

**THE EFFECT OF APPLYING THE SIX-SIGMA APPROACH ON THE COSTS OF ACTIVITIES  
OF THE GENERAL COMPANY FOR TEXTILE AND LEATHER INDUSTRIES**

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**Abstract**

The General Company for Textile and Leather Industries, a subsidiary of the Ministry of Industry and Minerals, plays a prominent role in reviving the national economy given its specific status. However, it is currently suffering from several problems, including the high costs of its activities, and a decrease in the accuracy of its production processes. These issues were reflected in the high percentage of defective production and a decline in the rate of proper production. Accordingly, the method of Six-Sigma came to help analyse production activities through the application of the Define, Measure, Analyse, Improve and Control (DMAIC) approach to identify cost-depleting activities that are not offset by the benefit and to prevent the defective production from the beginning instead of addressing it later and at a level of (3.4) defect per million opportunities.

Employing the abovementioned company as the research sample, several conclusions have been reached, the most important of which is the presence of several sources of waste and loss such as value-adding activities and processes , which resulted in high costs. This is in addition to the company's failure to use modern cost-effective methods that help in i) continuously

improving production processes and its outputs, ii) identifying the root problems of high costs, iii) eliminating sources of waste and loss, and iv) decreasing the quality of its products.

**Keywords:** DMAIC, Six-Sigma.

## **Introduction:**

The textile and leather industry occupies great importance, being the only industry in the Iraqi environment that produces wool, cotton and leather products, which constitute one of the main needs of customers. The profit-making of these industries is linked to the extent to which the customer accepts their products in terms of price, quality, designs, etc.. This signals the the importance of conducting a study that analyses the production activities of this industry in a manner consistent with its nature. Accordingly, this study, which used the Six-Sigma method, was conceived with the aim of developing solutions to the problems that the company suffers from.

## **Research methodology and previous studies**

### ***2.1 Research methodology***

#### **2.1.1 Research problem**

Various sectors in the Iraqi environment in general and the industrial sector in particular face obstacles to achieving the planned goals. This is ascribed to the reliance on traditional cost accounting systems to provide information for decision-makers and hence their inability to diagnose, analyse and address weaknesses from the stage of product design or service to the stage of offering it to the customer.

Based on the above, the research problem can be summarised through the following questions to avoid deficiencies in the traditional systems applied in the industrial sector units and as follows:

Does the adoption of the Six-Sigma method help guide the administration of the unit to the reasons that led to the high cost of productive activities?

Does the Six-Sigma method rationalize the cost of activities through the DMAIC approach?

### **2.1.2 Research Aim**

The research aims to achieve the following objectives:

Introducing the method of Six-Sigma as one of the modern cost methods that contribute to improving the cost of activities.

Preventing the occurrence of defects from the outset instead of addressing them later and up to almost zero defects.

Using the methods of analysis and measurement of comparisons, cause and effect chart, Burrito and others to help determine where improvement begins.

Improving the value of the product and the process by identifying the causes of fundamental deviations and addressing them and making continuous improvements to them.

### **2.1.3 The Importance of Research**

The importance of research can be summarised in the following points:

Addressing criticism of traditional systems applied by the company sampled in this research in identifying indicators of any problem or defect in the product or production process.

Focusing on production processes and identifying and measuring their defects with the aim of improving them by making performance efficiency up to 3.4 defects per million opportunities where they operate in an organized methodology that helps to identify the root causes of the problems of high costs and propose appropriate solutions and make continuous improvements under effective operational control.

Eliminating waste of resources such as damage, loss, recycling and others.

#### **2.1.4 Research Hypothesis**

The research is based on the following hypothesis:

The Six-Sigma method contributes to influencing the production activities in a way that raises their efficiency and reduces their costs.

#### **2.1.5 Research Limits**

The limitations of the research are as follows:

Spatial limits: The General Company for Textile and Leather Industries – Al Sofia Factory was chosen as our research site. This was due to the fact that most of the factory's factories did not keep pace with the technological developments that the world has reached in terms of manufacturing, designing and controlling. This consequently resulted in high costs, high prices, poor quality products, and weak competitive position.

Time limits: - The financial statements and cost reports for the years 2019-2020 were chosen to provide the required data in a way that facilitates studying them and identifying the most important problems that the company suffers from and proposing solutions to them, and thereby achieving the research objectives.

#### **2.1.6 Research Methodology:**

The inductive approach was relied upon to accomplish the theoretical aspect by consulting the literature related to the subject of the research as well as the descriptive analytical approach to accomplish the practical aspect by collecting and analysing the data.

#### **2.1.7 Previous studies**

Previous studies related to the Six-Sigma method can be presented in Table (1) below.

Table (1): Studies related to the Six-Sigma method

**The study of Hussein (2018)**

<b>Title</b>	The effect of applying Six-Sigma technology in reducing costs and improving the quality of banking service
<b>Type</b>	A letter submitted to the Council of the College of Administration and Economics - Al-Mustansiriya University, which is part of the requirements for obtaining a master's degree in accounting sciences
<b>Aim</b>	Apply the Six sigma technique to the banking sector in order to reduce errors and costs resulting from providing banking services and developing performance by focusing on improving the quality of these services
<b>The most important conclusions</b>	The Six-Sigma technique has proven its success and its ability to improve the quality of the operations of the economic units that it has adopted, whether industrial, service or other sectors.
<b>2- Study of Al-Khayyat (2017)</b>	
<b>Title</b>	Reducing costs by using the techniques of target cost and Six-Sigma for economic units operating in the Iraqi environment
<b>Type</b>	Applied research in Financial Links General Trading Company
<b>Aim</b>	Reaching the best contemporary techniques to manage the costs of the commercial economic units operating in the Iraqi business environment in light of the current economic conditions, which can be applied to similar cases in other countries, by: Showing the dimensions of the cost reduction process through the techniques of target cost and Six-Sigma and the practical application of the procedures of the target cost techniques and Six-Sigma, and to clarify their role in reducing costs while maintaining the quality of service provision.

<b>The most important conclusions</b>	The company's adoption of the field of research depends on traditional cost systems in managing its costs, despite the obvious shortcomings in the work of those systems. The company neglects the field of research for the issue of cost control in the periods when the activity is booming. The profits are achieved according to satisfactory ratios, and the stability of its market share forgetting the rapid changes in the modern business environment. The importance of increasing the market share or at least maintaining it by making low costs an advantage that contributes in its continuity.
<b>3- Study of Yassin (2017)</b>	
<b>Title</b>	The effect of Six-Sigma application requirements in reducing the cost of poor quality
<b>Type</b>	A case study on the ship's captain factory in Najaf
<b>Aim</b>	Explanation of the impact of the requirements for the application of Six-Sigma in reducing the cost of poor quality in the Rabban al-Safina factory in Najaf by i) providing a theoretical framework on the requirements for the application of Six-Sigma and the concepts related to the cost of poor quality, and ii) identifying the availability of requirements for the application of Six-Sigma and the level of cost of poor quality in the factory above, while determining the impact of the requirements of Six-Sigma. The application of Six-Sigma approach in reducing the cost of poor quality.
<b>The most important conclusions</b>	The presence of the effect of the requirements of Six-Sigma in reducing the cost of poor quality at the Rabban al-Safina factory in Najaf. This means the ability of the requirements of Six-Sigma to improve performance and develop work mechanisms that are reflected in reducing

	and reducing the cost of poor quality and work hard to offer goods that live up to international standards, capable of attracting more customers
<b>4- study of Adili (2014)</b>	
<b>Title</b>	The possibility of applying the Six Sigma method and its role in reducing costs and strengthening competitiveness
<b>Type</b>	An applied study in the Advanced Technologies Company for the re-manufacturing of consumables.
<b>Aim</b>	To demonstrate the role of the Six-Sigma technique in reducing defective production, maximizing profits, increasing production efficiency, and its impact on reducing costs and increasing the competitiveness of the unit.
<b>The most important conclusions</b>	The application of the Six-Sigma technique according to sound scientific foundations leads to the transfer of the unit from the lower levels to a higher level of six-sigma, which leads to a decrease in the percentage of defective production and an increase in the quality of products with a decrease in quality costs, in addition to achieving savings and profits for the unit. This leads to an increase in its capacity competitiveness.

## Six-Sigma and activity costs

### 3.1 The Concept:

In light of the intense competition witnessed by all sectors, the units strive to achieve a competitive advantage. This is in order to ensure that they maintain a market share by achieving a high level of quality of their products, which was considered by many units as a source of concern as they need considerable material and human resources. The units in general and the American ones in particular, relied on the method of comprehensive quality checking, that is,

(product checking by 100%). This method is an ineffective one in light of the production of large quantities, which makes the checking process uneconomic. This in turn obliged the units to search for modern methods in processes to achieve competitive advantage, and Six-Sigma approach is one of those methods (Eckes, 2001, pp.1-3). The main objective is to reduce defects to 3.4 defects per million opportunities (Furphy, 2010, p. 23). Table (2) below shows the Six-sigma levels, the number of units performed and the level of performance that correspond to each level, and as follows:

Table (2): Six-Sigma levels and performance and their relationship to the

Six-Sigma level	Number of defective units	performance level
1	691,500	30.85
2	308,300	69.15
3	67,000	93.32
4	6,220	.99.38
5	233	99.977
6	3.4	99.99966

Source : (Thompson, 2007, p. 40)

### 3.1 2 Principles of Six-Sigma Approach.

(Alghabban & Alghabban, 2020, p. 1231) the Six-Sigma approach is based on a set of principles:

Table (3): The principles on which the Six-Sigma method is based.



Details	sequence
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 that is 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 examination, which drains human and financial resources.

### 3.1.3 Elements of Six-Sigma approach

The following elements taking into account when working on the adoption and application of the Six-Sigma method and as follows:

(Narula & Grover, 2015, p 18), (Al-Ghabban, 2013, pp. 210-211), (Abdul Hafeez, 2016, p. 48).

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.

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

Linking the Six-Sigma method to accounting and management information systems.

Linking the system of promotions and incentives for the human resources working in the programs of Six-Sigma projects.

Focusing on internal processes that require prior planning and departure from reaction management to problem management before they occur.

### **3.1 4 Organizational Structure of the Six-Sigma Working Group:**

The belt system is important for the application of the Six-Sigma method. 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 different names, such as: the main black belt, the black belt, the green belt and these responsibilities and tasks escalate from one administrative level to another (Al-Baghdadi, 2018, pp. 161-162).

### **3.1.5 Six-Sigma Methodologies**

Six-Sigma has two working methodologies as follows (Al-Titi, 2011, p. 170):

(DMAIC) approach: It is used in projects that aim to improve their current business operations, and it consists of five steps (Define, measure, analyse, improve, and control). In the event that the unit for this approach failed to raise the level of performance, it applies the next approach, that is DMADV.

The (DMADV) approach: It is a method used in projects that aim to produce new products or design new processes, and it consists of the following steps (define, measure, analyse, design,

and verify). The DMAIC (Problem Solving) approach is better than others for the following reasons: (Al-Nuaimi and Sweiss, 2008, pp. 86-87)

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

Focusing on the external and internal customer.

Verification of the basis of the problem by means of facts that prove that this factor alone is the cause of the problem.

Eliminating previous habits, the solutions resulting from this method must generate real change and not simple changes.

Risk management is an essential part of this method and is considered logical.

Measuring results, the realistic impact of our solutions, supported by facts.

Continuous follow-up.

### **3.1.6 Tools used in applying the Six-Sigma method:**

A set of tools is used with the application of the Six-Sigma method. Cause and effect analysis, process mapping, benchmarking, process capability analysis, burrito analysis are among the most widely used tools when applying it. There are also another group of tools that are less used than the first group, as shown in Table (4) and as follows: (Shah, 2016, p. 916).

Table (4): The most and least used tools when applying the Six-Sigma method

(Setter, 2018, p. 206)

	Most used tools and techniques	Ratio%	Less used tools and techniques	The ratio%
1	Cause and Effect	76%		

	Analysis			
2	Operations Flow Diagram	52%	Quality Function Deployment	30%
3	reference measurement	50%	Experiment Design	18%
4	Burrito analysis	47%		
5	Process capacity analysis	47%		

### 3.1.7 The relationship between the Six-Sigma method and quality costs

Quality costs are defined as the sacrifice incurred by the unit due to the production of a good or service that does not conform to specifications from the first time (Al-Azzawi, 2012, p. 22). It is associated with achieving or not achieving product or service quality. Accordingly, it is divided into two parts:

good quality costs (prevention, evaluation) which is borne by the company in order to ensure the development and success of the product or service.

The costs of poor quality (internal and external failure) borne by the unit as a result of its knowledge of the defects that occurred in the product or service to make it acceptable to the customer (Al-Antari, 2020, p. 33).

Blocher *et al.* (2010, pp. 759-760) divided it into the following:

Prevention costs: are the sacrifices incurred by the unit to prevent the occurrence of quality defects from the beginning.

Evaluation costs: are the sacrifices made to determine the extent to which the outputs match the target specifications.

Internal failure costs: are the sacrifices related to defective processes or products that have been discovered before they reach the customer.

External failure costs: these are the sacrifices associated with quality defects that were discovered after delivering the defective product or service to the eventual customer.

The relationship between the Six-Sigma method and quality costs can be illustrated through the following table:

Table (5): The relationship between Six-Sigma level and quality costs

<b>Six-Sigma levels SS</b>	<b>Ratio of quality costs and according to diffraction levels</b>
1	unmeasured
2	Above 40%
3	25% to 40%
4	15% to 25%
5	5% to 15%
6	Less than 1%

Source: (Setter, 2018, p. 123).

It can be noted from Table (5) that the relationship between the Six-Sigma level and quality costs is a direct one. As far as these costs fall, they are associated with the number of units that the unit is the level of the unit (2), the quality costs will be high as more than 40% of total sales. At the level of (6), the failure costs are less than 1% of the total sales as the level of the limit rate decreased and therefore the costs decreased (Al Yamour, 2010, p. 11). Rawal et. al (2021), Poongodi M et. al(2022), Poongodi M et. al (2021), Dhiman P et.al (2022), Sahoo S.K et.al (2022), K.A et. al(2022) , Dhanraj R.K et. al (2020), Poongodi M et. al (2019), Poongodi M et. al (2020), M. M. Kamruzzaman et. al (2014), M. M. Kamruzzaman et. al (2021), Md Selim Hossain et. al (2019), Mingju Chen et. al (2019).

Achieving quality and its continuous improvement will lead to attracting the largest number of satisfied customers and consequently a decrease in the cost of the produced unit as a result of the increase in the number of units sold. (Al-Ajili *et al.*, 2016, p. 64).

The relationship between the Six-Sigma method and the reduction of quality costs is mainly focused on the desire to prevent defects before they occur, leading to the completion of operations in the correct manner from the beginning. When the administration is able to identify and measure the number of defects in production processes, it will certainly be able to take the right measures to reduce them by up to 3.4 defects per million opportunities. This is consistent with the modern view of quality based on the concept of continuous gradual improvement of quality and the resulting reduction in the cost of internal and external quality to the lowest possible level. Therefore, in order to reduce the costs of internal and external failure, unit administration should focus its attention on prevention and evaluation activities (cost of confirmation and quality assurance), as the discrepancy in the target specifications of both products and processes will result in an unjustified increase in quality costs. Thus, directing the unit's attention and focus on reducing the number of defects in its production processes and outputs will result in a significant reduction in the cost of internal and external quality with a slight increase in the cost of prevention and evaluation. This will begin to decline while improving the quality of operations and reducing its defects, thereby achieving the optimal quality level (Hilton, 1999, p. 499).

#### **4. The practical side: steps of applying the Six-Sigma method**

##### **4.1 The definition**

It includes identifying production defects according to their type and number to be a basis for measuring the level of diffraction with which the company operates. Before starting to identify the causes of defects in production, the product will first be described and the activities of production operations will be identified as follows:

The carpet is an interwoven fabric structure consisting of three dimensions (Z Y X), as its manufacturing requires three basic raw materials that overlap in texture to form the textile structure of the mechanical carpet as follows:

weft yarn in X direction (weft): to fix the pile threads and to tie the warp threads together with a single textile structure, as the main material used in weft yarn is jute.

Pile in Y direction: The pile yarn is distinguished from the upper shape of the rug, and it is possible to use various types of yarn as loose yarns that are included in the textile process such as silk, wool, acrylic, polypropylene, polyester, or other yarns.

Warp yarn in Z direction: Warp yarn is used in many types of textile materials such as polyester, polypropylene and polyamide, but the most commonly used material in warp yarn is divided into two parts:

A: Filling warp: These threads preserve the texture of the two carpets separately.

B: Weaving warp: These threads connect the weft threads with the filling warp to form the floor of the mechanical carpet.

latex, water, steam.

The following section is dedicated to determining the type and number of defects in the mechanical carpet product in the light of which it is possible to measure and determine the level of diffraction with which the company operates, as in Tables (6) and (7) and as follows:

Table (6): Types of defects in the products of the General Company for Textile and Leather Industries - mechanical carpets

Defect type	
1	Histological defects
2	Design defects (patterns and colors)
3	Confusion
4	Finishing
5	Product weight does not match specifications
6	Inaccurate measurements
7	Softness and smoothness

Source: Based on field visits to the laboratory

Table (6) shows the most frequent defects that totalled (7) defects and will be adopted when applying the equation for calculating the level of diffraction. Table (7) includes the classification of the actual production quantity for 2020, which amounted to (1230 m<sup>2</sup>) depending on its condition and as follows:

Table (7): Types of products distributed according to their proper and flawed quantities and proportions: Mechanical Carpet Woollen Factory / General Company for Textile and Leather Textiles for 2020

Product Type	Total product ion	Proper production	Proper production	Quantity of production	The proportion of defective



	quantity	ratio	quantity	defects	production
Baghdad acrylic carpet 3×4	288	0%	0	288	100%
Baghdad acrylic carpet 3×5	90	0%	0	90	100%
Baghdad antique acrylic carpet 1.25×1	219.5	10%	21.5	198	90%
Babel Polypropylene Carpet 2×3	140	14%	20	120	86%
Red Acrylic Ceremony Carpet	195	5%	10	185	95%
Baghdad acrylic carpet 2×3	104	4%	4	100	96%
Baghdad acrylic carpet 3×1	60	17%	10	50	83%
Baghdad acrylic carpet 1×2	116	5%	6	110	95%
Bubble Polypropylene Carpet 2.5×3.5	17.5	49%	8.5	9	51%
<b>Total</b>	<b>1230</b>	<b>7%</b>	<b>80</b>	<b>1150</b>	<b>93%</b>

Source: Based on field visits to the company

Table (7) reveals that the amount of defective production increased to (1150 m<sup>2</sup>), representing 93% of the total production amount (1230 m<sup>2</sup>), which is very high, as some production runs were in total as defective as Baghdad acrylic carpets measuring (3×4) and (3×5).

**Percentage of defects per unit = quantity of production defects x 100%**

**production quantity**

Defect ratio per unit =  $1150 \text{ m}^2 \times 100\% = 93\%$

1230 m<sup>2</sup>

**Accuracy ratio of operations = 1 – defects per unit**

Accuracy percentage of operations =  $1 - 93\% = 7\%$

Defects per million opportunities = **The amount of defects**

**Production quantity x types of defects**

Defects per million opportunities =  $1150 \text{ m}^2 = 1150 \text{ m}^2 = 0.13356562137$

$1230 \text{ m}^2 \times 7 \text{ 8610 m}^2$

$0.13356562137 \times 1000000 = \mathbf{133,566 \text{ defects}}$

From the above equations, it can be noted that the percentage of defects per unit has increased, reaching (93%), offset by a significant decrease in the percentage of accuracy of operations, which reached (7%). The probability of defects appearing per million opportunities is (133,566) opportunities, and to determine the level of deviation, the table for Six-Sigma levels is referred to as follows:

Table (8): Six-Sigma for the State Company for Textile and Leather Industries – Mechanical Carpets

**133,566**

Six-sigma level	Number of defective units	Performance level
1	691,500	30.85
2	308,300	69.15
3	67,000	93.32
4	6,220	.99.38
5	233	99.977
6	3.4	99.99966

From Table (8), it can be seen that the number (133,566) lies between the level (2) and (3). Based on the above results, it is necessary to search for the main reasons that led the company to this poor level of performance.

The ratio of quality costs can be determined through the relationship between levels of diffraction and quality costs, as shown in Table (9) and as follows:

**Table (9): Determining the percentage of quality costs in light of diffraction levels Mechanical carpet.**

Six-Sigma level	Number of defective units	Quality costs
1	691,500	<b>unmeasured</b>

2	308,300	<b>Above 40%</b>
3	67,000	<b>25% to 40%</b>
4	6,220	<b>15% to 25%</b>
5	233	<b>5% to 15%</b>
6	3.4	<b>Less than 1%</b>

It can be noticed from Table (9) that the percentage of quality costs that correspond to the level of diffraction with which the company operates is located between the first and second levels is (25%-40%), i.e. the rise in quality costs (internal failure, external failure) and the detailed analysis will be done in the analysis stage to determine the first cause.

Therefore, the following paragraph will include a detailed analysis of the production problems that the company suffers in order to identify the main causes as follows:

**4.2: The two stages of analysis and measurement**

The aim of these stages is to search for the possible causes of the production problems that the company suffers from and listed in Table (5), which led to a decrease in production and sales levels and a rise in production costs accompanied by a decrease in the quality of products, and the achievement of successive losses, the amount of which can be shown for the last three years as in Table (10) and as follows:

Table (10): Result of current operations activity.

Year	Amount of losses in dinars
2018	11,235,532,000

2019	11,443,993,160
2020	11,694,211,250

Source: Based on the financial statements of the research site.

Accordingly, the cause and effect diagram will be relied on to identify the root causes of the problems as follows:

Figure (1): Cause and Effect Analysis Chart (Effect)

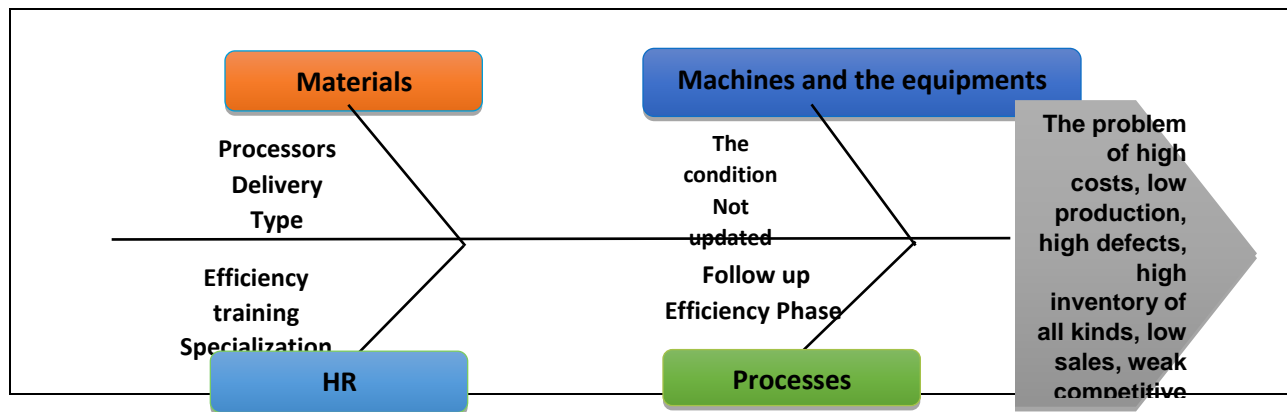


Figure (1) shows four main components for the possibility of the emergence of production problems represented by machines and equipment, processes, human resources, raw materials, then the sub-components will be entered for the main reasons as follows:

The first reason: Machines and equipment: In this paragraph, the analysis will be done through the following:

A review of the types, specifications and year of manufacture of the machines used in the production process, as well as the type of product produced by the machine and its measurements, as shown in Table (11) as follows:

Table (11): Types and specifications of the machines used in the production process.

	Number of machines	Machine type	Manufacturing year	Origin	Product type	Machine location
1	5	3m width carpet weaving machine with rapier system	1985	Belgian MICHEL VAN DE WIELE	Baghdad carpet production 25 knots / cm <sup>2</sup>	textile line
2	2	Carpet weaving machine, width 4m2It works with the rapier system	1985	Belgian MICHEL VAN DE WIELE	Baghdad carpet production 25 knots / cm <sup>2</sup>	
3	2	Carpet weaving machine, width 2m2Shuttle system	1975	German textema	Baghdad carpet production 26 knots / cm <sup>2</sup>	
4	2	Carpet weaving machine, width 2.5	1975	German textema	Babylon carpet production 13.86	

		m2Shuttle system			knots/cm2	
5	1	Carpet weaving machine, width 2m2Shuttle system	1975	German textema	Babylon carpet production 13.86 knots/cm2	
6	1	Belgian spinning machine	1990	Belgian VAN DE WIELE	Smoothing the back of the product	complement line
7	1	carpet trimmer	2014	German textema	Carpet face trimming	
8	1	Rosary machine	1984	Belgian titan	Tailoring rosary	
9	1	Stitching machine	1976	German union special	Stitching the hem	
10	1	Stitching machine	2014	Taiwan liberty	Stitching the hem	

Source: Based on the company data

It can be noted from Table (11) that the machines used in the production of carpets are large-sized machines with different production measurements. They were introduced for production in

the early 1970s and late 1980s. Some of them operate the shuttle system, which is one of the old systems in production imported from the German company TextEma in the early 1970s, including the newer machines operating the Reiber system, which was imported from Michel van de WIELE of Belgium at the end of the 1980s, and its production measurements are 3m-4m-2.5m-2m-2m.

In general, machines with old technology are considered, and most of the industrialized countries of the world today do not use these systems (shuttle system and mechanical engraving system by cartoon). Rather, they use machines with electronic systems and high production capacities and speed and accuracy of control of inscriptions, colours and measurements as well as lack of need for maintenance.

Measuring the capacity of operations: The capacity of operations was measured by dividing the actual production volume of 2020 by the actual capacity of the same year and as in Table 12 below:

Table (12): Measuring the capacity of carpet completion line machines

	<b>Machine capacity</b>  %  <b>Actual ÷ scheme</b>	<b>Planned production capacity</b>  <b>For the year 2020</b>	<b>Total actual power</b>  <b>For the year 2020</b>	<b>T</b>
<b>1</b>	<b>Textile line</b>	<b>50000</b>	<b>1230</b>	<b>2.46%</b>
<b>2</b>	<b>Completion line</b>	<b>50000</b>	<b>1230</b>	

Source: Based on company data

Table (12) reveals the decrease in the capacity of the textile line and the completion line, with a capacity of 2.46%. One of the reasons that led to the failure to achieve the plan, which was

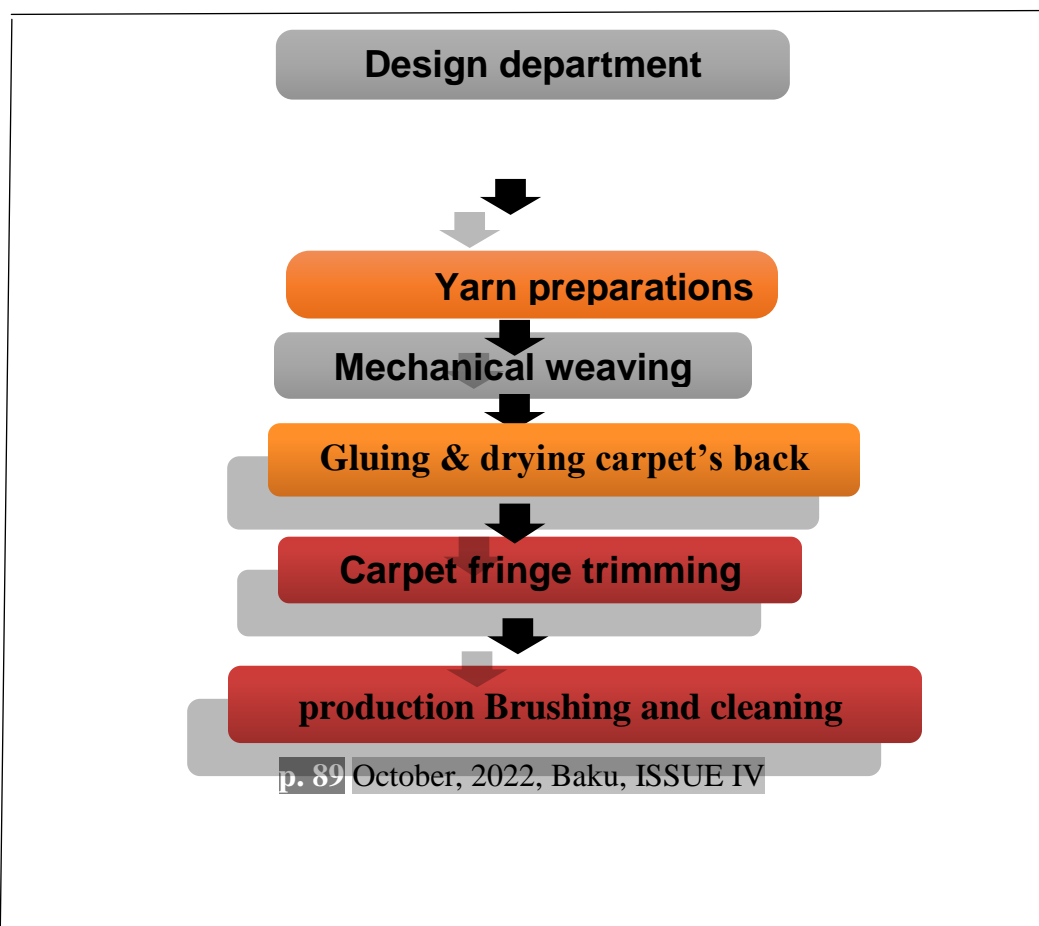


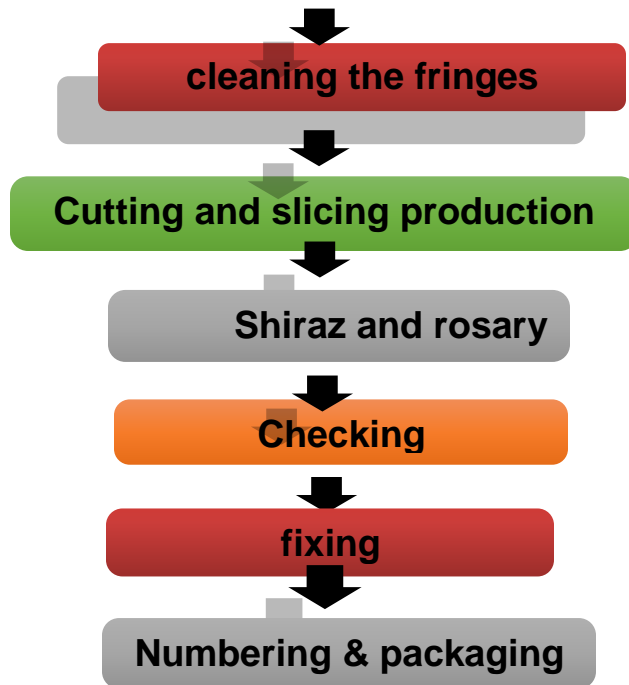
determined during interviews with production engineers, is that the company planned a larger amount Of the actual capacity of its machines. The actual capacity here is only (5%) of the planned 50,000 m<sup>2</sup>, equivalent to (2500 m<sup>2</sup>) assuming the use of (7) hours per day and the absence of sudden interruptions as power outages, or maintenance.

B) The second reason: operations:

Analysing the processes more clearly will be based on the technological path of the mechanical carpet product will help in identifying activities and problems that affect the production process as well as the type and cost of value and non-value adding activities and as in Figure (2) as follows:

Figure (2): The technological path and the cost of its activities.





Source: Based on the company's convicted visits

The carpet industry process goes through several stages of production, from the design phase to the numbering and packaging of the product. Table (13) shows the cost of each activity with a definition of value-adding activities and as follows:

Table (13): Cost of production activities

Activity name	Total cost of activities	Non-adding value
designs	167,435,666	80%
		133,948,533

preparations	55,675,021	55,675,021
fabric	1,106,028,438	20% 221,205,688
nurture	315,058,851	0
Brushing	12,602,354	4% 12,602,354
Trimming	31,505,885	10% 31,505,885
cleaning	15,752,943	5% 15,752,943
Cutting	12,042,240	12,042,240
Stitching and rosary	38,282,964	0
Checking	32,868,000	32,868,000
Fixing	126,443,520	126,443,520
Numbering and packaging	25,318,056	0
Total	1,879,152,756	642,044,184

Source: Based on the company's cost reports

It can be seen from Table (13) an increase in the costs of activities, as their total cost amounted to (1,879,152,756) dinars, of which (642,044,184) dinars are for the costs of non-value adding activities. These activities, which caused the high cost, were identified during field visits to the company and inquiries directed to production engineers. The checking process is carried out once at the end of the production process, i.e. after the error and defect have occurred and cannot be avoided and therefore the cost of the production is high.

C) The third reason: working human resources: The working human resources will be analysed by their numbers, costs, and classifications, as in Table (14).

Table (14): Number, type and cost of manpower in the mechanical carpet factory for the period from 1/1 – 31/12/2020

Type	Number	Salary	Percentage
Full-Time Employees	223	1,134,805,287	
Contracted Employees	6	25,200,000	
Total	229	1,160,005,287	
Non-participatants in the process	160	812,003,701	70%
Participants in the production process	69	348,001,586	30%
Total	229	1,160,005,287	100%

Source: Manpower List for the year 2020.

The number of workers classified as non-participants in the production process was (160) workers, i.e. 70% of the total workers and at a cost (812,003,701) dinars. This constitutes a burden on the production process, i.e. the existence of a cost that is not offset by benefit and hence a significant increase in the cost of production. In addition, the company appoints employees to the owners of contracts despite a surplus of workers, accounting for (2%) of the total number of employees and at a cost of (25,200,000) dinars.

D) Fourth reason: Raw materials: Through field visits to technical laboratories to determine the efficiency of raw materials, it was found that the yarn used to produce carpets with different lengths. Also, cutting the upper and lower carpets on the fabric machine leads to the fall of loose bristles on the surface of the two carpets produced and more on the lower carpet. The release of short bristles depends on the type of yarn, especially the specification of softness, the length of the bristle as well as the number of suitable bristles for yarn and the type of yarn technology. Another major reason for the higher production cost was the purchase and storage of large quantities of yarn in the company's warehouses, a large proportion of which was damaged by poor storage. Table (15) shows the cost of raw materials and as follows:

Table (15): Raw materials supply cost

Directory no.	Warehouse type	The cost in dinars		Change amount in Dinar
		Year 2019	Year 2020	
131	Raw materials and raw materials	3,091,141,350	3,444,593,134	353,451,784

Source: Based on the company's financial statements

It can be seen from Table (15) that the cost of raw materials supply increased, as it reached (3,444,593,134) dinars and (3,091,141,350) dinars for the years 2020 and 2019 respectively with an increase for the year 2020 of (353,451,784) dinars. This indicates the company's

reliance on the traditional methods of the cost accounting system and the failure to apply modern methods of timely purchasing. This results in a waste of resources as a result of storing large quantities, and the damage of a large part of them resulting from the lack of a sound storage environment.

#### ***4.3 The stage of improvement.***

It includes developing solutions to the problems that the company suffers from depending on the results of the analysis stage and by linking the causes and roots of the problem to the appropriate solutions to it as follows:

Introducing modern manufacturing technology through the purchase of (3) textile machines with the following specifications:

Two modern weaving machines type (RCE02 – 400) with a production width of (4 m<sup>2</sup>), to produce patterned carpets of multiple colours and with various types of yarn (polypropylene – acrylic – wool) and with a 2-stroke (1/2 V) textile structure.

A Modern fabric machine (RCI 03-400) (1) with a production display (4 m<sup>2</sup>) of carpet of different yarns (polypropylene – acrylic – wool), in colours and structure of nuclei 3 run (2/3 v).

The machines should be of a reliable European origin. This is because the technology of carpet manufacturing is a specialized technique, and that the use of approved weaving machines from these sources will be more efficient in terms of production, maintenance costs, operation and consumption, as well as the useful life of the machine.

As for the technical specifications of the machine type (RCE02 – 400) and type (RCI 03-400), they run as follows:

The possibility of forming a variety of textile structures and multiple options in terms of accuracy, textile smoothness, and weight per square meter instead of a fixed weight and textile composition. This is in addition to an advantage in production speed compared to the machines currently used.

The design is based on electronic systems (software) that works with a multi-coloured engraving that adds beauty and clarity of details in the patterns of the produced carpets with the speed of completion of designs unlike the approved machines that work with the mechanical jacquard system, which is riddled with malfunctions.

It operates with a central control panel that controls all functions, i.e. the examination is carried out during the production process. This helps to avoid defects before they occur, unlike the used machines, which are checked at the end of the production process.

Cutting the hem is done automatically and regularly instead of the approved mechanism for cutting the hem manually, which causes problems in terms of inaccuracy and regularity of measurements.

It can be seen from the above that the Six-Sigma method contributed to identifying the root causes that were represented by the presence of non-value adding activities that affected the quality, cost, time, customer satisfaction and developing appropriate solutions to eliminate them. Table (16) illustrates this.

Table (16): Classification and measurement of costs of activities.

Activity name	Non-adding value	adding value	Total cost of activities
Designs	80% 133,948,533	20% 33,487,133	167,435,666
preparations	55,675,021	0	55,675,021
fabric	20% 221,205,688	80% 884,822,750	1,106,028,438

nurture	0	255197669	315,058,851
Brushing	4%	0	
	12,602,354		12,602,354
Trimming	10%	0	
	31,505,885		31,505,885
cleaning	5%	0	
	15,752,943		15,752,943
Cutting	12,042,240	0	12,042,240
Stitching and rosary	0	38,282,964	38,282,964
Checking	32,868,000	0	32,868,000
Fixing	126,443,520	0	126,443,520
Numbering and packaging	0	25,318,056	25,318,056
Total	642,044,184	1,237,108,572	1,879,152,756

It can be seen from Table (16) that the costs of non-value adding activities have increased, reaching (642,044,184) dinars, which is equivalent to (34%).

#### **4.4 Control stage:**



It is a continuous stage that the company must be keen to implement in every joint of the production process in order to discover deviations and predict them before they occur to ensure that the necessary precautions are taken and any problem is addressed as soon as it occurs, that is, to avoid the error before it occurs and this is what the Six-Sigma method seeks through working methodology.

From the foregoing, the effect of the Six-Sigma method on production activities can be shown by improving the quality of production processes by excluding value-adding activities and have a significant impact on the cost of carpets, as shown in Table (17) as follows:

Table (17): The effect of applying the Six-Sigma method on the cost of production

Activities	Activities costs	
	Before applying the Six-Sigma method	After applying the Six-Sigma method
designs	167,435,666	33,487,133
preparations	55,675,021	-----
fabric	1,106,028,438	884,822,750
nurture	315,058,851	255197669
brushing	12,602,354	
trimming	31,505,885	-----
cleaning	15,752,943	
cutting	12,042,240	-----

Stitching and rosary	38,282,964	38,282,964
checking	32,868,000	-----
fixing	126,443,520	-----
Numbering and packaging	25,318,056	25,318,056

## **5. Conclusions and Recommendations**

### ***The conclusions***

The factory still depends on machines with outdated production systems that countries in the developed world no longer use.

The high percentage of defects per unit is offset by a significant decrease in the accuracy of operations and a low level of performance in which the company operates.

Existence of non-value adding activities that contribute to raising production costs.

The decrease in the number of participants in the production process with an increase in the number of workers classified among the non-participants in the production process, that is, the existence of a cost that is not matched by a benefit, and hence a significant increase in production costs.

The high cost of the stock of raw materials as a result of the company's reliance on the traditional methods of the cost accounting system, which results in a waste of resources as a result of the grief of large quantities, and the damage of a large part of it resulting from the lack of a sound storage environment

### **5.2 Recommendations**

Introducing modern technology in the Iraqi carpet industry by adopting machines with advanced systems.

Improving the accuracy of operations to contribute to reducing the number and proportion of the diffraction and in accordance with the distance level of the Iraqi mechanical carpet laboratory.

Working on eliminating non-value-adding textile activities.

Reorganizing and distributing the human resources working in the mechanical carpet factory. This includes everyone's contribution to the production process, each according to his/her specialization.

Reducing supply costs by applying modern methods of on-time purchasing.

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