

# Green Continuous Improvement Technology and Its Role in Reducing Failure Costs and Achieving Competitive Advantage

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**Abstract:** The Industrial companies suffer from high costs, especially the costs of failure in production, both internal and external, as a result of the lack of advanced and modern technology necessary to manufacture products, in addition to the use of poor quality raw materials, which led to the decline of these companies to low levels due to the high cost of production and the manufacture of poor quality products, which led to the loss of industrial companies in terms of the customer and the financial aspect, and the customer's orientation towards foreign products. In light of this, this research came to shed light on the necessary solutions and proposals to reduce the cost of production, especially about the costs of failure to improve the quality of products by moving towards strategic cost management techniques, as these techniques help reduce product costs and achieve a competitive advantage for industrial companies by enhancing the performance and quality of products, and one of these techniques is the Green Continuous Improvement technique.

## 1 INTRODUCTION

Industrial companies suffer from high costs, especially the costs of failure in production, both internal and external, as a result of the lack of advanced and modern technology necessary to manufacture products, in addition to the use of poor quality raw materials, which led to the decline of these companies to low levels due to the high cost of production and the manufacture of poor quality products, which led to the loss of industrial companies in terms of the customer and the financial aspect, and the customer's orientation towards foreign products [1].

In light of this, this research came to shed light on the necessary solutions and proposals to reduce the cost of production, especially about the costs of failure to improve the quality of products by moving towards strategic cost management techniques, as these techniques help reduce product costs and achieve a competitive advantage for industrial companies by enhancing the performance and quality of products, and one of these techniques is the Green Continuous Improvement technique [2].

The Green Continuous Improvement technique aims to continuously strive to develop the performance and quality of products to maximize the benefit obtained by the customer and reduce the cost to the lowest level without affecting the quality of the product functions, as the Green Continuous Improvement technique works to increase the effectiveness and efficiency of production processes and respond to customer requests and needs. This technique also emphasizes continuous teamwork, as it relies on human elements to introduce improvements to products during the stages of production that make up the product, reducing errors and defects and increasing product quality [3].

To achieve the research objectives, Section 2 covers the research methodology, while Section 3 presents the theoretical framework of the Green Continuous Improvement technique. In contrast, the third section addressed the use of Green Continuous Improvement tools to reduce product failure costs. As for the fourth section, it included the most important conclusions that were reached and the necessary recommendations.

## **2 RESEARCH METHODOLOGY**

### **2.1 Research Problem**

Industrial companies suffer from high costs of internal and external failure, which is represented by the presence of large quantities of defective production units before the sale process to customers and during and after the completion of the sale, which leads to industrial companies losing their reputation in the markets and losing customers, in addition to financial loss. Among the reasons for this product failure are the shortage of modern industrial equipment and machines, reliance on old equipment in production processes, poor laboratory and manufacturing methods, and low worker performance and skill levels. In light of this, the following question was raised to contribute to solving the research problem:

- Does the use of Green Continuous Improvement technology help the management of the economic unit reduce production costs, mainly internal and external failure costs?

### **2.2 The Importance of the Research**

The importance of the research is represented in helping the industrial company to reduce the cost of internal and external failure and improve the performance and quality of products to create a competitive advantage and improve the company's reputation among customers by moving to modern technologies instead of old technologies and helping the management of companies to advance and raise the level of products provided to customers by using the Green Continuous Improvement technology [1].

### **2.3 Research Objectives**

The research aims to achieve the following:

- 1) Present the cognitive foundations of Green Continuous Improvement technology and explain its role in reducing costs.
- 2) Explain the role of Green Continuous Improvement tools in reducing the costs of product failure and improving quality.
- 3) The causes that lead to failure and finding appropriate solutions for them.

### **2.4 Research Hypothesis**

The research hypothesis is based on the Green Continuous improvement technology, which can help industrial companies reduce product failure costs,

design and manufacturing time, and improve performance and quality.

### **2.5 The Scientific Research Method**

To achieve the research objectives, two scientific methods are followed:

- 1) The deductive method: This method was used in the theoretical aspect of the research by relying on university theses and dissertations, foreign books, periodicals, and articles published on the Internet.
- 2) The inductive method: This method was used in the practical aspect of the research by relying on the means obtained from the company, such as field experience and personal interviews with officials, in addition to reviewing reports and statements related to the company.

## **3 THE THEORETICAL FRAMEWORK**

### **3.1 The Emergence of Green Continuous Improvement**

The concept of Green Continuous Improvement first appeared in Japan, where economic and industrial organizations adopted it as the idea of Green Continuous Improvement was developed by the Japanese company Toyota in 1946 to make improvements in the company's industrial operations and work to involve all employees in performing operations and making improvements to make significant changes in the company to contribute to improving its performance and developing the capabilities and skills of employees and reducing the cost of products, thus meeting the needs of customers and contributing to achieving the desires and needs of customers by producing environmentally friendly products, which leads to increasing the profitability of economic units [1].

### **3.2 The Concept of Continuous Green Improvement**

Green Continuous Improvement technology has been widely used across economic units, whether industrial or service, due to the many advantages it delivers. The concept of Green Continuous Improvement technology can be explained according to the opinions of researchers as follows:

- 1) Green Continuous Improvement technology means the ability of economic units to adapt to developments in the business environment to implement the needs of users and the possibility of applying the best practices and methodologies that help in developing the performance of units and addressing problems related to products in particular and units, in general, to improve performance and quality and raise the efficiency of the product [2].
- 2) Green Continuous Improvement is defined as a method developed by Japanese companies to reduce damaged materials and elements, increase workers' efforts, and develop their capabilities to achieve efficiency in products and enhance activities that add value to these products to achieve the highest levels of quality [3].
- 3) Green Continuous Improvement has been defined as the process of continuing improvements during the production stages to reduce costs and work to eliminate problems that occur during production processes to improve quality and performance [4].
- 4) It means searching for the highest level of performance and quality to achieve customer desires. Green Continuous Improvement helps managers use variance analysis to establish an effective cycle to achieve the required goals by identifying recurring problems, addressing them, and evaluating results to drive continuous improvement, and by training workers to reduce product damage and defects [5].
- 5) The researchers believe that the concept of Green Continuous Improvement means making efforts to achieve continuous improvements in products, as these improvements are made in All company activities through the participation of all employees at all levels and departments to identify problems or obstacles facing production processes and work to remove them to develop products and present them to customers on time with high quality and at the lowest possible cost.

### 3.3 The Importance of Continuous Green Improvement

The importance of Green Continuous Improvement appears through its focus on meeting customer desires, as it works to obtain features and advantages that enable units to raise their performance and achieve their customers' requests and the possibility of obtaining additional benefits and advantages for institutions or customers related to products, and the

importance of Green Continuous Improvement appears through the following [6]:

- 1) Green Continuous Improvement works to meet customer requests, which is what companies seek to compete in the market.
- 2) Green Continuous Improvement focuses widely on the supplier and the end user.
- 3) The characteristics of operations have a significant impact on production.
- 4) Each employee or department has a specific job to do.
- 5) Green Continuous Improvement technology also helps economic units to identify activities that represent bottlenecks that lead to unused energies, which allows the management of these units to make appropriate decisions; this technology also seeks to enhance the health requirements of workers in economic units by converting their activities into environmentally friendly activities [7].

### 3.4 Green Continuous Improvement Objective

Green Continuous Improvement seeks to achieve a set of goals as follows [8]:

- 1) Green Continuous Improvement seeks to diagnose the problems facing production processes, find appropriate solutions, and address them, which improves the product's efficiency. Green Continuous Improvement aims to involve employees and workers in finding solutions to improve their performance and develop their activities to develop products.
- 2) Green Continuous Improvement aims to help economic units develop their manufacturing processes to achieve the highest value for their products, enabling them to meet customers' needs.
- 3) Green Continuous Improvement seeks to address failure and reduce activities that do not add value, work to develop the skills and performance of human elements, and contribute to reducing costs while maintaining quality.
- 4) Green Continuous Improvement works to describe and identify the procedures that contribute to developing products and increasing their quality.

### 3.5 Green Continuous Improvement Technology Implementation

Green Continuous Improvement is applied in economic units to address problems they face using

the PDCA model, which was developed by Deming in 1950, to drive further improvements and achieve product efficiency and quality. This model was called the Deming (PDCA) model (Plan, Do, Check, Act), and the Deming model can be explained as follows [9]:

- 1) Plan. In this step, the problems that accompany the production process and the production planning process are diagnosed to establish quality standards and to develop products continuously.
- 2) Do. This is the step in which improvements are implemented to address problems, collect appropriate data during the production stages, and determine the development improvements made to the product.
- 3) Check. This step aims to develop methods to unify improvements and analyze the data collected in the previous step. A comparison is then made before and after production to ensure that these improvements have contributed to achieving the desired results. Work stops upon detection of a defect, and the plan is re-evaluated.
- 4) Act. This step involves carrying out the inspection process, confirming the successful experiments used, setting appropriate standards to facilitate the use of treatments in the future, and unifying the results to take the correct measures to address problems and deviations in implementing plans and correcting errors.

### 3.6 Green Continuous Improvement Tools

Implementing Green Continuous Improvement procedures requires using a set of tools to address problems that occur during the production process, reduce errors, improve quality, and develop performance to meet customer demands. These tools include the following:

- 1) Control Charts. These charts are used in quality control as they consist of two types of charts; the first type is referred to as the univariate control chart, which is characterized by the quality characteristic, while the second type is referred to as the multivariate control chart which represents more than one quality characteristic, and control charts work to clarify the quality characteristics against time or samples being analyzed, and these charts contain a central line which represents the average value of the control elements [10].

- 2) Pareto Diagram. This chart is used to identify problems and defects that occur during production. These defects are classified according to their frequency from highest to lowest and determine the percentage of the impact of these defects on the products, and finding appropriate solutions for them; the Pareto chart aims to increase cooperation and interest among workers and all employees responsible for improvement procedures to develop their performance and increase their efficiency to improve product quality [11].
- 3) Cause and Effect Diagram. The cause-and-effect diagram is used to identify the causes and problems that cause failure and damage to products and analyze them according to the degree of their recurrence to work on developing the performance of the economic unit, as data is collected about the problem and its causes to address it. The causes of these problems and defects may be human factors or the laboratory environment [12].
- 4) Personal Interview. The personal interview means that senior management conducts interviews with the work team and employees responsible for work related to making improvements and taking their suggestions and solutions that they see as appropriate in improving products and increasing their quality, as the personal interview procedures are of great importance to the economic unit as they help to identify the problems and errors that hinder the work team and prevent them from performing their work at the required level, which requires standing on these problems and working to find solutions to them as soon as possible to implement the needs of the customers and achieve their satisfaction [13].

### 3.7 Green Continuous Improvement Methods

Green Continuous Improvement consists of two methods, which are:

- 1) The Japanese method (Kaizen). The Japanese method refers to improvements that are small and low-cost, as this method is used to describe a small project to address specific problems that occur at a certain point and in a particular period of time, and this method makes improvements in the form of small and repeated batches to address problems and errors that occur during the production process, and the Japanese method focuses on human cadres to make

improvements, and the Kaizen method aims to improve three criteria, which are Quality Cost Delivery (QCD), which means that Kaizen focuses on improving the quality of products or services, and seeks to reduce costs at every stage of business organization to facilitate working times, as the meaning of Kaizen is a change for the better. Therefore, this method can be used across different fields, as it focuses on each individual's contribution to the company to drive sustainable change [14].

- 2) The American method (Innovation). This method makes improvements based on modern technology and therefore requires high costs. The American method makes improvements in large batches and intermittently. This method searches for new customer needs and, to implement them, companies develop their products by making changes to existing products to improve quality. This method is of great interest because it enhances product performance and quality, enabling a competitive advantage and increasing unit profits. The innovation method identifies new consumer needs and, to meet them, companies develop new products and change existing ones, thereby sustaining the innovation process. Interest in innovation is linked to its role in improving performance and operations, thereby obtaining a competitive advantage and increasing profits.

### 3.8 Green Continuous Improvement Methodologies

A group of methodologies helps reduce damage and loss, thereby improving product performance and quality to meet customer needs. These methodologies include the following:

- 1) The six-point diffraction method. The six-point diffraction method refers to those processes that aim to improve quality and performance by collecting data related to defects and errors that occur during the production process to enhance the ability to predict in various fields. The six-point diffraction method determines the multiple procedures and analyses related to operations. It focuses on values to expect high returns and obtain the best benefits, as it creates an internal change that begins with management support. The six-point diffraction aims to reduce the number of defects to the lowest possible level by improving product quality and reducing the cost of failure.

- 2) Lean manufacturing. Lean manufacturing is a method that aims to develop manufacturing efficiency by achieving high levels of performance and quality, working to reduce costs to the lowest possible level, and reducing assembly and manufacturing time. This is done by reducing loss and damage to meet customer needs.
- 3) Total quality management. Total quality management is a method or practice that aims to discover and address errors and reduce problems that occur during the production process to improve product quality. This can be done by simplifying workers' competencies through training and learning programs, statistical methods, and quality engineering controls to reduce manufacturing and assembly time and the cost of damage, and to meet customer requests through Green Continuous Improvement procedures.

### 3.9 Requirements for the Success of Continuous Improvement

Management at all levels must support the requirements of Green Continuous Improvement to increase long-term efforts and practices to drive improvement. This is done by making changes in the organizational culture, where management is responsible for adopting and encouraging change processes in the organizational culture, as this requires some administrative behaviors, including the following [15]:

- 1) Working to develop administrative patterns that encourage cooperation and culture.
- 2) Working to develop a tactical and strategic vision for organizations to engage workers.
- 3) Using programs to train workers continuously.
- 4) Establishing a reward system to encourage cooperation.
- 5) Maintaining the goal, especially in crises and critical times.
- 6) Adopt balanced views and perspectives between the short term and the long term.
- 7) Recognizing the achievements made in ways that contribute to supporting individual and collective efforts.

## 4 IMPLEMENTATION

Using Green Continuous Improvement technology leads to reducing failure costs and improving product quality by applying the steps of the Deming PDCA

model (Plan, Do, Check, Act) by using a set of tools, including the following:

### 4.1 Control Maps

Control maps help reduce the number of quality inspectors and those related to production lines, discover product-related deviations and errors, and determine their causes to treat them. Control maps will be applied to the research sample product (400/11 transformer) using production as the sample for 8 days. To prepare control maps, the number of damaged parts can be clarified and their percentage of the product determined, as shown in Table 1.

Table 1: Number of damaged parts and their percentage of the product, 400/11KVA transformer.

Sample	Sample Production Volume	Number of damaged Parts	Percentage of damaged Parts
1	18	4	0.22%
2	18	2	0.11%
3	18	2	0.11%
4	18	13	0.72%
5	18	5	0.27%
6	18	12	0.66%
7	18	4	0.22%
8	18	5	0.27%
Total	144	47	2.58%

Table 2: Reasons for deviation from the control limits of the product (400/11 KVA transformer).

	Errors\Defects	Number of times the error occurred	Errors Rate
1	scratch on paint	15	0.33%
2	Radiators exposed to holes	8	0.17%
3	Insulators not working	5	0.11%
4	Appearance defect	5	0.11%
5	Pressure relief device connection error	3	0.06%
	Total	36	

We notice from Table 2, which shows the reasons for errors in the product (research sample), that there is an increase in the number of times scratches occur in the painting process, reaching 15, and at a rate of 0.33% due to the obsolescence of the machines used in the production line for the painting process. The factory carries out the painting process in two stages: the first stage is called (primary painting). After manufacturing, the parts that require painting, such as the tank and iron structures, are painted. The second stage is called (final painting), which is done after the

completion of the manufacturing of the transformer, as the transformer is exposed to scratches in the paint due to its movement from one place to another in the factory.

To treat the scratch, nylon is placed over the paint to protect it. It is also noted from the table that the radiators are exposed to holes (8) times and at a rate of 0.17% due to a malfunction in the machine for manufacturing metals and the tank, which leads to stopping the production process and increasing the number of errors in the radiators.

### 4.2 Hexagonal Diffraction

Hexagonal diffraction works to reduce product defects to the lowest possible level to raise efficiency and performance and improve product quality (research sample) and to apply hexagonal diffraction in the laboratory, specifically on the product, a 400/11 KVA transformer, to reach the number or quantities of defective units per million opportunities and determine the Sigma Level for the product (research sample). The relationship between the number of defects per million opportunities and the Sigma Level is shown in Table 3.

Table 3: The relationship between the number of defects per million opportunities and the Sigma Level.

	Number of defects per million opportunities	Sigma level
1	691500	1
2	500000	1.5
3	308300	2
4	158650	2.5
5	67000	3
6	22700	3.5
7	6220	4
8	1350	4.5
9	233	5
10	32	5.5
11	3.4	6

## 5 CONCLUSIONS

The conclusions reached by the researchers are as follows:

- 1) Green Continuous Improvement technology is one of the modern techniques for strategic cost management, as it seeks to achieve a high level of quality and performance, and works to reduce design and manufacturing time and reduce the cost of the product to help economic units compete in the markets.

- 2) Green continuous improvement technology seeks to train workers to develop their skills, improve their efficiency, and acquire capabilities and experiences that enable them to find solutions to problems related to products, in particular, the laboratory, and the company in general.
- 3) Green Continuous Improvement consists of two methods: the first is the Japanese method, which is called the Kaizen method and aims to make minor improvements at low cost, and the second is the American method, which is called creativity or innovation and strives to make continuous improvements by relying on modern technology, and thus it requires a high cost.
- 4) Green Continuous Improvement technology is applied by relying on the Deming (PDCA) model to address the problems and errors that economic units suffer from. The Green Continuous Improvement steps include (Plan, Do, Check, Act).

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