



The impact of Total Productive Maintenance (TPM) principles on promoting clean production practices: An analytical field study at the The Domestic Wires Factory of the Ur General Company – Dhi Qar Governorate

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Abstract

The current study aims to test the correlation and impact of the Total Productive Maintenance (TPM) system on clean production practices. A questionnaire was used as a tool to collect data and information, which was distributed to a sample of workers at the Domestic Wire Factory in Ur Company, Dhi Qar Province. The sample size was 55 individuals, of which 53 were found to be suitable for analysis. This indicates an 88% response rate. To reach the desired results and perform the appropriate statistical analyses, the SPSS (version 28) statistical packages were used. The study found that the pillars of comprehensive production maintenance have an impact on promoting clean production practices, as these pillars contribute to reducing waste of materials and energy, improving the efficiency of production processes, and increasing the utilization of available resources. The study also recommended that production organizations apply the principles of Total Productive Maintenance and develop preventive maintenance programs and ongoing training for employees, as this is important for promoting clean production practices and achieving environmental sustainability.

Keywords: Total Productive Maintenance (TPM), Clean Production Practices.

Introduction

Modern productivity needs to be so, and depends on maintaining efficiency and effectiveness. This has included increased competition at the local and regional levels, along with increased interest in social issues and the need to achieve development. This has led to administrative work and modern, effective administrative work on the one hand, and other effective effects of industrial activities on the other hand. This has led to limitless work on evaluating the performance of operations, different through maintaining their skills and processes using other management techniques such as comprehensive work. TPM, one of the most important systems developed by the Japanese, is a comprehensive system based on the participation of all employees in an organization. It is a crucial system for improving the efficiency of machinery and equipment, maximizing equipment performance, and reducing breakdowns and waste. This is achieved through the active participation of all employees in activating and improving team performance. The concept of clean operation, a major area in industrial process management, plays a significant role in reducing new environmental pollution, even from industrial waste. This is accomplished through efficient processes for stakeholders and corporate activities, including the economic and environmental diversification of organizations. Clean production is one of the tools aimed at industrial sustainability and contributing to local diversification within organizations. From this foundation, comprehensive maintenance can



play a vital role in supporting clean production practices by reducing breakdowns and waste, improving equipment efficiency, and ultimately reducing resource consumption and industrial waste.

First: Research Methodology

1-1 Research Problem

Most of our local organizations in general, and the Domestic wires factory– Ur General Company in particular, face increasing challenges in achieving high levels of production efficiency while adhering to environmental requirements and minimizing the negative impacts of production processes. Many production organizations suffer from problems related to frequent breakdowns in production equipment, high rates of material and energy waste, and increased waste and emissions resulting from production processes, all of which negatively affect production and environmental performance.

The need has arisen for organizations to adopt modern management approaches that contribute to improving the operational efficiency of equipment and machinery and maximizing the utilization of available resources. Organizations also strive to reduce environmental pollution and improve resource utilization efficiency through the development of production processes. Therefore, the research problem can be formulated through the following questions:

- What is the current state of maintenance in general, and the principles of Total Productive Maintenance (TPM) in particular, at the Domestic Wire Factory?
- What is the level of adoption of clean production practices at the Domestic Wire Factory?
- Is there a correlation and impact between the principles of TPM and clean production practices? 4. Does the relationship of correlation and influence between these two topics have positive implications for the Domestic wiring factory?

1-2The Importance of the Research

The importance of this research stems from the significance of the variables studied and the emphasis on their positive and crucial role. It also draws the attention of those responsible for planning maintenance work and the foundations of Total Productive Maintenance (TPM) to the necessity of paying attention to this system and working to improve its performance in a way that positively impacts clean production practices. This aims to maximize the added value resulting from the combined operation of these two systems. The research clarifies modern management methods for reducing industrial pollution and improving resource and energy utilization, thereby fulfilling the requirements of clean production and sustainable development.

1-3 Research Objective

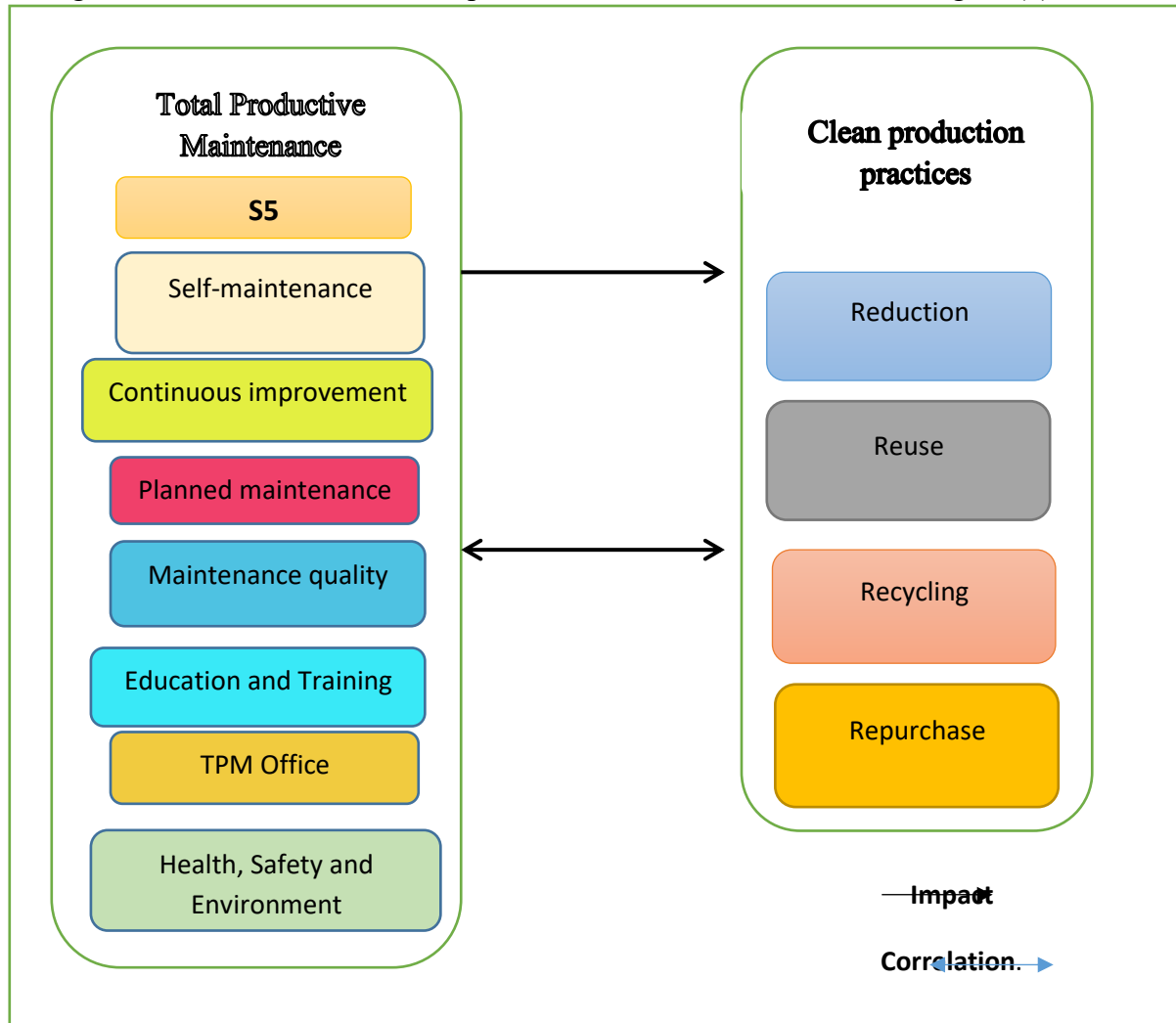
The main objective of this research can be summarized as demonstrating the impact of Total Productive Maintenance (TPM) on clean production practices. This objective leads to the following sub-objectives:

- To verify that the research sample possesses complete knowledge and understanding of TPM and its level of application in the researched factory.
- To determine the performance level of TPM operations in the Domestic wire factory under investigation.

- To determine the level of adoption of clean production practices within the Domestic wire factory.
- To diagnose the nature of the relationship and influence between the pillars of TPM and clean production practices.

1-4 Research Hypothesis

In light of the research problem and to achieve the objectives of this research, a hypothetical scenario was designed to illustrate the relationship between its variables, as shown in Figure (1).



Based on the research hypothetical framework, the following hypotheses can be formulated:

1. There is a statistically significant correlation between the Total Productive Maintenance (TPM) system and the Clean Production Practices (CP) system. This main hypothesis branches into the following two sub-hypotheses:

a. There is a statistically significant correlation between the TPM system and each dimension of the CP system (reduce, reuse, recycle, and buy back).

b. There is a statistically significant correlation between each dimension of the TPM system (S5, self-maintenance, continuous improvement, planned maintenance, maintenance quality, training and



education, TPM office, and health, safety, and environment) and each dimension of the CP system (reduce, reuse, recycle, and buy back).

2. There is a statistically significant impact relationship between the TPM system and the CP system. This main hypothesis leads to the following two sub-hypotheses:

a) There is a statistically significant relationship between the Total Productive Maintenance (TPM) system and each dimension of clean production practices (reduce, reuse, recycle, buy back).

b) There is a statistically significant relationship between each dimension of the TPM system (S5, self-maintenance, continuous improvement, planned maintenance, maintenance quality, training and education, TPM office, health, safety and environment) and each dimension of clean production practices (reduce, reuse, recycle, buy back).

1-5 Research Population and Sample

The research targeted all employees of the Domestic wiring factory as its population, and (60) individuals were selected as the research sample. A questionnaire was distributed to them and used as the research instrument. (55) questionnaires were returned. After tabulating the data and information for analysis, it was found that only (53) questionnaires were suitable for analysis, meaning that the response rate was (88%).

1-6 Research Scale

The research adopted the scale used in a previous study with high credibility, namely (Al-Awadi: 2018) and (Saeed: 2023).

Second: Theoretical Aspect

2-1 Total Productive Maintenance (TPM) System

2-1-1 The Concept of Total Productive Maintenance (TPM)

TPM can be defined as a strategy consisting of a series of organized activities performed in a single phase that helps improve the competitiveness of an industrial or service organization. TPM is a widely used strategy in production fields that aims to increase the availability of machinery and production equipment, as well as the economic benefits for companies (Reyes et al., 2018: 815). TPM is expressed as a method that rapidly improves production processes through employee participation and empowerment (Diaz-Reza et al., 2018: 2). It is a combination of all technical and managerial procedures throughout the lifecycle of an item, aimed at maintaining or restoring it to perform its required function. In its narrow sense, maintenance includes all activities related to maintaining a certain level of availability, reliability, and the ability of a machine and its components to perform at a standard level of quality (Ratby & Mabrouki, 2018: 6315). This maintenance concept encompasses all workers who aim to achieve efficiency throughout the production system by participating in productive, proactive, and planned activities. (Prabowo et al., 2018: 13) It is a program that handles equipment maintenance through system staff and delivers comprehensive maintenance from production and maintenance staff to top management (Pascal et al., 2019: 86).

2-1-2 Total Productive Maintenance (TPM) Objectives

Total Productive Maintenance aims to increase the capacity of existing equipment in a given situation while minimizing the need for further capital investment (Haddad & Jaaron, 2012: 148). The goal of any TPM program is to improve productivity and quality, along with increasing employee morale and job satisfaction. Previously considered a non-value-added process, preventive maintenance is now a prerequisite for a longer machine lifecycle in industry (Singh et al., 2013: 592). TPM aims to maximize equipment efficiency by establishing a productive maintenance system that encompasses all equipment and extends to all fields related to it, with the participation of all workers, from top supervisors to shop staff, to advance production through voluntary group activities (Darabi et al., 2014: 46). The main objective of maintenance is to improve the overall asset lifecycle, meaning increasing the availability and reliability of assets and equipment to produce the required quantity of products with the required quality specifications on time. This objective must be achieved in a cost-effective manner and in accordance with safety and environmental regulations. (Rattby & Mabrouki, 2018: 6315)

2-1-3 Pillars of Total Productive Maintenance (TPM)

The Japan Institute of Plant Engineers (JIPE) defined the TPM strategy using an eight-pillar implementation plan to maximize equipment effectiveness by establishing a preventive maintenance plan for the equipment's lifespan. This is achieved through the involvement of the entire organization and by motivating management and small group activities. The eight pillars of TPM include the five

S's (S5), self-maintenance, continuous improvement, planned maintenance, quality maintenance, training, the PTM office, and health, safety, and environment (Susomrith & Rermlawan, 2018: 87). Figure (2) illustrates these pillars.

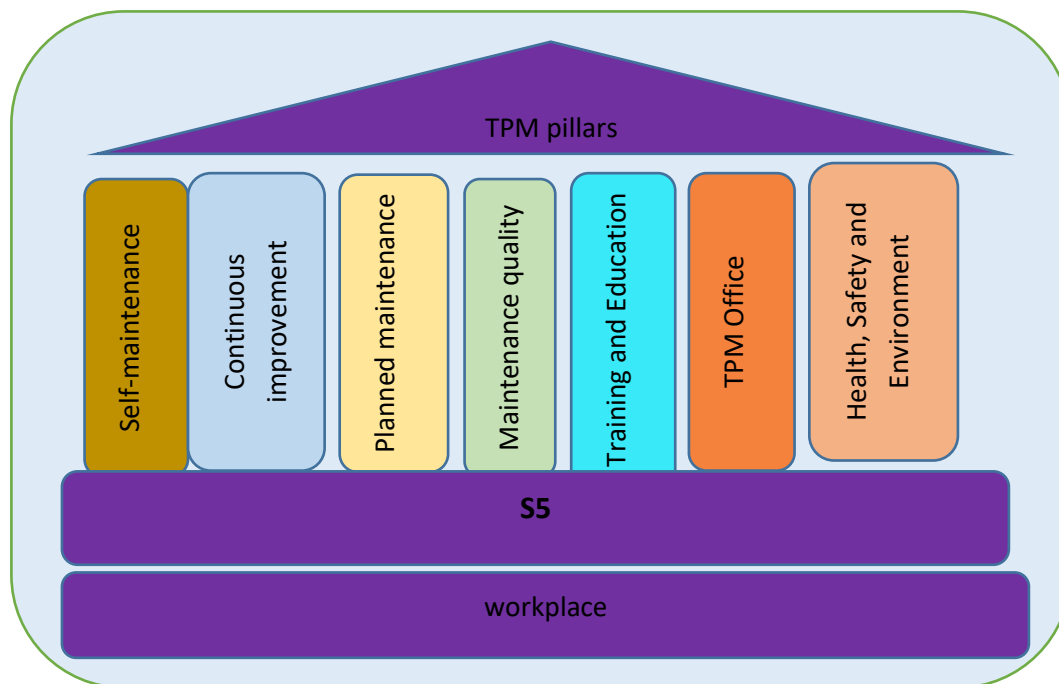


Figure (2)

Principles of Total Productive Maintenance

Source: Susomrith , Paisith & Sineenat , Rermlawan , 2018 " Proposed TPM Implementation Process based on Organisational Readiness for Change " Advances in Social Sciences Research Journal, Vol.5, No.3 , P : 87

The Five S5: The S5 approach requires a new philosophy and method of operation, which can be divided into five stages named after five Japanese words beginning with the letter "S" (Sorting, Organizing, Cleaning, Profiling, Self-Discipline). Hence the name S5. Methods and techniques based on the TPM concept have been successfully implemented in Japan and many other countries. Today, TPM is among the core strategies of maintenance policies (Pascal et al., 2019: 86). Different S5s are described below: (Sethia et al., 2014: 126) and (Darabi et al., 2014: 50). Filtering (Seiri): This means sorting and removing unnecessary items from the shop floor or workspace and sorting and organizing items according to frequency of use. Organizing (Seiton): This means arranging essential items in a suitable order so they can be easily picked up for use when needed and stored in an organized manner. Cleaning (Seiso): This means cleaning the workplace completely free of debris, grease, oil, water, waste, or scrap, such as thoroughly cleaning the workpiece. Standardization (Seiketsu): This means making decisions about the standards to be followed in order to maintain equipment, machinery, and the workplace in good condition. Self-discipline (Shitsuke): This means training and motivating people to follow established procedures to work effectively and independently.

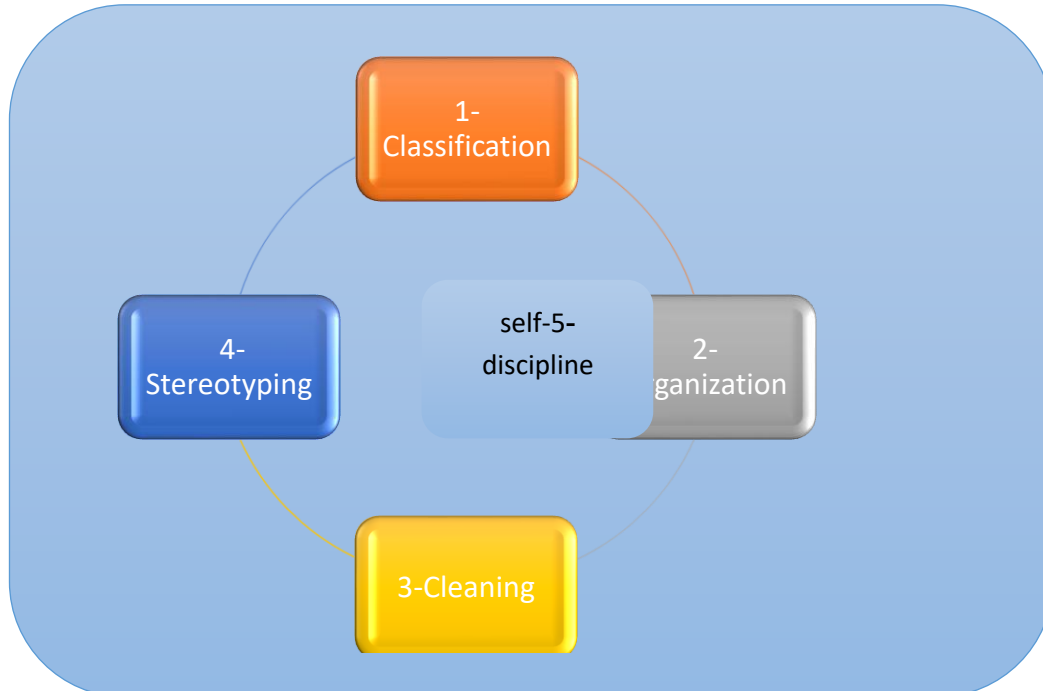


Figure (3) illustrates S5.

Source : Krajewski , Lee J. Malhotra , Manoj K. & Ritzman , Larry P.(2016) "Operations Management Processes and Supply Chains " 11th Edition . Published by Pearson Education Limited , p: 235 .



- **Self-Maintenance:** This refers to the daily maintenance routine performed by operators, such as cleaning, lubricating, and inspecting machines. These tasks are easy for operators, fostering a sense of belonging to the machine and increasing their knowledge of the equipment they use. Another objective is to identify any potential damage early on to prevent further harm (Sulistyoadi, 2016: 399). - **Planned Maintenance:** This is a maintenance management activity implemented to prepare a maintenance plan. The maintenance plan consists of a structured set of tasks, including activities, procedures, resources, and the timeframe required to carry out the maintenance. Once the plan is established, i.e., the required maintenance task is defined, and the maintenance support needs—the resources, services, and management required to implement the plan—must be identified (Rattby & Mabrouki, 2018: 6319). - **Continuous Improvement (Kaizen):** The word "Kaizen" means continuous improvement. Repairs are carried out by a small team formed from the lowest level. This small team identifies the problem in the machine or device and proposes improvement suggestions (Sulistyoadi, 2016). 399)

Quality Maintenance: This is geared towards achieving customer satisfaction by delivering high-quality products. It focuses on eliminating defects through process-focused improvement after identifying the machine parameters that affect product quality and transitioning from quality control to quality assurance (Singh et al., 2013: 592). Quality maintenance aims to keep equipment in good working order so that high-quality products are delivered to customers through defect-free manufacturing. Quality management activities involve defining equipment conditions that prevent quality defects (Attri et al., 2015: 6).

Quality maintenance is also focused on improving the quality of equipment and ensuring that high-quality products are delivered to customers through defect-free manufacturing. - **Training and Education:** This aims to provide employees with diverse skills to manage production. It focuses on motivating employees to work and perform their jobs better in an efficient and courteous manner. Education is also provided to employees to improve their skills so they can perform better in the workplace. It focuses on training employees and allowing them the necessary education to perform work with high quality (Singh & Kumar, 2017: 16626).

- **TPM Office:** This pillar should begin after the successful implementation of the four pillars of TPM: self-maintenance, continuous improvement, planned maintenance, and quality maintenance. It should be followed to improve the productivity and efficiency of administrative functions and to analyze processes and procedures towards increasing office automation (Sethia et al., 2014: 285).

- **Safety, Health, and Environment:** The focus in this area is on creating a safe workplace and a safe surrounding area that is not harmed by our procedures. This pillar will play an active role in each of the other pillars on a regular basis. The goal of this pillar is zero accidents, zero health hazards, and zero fires (Kumar et al., 2016: 84)

2-2 Clean Production

2-2-1 The Concept of Clean Production

Clean production is a preventative strategy aimed at reducing the environmental impact of production and products. Companies that control production processes are the main players in this field, and these companies are heavily influenced by their customers (whether from the private, public, or other sectors) and by policies (through laws, regulations, and taxes) (Fresner, 1998: 171). Clean production is a dynamic process that strives for continuous improvement and incorporates the latest engineering designs and other technical and financial capabilities (Basu & Zyl, 2006: 302). Clean



production is a preventative strategy that may concern both manufacturing processes and products. Developing cleaner products is interpreted as the most radical type of improvement (Thrane et al., 2009: 381). It is a wise production process that eliminates pollutants before they occur, rather than the costly traditional approach of treating pollution after it has occurred. It is also the continuous application of a preventative strategy that includes manufacturing, marketing, and services, and aims to increase efficiency and reduce risks. It impacts human health and the environment, and this process requires changes in the attitudes, behaviors, and policies of both government and industry (Ahmed & Hamza, 2012: 167). The concept of clean production refers to the procedures that allow a company to qualify itself as an efficient user of raw materials and energy during the production process, with the aim of increasing productivity, thereby increasing competitiveness and improving organizational performance (Severo et al., 2015: 118).

Clean production is also defined as an integrated environmental and preventative strategy that aims to improve resource utilization efficiency, reduce environmental risks and impact, and lower waste production in organizational operations. Clean production is defined as the continuous improvement of production processes, products, and services with the aim of reducing the consumption of natural resources, preventing pollution, and reducing the amount of waste generated by the company in order to reduce the risks to which humanity and the environment are exposed (Boualaq and Rahal, 2020: 49). Clean production is considered globally as a tool for achieving sustainable development, as it combines the use of environmentally preventive methods in processes, products, and services with the aim of increasing efficiency and reducing risks that threaten society and the environment. These preventive practices contribute to achieving economic savings (Giannetti et al., 2020: 2). Clean production is an integrated approach and a comprehensive concept for the project, whose application is not limited to a specific process, but rather includes the entire system, starting from inputs, through processes, to outputs. Its application requires acquiring knowledge, innovative ideas, and advanced technology that ensures the reduction of negative environmental impacts, which contributes to raising the environmental and economic performance of the project to ensure its continuity and support its competitiveness (Said, 2023: 25).

2-2-2 Clean Production Objectives

The primary objective of a clean production initiative in an economic institution is to achieve significant financial savings and environmental improvements at a relatively low cost. Furthermore, clean production can help the institution achieve other goals (Said, 2023: 28). The most important objectives of clean production can be summarized as follows (Boualaq and Rahal, 2020: 50):

1. Rationalizing the exploitation of natural resources and ensuring their availability for future generations.
2. Addressing environmental problems at their source rather than after they occur.
3. Managing renewable resources sustainably and rationalizing their use.
4. Spreading and increasing environmental awareness and creating an environment that encourages investment in clean technologies and environmentally friendly production processes.



5. Establishing appropriate systems for informing the public and notifying relevant official bodies of all information related to health or environmental risks associated with production in industrial institutions.

2-2-3 Clean Production Applications

Clean production applications can be classified into three main categories (Toprak & Anis, 2017:430):

1. Waste Reduction Practices at Source

Waste reduction and resource consumption reduction are achieved through the following practices:

First: Preventive Management Measures: These measures are among the simplest methods of clean production. They are inexpensive as they do not require investment and can be implemented immediately upon identifying the necessary resources.

Second: Improving Process Control: Temperature, time, pressure, pH, process speed, etc., must be monitored.

Third: Material Substitution: This means increasing manufacturing productivity by using higher-quality materials without compromising quality or cost.

Fourth: Equipment Modification: Equipment modification refers to upgrading existing equipment to reduce waste and ensure the efficiency of production processes.

Fifth: New Process Technologies: This method relies on the use of more modern and efficient technologies, and these applications also contribute to improving product quality and production output.

2. Reuse/Recycling

This process includes collecting waste and reusing it within the same production stages or at different stages. Unavoidable waste can be recycled or sold as a by-product. This includes producing by-products and selling waste to consumers or other companies after collection.

3. Product Modification

Changing product characteristics is a key aspect of cleaner production to reduce pollution. This modification requires reconsidering the product and its requirements.

2-2-4 Dimensions of Clean Production

Clean production is an approach to reviewing processes, management, and hygiene practices throughout the business cycle, focusing on reducing waste and pollution at the source. Clean production focuses on developing strategies to prevent pollution, reduce waste, recycle, and reuse. This approach aligns with lean manufacturing (Khalili et al., 2015:1). Researchers consider the dimensions of clean production to be as follows: (Saeed, 2023:31) (Taleb & Al-Awadi, 2017:17)



1. Reduction: In simple terms, reduction means purchasing only what the organization needs, as the best way to reduce waste is to avoid creating it altogether. Therefore, reducing the purchase of waste materials means reducing them at the source, i.e., reducing waste. What isn't used won't be thrown away. Therefore, reducing the source conserves natural resources, achieves less pollution, and saves money. Reducing the source of waste helps conserve natural resources, results in less pollution, and saves money.

2. Reuse: Reuse ensures the repeated use of items or parts thereof that remain usable. The idea that humans are the cause of waste is unprofitable, yet most people continue to generate waste because they are unable to think of an optimal alternative for disposing of their old belongings without considering the consequences.

3. Recycling: Recycling means using waste itself as a resource. In this way, it offers economic and environmental benefits because recycling plays a prominent role in waste management strategies. It involves processing waste and converting it into usable raw materials or products. This extends the lifespan of materials, reduces material consumption, and avoids disposal costs. It must be said that when consumers repurchase recycled materials and products, they contribute to the demand for these products, which increases the manufacturing need for goods to be recycled.

4. Repurchase: This process can be interpreted from two perspectives. From the consumer's perspective, it is repurchase, and from the manufacturer's perspective, it is resale. Recycling occupies the second position in the waste management hierarchy. For the process to be effective in solid waste management, it must go beyond simply storing recycled materials. It must also process, manufacture, and transform recycled materials. To marketable materials, therefore purchasing these materials is necessary to close this cycle. Converting recycled materials into new products is an important step in the recycling process.

Third: Practical Aspects

3-1 Description and coding of research variables

Table (1) shows the description and coding of the research variables to ensure ease and accuracy in conducting the statistical analysis, as shown below.

Axes	Variables	Dimensions	Paragraphs	symbol
First axis	Total Productive Maintenance (TPMA)	The Five S's (5S) Principle	4	PXMA
		Self-Maintenance	4	AUMA
		Planned Maintenance	4	PLMA
		Continuous Improvement	5	KAMA
		Maintenance Quality	4	QUMA
		Training	3	TRMA

		Total Productive Maintenance Office	3	OTMA
		Health, Safety, and Environment	3	HEMA
Second axis	Clean Production Practices (CP)	Reduce	4	RE
		Reuse	4	REU
		Recycle	4	REC
		Repurchase	4	REP

Source: Prepared by the researcher

3-2 Data Normality Test

The results of Table (2) reveal the (Kolmogorow-Smirnow) test for the research variables, as the statistical significance value for the research dimensions and items was higher than (0.05), while the tabulated value of the p-value is less than (1.96). This reveals the normality of the data at the dimensional level, especially at the dimensional level. Based on this, it can be said that the data is parametric and we can conduct the appropriate statistical tests for it.

Variable	Kol-Smi	P-value
	Test Statistic	
The 5S Principle	.331	0.107
Self-Maintenance	.272	0.174
Planned Maintenance	.297	0.096
Continuous Improvement	.227	0.160
Maintenance Quality	.310	0.167
Training	.322	0.168
Total Productive Maintenance Office	.317	0.173
Health, Safety, and Environment	.360	0.177
Reduce	.358	0.166
Reuse	.214	0.176
Recycle	.357	0.157
Repurchase	.323	

Source: Prepared by the researcher using (SPSS. 28)

3-3 Measuring Structural Reliability

To facilitate data processing using SPSS 28, the research scale was coded. To ensure accurate results that best represent the population, a suitable statistical method was selected that aligned with the normal distribution of the data. The normality test was performed by calculating the kurtosis and skewness coefficients for the research dimensions. According to most studies, and based on Hair et al. (2010), values between +1.96 and -1.96 are considered acceptable, indicating a normal distribution. Reliability was confirmed using Cronbach's alpha coefficient, where values of -0.70 or higher are considered acceptable, based on Nonnaly and Bernstein (1994). The conditions for the reliability coefficient and normality were met, as shown in Table 3.

Table (3) Cronbach's Alpha Coefficients

Dimensions	Paragraphs	Skewness	Kurtosis	Cronbach's Alpha
The 5S Principle	4	-1.075	0.942	89.2%
Self-Maintenance	4	-1.433	1.241	94.4%
Planned Maintenance	4	-0.884	0.837	85.2%
Continuous Improvement	5	-1.213	1.158	93.1%
Maintenance Quality	4	-1.538	1.347	95.3%
Training	3	-0.648	0.937	83.4%
Total Productive Maintenance Office	3	-1.114	1.020	94.3%
Health, Safety, and Environment	3	-1.069	0.978	90.1%
Total Productive Maintenance	30	-1.121	1.057	90.6%
Reduce	4	-0.989	0.789	82.1%
Reuse	4	-0.788	1.172	84.2%
Recycle	4	-1.232	1.202	92.2%
Repurchase	4	1.019	0.998	89.6%
Clean production practices	16	1.007	1.040	87.02%

Source: Prepared by the researcher using (SPSS. 28)

The table above shows

- Reliability coefficient (Cronbach's alpha): All values for the alpha coefficient are high (ranging from 82.1% to 95.3%), indicating internal consistency across the different dimensions. This demonstrates that all questions within each dimension consistently measure the concept.
- In the same vein, the skewness and kurtosis values clearly shown in the table indicate how close the data are to a normal distribution for each dimension. Overall, the values (Kurtosis) ranging from 0.789 to 1.241 and the values (Skewness) ranging from -1.538 to -0.648 indicate that the data are normally distributed in each dimension, as there is no significant skewness or kurtosis that would suggest the data deviates significantly from normality.

3-4 Confirmatory Factor Analysis

To ensure the structural validity of the research scale (its variables, dimensions, and items), structural equation modeling, particularly confirmatory factor analysis, is employed to verify the accuracy of the proposed model.

The researcher aims to achieve two main objectives by using structural equation modeling:

- 1-Verify that the research dimensions accurately reflect the variables being investigated and that all questionnaire items possess construct validity and are statistically acceptable.

2-Ensure that the data collected from the sample closely matches the constructivist hypothetical approach.

This verification process will be carried out based on two main criteria:

- Item saturation values exceeding or equaling 0.40 or higher.
- Fit quality criteria as per the following table.

Table (4) Structural Modeling Equation

Index		General rule
1- Goodness-of-Fit		
a.	Kai Square X^2	-
b.	Degrees of Freedom (DF)	-
c.	The ratio between X^2 and degrees of freedom DF	(X^2 / DF) Less than 5
d.	Good Conformity Index	Greater than 0.90
e.	Root Mean Square Error (RMSEA)	between 0.08 - 0.05
f.	Comparative Conformity Index (CFI)	Bigger than 0.90
g.	Lewis Tokr Index (TLI)	Bigger than 0.90
2- Standardized regression weights (standardized saturations)		Acceptable weights ≥ 0.5

Source: Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010). "Multivariate Data Analysis", 7th ed., Prentice Hall, Upper Saddle. , Chan, F., Lee, G., Lee, E., Kubota, C., & Allen, Ch., (2007), "Structural Equation Modeling in Rehabilitation Counseling Research", Rehabilitation Counseling Bulletin, 51:1, 53-66.

A- Confirmatory Factor Analysis of Total Productive Maintenance (TPM)

Table (5) reveals the confirmatory factor analysis for TPM according to Modification Indices. It consists of eight dimensions comprising (30) items. The results in Table (5) show that all items are greater than (0.50), indicating a good fit. These results provide a good and suitable indicator for conducting further statistical analysis. All model estimates are statistically significant ($p < 0.05$), and all standard regression weight values for the TPM dimensions are greater than or equal to 0.50, which is a good indicator.

Table (5) shows the conformity indicators for the Total Productive Maintenance variable

Index		ratio
1-Goodness-of-Fit		
a	Kai Square X^2	113.299
b	Degrees of Freedom (DF)	40
c	The ratio between X^2 and degrees of freedom DF	3.6766
d	Good Conformity Index	0.910
e	Root Mean Square Error (RMSEA)	0.081
f	Comparative Conformity Index (CFI)	0.921
g	Lewis Tokr Index (TLI)	0.903
2- (standardized saturations)		Acceptable weights ≥ 0.5

B- Confirmatory Factor Analysis of Clean Production Practices.



Table (6) shows the confirmatory factor analysis of clean production practices using Modification Indices. It consists of four dimensions comprising (16) items. Table (6) indicates that all items for the clean production practices variable were greater than (0.50), indicating a good fit. This means that further statistical analyses can be performed. All model estimates are statistically significant at (0.05), and all standard regression weights for clean production practices are equal to or greater than 0.50, which is a good indicator.

Table (6) Good Conformity Indicators for the Clean Production Practices Variable

Index		ratio
1-Goodness-of-Fit		
a	Kai Square X^2	192.36
b	Degrees of Freedom (DF)	46
c	The ratio between X^2 and degrees of freedom DF	4.171
d	Good Conformity Index	0.930
e	Root Mean Square Error (RMSEA)	0.063
f	Comparative Conformity Index (CFI)	0.910
g	Lewis Tokr Index (TLI)	0.923
2- (standardized saturations)		Acceptable weights \geq 0.5

3-5 Descriptive Statistics

This analysis aims to reveal the true reality of the research variables and dimensions by examining, analyzing, and interpreting the opinions of the sample, which consisted of (53) managers in the household wire factory of the Ur General Company - Dhi Qar Governorate. The level of responses will be determined according to their answers to the questions of the questionnaire and through the use of the five-point Likert scale.

A- Descriptive Statistics for the Total Productive Maintenance (TPM) Variable:

Table (7) summarizes the results for the TPM variable. According to the table, the TPM variable achieved an overall arithmetic mean of (4.23), with a standard deviation of (0.630), representing an agreement level of (81.6%). This indicates that the responses were largely in agreement. The table also shows the following results for the variable's dimensions:

-The (Continuous Improvement) dimension achieved an arithmetic mean of (4.33), a standard deviation of (0.594), and a relative importance of (88.2%), placing it at the (first) level in terms of overall agreement percentage.

- The (Health, Safety, and Environment) dimension achieved an arithmetic mean of (3.84), a standard deviation of (0.690), and a relative importance of (73.5%), placing it at the (last) level in terms of overall agreement percentage.

Table (7) Summary of descriptive statistics for the dimensions of the Total Productive Maintenance variable

Dimensions o (TPM) variable	arithme tic mean	standard deviation	Direction of answer	relative importance	Answer level	Sequence
The 5S Principle	3.97	0.658	I agree.	76.7%	high	6
Self-Maintenance	3.92	0.665	I agree.	75.4%	high	7

Planned Maintenance	4.23	0.607	I strongly agree.	85.2%	high	3
Continuous Improvement	4.33	0.594	I strongly agree.	88.2 %	high	1
Maintenance Quality	4.10	0.616	I strongly agree.	83.6 %	high	5
Training	4.21	0.609	I strongly agree.	84.4%	high	4
Total Productive Maintenance Office	4.25	0.603	I strongly agree	86.3%	high	2
Health, Safety, and Environment	3.84	0.690	I agree.	73.5 %	high	8
Total Productive Maintenance	4.23	0.630	I strongly agree	81.6%	high	

B- Descriptive Statistics for the Clean Production Practices Dimension:

Table (8) summarizes the results for the Clean Production Practices variable. According to the table, the Total Productive Maintenance (TPM) variable achieved an overall arithmetic mean of (3.87), with a standard deviation of (0.711), representing a level of agreement of (74.1%). This indicates that the responses were largely in agreement. The table also shows the following results for the overall dimensions of the variable:

-The (Reduction) dimension achieved an arithmetic mean of (3.96), a standard deviation of (0.661), and a relative importance of (75.5%), placing it at the (first) level in terms of the overall agreement percentage.

- The (Repurchase) dimension achieved an arithmetic mean of (3.76), a standard deviation of (0.815), and a relative importance of (72.8%), placing it at the (last) level in terms of the overall agreement percentage.

Table (8) Summary of descriptive statistics for the dimensions of the clean production practices variable

Dimensions o (cp) variable	arithme tic mean	standard deviation	Direction of answer	relative importance	Answer level	Sequence
Reduce	3.96	0.661	I agree.	75.5%	high	1
Reuse	3.83	0.692	I agree.	73.6%	high	3
Recycle	3.92	0.678	I agree.	74.7%	high	2
Repurchase	3.79	0.815	I agree.	72.8%	high	4
Clean production practices	3.87	0.711	I agree.	74.1%	high	



3-6 Hypothesis Testing

A- Correlation Hypothesis

Table (9) reveals the results obtained for the Pearson correlation coefficient values between the research variables (Total Productive Maintenance (TPM) and Clean Production Practices

A. Testing the first main research hypothesis, which states: (There is a statistically significant correlation between each dimension of the TPM system pillars (S5, Self-Maintenance, Continuous Improvement, Planned Maintenance, Maintenance Quality, Training and Education, TPM Office, Health, Safety and Environment) and each dimension of Clean Production Practices (Reduce, Reuse, Recycle, Buy Back). The correlation coefficient between TPM and Clean Production Practices was (0.612**) at a significance level of (0.000), and the calculated test Z-value was (10.898). This value is greater than the tabulated Z-value of (1.65), indicating a strong and statistically significant correlation.

variable	Significance	Clean production practices	Z calculated	Z Tabular	Significance
Total Productive Maintenance	Correlation	**0.612	10.898	1.65	moral
	Sig	0.000			

Source: SPSS V.23

B- Influence Hypotheses

Based on Structural Equation Modeling (SEM), an advanced statistical method used to study relationships between several variables, the equation aims to show how one or more variables (independent variables) affect another variable (dependent variable).

A. Testing the impact hypothesis stating that there is a statistically significant relationship between each dimension of the Total Productive Maintenance (TPM) system (S5, self-maintenance, continuous improvement, planned maintenance, maintenance quality, training and education, TPM office, health, safety and environment) and each dimension of clean production practices (reduce, reuse, recycle, buy back). The value of the C.R. coefficient between TPM and clean production practices was 7.506. This value is greater than 1.96 at a significance level of 0.000, and less than the significance level of 0.05. This confirms the existence of a statistically significant relationship between TPM and clean production practices, as the impact value was 0.417. This proves that an increase of one unit in TPM results in a 42% increase in clean production practices. This is evident from the estimated value of the coefficient of determination (R²). (0.387) The Total Productive Maintenance variable is able to explain (39%) of the changes that occur on the Clean Production Practices variable, while the remaining percentage (61%) is attributed to other factors separate from the research model, as shown in Table (10).

Variables			Estimate	S.E.	C.R.	P	R ²
Clean production practices	<---	Total Productive Maintenance	0.417	0.053	7.506	***	0.387

Fourth: Conclusions and Recommendations



4-1. Conclusions

1. A strong correlation exists between Total Productive Maintenance (TPM) and clean production practices. This indicates that the organization under study prioritizes maintaining workplace cleanliness and ensuring proper lubrication of equipment by its operators. Furthermore, it emphasizes providing employees with accumulated experience in lubrication, electrical inspection, safety, and related areas.
2. A positive impact exists between TPM and clean production practices. Therefore, the organization under study should implement appropriate procedures for proactive fault detection. This will enable the organization to develop suitable plans and programs for continuous product quality improvement, waste reduction, and product reuse/recycling.
3. The organization under study lacks attention to machinery and equipment. This necessitates that technicians identify the parts in machinery and equipment that affect product quality and contribute to increased material and energy consumption.
4. The organization under study lacks internal and external training courses for its employees, leading to errors during production and a high level of product defects.
5. The organization under study is committed to involving all employees in product design and delivery to consumers according to agreed-upon quality and specifications.
6. The organization under study emphasizes the importance of providing appropriate health and safety guidelines to educate employees and raise awareness of environmental responsibility and sustainability.

4-2. Recommendations

1. The local wire factory should dispose of unnecessary materials and tools used in product manufacturing, improve equipment maintenance, and store raw materials near their points of use.
2. Clear schedules for the periodic cleaning of factory equipment should be established. This requires the organization to develop a plan for preventive maintenance activities and raise awareness of environmental responsibility and sustainability.
3. The causes and obstacles to equipment downtime should be identified, given their significant impact on increasing raw material waste. Appropriate solutions should be developed that are compatible with the nature of the work and reduce pollution and waste in operations.
4. The required product quality must be maintained by providing the necessary flexibility to make modifications to machinery.
5. Continuous efforts should be made to provide the necessary maintenance supplies, including spare parts and appropriate tools, which are essential for repairing malfunctions.
6. A training system should be established to target production staff, qualify them, and develop their skills in a way that serves and improves the work.
7. Appropriate mechanisms should be established to exchange information and facilitate communication between maintenance departments and operators to reduce time, material waste, and energy consumption.

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