter to prevent clays from entering the cooler
6	Temperature and humidity measuring device
Second: Electric motors with the control unit and electrical connection wires	
1	A main cooler motor contains (4) speeds
2	Water pump device, count (1)
3	Master air distributor, count (1)
4	Remote operation device (contains light alarm to run out of water)

The detailed design has been drawn up, the product manufacturing process will begin, which will be addressed in the second dimension, which will be addressed as follows:

The production process takes place over the course of (25) days within one month, during the month of April 2019, the unit produced (6700) units, that is, the rate of (258) units per day. (50) workers were employed during this month, and their work period was (8) hours The economic unit owns (14) machines of different sizes that can be divided into (7) large and (7) small, the unit transfers the molds between the machines until the needs of the assembly line are covered, in some days the work is continuous on some machines for a period of (24) An hour to fill the assembly line needs. The design of the new production process required (28) workers only and did not work throughout the month.

Cost of work for April 2019:
50 workers X 25 days X 16,500 dinars per day = 20625,000 dinars during the month of April
The cost of working according to the new plan as shown in Table (18) above is 9504000
The difference in the cost of work between the new and the old plan = 11,121,000 dinars

Table 5, shows the costs that can be avoided during the month of April for the water cutting part (the raft) as follows.

Table 5 The costs that could be avoided by purchasing the raft instead of manufacturing it

Phrase	Details
The number of parts required for production during the month (each refrigerated needs one part)	part6700
Part cost when manufactured	2250
Total manufacturing cost	15075000
The number of parts required for production during the month (each refrigerated needs one part)	part 6700
Part cost when purchasing (Importe)	408
The total purchase cost	2733600
The difference between purchasing and production within the unit	12341400

Based on the financial statements for April 2019

Below we show the costs that can be avoided in the economic unit when applied after the sustainability of the product during the month of April 2019 as follows:

Table 6 The reduced costs of the recycling process

Details	Cost and weight
The total need of the units amounting to (6700) units of raw materials	Kg116.509
The percentage of normal spoilage	%5
The total amount of damaged items is normal damage	Kg 5.825
Purchase price for one kilogram of recycled propylene	792
Total reductions measured after adopting recycling	4613400

Based on the financial statements for April 2019

Testing the Competitiveness from Concurrent Engineering

- **First: Testing the Competitiveness through the Cost Index**

Reducing the costs required for production is one of the indicators that enable economic units to enhance their competitiveness. If the cost of the product belonging to the economic unit is less than the cost of similar products for the rest of the units in the markets, this allows the unit to control the selling price to the extent that enables the economic unit to sell its products at competitive prices The current study focused on the

product of the second model of the evaporative cooler as it was developed during the last period by the economic unit under study, and the study developed it to the extent that it meets the needs of customers largely by polling their opinions through the questionnaire. The economic unit produces the second model product at an amount of (87431 dinars / unit) and after the process of developing this model through the study, its cost became (94188 dinars / unit), and through this study the costs of this model were reduced to (85942 dinars / unit), which is a lower cost than the cost of the model before it was developed, as well as This development increased the selling price of the product by (18000) dinars approximately equal to the selling prices of products that possess the same specifications developed for the second model and the table in AD. Table 7, shows the total costs that were reduced through this study, which enhance the competitiveness of the unit, as follows:

Table 7 The total costs that have been reduced

The details	First prototype product	Second model producer
Cost is in unit records	83917	87431
Cost after product development with concurrent engineering application	———	94188
Reduced cost due to the application of concurrent engineering	8246	8246
The cost after using concurrent engineering	75671	85942

- **Second: Test the Competitiveness through the Profitability Index**

The profitability index is one of the indicators that indicate the organizational capacity and efficiency of the economic unit, and it is a sufficient indicator of competitiveness. In terms of accounting, profitability represents the difference between total revenues and total expenditures. This development is based on the selling price of this developed product at an amount of (18,000) dinars, which was reflected in the profitability of the unit in general. The selling price of the first product is (108,000) dinars, while the selling price of the second product before its development is (114,000) dinars, but after the development, its price becomes (132,000) dinars, similar to the rest of the products bearing the same developed specifications, and the table below shows the difference between the profitability of the company before using the integration between concurrent engineering, accounting for resource consumption and after its use in the following:

Table 8 The results after applying a new model

The details	Before studying	after studying
First model product		
The difference between cost and selling price	108000-83917	108000-75671
The profitability of the unit	24083	32329
number of units	3500 units	3500 units
The total profit of the product of the first model	84290500	113151500
Second model producer		
The difference between cost and selling price	114000-87431	132000-85942
The profitability of the unit	26569	46058
number of units	3200 units	3200 units
The total profit of the product of the second model	85020800	147385600
The total profit of the product of the two models	**169311300**	**260537100**
The difference in profit before and after the study for the month of April 2019		91225800 dinars

- **Third: Test the Competitiveness through the Productivity Index**

The productivity of the unit during the month of April 2019 reached (6700) units with a work capacity (15000) hours, resulting from (75 total workers x 25 days x 8 hours per day), and after conducting the study, the economic unit will be able to produce (6700) units with a work card (9608) An hour, as a result of (53 total workers x 25 days x 8 hours a day), at a rate of (86.04) minutes per unit, the reduced hours amounted to (5392) hours.

If the economic unit uses the total work capacity of (15000) hours, it will be able to produce (10460) units

$$\text{Percentage of production before the study} = \frac{6700}{10460} = 64\%$$

$$\text{Productivity after integration} = \frac{8870}{10460} = 85\%$$

Increase in productivity (85%) - (64%) = 21%

- **Fourth: Testing the Competitiveness through the Market Share Index**

The early introduction of products to the market would have a very positive impact on the volume of sales of the economic unit (its market share) and its profits and through the study, the time for the product to reach the market was reduced from (75) days to (58) days, which helps to increase the market share. Of economic unity, which in turn is reflected in enhancing the competitiveness of the economic unit.

The increase in unit productivity makes it occupies a market share in comparison with the total market production, according to the data published by Al-Hilal Company for Chillers Production, that (2,500,000) units represent more than half of the market's production, so we assume that the total market production reaches (4,000,000) refrigerated Almost evaporative.

$$\text{Market share before the study} = \frac{26\,800}{400{,}000} = 6.7\%$$

$$\text{Market share after the study} = \frac{35480}{400{,}000} = 8.9\%$$

Conclusion

This paper examines the application of developed concurrent engineering in the Iraqi industry and its role for enhancing competitiveness after adding a fourth dimension called environmental sustainability. The methods by analyze the contribution of each dimension in reducing costs and showing that the transfer units from the development of sequential products to the development of concurrent products. For making the manufacturing system able to work and respond quickly by reducing time of introducing their products to the market and adapting to changing work environments. Following concurrent engineering for product development is a fast way in the process of design and development of products. the technique of concurrent engineering four-dimensional works to reach the desires of customers through its four dimensions, this technology is one of the most prominent technologies facing Competitive environments are rapidly changing in the world of competition today, as it seeks through its dimensions.

The functional characteristics that customer wishes to include in the product, while the second dimension is after the design of the production process through which the unit seeks to produce quality products. Namely One of the customers' requirements is through

a good design of the production process, while the third dimension is a design dimension The supply chain, the unit seeks through this dimension to take important decisions based on suppliers' information, and the last dimension is after designing the sustainability of the product.

The study showed a major role of concurrent engineering for raising the reputation of the firms, especially since the global trends in environmental sustainability make the unit meeting the sustainability requirements at the forefront of the units that Customers strive to deal with it. Finally, the contribution of each of the four dimensions, whether in terms of quickly reaching customers' desires or reducing costs by making a decision related to manufacturing or recycling waste, leads to enhancing the competitiveness of economic units applied to four-dimensional concurrent engineering.

References

Basu, S., Biswas, N., Biswas, S.N., & Sarkar, S. (2013). A study on concurrent engineering-based design and product development. *International Journal of Recent advances in Mechanical Engineering*, *2*(1), 15-20.

Bansal, Er. Ankur & Gupta, Deepak & Rajkumar. (2016). Study of Concurrent Engineering Practices: A Case of Rice Industry. *International Journal for Research in Technological Studies*, *3*(10), 6-10.

Ramana, V.V., & Kumar, H.M.A., & Nagaraj, B. (2015). Realizing Concurrent Engineering in Product Development: A Survey on Two Wheeler Auto Industry. *International Journal of Advanced Technology in Engineering and Science*, *3*(1), 734-740.

Ramana, V.V. (2012). Concurrent Engineering: Impact on New Product Design and Development in Indian Two Wheeler Auto Industry. *International Journal of Modern Engineering Research (IJMER)*, *2*(4), 2699-2701.

Loureiro, G., Adinolfi, A.G., Ribeiro, C.E.V., & De Andrade, R.C.B. (2010). System concurrent engineering for the development of an aeronautical navigation system. *Product: Management and Development*, *8*(2), 107-122.

Qamara, S., Azizb, M.H., Tayyab, A., Wasim, A., Hussain, S., & Saha, C. (2016). Application of Concurrent Engineering for Collaborative Learning and New Product Design. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Kuala Lumpur, Malaysia, 760-769.

Dahmas, S., Li, Z., & Liu, S. (2019). Solving the Difficulties and Challenges Facing Construction Based on Concurrent Engineering in Yemen. *Sustainability Journal*, *11*(11), 1-11.

Fine, C.H., Golany, B., & Naseraldin, H. (2005). Modeling tradeoffs in three-dimensional concurrent engineering: a goal programming approach. *Journal of Operations management*, *23*(3-4), 389-403.

Ilhami, M.A., & Masruroh, N.A. (2018). Trade-offs mathematical modelling of 3DCE in new product development: real three dimensions and directions for development. *In IOP Conference Series: Materials Science and Engineering*, *337*(1), 012025.

Mombeshora, I.M., & Dekoninc, E.A., Cayzer, S., & Mombeshora, Ms. Mendy. (2014). Environmental New Product Development Through The Three Dimensional Concurrent Engineering Approach. *International Design Conference Dubrovnik*-Croatia, 1601-1610.

Pil, F.K., & Rothenberg, S. (2003). Environmental performance as a driver of superior quality. *Production and Operations Management*, *12*(3), 404-415.

Gubi, E., & Heikkilä, J. (2003). *Concurrent Product and Demand Chain Creation– In Search of Contingencies and Strategic Choices*. TAI Research Centre, Helsinki University of Technology.

Rush, C., & Roy, R. (2000). Analysis of cost estimating processes used within a concurrent engineering environment throughout a product life cycle. *In 7th ISPE International Conference on Concurrent Engineering: Research and Applications*, 58-67.

Anumba, C.J., Siemieniuch, C.E., & Sinclair, W.A. (2000). Supply chain implications o2 concurrent engineering. *International Journal of Physical Distribution & Logistics Wanagement, 30*(8), 566-594).

Maulana, M.I.I.M., Flisiak, J.W., Al-Ashaab, A.H.M.E.D., Araci, Z.C., Lasisz, P.W., Beg, N., & Rehman, A.B.D.U.L.L.A.H. (2016). The application of set-based concurrent engineering to enhance the design performance of surface jet pump. W*SEAS Transactions on Business and Economics*, *13*, 634-643.

Kumar., & Gangadhari, R. (2017). Concurrent Engineering-for Environment & Sustainability. *International Research Journal of Engineering and Technology (IRJET)*, *4*(9), 1066-1070.

Atakulu, I., Shalpegin, T., & Wynn, D.C. (2019). Integration Model to Support Configuration of Product Architecture and Supply Chain Design. *International Dependency And Structure Modeling Conference*, Dsm Monterey, CA, USA, 79-88.

Chikwendu, C., & Jude, E. (2017). Benefits and Barriers to Successful Concurrent Engineering Implementation. *Journal of Multidisciplinary Engineering Science and Technology 4*(8), 7868-7873.

Gungor, A., & Gupta, S.M. (1999). Issues in environmentally conscious manufacturing and product recovery: a survey. *Computers & Industrial Engineering*, *36*(4), 811-853.

Chang, X., & Shen, F. (2019). Strategic Commitment to Price in a Supply Chain with Downstream Innovation. *Open Journal of Business and Management*, *7*(4), 1690-1704.

Nielsen, P.H., & Wenzel, H. (2002). Integration of environmental aspects in product development: a stepwise procedure based on quantitative life cycle assessment. *Journal of Cleaner Production*, *10*(3), 247-257.

Sapuan, S.M., & Mansor, M.R. (2014). Concurrent engineering approach in the development of composite products: a review. *Materials & Design*, *58*, 161-167.

Ahmad, I., Khan, M. I., Khan, H., Ishaq, M., Tariq, R., Gul, K., & Ahmad, W. (2015). Pyrolysis study of polypropylene and polyethylene into premium oil products. *International journal of green energy*, *12*(7), 663-671.