REDUCING QUALITY COSTS USING ERROR PREVENTION AND VISUAL CONTROL TOOL AN APPLIED STUDY AT THE GENERAL COMPANY FOR RUBBER INDUSTRIES/AL-DIWANIYAH TIRES FACTORY

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ABSTRACT

Because of the developments in the modern business environment, and the different needs of customers, which required the use of modern technologies that reduce production costs while maintaining the quality required by the customer. Through the use of error prevention and visual control tool. This is to reduce quality costs by using modern technology, as quality costs represent an essential proportion of production costs, which works to reduce waste and waste of resources for the purpose of achieving the largest possible profitability. The research data was collected from the General Company for Rubber Industries / Al-Diwaniyah Tires Factory, for the producers (1200-20) and (1200-24) for the year 2016. The research found that the use of traditional systems, large employee salaries, high costs of damage and the inability to compete with the product all this led to a rise in production costs. The research recommended the great importance of quality and opening records concerned with classifying quality costs into their types and analyzing them, as well as applying the error prevention and visual control tool to reduce production costs.

Keywords: Quality Cost, Cost Reducing, Visual Control Tools.

INTRODUCTION

Because of the economic development and the unity of competition, the goal of industrial companies has become the continuous improvement of their production at the lowest cost and highest quality, and this can only be done by using modern technologies based on reducing the cost of inputs to obtain the same outputs. From this direction, the current research started to the most important modern technologies that industrial companies seek to its application is a tool for preventing error and visual control. For the purpose of identifying production methods and the extent of the possibility of using modern technologies, the practical side of the research was carried out in the General Company for Rubber Industries / Al-Diwaniyah Tires Factory, and the case of producers of tires type (1200-20) and (1200-24) was studied, and calculate their quality costs in order to reduce these costs by using modern technologies, in order to increase sales and increase profits, which will not be available using traditional production systems. The research deals with four topics, the first topic is the research methodology, the second topic deals with the

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theoretical side, while the third topic deals with the practical side, the fourth and final topic deals with conclusions and recommendations.

The Concept of Error Prevention and Visual Control

Error prevention: It is to identify the defects of the products that occur due to the mistakes of the workers and try to prevent them, the aim of which is to get rid of all defects and control the quality of the product. Larsson (2006) it is also an important way to apply quality at the source, through a very simple work mechanism that prevents errors and defects, and that is by applying methods to detect errors, which aim to make safe methods from failure to reduce the errors of workers (Mohsen & Al-Najjar, 2012). It is also an important way to apply quality at the source, through a very simple work mechanism that prevents errors and defects, and that is by applying methods to detect errors, which aim to make safe methods from failure to reduce the errors of workers (Mohsen & Al-Najjar, 2012).

Visual control: It is one of the tools of Lean production technology and has a basic importance, and it can be applied in all areas of the company, and it is the duty of all employees to adhere to and participate in it, and the ability to understand and realize this tool (Hawkins & Knowledge, 2001) and it is also a system for determining the state of production In the work center and it is different, the green color indicates that there are no problems, while the yellow indicates that attention should be paid, while the red indicates that the production process must be stopped. (Othman, 2007) has clarified that it is the control of the process Production through a visual display of information about the production process. There are special lights for calling those responsible for production.

Forms of Wastage and Loss

The researchers identified the forms of waste and loss as follows

1. Overproduction: This loss occurs when production exceeds the quantity demanded or faster than the demands or production before it is needed. Which requires an increase in production to cover the fixed indirect industrial costs (AL-Samman, 2008).
2. Waiting: lost time, storage and waiting are all considered waste because they do not add value to the product. When the product is left without transportation or treatment, that time becomes lost. Also, the use of long meals in production leads to waiting, and the slow flow of materials (Mohsen & Al-Najjar, 2010.
3. Transportation and material handling: One of the operations that costs the company and causes a loss of time is the transportation of materials, and when the loss of time during transportation is reduced, the cellular arrangement must be taken advantage of within the manufacturing in order to eliminate unnecessary transportation operations (Nightingale, 2002).
4. Operations: - Some operations that have a weak design are a source of waste and loss, and there may be no need for these operations and they can be reduced. (Slack et al., 2004).
5. Movement: The increase in the unnecessary movement of workers causes a waste of time and an increase in effort, which pushes the company to bear additional costs, as well as causes the loss of the optimal use of workers' capabilities (creativity, experiences, ideas, skills) (George & Manos, 2006).
6. Defects: Because of poor quality, there are losses that lead to an increase in quality costs more than the normal, and this requires following up on the reasons for this increase in costs (Slack et al., 2010).
7. Storage: It is the loss as a result of storing semi-manufactured materials and finished materials, and this requires additional costs (Apel et al., 2007).

   (Krajewski et al., 2010) adds an eighth form to the forms of waste and loss, which is the result of the bad behavior of some workers.

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The Concept of Quality Costs

Table 1 shows the concepts of quality costs, according to the opinions of researchers.

Table 1
THE CONCEPTS OF QUALITY COSTS

Concept	Researcher name / year / page	N
He believes that it is necessary to limit the costs of quality, collect them and isolate them from other cost elements that are at the company's expense (marketing, administrative and production costs) in order to analyze and control them easily	(Jablonsk,2010:10)	1
APICS defined it as the total costs that are related to the activities of prevention and improvement of quality in all departments of the company before, after and during the production process.	(Crandall,2010)	2
Quality costs are the costs associated with achieving or not achieving quality in services or products.	(Crosson,Needles,2011:520)	3
It is the sum of the costs added to the product or service that relate to determining the level of quality in the product And controlling it and knowing the compatibility of the product's features with the customer's desires with the costs of the breach that occur due to the failure to meet the customer's need at the internal and external levels in the company.	**(**108 :Abboud and Abdullah, 2014**)**	4
Quality costs are the expenses paid by the company in return for the production of goods and services in accordance with the requirements and expectations of the customer.	**(**59 :Al-Najjar and Jawad, 2017**)**	5
Quality costs are defined as the costs incurred in order to provide products and services according to the customer's desire and demand (prevention and evaluation costs), and the costs that occur due to the poor quality of products and services provided to the customer (failure costs).	**(**Defensive and Back, 2019:98**)**	6

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According to the previous definitions of quality costs, the researcher believes that quality costs are the expenses paid by the company in order for the product to be in accordance with the required level in terms of quality and features requested by the customer.

Importance of Quality Costs

Quality costs are among the quality management methods that the company can use to develop the concept of total quality management and thus improve quality and its knowledge, and quality costs have a positive impact on the type of products, sales quantity, company profitability and competitive advantage, (Abboud & Abdullah, 2014).

There is importance in the study of quality costs because it leads to improving the quality of the product by knowing the failure points and the sources of defects by following the statistical tools, matching the products and services with the characteristics required by the customer and can have an impact on the success or failure of any company.

For the purpose of gaining customer satisfaction and achieving the desired profit, the company must organize the administrative and technical activities that affect the quality of the product and also direct the workers to stay away from mistakes as much as possible, using modern scientific methods. Al-Najjar and Jawad (2017) as the existence of quality costs achieves the following: (Al-Khanaq & Al-Rubaie, 2005).

(Leading the investments related to the control and preventive activities, identifying the costs of non-conformance, identifying the savings of the company's activities).

Objectives of Quality Costs

The measurement of quality costs aims to identify and know the costs that currently cost the company due to quality, and work to reduce these costs by using the wise method of quality costs forms. It has been shown at the present time that it is possible to reduce the costs of internal failure and the costs of external failure by increasing the costs of prevention, and that improving the relationship with suppliers, improving product design, and improving production control, this leads to a significant reduction in evaluation costs as well (Abboud & Abdullah, 2014) and focused (Al-Kassam, 2003) on the following objectives of quality costs:

1. Confirmation that improvement is possible in the production process.
2. The statement that business activities in correcting errors are necessary.
3. All management levels in the company focus on the economic factor.

Types of Quality Costs

Quality costs are costs incurred for the purpose of preventing products from being of low quality, and they are classified into the following groups:

Prevention costs

Defined by Hornkern as the costs spent to prevent the occurrence of products that are not among the required characteristics. As described by (Al-Jubouri & Salman, 2016) as one of the most important methods in reducing quality costs, while maintaining quality in the product, is to

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prevent any problems from occurring from the beginning, and this is what is required in this type of quality costs. These costs are related to the activities of the quality departments And statistical control, which includes manpower, machinery, and materials, as Al-Jubouri divided these costs into: (quality engineering costs, equipment measurement and quality control costs, pelletizing and qualifying manpower in quality departments, technical guidance costs for suppliers, process engineering costs and design, costs of supplier evaluation, costs of control and control of prevention activities).

Appraisal costs

Are costs incurred to find out the units produced that are not compatible with the required characteristics? defined (Al-Jubouri & Salman, 2016) as the costs of inspection, which are the costs that prevent the occurrence of defects in the products, and the best way is to identify defects early. These costs are spent to identify the defective product before it is shipped to the customer. These costs can be divided into: (costs of inspecting materials received from suppliers, costs of electricity and water used in inspection departments, costs of checking production under manufacture, costs of full product inspection, consumption of inspection equipment, maintenance of inspection equipment.)

Internal failure costs

They are costs spent to know the defective units of products before they are delivered to customers. Al-Jubouri and Salman (2016) defined failure costs as the costs incurred upon failure. The product is not suitable for the required characteristics. It is of two types, internal or external. It is internal when the defective product is identified during the evaluation process, which is carried out through production errors that did not prevent the occurrence (Jablonski, 2010). This type can be divided into: (re-testing and examination costs for repaired products, net costs of defects or scrap, costs of lost time due to quality problems, Loss of selling defective products, costs of using computer software due to defective production).

External failure costs

They are costs incurred after knowing the units of defective products and after they have been delivered to customers. Al-Jubouri also defined it (Al-Jubouri & Salman 2016) as the costs that are incurred due to the marketing of defective products that are not within the required characteristics, in addition to the expenses of maintenance and warranty after the sale and all expenses for legal obligations that arise towards the company by customers. It can be divided into: (The cost of returned units and allowances as a result of quality problems, the cost of guarantee processing, after-sales expenses, loss of sales due to poor quality products, the cost of legal obligations towards the company).

RESEARCH METHODOLOGY

The aim of the research is mainly based on the possibility of a tool to prevent error and visual control in reducing quality costs, and achieving the element of competition with foreign goods, through its use by the research sample factory, in addition to reaching the following goals:

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1. Providing a theoretical and scientific framework on the concepts of error prevention, visual control and quality costs.
2. Elimination of all activities that do not add value to the product, as well as reducing the idle time between stations in the production departments of the factory.
3. Reducing quality costs and avoiding wastage and loss in production by applying the error prevention and visual control tool.

The importance of the research stems from its focus on the local product being comparable to the imported product in terms of quality and price, by highlighting the defects of traditional systems in calculating production costs, and that they are not taken into consideration the customer's desire to obtain the appropriate product for him. And getting to know the concept of the error prevention and visual control tool, as well as knowing the concept of quality costs and showing its four types (prevention costs, evaluation costs, internal failure costs, external failure costs).

The research was applied in the General Company for Rubber Industries / Al-Diwaniyah Tire Factory.

THE PRACTICAL ASPECT OF RESEARCH

An Introduction to the Factory, the Research Sample

Al-Diwaniyah Tires Factory is one of the company's rubber and tire factories, which is located in the center of Iraq in Al-Diwaniyah Governorate, on the road leading to Al-Muthanna Governorate, with an area of 227,500 square meters. The factory was established in 1974 and production began in 1978, and production lines were added and updated in 1989, such as the American line of machines for manufacturing tire size (24-1200). The factory's senior management is trying to reduce production costs due to the intense competition for similar products in the local markets at lower prices than the factory's products. And durability and endurance, and the brand of the factory is (Diwaniyah tires).

Describe the Current Work Streams for Al-Diwaniyah Tire Factory

Through the experience of the field researcher of the factory, the research sample, it is possible to describe the current course of work in the following form:

Production departments in the factory

There are main sections that the tire passes through during the production process, which are as follows:

1. Department of Design and Technology: This department undertakes the task of designing the parts that make up the frame. It consists of a group of laboratories that examine raw and chemical materials after their preparation. These tests are of two types: chemical and physical.
2. Preparation section: In this stage, the raw materials are mixed together to produce the rubber dough according to the specifications of each kneader. On the rings laboratory before moving to the next stage.
3. Forming section: At this stage, the dough received from the preparation section is formed, as this section undertakes to re-knead it and then mix it using juicers, with the addition of the reinforced

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fabric to produce the semi-finished parts such as the side wall of the tire and the part in contact with the ground and rubber gaskets and according to the required specifications.

4. Construction section: in which the semi-finished parts are assembled to build the green frame, and these parts consist of the first bucket, which includes four fabric layers, and the second bucket, which also contains four layers, is placed on top of it, and then the third bucket. The number of layers is according to the size of the required frame. This is done from during the use of machines prepared for this purpose containing iron cylinders according to the sizes of tires to be produced.
5. Stabilization section: After the completion of the frame construction phase and its purification to facilitate the process of escaping the air trapped between its layers, the half-factory frame is transferred to the installation section (pistons), which is the last stage of the frame production stages, where it is pressed with special molds according to the size required to be produced, as it is exposed inside the mold For certain conditions of temperature, pressure, and times, up to (55-60) minutes, after which a tire in its final form is ready for storage. This process is called tire cooking or vulcanization.
6. Quality Control Department: This department follows up on the product starting from the preparation department, where the dough is tested in the laboratory until the end of the tire production process in the pistons (installation) department, where the final inspection of the product is done before it is entered into the warehouses.

Current quality costs in the factory

Quality costs data were collected through field cohabitation by the researcher for Al-Diwaniyah Tires Factory for a period of three months, from (27/1/2021 to 27/4/2021), as the data and information for these costs were recorded by looking at the records and documents of the Department Production and Quality Control Department for the period from (1/1/2016 until 31/12/2016) for the production of tires types (1200-20) and (1200-24), and the following Table 2 shows the types of quality costs that were adopted in the factory.

Table 2
QUALITY COST REPORT

N	Types of quality costs	amount
1	Prevention costs	
	Quality control reporting costs	**76850000**
	Wages paid to employees	**36200000**
	Total prevention costs	**E+081.13**
2	Calendar costs**:**	
	Examination costs of incoming raw materials	**17000000**
	Production inspection costs during operation	**15900000**
	Costs of requirements for examination and testing activities	**1000000**
	Examination equipment maintenance costs	**6400000**
	Examination equipment costs	**837500**
	The total cost of the calendar	**41137500**
3	Internal failure costs	
	Incurred damage costs	**E+081.55**
	Re-examination costs	**58500000**
	Failure analysis costs	**51600000**
	Total internal failure costs	**E+082.65**
4	External failure costs	
	Compensation costs for defective products	**630000**
	Costs of following up on handling customer complaints	**21600000**
	Total external failure costs	**22230000**
	Total quality costs	**E+084.42**

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Source: Prepared by the researcher based on the records of the production department, quality control department, and planning department.

This concept can be used in production processes that are very routine, but the benefit from it is more clear in the tests department to reduce defective quantities by focusing on the testing stages as one of the appropriate treatments with regard to testing the finished product to prevent errors and defects that arise as a result of the error during Repeated production process. Therefore, visual control is a tool closely related to the culture of error prevention and is a means for many tools of agile production. It also works to develop supplies of raw materials through observations of shortages in raw materials, as well as defects that exist in the framework industry structure, which is the responsibility of the control team. The quality, therefore, depends on the use of the naked eye in the process of virtual control only, and through the experience of the field researcher, it was noted that there is no error prevention along the line, but with the exception of virtual viewing on the frame structure, but the real test point for detecting errors lies in the stage of quality control. The use of visual control and error prevention will facilitate the implementation of production adjustment. In addition, the use of these means will improve communication and coordination between departments, reduce or eliminate delays caused by parts matching times in stages, improve flow, and eliminate or minimize errors and defects. In this case, the programming is given about the setting of the tire and it is used. Because of the lack of error prevention, we note that there is a large percentage of defects that are discovered in the testing phase, reaching 20%, which is reworked according to the type of defect The discoverer, so the researcher tries to control the quality at the source by using the tools of error prevention and visual control, which are almost non-existent in the production line in order to reduce the percentage of defects in the testing phase.

The Proposed Situation of the Factory, the Research Sample, if the Error Prevention and Visual Control Tool are Applied

Through the experience of the field researcher in the Al-Diwaniyah tire factory, the concept of error prevention and visual management was presented to the supervisors and workers in the factory and some experts in designing the size of tires (1200-20) and (1200-24). Production that is very routine, but the benefit is clear in the testing department to reduce defective quantities by focusing on the testing stages as part of the appropriate treatments with regard to testing the finished product, and to prevent errors and defects that arise due to errors during the repeated production process.

The researcher has suggested a set of means that can be used for visual control in preventing error to develop performance within the factory, the research sample and the progress of production processes in it, and these methods include the following:

1. By merging stations that can be combined with each other.
2. Working on making improvements to the activity of internal suppliers by providing stores for raw materials in accordance with the standards and specifications required for storage, and this reduces the percentage of material damage and thus contributes to reducing the total cost of production.
   The amount of damaged raw materials for the year 2016 amounted to (51,993 kg) at a price of (155,023,000 ID), according to the information obtained from the Planning Department in the factory.
3. Working on introducing new improvements to the equipment and machinery of the factory and replacing them with modern machines.

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4. Through field coexistence and inquiry, it was noted that the factory has no external branches, so the researcher suggests that the factory should work on setting up multiple branches for it throughout Iraq, given that the Diwaniyah tire factory is the only local factory that produces tire size (1200-20, 1200-24).
5. The similarity of routine work in production stations makes workers bored with the repetition of daily work, and also the large number of workers in one station leads to many errors in the production process, which leads to the transfer of the product to the next station without completing the production process, the work must be distributed among workers Rotating and excluding all employees who do not add value to the product.
6. Putting a list of the names of the teams and workers, and working on the alternative system in the station, as it was noticed that many of the stops are due to leave or absence of some workers in the factory.
7. Replacing the slow-moving associates who cause a suffocation of work in the production stations.
8. Establishing a list of the sequence of production processes and the approved instructions attached to each station, and emphasizing the need to adhere to the established sequence of work procedures and work instructions. Wires and threads unbalanced before installation in vulcanization.
9. Putting a board in each section showing the monthly, weekly and daily production scheduling to ensure production in the specified quantities of types of tires and not to strive in the production of some types or quantities, which leads to a non-smooth flow of work.
10. Working to provide the stations with the specified time to complete the process, and with an alarm timer similar to the one that works in the mobile device, in order to prevent the delay that occurs before the tire conveyor belt moves in this process, and to alert and guide the workers in the factory.
11. A way must be found to control quality within the production line using electronic or manual tools for the purpose of reducing errors, thus reducing defects and activating quality cycles.
12. Arranging the store of raw materials for each type of tire after it was stored randomly, in order to know the available quantities of each type in an easy and fast manner and with less time and effort, and to report early on the shortage in quantities. The benefits derived from the use of visual control and the prevention of error, is its use in the development of communications and coordination between the stages of the production process (preparatory - mechanical - final), reducing or eliminating the delay caused by choke points in the production process stations, and developing the flow in production. Eliminate or reduce errors and defects in order to improve factory performance and raise competitiveness.

List of Suggested Quality Costs

After applying the error prevention and visual control tool in the production departments, it was noted that it worked by eliminating the damaged and defective, and shortening the time and effort, in addition to excluding the non-value-adding activities that had reduced the total production costs. Therefore, the researcher made a proposed list of quality costs for the Diwaniyah tire factory showed in the Table 3. If he applies error prevention and visual control according to what suits the nature of his work and the internal environment, which are as follows:

Table 3
SUGGESTED LIST OF QUALITY COSTS FOR AL-DIWANIYAH TIRE FACTORY IN CASE THE FAULT PREVENTION AND VISUAL CONTROL TOOL IS APPLIED

N	Types of quality costs	Partial	Total
1	Prevention costs		
A	Wages paid to employee	**28960000**	
B	Quality control reporting costs	**61480000**	
	Total prevention costs		**90440000**
2	Evaluation costs		
A	Examination costs of incoming raw materials	**13600000**	
B	Production inspection costs during operation	**12720000**	
C	The costs of depreciation of examination equipment and	**1000000**	

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	devices		
D	Examination and testing activity requirements costs	**837500**	
E	Examination equipment maintenance costs	**5120000**	
	Total evaluation costs		**33277500**
3	The costs of internal failure		
A	Costs of the amount of damage incurred	**124018400**	
B	Re-examination costs	**46800000**	
C	Failure analysis costs	**41280000**	
	Total internal failure costs		**212098400**
4	External failure costs		
A	Replacement costs for defective products	**315000**	
B	Costs of following up on handling customer complaints	**17280000**	
	Total external failure costs		**17595000**
	Total Quality Costs		**353410900**

Source: Prepared by the researcher

As a result of analyzing the proposed list of quality costs after applying the error prevention and visual control tool, we find that quality costs have decreased by (20%) than they were in the past.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Not using modern technologies in production, and thus the product has a high cost and is greater than the price of the product in the market, as the factory suffers from the inflation of its products and the inability to create a competitive advantage that makes it able to compete with the imported product, and the reason for this is due to following the traditional methods of production.
2. The research sample factory lacks a classification of quality costs, and many workers, engineers and accountants, are ignorant of their types (prevention, evaluation, internal failure, external failure), as the factory works to charge these costs to cost centers without categorizing these costs.
3. The high production costs as a result of the high defective, damaged and exceeded the normal limit, in addition to a lot of losses in waiting times during the completion of the production process, represented in the travel times from one station to another, as well as the time of delays inside the stations.
4. Using the error prevention and visual control tool in the production departments to know the cases of loss in the production line and eliminate it, and it was found that the times of non-adding value have been reduced by (90%).
5. Take advantage of the application of the error prevention and visual control tool to reduce the quality costs of products while maintaining their quality and getting rid of all the resulting losses and waste due to following the traditional systems in production, as it was found that these costs decreased by (20%) from the current situation of the factory, the research sample.

Recommendations

1. Directing the two production lines for the size of the two frames (1200-24, 1200-20) towards adopting a better error prevention and visual control tool when improving production processes, and adopting it as a basic tool in the factory to eliminate non-value-adding activities and reduce apparent waste.
2. The researcher suggests that the factory work on setting up multiple branches in all parts of Iraq, considering that the Diwaniyah tire factory is the only local factory that produces tire size (1200-20, 1200-24) throughout Iraq.

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3. The need for workers to participate in development and rehabilitation courses for the purpose of optimizing the use of resources and reducing waste, and to hold workshops that explain the importance of the error prevention and visual control tool.
4. The researcher recommends the great importance of quality, and the need to open records for quality costs, and consider product quality one of the most important goals that industrial companies are working to achieve to gain customer satisfaction.
5. The necessity of the presence of control committees within the production departments, to reduce large quantities of damaged and defective, in order to preserve public money, and to monitor production before and during the production process to avoid the occurrence of errors that cause waste and loss.

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