



APPLICATION OF SIX SIGMA TECHNOLOGY TO HYBRID MANUFACTURING PROCESSES APPLIED RESEARCH IN BAGHDAD COMPANY FOR SOFT DRINKS

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Article history:	Abstract:
<p>Received: April 26th 2022 Accepted: May 26th 2022 Published: June 28th 2022</p>	<p>The aim of the research is to present the methodology of the research sample company to apply the requirements of hybrid manufacturing using a checklist that includes the following paragraphs (quality, cost, productivity, waiting time and service level). And the application of the six sigma approach to reduce defects in its production processes. Through a checklist that consists of paragraphs (commitment and support of senior management, training and reward and recognition system, organization culture, financial capabilities and statistical and technical tools). In order to know the actual reality, identify the gap and work to reduce this gap. The importance of this research stems from the importance of providing a theoretical and conceptual framework. A practical application of using two methodologies to help economic units improve the quality of their products and reduce the costs of poor quality.</p> <p>The research reached a set of conclusions. The most important of which is that the company is able to implement this system significantly. Through the results shown by the checklist and the availability of dimensions or performance measures for this system in the company.</p>

Keywords: six sigma, hybrid manufacturing processes, productivity

FIRST: RESEARCH PROBLEM

The research problem focuses on preparing the customer without wasting the production process by reducing inventory and reducing waste, costs and waiting time. All of these criteria lead to no problems in production. And give early warning to solve quality problems. And give the command feedback immediately to find solutions. And the lack of a clear vision in solving quality problems. As well as the company's lack of statistical measures to measure the level of quality and the ability of production processes. Which in turn is reflected in the fluctuation of performance and low level of sigma. The company's survival and continuity today depends largely on the quality of its products. Based on the foregoing, the research problem can be formulated through the following questions:

1. What are the requirements for applying the six sigma technique in the research sample company?
2. What is the level of availability of the requirements of the hybrid manufacturing system in the research sample company?

3. What is the possibility of using quality control tools in determining the deviations of the process in the company?

SECOND: IMPORTANCE OF RESEARCH

- 1- Improving the reality of the production process through the use of modern methods of process control. Reducing deviations and eliminating or reducing spoilage in a way that leads to a reduction in production costs.
- 2- Verify the possibility of compatibility between Six Sigma and Six Sigma technology, the production methods used in the company, in the case of research, in order to achieve competitive advantage.
- 3- Indicating the areas of application of (six sigma) technology and potential obstacles.
- 4- How to apply the requirements of six sigma in the research sample company and its role in hybrid manufacturing. Determine the gap between requirements for hybrid manufacturing and six sigma in the company.



THIRD: RESEARCH OBJECTIVES

- 1- Assisting the company's management in getting acquainted with (six sigma) technology and identifying the possibilities of procedurally activating it. Focusing the trend towards its role in achieving the highest levels of quality. This affected the competitive position of the company.
- 2- To reveal the importance of (six sigma) technology and its methodology. And what it contains of important essential advantages that contribute to paving the way for the establishment of different contemporary quality. With raising awareness of the importance of quality as one of the most important languages in the contemporary market environment.
- 3- Presenting a methodology for hybrid manufacturing. And what are its pillars that the company can rely on.
- 4- Measuring the extent of applying the hybrid manufacturing system in the company.

FOURTH: COMMUNITY AND RESEARCH SAMPLE

Baghdad Company for the production of soft drinks was approved as an area of research application. And obtain the required data through the checklist and field visits to the workflow. As for the research sample, some of the company's products were selected within category (A), including (Cola), by adopting its data as a field for research.

Fifth: Research Methodology

The case study method was adopted. The importance of research lies in diagnosing and interpreting existing phenomena and predicting their results in the future according to the size of the gap that researchers will recognize. It is based on careful analysis and detection of the relationship between the study variables and their dimensions for the purpose of reaching realistic results.

It is a scientific method characterized by a detailed and accurate description of the information related to the research. Because it combines more than one research method through its reliance on observation, personal interviews, field coexistence, access to official documents and the use of the checklist. For the purpose of obtaining data and information directly and analyzing it according to the scientific basis to reach the desired goals.

THEORETICAL FRAMING

Six sigma technology and lean manufacturing processes

Six sigma came to prominence in the mid-1980s at Motorola. It combined the principles and statistical methods that have characterized engineering quality departments for decades. I worked on integrating it with business activities to give the foundation of an integrated management system (management) with high uses and aspects. And entered into the study programs of a huge number of universities in the world. It now represents the latest technology of the era in the field of business.

First: Six Sigma

1- six sigma concept

Six sigma is a statistical symbol (6σ) which means that the area specified in the production process stage is six standard deviations. These are the exact specifications specified by the beneficiary. There were many definitions that tried to give a concept to clarify the features of this distinguished statistical model. Yang & Haik, 2003:21 defined it as a method that provides businesses with tools to improve the capabilities of their operations. As for (2): (Brue, 2006) he defined it as a statistical concept that measures defects in the process for the purpose of completing a process in which the defects rate is only 4.3 per million opportunities. Both (Al-Qazzaz and Al-Hadithi, 16:2009) see it as a more effective way to solve business problems And improving organizational performance. As for Zugelder, 2012:5), he defined it as a system that focuses on improving quality, increasing productivity and reducing costs in any organization. Through a combination of two different models, but working together on continuous improvement. And defined (Shokri, 2017:608) as a business strategy and methodology that increases the performance of operations, which leads to improved customer satisfaction and improved final results.

Through the most important previous definitions, the Six sigma model is basically an integrated statistical method that uses a set of tools and methods that can be applied correctly to improve performance. This allows early detection of errors and early correction of them. Thus, the dramatic reduction in costs while controlling the specifications to a degree that does not exceed 3.4 errors per million production units. Which raises the level of customer satisfaction, which leads to a growth in its revenues and to ensure its survival and continuity in the market.



2- Principles of Hexagonal Diffraction

Six sigma is based on a set of principles represented in the following ((Alghabban & Alghabban, 2020:1231

No.	details
first principle	Focus on customer satisfaction by studying their requirements and desires
second principle	Rely on facts to clarify the criteria that will be used to evaluate performance
Third principle	Effective management based on advance planning to address problems and focus on prevention
Fourth principle	Unlimited cooperation between workers at various administrative levels and improving teamwork performance
Fifth principle	Continuous improvement to reduce deviations, maintain quality and increase productivity by adopting new methods
Sixth principle	Participation and teamwork, as well as emphasizing the importance of decentralized communications and horizontal communications
Seventh principle	Prevention rather than screening, which drains human and financial resources

3- Six sigma components: it is required to take into account the following elements when working on the adoption and application of the six sigma method as follows:

(Virender & Sandeep, Vol. 26, No. 1, 2015:18) (Abdul Hafeez, 48: 2016)

1- The support and commitment of the senior management to the six sigma method is a condition for the success of its application as a strategic process.

2- Changing the culture of the unit towards its reliance on motivating and directing employees in making decisions and urging teamwork.

3- Linking the six sigma method to accounting and management information systems.

4- Linking the promotions and incentives systems for the human resources working in the six-diffraction projects programs.

5- Focusing on internal processes that require advance planning and transfer from reaction management to dealing with problems before they occur.

4- The organizational structure of the six sigma working group:

The belt system is important for the application of the six sigma methodology. Once the administration intends to adopt the six sigma method, the implementation of the work becomes the responsibility of multiple work teams. The skills of these teams and their leaders are called by different names, such as: the main black belt, the black belt, and the green belt. These responsibilities and tasks escalate from one administrative level to another. Six sigma has two working methodologies as follows: (Maurice & Davy, 2017:18)

A- First Methodology (DMADV): It is an improvement methodology used to develop new processes or products. This methodology is related to the DFSS system, which is the design for hexagonal diffraction. It consists of five steps (definition, measurement, analysis, design, verification).

b- Second Methodology (DMAIC): It is a methodology used to improve quality and reduce variance in the current process. It is one of the elements of production simplification and has been increasingly used to solve problems in several areas, including management and productivity, to improve the consistency of operations. The methodology passes through five stages that improve the process (definition, measurement, analysis, improvement, and control).

The (DMAIC) approach to problem solving is better than others for the following reasons) Al-Nuaimi and Sweis (2008: 87-86).

Measuring the problem: it is not limited to defining the problem, but working to prove its credibility with facts.

2- Focus on the external and internal customer.

3- Verifying the basis of the problem through facts that prove that this factor alone is the cause of the problem.

4- Get rid of previous habits. And that the solutions resulting from this method must generate real change and not simple changes.



Third: Hybrid manufacturing

1- Hybrid Manufacturing Concept

Modern manufacturing systems is one of the newly dominant research areas in the field of production and operations management at the present time. Many advanced systems and models have been developed to improve manufacturing such as Lean, Efficient and Hybrid Manufacturing. These systems specifically address resilience. By focusing on making a variety of products in small quantities while responding quickly to dynamic changes in demand. And that production is short-term and low-volume in order to support the competitive advantage of companies and integrated systems such as hybrid manufacturing that have been developed for this purpose.

It is defined (nagaaba, 2017:15) as a mixture of agile and effective models that stem from the overall supply chain strategy and by identifying the point of no convergence (postponement) that does not fit with market fluctuations and customer demands. Whereas (fatime, 2019:2) defined it as a system designed to achieve the highest level of benefit by collecting performance standards, which include cost, quality, reliability and flexibility, which give indicators of high diversity in products. As well as addressing activities related to technology, equipment and machinery through continuous improvement and reducing inventory (JIT) and response and customization system.

2- The importance of hybrid manufacturing

Many organizations today seek to achieve their goals through continuous improvement of their policies and strategies to meet the changing needs, desires and expectations of customers. As well as in line with the changes of the external environment represented by global markets. Especially these markets are witnessing rapid development and growth. As well as the development in the needs and tastes of its customers and the invention of competitors new challenges. Therefore, these organizations sought to provide products and services that bear specifications that have a competitive advantage. Accordingly, organizations can obtain a larger market share than their competitors (mankute, 2013:722).

(Stefanelli, 2019:6) indicated that the hybrid manufacturing system is a system with multiple dimensions. It seeks to discuss and solve problems within the organization. It has the ability to generate ideas and provide the best for the organization. It is also important in raising the level of productivity and reducing costs by taking advantage of modern technology activities and total quality management

programs. Including production on time and managing the minimum stock that have a role in reducing waste and waste, continuous improvement and rapid response. Therefore, the organization has a competitive sustainability that distinguishes it from other organizations.

3- Factors affecting hybrid manufacturing

There are many factors that affect a hybrid manufacturing system differently. The relationship between these different factors varies according to the amount of influence of each individual factor in the manufacture of the main objectives of the hybrid manufacturing system. It may sometimes be vague and unclear. And (sahai, 2019:1023) identified five factors, which are:

A- Human Resources: Human resources in organizations are of unparalleled importance because they are one of the most important factors on which the success of the organization depends in establishing an effective investment program for the human resources used in production. It is no secret that the human resource has become the rare and rare resource that determines the efficiency of the organization's performance of its various types. It includes the worker's commitment to work, the worker's experience, work skills, the worker's attitude, teamwork, personal skills, employees' interest in research and development activities, resistance to change.

B - Factors of production: The factors affecting productivity are many and varied. It can be said that there is no unified classification of factors as determined by thinkers and researchers. This is the result of their different views or the nature of the studies themselves. As these factors affected the conduct of production processes in the form of a flexible and variable production and operational activity in line with the noticeable change in the quality and quantity of demand. Which requires flexibility in the processes, decisions and levels of quality required for production. The group's technology includes cellular networks, the use of advanced manufacturing methods using robots, and the process sequence to be followed.

C - Administrative factors: Management is considered one of the most important human activities in any society. On the basis of its different stages and development. This is due to the administration's impact on the lives of societies because of its association with economic and social affairs. And it has



a fundamental role in making social progress and the success of the organization and its superiority over its competitors. It seeks to achieve the set goals using the optimal use of the available resources according to a specific approach to reach the best results in the shortest way and the least material costs. It includes managing the supply chain, administrative support for the implementation of strategies, spending money on the training and development side, and decentralizing authority.

D-Design factors: The design of a product or service is a multifunctional, knowledge-based process. This process is a critical factor in organizational success. Because it determines the characteristics and performance of the product or service and the quality that consumers demand. It is a major strategic activity in many companies because of its contribution to the production of new products and contributes significantly to sales. Accordingly, the design process has a competitive role in finding similar products in the market in terms of quality, appearance, performance, product life and price.

C- Quality tools and techniques: Various organizations have recognized that the development of quality tools and techniques has a major role in the quality of the product or service provided. As well as the satisfaction of its customers and distinguish it from its competitors. As well as being a force to enter the market. And to give sufficient attention to this strategy to maintain the survival, continuity and sustainability of organizations. It includes quality control tools, benchmarking, acceptance sampling, total quality management (TQM), value flow map (VSM).

4- Hybrid manufacturing performance metrics

Companies seek to choose the system that helps them achieve distinction in the markets in which they deal. Through the products it offers that meet the needs and desires of its customers. Because of the developments and changes taking place in the competitive environment, there are companies that depend on reducing costs, others that rely on providing a high-quality product, and others that seek by reducing waiting time and flexibility in demand. Accordingly, these companies want to stay in the forefront and outperform their competitors and adopt the scale or dimension that matches their capabilities and capabilities.

The sub-variables of the hybrid manufacturing system that serve as performance measures for this system. The performance measure measures the

extent to which the organization succeeds in achieving its goals. Relying on a number of foreign and Arab sources that dealt with hybrid manufacturing, it was found that most researchers agreed on the five criteria:

A - Quality: Quality can be defined in general as superiority or distinction. As for a product, it is anything that can be presented to the market that raises interest for the purpose of acquisition, use or consumption that may meet the consumer's need. "The quality of the product is the customer's perception of the overall quality or the superiority of the product in relation to its intended purpose and in terms of comparing it with alternatives" (Razak, 2016: 61). Quality is one of the important tools to maintain a competitive advantage in the market. Product development to achieve customer satisfaction and raise the level of quality. This indicates that the real product quality should be visible in improving the quality of product performance. (Hussein & ranabhat, 2013: 12-13).

b- Service level: Service is any useful activity that one party can provide to another party. It is essentially intangible and does not result in ownership of anything. The service negates its need with the passage of time, such as comfort, entertainment, or solving the problems facing the customer. As for the quality of service, it is the effort to meet the needs of customers, which is necessary for the survival and growth of the organization (jama, 2013, 12-13).

It can be measured by the extent to which the product serves the success or symptoms of consumers. Customer service is one of the organizational processes that the company performs, taking into consideration the increasing competition and attracting entrepreneurial opportunities to increase profitability, improve market access, and increase the level of customer satisfaction and loyalty.

C- Waiting time: One of the challenges that most companies face in today's customer-centric business environment is to establish processes that facilitate responding to customer requirements. It is widely recognized that short delivery time is of great importance to customers. They want to get the required products as soon as possible.

The designation of waiting time differs from several points of view. For the customer, the waiting time is from the order process until the product arrives in his hand. From the company's point of view, suppliers deliver parts to the main manufacturer. The manufacturer is the customer.



d- Productivity: The productivity of the company is a major factor for its success in the global market. However, the term productivity is multidimensional and the meaning varies according to the context in which the term is used. Productivity generally expresses the relationship between outputs and inputs in a manufacturing transformation process. Most of the time, production is a commodity that is consumed as an expendable resource. Productivity is closely related to the use and availability of resources. Simply, productivity is reduced if the company's resources are not used properly or if there is a shortage of them (Belin & Hedman, 2010:10).

There are factors that can affect productivity, whether positively or negatively, including: product quality, process quality, management quality, work methods and procedures, skills resulting from training and experience, and government legislation and regulations.

c- Cost: The financial value that is used to produce a product or provide a service. As companies today seek to offer their products at the lowest prices compared to competitors. In order to increase its market share. When the company's management chooses to reduce

costs as a competitive priority, it is in essence competing with its competitors on the basis of cost. That is, providing the product or service at the lowest price in the market to reduce costs. Manufacturing companies may seek to use modern manufacturing systems such as Lean, Efficient, Hybrid, and others. As well as reducing the costs of inputs, resources and use of information technology, enhancing productivity and efficiency, and so on.

There are three competitive cost strategies identified by Porter: (awwad, 2010:265)

Cost leadership strategy: The advantages of this strategy are low cost compared to competitors, related and standardized products, and economies of scale. A cost leadership strategy requires extensive work oversight, tight cost control, frequent and detailed monitoring reports, and organization and accountability.

Differentiation Strategy: This strategy is described in terms of product uniqueness, focus on marketing and research, and a flexible structure.

Focus strategy: This strategy involves focusing on a narrow strategic objective (buyer group, product line, market or geography).

THE SECOND TOPIC

Checklist analysis

View and analyze the results of the checklist:

First: Hybrid manufacturing performance measures

A- Quality: Table (1) shows the quality scale checklist.

Table (1) Results of Quality Performance Scale Analysis

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
1.	The company can establish a system through which performance is measured and monitored.	✓				
2.	The company seeks to provide high performance products.		✓			
3.	The company checks its products before introducing them to the market.		✓			
4.	The company's products are always well received by customers.		✓			
5.	The company believes that the quality of product performance is achieved by keeping pace with the product developments.			✓		
	weights	4	3	2	1	0
	frequencies	1	3	1	0	0
	result	4	9	2	0	0
	Weighted arithmetic mean	3				



(application rate(
Percentage of application	0.75
Gap size	0.25

It was relied on equations (1) (2) (3) mentioned in the research methodology to calculate the application rate and the size of the gap, which will be applied later in all the gap measurement tables.

Based on the results of the checklist for analyzing the performance measure for quality in Table (9), we note that the overall rate of applying quality standards (weighted arithmetic mean) is (3) out of (4). This indicates that the quality system is partially implemented through the scale installed at the top of the table. And the application rate was (0.75). As for the gap, it was 0.25. We note that the gap ratio is relatively small. This is a good indication that the company applies quality standards well.

•Strength Point:

- The company applies international standards in order to measure the quality of its products and to achieve the safety of their use by the customer.

- The quality of raw materials has a major role in improving the quality of final products in order to reach customer satisfaction.

• Weaknesses:

- The appearance of defective products during the stages of the production process in liquid materials (food). As well as in the forms of plastic and metal cans. The company's management faces some difficulties in resolving them.
- Weak awareness of the company's management and employees about the existence of contemporary techniques such as Six Sigma diffraction technology, which works to reduce defects to reach a high quality level and low costs.

B- Cost: Table (2) Shows The Cost Scale Checklist.

Table (2) Results of the cost performance measure analysis

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
6.	The company's management is working to reduce production costs.		✓			
7.	The company's management seeks to reduce storage costs	✓				
8.	The company's management works to reduce the costs of purchasing raw materials compared to other competing companies.		✓			
9.	The company's management seeks to reduce the indirect industrial costs (marketing, administrative) at work.		✓			
10.	The company's management works to reduce operating costs (raw materials, energy) by improving its production processes.		✓			
	weights	4	3	2	1	0
	Frequencies	1	4	0	0	0
	results	4	12	0	0	0
	Weighted arithmetic mean (application rate(3.2				
	Percentage of application	0.80				
	Gap size	0.20				



The checklist for cost performance measure analysis in Table (2) shows that the overall rate of application of cost criteria (weighted arithmetic mean) is (3.2) out of (4). This indicates that the cost reduction system is partially applied through the scale installed at the top of the table. And the application rate was (0.80). As for the gap, it amounted to (0.20). It is how far away from the ideal state. We note that the gap ratio is small and this is a good indication that the company is striving greatly to reduce costs of all kinds.

•Strength Point:

- The company applies a clear policy to reduce storage costs, and this in turn returns to the company a high benefit as well as preserving the nutritional value of the products.

- The company's continuous improvement of its operations is reflected positively on reducing indirect industrial costs such as marketing, administrative and office costs.
- The company seeks to reduce interruptions in production processes and the continuity of work, as well as reducing the process of wasting energy.

• Weaknesses:

- In some cases, the company's management fails to reduce the costs of purchasing raw materials due to bad deals related to procurement operations, which leads to a relatively high total production costs. Figure (3) shows the percentage of application of quality cost performance standards in the company and the size of the gap in the cost dimension.

C- Productivity: Table (3) shows the productivity scale checklist.

Table (3) Results of Productivity Performance Scale Analysis

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
11.	The company offers customers safe and reliable products.	✓				
12.	The company's products are distinguished by a high degree of reliability in use.		✓			
13.	The company is interested in presenting the products correctly the first time.		✓			
14.	The company believes in the principle that the unreliable product will be less demanded.		✓			
15.	The company's management develops its product designs based on research and development results.		✓			
	weights	4	3	2	1	0
	Frequencies	1	4	0	0	0
	Result	4	12	0	0	0
	Weighted arithmetic mean (application rate)	3.2				
	Percentage of application	0.80				
	Gap size	0.20				

Based on the results of the checklist for the productivity performance measure analysis in Table (11). We note that the overall rate of applying productivity standards (weighted arithmetic mean) is (3.2) out of (4). This indicates that the productivity system is partially applied through the scale installed at the top of the table, with an application rate of (0.80). As for the gap, it amounted to (0.20). We note

that the percentage of the gap is small and this is a good indication that the company applies the productivity standards well.

•Strength Point:

- Rapid response to customer requests and product design according to their desires and tastes, due to the great loyalty of the company by customers.



• Working with the strategy of not meeting or delaying, brings great benefits to the company, including not accumulating products in stores, as well as expediting the fulfillment of customer requests.

• **Weaknesses:**

• Some places lack panels for control and alert signals on production lines.
 • Lack of employee participation in opinions and taking their notes on the production process has a great impact on the psyche of workers and increase their eagerness and loyalty to strive to develop the company's products.

D- Waiting time: Table (4) shows the waiting time scale checklist.

Table (4) Results of Checklist Analysis for Waiting Time Scale

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
16.	The company's management reduces waiting time through optimization of manufacturing processes.		✓			
17.	The company's management reduces the production cycle time from receiving the customer's request to meeting it compared to competing companies.		✓			
18.	The company's management uses multimodal transportation to avoid order delays.		✓			
19.	The company's management seeks to reduce the waiting time in order to increase its ability to respond to changes and raise the level of flexibility in processing.		✓			
20.	Reducing the waiting time does not lead to additional costs borne by the customer for express shipping operations.		✓			
	weights	4	3	2	1	0
	Frequencies	0	5	0	0	0
	Result	0	15	0	0	0
	Weighted arithmetic mean (application rate)	3				
	Percentage of application	0.75				
	Gap size	0.25				

*Source: Prepared by researchers

The checklist for the performance scale analysis and waiting time in Table (12) shows that the overall rate of application of waiting time (weighted mean) is (3) out of (4). This indicates that the system of reducing the waiting time is partially applied through the scale installed at the top of the table, with an application rate of (0.75). As for the gap, it was 0.25. It is how far away from the ideal state. We note that the gap ratio is small and this is a good indication that

the company is working to reduce waiting times in its operations.

• **Strength Point:**

• Reducing waiting times is the company's goal by improving its production processes, adhering to the established specifications, and working to improve the performance of employees.
 • The company works to reduce the actual time of production of the product while maintaining the quality



of performance, so as to avoid delaying the requests submitted to it.

- In order to avoid order delays and loss of customer satisfaction, the company's management contracts with another company that takes care of transportation from warehouses to distribution points in most of the country's governorates.

• **Weaknesses:**

- Express freight operations can lead to high costs borne by the company, including the risks related to transportation operations (such as the exposure of trucks to traffic accidents or theft of those trucks).

e- **Service level: Table (5) shows the service level meter checklist.**

Table (5) Results of Checklist Analysis for Service Level Meter

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
21.	The company applies training programs to guide and educate employees to increase their expertise.		✓			
22.	The company relies on its experience and skills in making environmental protection decisions.		✓			
23.	The company motivates employees to increase production by activating the incentive and reward system.		✓			
24.	The company's management recommends adopting internal management practices that reinforce environmental awareness among employees.			✓		
25.	The company's management is concerned with government trends in support of investment operations related to Lean Production Technology.		✓			
	weights	4	3	2	1	0
	Frequencies	0	4	1	0	0
	Result	0	12	2	0	0
	Weighted arithmetic mean (application rate)	2.8				
	Percentage of application	0.70				
	Gap size	0.30				

The checklist for analyzing the service level performance measure in Table (13) shows that the overall application rate of the service level (weighted arithmetic mean) is (2.8) out of (4). This indicates that the service level system is implemented to some extent through the scale installed at the top of the table. And the application rate was (0.70). As for the gap, it amounted to (0.30). It is how far away from the ideal case, and we note that the gap ratio is somewhat small, and this is a good indicator. Here the level of service is satisfactory and it is heading towards

idealization, that is, the company is working well to improve the level of its services.

• **Strength Point:**

- Keeping machines and equipment in a high operational condition, in turn, is reflected in the company's productivity and the speed in completing the order planned by the management. As well as maintaining the quality of product performance.
- The use of modern techniques such as CNC machines reduce human effort and give high accuracy with speed of completion.



• Creativity in design and manufacturing has a great impact on customer satisfaction. As well as gaining market share and increasing the company's competitive capabilities.

• **Weaknesses:**

• The company's receipt of urgent orders in certain seasons of the year, such as summer, requires the company to have adequate storage to cover these requests. The process of receiving the order and

converting it into a production plan may take some time, which leads to delays in the requests of some customers.

Second: Success Factors Of Hexagonal Diffraction

A- Senior management commitment and support: Table (6) shows the results of the checklist for one of the critical success factors for Six Sigma Agile, which is the commitment and support of senior management

Table (6) Results of Checklist Analysis for Senior Management Support Factor

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
26.	Top management encourages the participation of workers in the production improvement process.		✓			
27.	Top management considers the quality of performance the highest priority in the evaluation of plant management.	✓				
28.	The company's management equips the factory with modern devices with advanced technology in measuring the quality of products.		✓			
29.	The company's senior management supports the Six Sigma technology application programs.			✓		
30.	The company's management evaluates the performance of operations based on the quality of the products it offers and customer satisfaction.		✓			
	weights	4	3	2	1	0
	Frequencies	1	3	1	0	0
	Result	4	9	2	0	0
	Weighted arithmetic mean (application rate)	3				
	Percentage of application	0.75				
	Gap size	0.25				

The checklist for analyzing the commitment and support factor of senior management in Table (6) shows that the overall application rate for this factor or requirement (weighted arithmetic mean) is (3) out of (4). This indicates that the support of senior management is partially applied through the scale installed at the top of the table, with an application rate of (0.75). As for the gap, it was 0.25. It is how far away from the ideal state. We note that the gap ratio is small, and this is a good indicator for the company,

as the support of the senior management for quality projects is high.

• **Strength Point:**

• The quality of the performance of the products leads to the delight of the customer, meeting his needs and requirements and gaining his satisfaction, and this is important for the senior management, as it evaluates the performance of the factory accordingly.
 • The presence of high-tech devices and equipment gives the company confidence in the direction of its



final outputs, as these devices work to produce a high-quality product, as well as to exclude the damaged before it reaches the customer.

• **Weaknesses:**

- The workers' poor awareness of quality techniques has a great impact on their performance inside the factory.

B- Training: Table (7) shows the results of the checklist for one of the critical success factors for Six Sigma Agile, which is the training factor.

Table (7) Results of the checklist analysis for the training worker

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
31.	New employees are selected and appointed according to their level of competence and technical knowledge.			✓		
32.	The company's employees are trained according to advanced training programs.		✓			
33.	The company trains its employees regularly on the programs to reduce waste and waste in the production process.	✓				
34.	The company holds scientific seminars and training courses to teach employees how to avoid defects and deviations in the production process.			✓		
35.	The company provides financial allocations for quality-oriented training activities.		✓			
	weights	4	3	2	1	0
	Frequencies	1	2	2	0	0
	Result	4	6	4	0	0
	Weighted arithmetic mean (application rate)	2.8				
	Percentage of application	0.70				
	Gap size	0.30				

Based on the results of the checklist for analyzing the employee training factor in Table (15), it is clear that the overall application rate of this factor or requirement (weighted arithmetic mean) is (2.8) out of (4). This indicates that the requirement to train workers is "somewhat applied" through the scale installed at the top of the table, with an application rate of (0.70). As for the gap, it amounted to (0.30), which is how far away from the ideal case. We note that the gap ratio is rather small, and this is a good indication that the company supports training systems and trains its employees to raise the level of quality.

• **strength point:**

- The company's management is working on forming committees to reduce the process of waste and losses and to follow up the progress of production processes starting from entering the raw materials through the production stages until reaching the warehouses and recording the waste.
- If it is related to the quality of the products, then the company spends a lot of money to train employees and buy modern equipment to reach the highest levels of quality.
- The presence of high-tech devices and equipment that gives the company confidence in the direction of its final outputs. These devices produce a high quality product and also eliminate the damaged before it reaches the customer.



• **Weaknesses:**

• The selection of new workers is sometimes not subject to the quality criteria of differentiation because of the company's need for them, and its impact will return to the level of productivity of that worker. And also one of the reasons for the waste process is due to his lack of experience in dealing with advanced devices.

• Application of the company's employee training factor and the size of the application gap.

C- Rewards and Recognition System: Table (8) shows the results of the checklist with respect to one of the critical success factors for the agile Six Sigma system, which is the rewards and appreciation system.

Table (8) Results of the Checklist Analysis of the Rewards and Recognition System

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
36.	The company offers incentives and incentive bonuses to employees who excel in the performance of their work.			✓		
37.	The company awards discretionary rewards and incentives in return for the successful implementation of quality improvement programs.			✓		
38.	The company evaluates the performance of its employees based on the quality of the products provided.				✓	
39.	The company gives its employees financial rewards for improving the actual performance of production.				✓	
	weights	4	3	2	1	0
	Frequencies	0	0	2	2	0
	Result	0	0	4	2	0
	Weighted arithmetic mean (application rate)	1.5				
	Percentage of application	0.38				
	Gap size	0.62				

Disbursing incentive bonuses to some employees of the company in return for doing their work in a professional and distinguished manner that can motivate other employees to work seriously and faithfully.

• **Weaknesses:**

The checklist for rewards and appreciation system analysis in Table (16) shows that the overall application rate for this factor or requirement (weighted arithmetic mean) is (1.5) out of (4). This indicates that the system of rewards and appreciation is poorly applied through the scale installed at the top of the table. And the application rate was (0.38). As for the gap, it amounted to (0.62), which is how far away from the ideal case. We note that the gap ratio is large and this is a dangerous indicator for the

company, which draws attention to this important factor.

• **Strength Point:**

• The company's management's lack of awareness of the importance of incentive rewards granted to workers to improve the actual performance of production has a significant impact on the worker's performance and work. The salary allocated to the worker may not be at the required level, and these bonuses give a moral boost to the workers to perfect their work.

• It does not reward its employees for the great work they do. When the level of production decreases or complaints arrive to the administration, it punishes them based on the answers of the personal interviews.



D- Organizational culture: Table (9) shows the results of the checklist for one of the critical success factors for Agile Six Sigma, which is the organizational culture factor.

Table (9) Results of the organization's culture checklist analysis

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
40.	The company seeks through its products to raise its reputation among companies.			✓		
41.	The company has a distinctive brand that customers prefer.	✓				
42.	The company raises the slogan of improving product quality, everyone's responsibility.		✓			
43.	The company is characterized by credibility in dealing with suppliers and customers.		✓			
	weights	4	3	2	1	0
	Frequencies	1	2	1	0	0
	Result	4	6	2	0	0
	Weighted arithmetic mean (application rate)	3				
	Percentage of application	0.75				
	Gap size	0.25				

Based on the results of the checklist for analyzing the culture of the organization in Table (9), the overall application rate of this factor or requirement (weighted arithmetic mean) is (3) out of (4). This indicates that the organization's culture is partially applied through the scale installed at the top of the table. And the application rate was (0.75). As for the gap, it reached (0.25), which is the distance from the ideal state. We note that the gap ratio is relatively small, and this indicates the company's culture that helps creativity and encourages teamwork.

•Strength Point:

- One of the most important things that help companies succeed is their constant communication with suppliers and customers. The company is working greatly to improve the means of communication between it and the suppliers and between it and its customers. In order to obtain high quality raw materials at an affordable price from the suppliers. On the one hand the customer will meet his needs and listen to the complaints about the products.
- Forming teams to lead quality projects or the so-called (quality circles) is important to discuss process quality problems. And also use the method of

brainstorming ideas to find radical solutions. They work first to define the problem and then collect and diagnose information and propose alternatives. Finally, take the appropriate decision and follow up on the progress of the application process.

• Weaknesses:

- Poor compatibility and rapprochement between managers and working individuals may lead to a decrease in the productivity of the company and the loss of team spirit. As well as the loss of the atmosphere that helps creativity at work and the absence of familiarity and love within the company's halls.
- Managers may be one of the reasons for the weak culture of the organization due to poor communication between them and employees. As well as the lack of exchange of information about the process. Also, the lack of fulfillment of the covenants and giving the employees their entitlement due to its impact on the employees leaving the work in the company.

E- Financial capabilities: Table (10) shows the results of the checklist for one of the critical success factors of Six Sigma Agile, which is the financial capabilities factor.

Table (10) results of the analysis of the checklist of the financial capabilities of the company



No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
44.	The company's management allocates sufficient budget to finance quality projects.		✓			
45.	The company's management provides the necessary funds to support the diversification strategy in its products.		✓			
46.	There is sufficient budget to establish the infrastructure to support the expansion of production lines.		✓			
47.	The company's management allocates sufficient funds to support research and development projects.			✓		
	weights	4	3	2	1	0
	Frequencies	0	3	1	0	0
	Result	0	9	2	0	0
	Weighted arithmetic mean (application rate)	2.75				
	Percentage of application	0.69				
	Gap size	0.31				

Based on the results of the checklist for financial capabilities analysis in Table (10), the overall application rate for this factor or requirement (weighted arithmetic mean) is (2.75) out of (4). This indicates that the company's financial capabilities are somewhat applied and close to partial implementation through the scale installed at the top of the table. And the application rate was (0.69). As for the gap, it reached (0.31), which is the distance from the ideal state. We note that the gap ratio is rather small, and this indicates that the company is investing in its money on the positive side.

•Strength Point:

• The company's management allocates an adequate budget to support quality projects and a mechanism for upgrading them. As well as in terms of productivity and opening new production lines to increase the volume of production.

• Diversity in products is important, giving the company the opportunity to enter new markets, compete, acquire market shares and increase competitiveness. It varies with products correlatively and unconnectedly.

• Weaknesses:

• The company's lack of a research and development department could negatively affect the development of its products, creativity and innovation in designs. As well as losing the mechanism of finding alternatives and removing the burden from the rest of the departments regarding research and development.

f- Statistical and technical tools: Table (11) shows the results of the checklist for one of the critical success factors of Six Sigma Agile, which is the factor of statistical and technical tools.

Table (11) Results of the analysis of the checklist for statistical and technical tools

No.	Item	fully applied	Partially applied	somewhat applicable	poorly applied	Not Applicable
48.	The company uses technical tools to measure the level of quality performance of products.		✓			
49.	The company's management sets alert			✓		



	signs for the purpose of monitoring the machines.					
50.	The company's management adopts tools to detect the defects of its products before they become finished products.	✓				
51.	Company management uses process control and control charts to determine the cause of quality problems.		✓			
	weights	4	3	2	1	0
	Frequencies	1	2	1	0	0
	Result	4	6	2	0	0
	Weighted arithmetic mean (application rate)	3				
	Percentage of application	0.75				
	Gap size	0.25				

Based on the results of the checklist for the analysis of statistical and technical tools in Table (11). The overall application rate for this factor or requirement (weighted arithmetic mean) is (3) out of (4). This indicates that the statistical and technical tools are partially applied in the company through the scale installed at the top of the table. And the application rate was (0.75). As for the gap, it reached (0.25), which is the distance from the ideal state. We note that the gap ratio is relatively small, and this indicates that the company uses modern techniques and tools in its work to reach a high quality level.

•Strength Point:

• What distinguishes the company is its use of devices to detect defects in products before they become fully manufactured as much as possible and before they are transferred to warehouses. Here, the company mitigates the costs of external quality failures

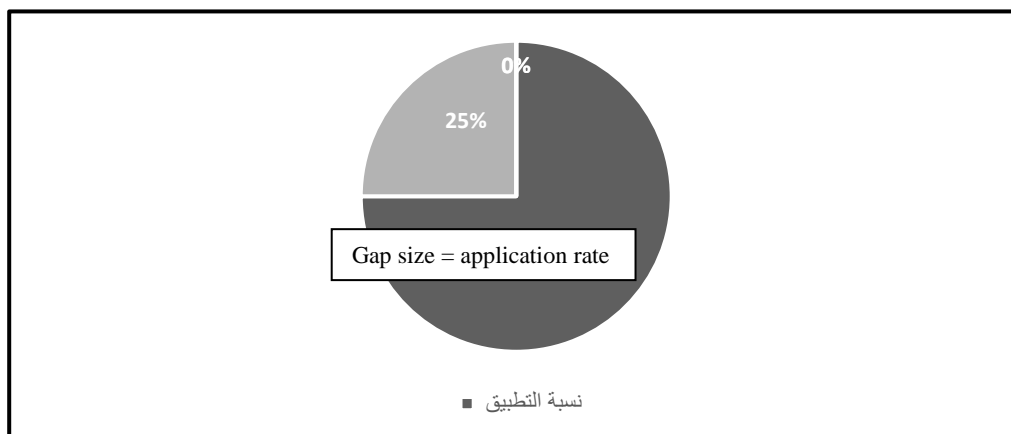
that are discovered by the customer and affect the company's reputation.

• The use of process control and control schemes, as well as the use of robots in the process, contributes greatly to reducing errors, defects and deviations in the process, and thus reduces waste, losses and costs and increases the quality of products.

• Weaknesses:

• The lack of alert systems that are placed on production lines for the purpose of indicating the presence of deviations in the manufacturing processes has a significant impact on the product. It is possible that the process will continue uncontrolled and the flow of production lines will lead to large losses because the batch exit containing defective and damaged products.

Figure (1) below shows the percentage of the possibility of applying statistical and technical tools in the company and the size of the application gap.



Third: Analyze the results



The study focused, by analyzing the results of the checklist, on two variables: the hybrid manufacturing system and the graceful six sigma technique, measuring the extent to which they can be applied in the company, the research sample, and indicating the extent of the application gap.

On the part of the hybrid manufacturing, the researcher found that the company is able to apply

this system in a large way through the results shown by the checklist and the availability of dimensions or performance measures for this system in the research sample company. Table (12) shows the final results of the checklist of performance measures for hybrid manufacturing. The size of the gap between these metrics can also be shown in a company for soft drinks, juices and healthy water.

Table (12) Final results of the hybrid manufacturing performance metrics checklist

No.	Performance Metrics for Hybrid Manufacturing System	Weighted arithmetic mean rate(Percentage of application	Gap size
1.	Quality	3	%0.75	%0.25
2.	Cost	3.2	%0.80	%0.20
3.	Productivity	3.2	%0.80	%0.20
4.	Lead Time	3	%0.75	%0.25
5.	Service Level	2.8	%0.70	%0.30
	Overall percentage of application rate of performance measures for a hybrid manufacturing system	3.04	%0.76	%0.24

Based on the results of Table (12), the total percentage of the application rate of performance measures for the hybrid manufacturing system in the research sample company reached (3.04), and the application rate (0.76%) and the gap size amounted to (0.24%), which is the extent of the distance from the ideal case.

Hybrid manufacturing system performance measures: measure the organization's success in achieving its goals. In order to measure the performance of a company, it is necessary to use the measures of this system, including (quality scale, cost, productivity, waiting time, level of service). And using the checklist by asking questions and knowing the duration of their application within the corridors of the company. The quality of the application was 75%. This is a highly significant percentage because the company adheres to most of the quality standards for products and the extent to which it strives to satisfy customers. While the application cost rate was 80%. This is a highly significant percentage, as the company seeks to reduce quality and production costs, which in turn reduces the company's total costs. As for productivity, the percentage of its application reached 80%. This is a highly significant percentage, as the company applies modern production systems that contribute to maintaining the quality of the products it offers, as well as using the principles of the "point of no convergence" strategy. While the waiting time has reached 75%, which is a rather high percentage. This

percentage is an indication of the company's quest to reduce waiting times, whether in purchases, during production stages, or even on-time delivery. As for the level of service, the results showed that the application rate reached 70%, which is a fairly good percentage. This is because the company seeks to satisfy its customers and increase the level of services provided to them.

It is clear that the total application rate (76%), which is a high percentage, is that the company possesses the qualifications for the application of its work at high quality levels, in addition to its serious quest to reduce costs and raise the level of productivity. It also reduces the waiting time at different stages in its operations and raises the level of services provided to customers.

As for the graceful six sigma aspect, the critical success factors, which are also called (the requirements for the success of the hexagonal diffraction), were used. These requirements are a critical and important factor for the success of any company or organization. It is through these factors that the company's ability and willingness to implement the six sigma technology can be measured. As well as the availability of the appropriate ground for the application tools. Table (13) shows the final results of the checklist for the critical success factors or the requirements for applying this technology in a company for soft drinks, juices and healthy water.



Table (13) Final Results for LSS Critical Success Factors Checklist

No.	Critical success factors (success requirements) for graceful hexagonal diffraction	Weighted arithmetic mean rate (application)	Percentage of application	Gap size
1.	Senior management commitment and support	3	%0.75	%0.25
2.	training	2.8	%0.70	%0.30
3.	Rewards and Recognition System	1.5	%0.38	%0.62
4.	organization culture	3	%0.75	%0.25
5.	financial capabilities	2.75	%0.69	%0.31
6.	Statistical and technical tools	3	%0.75	%0.25
	Overall percentage of agile six sigmarate	2.72	%0.68	%0.32

Based on the results of Table (13) above, the possibility of applying the six sigma technique in the company depending on the critical success factors or success requirements has reached (2.72) and an application rate of (0.68%) and a gap size of (0.32%), which is the extent of the distance from the ideal case.

FOURTH TOPIC

Conclusions and Recommendations

First: the conclusions

1. The company is interested in the research sample greatly in the field of quality and in various aspects by obtaining the ISO certificate. As well as its quest to improve the products put on the market. But it did not reach the top of the performance in terms of quality.
2. The company has the possibility to reduce the total costs through its endeavor to reduce the costs of storage and the costs of purchasing most of the raw materials. As well as rationing the use of raw materials and production capacity in excess of need. However, it was noted that there was an unjustified rise in the costs of quality, represented in the costs of examination and inspection, as well as the costs of internal failure as a result of the emergence of some problems in the production lines.
3. The company's management interest in production processes by equipping the factory with modern machines and production systems, whether in the field of line control or control and control systems. As well as increasing its ability to produce and develop new products to respond quickly to customer requests according to a pre-prepared plan. However, it did not reach the optimum level due to the emergence of some problems in the production lines due to the failure of some machines to perform their tasks correctly and properly.

4. The company's management seeks to reduce waiting times in various areas, including productivity, such as improving its operations and increasing its ability to respond quickly to customer requests, flexibility in processing those requests, and other speeds in delivering those products to avoid delays. However, this is at the expense of other activities, such as high costs on the production side as a result of the speed in meeting requests, as well as the risks of speedy transportation of products.

5. The support of the senior management of the company's activities is important in its work through its support for workers to participate in improving performance and equipping the factory with modern technology and laboratories in the field of measuring product quality and giving quality at work a high priority. While it is not aware of some modern technologies, such as the graceful six sigma technique, which may affect its quest to improve the quality of performance.

6. The company's management's lack of interest in the remuneration system has a negative impact on the factory's performance in general and on the employees' performance and psychology. Especially since this failure has consequences, including the loss of trust between the company's management and employees, and the weakness of the employees' loyalty to the company. And its lack of awareness of the importance of incentive rewards and incentives could affect the company's overall productive performance.

Second: Recommendations

- 1- The company should work more to reduce the size of the gap and raise the level of application while searching for the reasons for the low level of



performance in the aspects that were touched upon, such as quality, productivity and cost.

2- Working with the strategy of the point of no convergence (postponement), as it separates the production processes by delaying some important production activities until receiving customers' orders and then completing the production process. And it is important in terms of reducing inventory as well as expediting the fulfillment of orders. That is, it does not produce and accumulate goods in warehouses, but rather depends on the requests directed by its customers based on a time production plan.

3- The company's management must maintain a certain stock level in order to meet the urgent demands it receives in certain seasons of the year, such as summer. It must have an adequate level of storage to cover these demands. Receiving the request and converting it into a production plan may take time, which leads to delays in the requests of some customers.

4- Here we must refer to the process of repeated layoffs, one of the reasons for which is the lack of financial allocations granted by the company or because of the pressure of overtime work, which leads to contracting with new workers. One of the issues arising from the contracting process is the weak performance of the new worker and his lack of experience in dealing with modern technologies. As well as the occurrence of frequent errors as a result of the lack of specialized training courses at work.

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