

# Total Productive Maintenance and its Effecting on the Application of Lean Production System

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**ABSTRACT**— *Increasing the amount of production, the diversity of products, a commodity and / or service, and increasing the productivity factor ratios contribute to developing the competitive strength of the organization in light of the increasingly difficult market conditions. That made all organizations work according to competitive strategies, including the production strategy for the purpose of achieving the organizations goal through the set of goals that they put. They rely on several new management systems of a strategic nature aimed at their survival and continuity in the production market. Hence, this research aims to evaluate the total productivity maintenance capacity in lean production throughout reducing the various kinds of losses, as the lean production is based on reducing each defective product (a commodity and / or service), costs, errors, and area, and all that and others aimed at improving product quality and customer satisfaction. However, the overall goals and production programs often encounter unexpected breakdowns at unexpected times, which lead to a breakdown in production and an imbalance in production plans as a result. Consequently, the companies suffer the expected revenue loss because they fail to reach the targeted production amount. The research has adopted a questionnaire that has been distributed to (50) employees of the General Company for Electric Power Production, the central region in Baghdad, which constituted more than 10% of the company's employees. The results show that there is a strong direct relationship between the independent variable (total productivity maintenance) and the dependent variable (lean production). This distinction has explained 90% of the variables in the dependent variable.*

**Keywords**—Total Productivity Maintenance, Lean Production, Continuous Improvement Flexibility.

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## 1. INTRODUCTION

Waste (time / money / effort / spaces, etc.) are among the problems experienced by industrial production lines in most factories and industrial companies, including the company in the field of research. This is due to the wide variation in the majority of times between the completion times of activities and operations, which results in the presence of lost times, which causes lost selling opportunities or accumulation of storage under operation between the activities of the production line and as a result a clear decrease in the efficiency of the line by exploiting the main production elements (materials of all kinds and the workforce according to their levels as well as Machinery, equipment, capital, these elements, and others combined or separately, on the one hand, and the emergence of the lean production system as a modern system on the other hand, which contributes to reducing losses to contribute to facing the diversity of customer demand, globalization, and the intensity of competition between companies and Factories that made organizations look for systems and methods that contribute to reducing the cost of the product a good or service and thus the price and industrial organizations seeking to search for unconventional systems in production to keep pace with the development in the industry and for the purpose of the success of the application of this system, we must get rid of the obstacles to its application, including stops and holidays of various kinds and this In itself, it requires the use of the best maintenance systems, which is Total Productive Maintenance. For the purpose of taking note of all aspects of the research, the research has been divided into four Sections. The first is included the research methodology according to the approved scientific methods and the second is devoted to the theoretical framework, which included an explanation of lymph. The most important, important, nature and components of both variables, while the third is devoted to the applied aspect and statistical analysis, which adopted the most common statistical methods, including the pre-requisite application of Social Sciences (SPSS) to extract the following:

Weighted mean and standard deviation to describe search variables.

-Simple linear correlation (Spearman) to determine the type and strength of the relationship between search variables.

- Determination coefficient ( $R^2$ ) to show the effect of the independent variable on the dependent variable.
  - The regression coefficients ( $\beta_i$ ) expressing the increase by a specified amount in the independent variable, as opposed to in the dependent variable.
  - Test (F) of the test of the significant effect of the independent variable in the dependent variable.
  - The test (T) of the significant effect test between the independent variable and the dependent variable.
- Which can be used in such research and whose results are clear in the tables of analysis in the relevant. The Finally is devoted to the conclusions and recommendations of the research.

According to the foregoing, the research is considered a scientific and practical contribution according to the responses of the respondents in the company, as well as the problems and difficulties facing the production of electric energy in Iraq, which caused a decline and poor performance and the ability to compete with the importer, which has become necessary for the company to build an introduction to its production system or a method To improve its production processes to solve its problems and improve its service capacity to society.

## 2. METHODOLOGY

### 1. The Problem:-

Most industrial companies in Iraq suffer from many pauses that lead to poor productivity and thus the efficient use of the best material and human resources will also be poor. This problem arises from the use of traditional methods of maintenance and the lack of adoption of total productivity maintenance, which represents an advanced approach and guarantor of operational efficiency. Thus, it can be said that lean production cannot be used in these companies unless total productivity maintenance is used and thus the problem can be identified as follows:

- A- Can the General Company of Electric Power Production (Search the application of total productivity maintenance?)
- B- Is there a relationship between total productivity maintenance and lean production?
- C- Does total productivity maintenance contribute to the goals of lean production?

### 2. Hypotheses:-

The first hypothesis: There is a significant relationship between total production maintenance and lean production. It includes the following:

- A- There is a significant relationship between human resources in the management of total production maintenance and lean production.
- B - The existence of a significant relationship between the raw materials used in the maintenance of total productivity and lean production.
- C - There is a significant relationship between the spare tools used in the maintenance of total production and lean production.
- D - There is a significant relationship between the applied maintenance systems and lean production.
- E - There is a significant relationship between the equipment used in the total production maintenance and lean production.

The second hypothesis: the existence of a significant effect of a statistical nature between total productivity maintenance and lean production through the following hypotheses:

- A- There is a significant of effect a statistical nature between the labor force in the total production maintenance and lean production.
- B - The presence of a significant effect of statistical nature between the raw materials used in total productive maintenance lean production.
- C - There is a significant effect of statistical nature between the spare tools used in total productive maintenance and lean production.
- D - The presence of a significant effect of statistical nature between the maintenance systems applied and lean production.
- E - The presence of a significant statistical effect between the equipment used in total productive maintenance and lean production.

### 3. Objectives

The objectives of the research are to assess the ability of total productive maintenance to lean production through:

- Reducing or even overcoming wastages on holidays.
- Reducing the number of workers, especially unskilled, to reduce the wastages in human effort.
- Improving the efficiency of the performance of machinery and equipment through total production maintenance programs and thus increasing the amount of production.

- Studying the relationship and impact between total productive maintenance and lean production to reach a practical and scientific conclusion about this relationship to recommend the adoption of total productive maintenance in industrial organizations

#### 4. Significance

The significance of the research lies in the fact that it is an attempt to test the impact of total production maintenance through the application of lean production system using statistical testing methods. The research also has practical importance in industrial companies, including the field of testing to increase the efficiency and effectiveness of its work in the development of future plans.

#### 5. Methodology

The methodology used to study the company is through organizing a question distributed to a number of employees (50 affiliates) on the total production maintenance and lean production system. It has been distributed randomly.

#### 6. Limits

Research limits include the following areas:

A-Spatial limits: It includes the General Company for Electricity Distribution / Baghdad.

B- Human limits: (50 questionnaires) are distributed randomly to a total of 430 employees of the company.

C- Research limits: The research limits included the following variables:

- The independent variable "Total Productivity Maintenance".
- The dependent variable "lean production system".

#### 7. Statistical Tools

Using (SPSS) program to extract the following:

- Weighted mean and standard deviation to describe search variables.
- Simple linear correlation (Spearman) to determine the type and strength of the relationship between search variables.
- Determination coefficient ( $R^2$ ) to indicate the effect of the independent variable on the dependent variable.
- The regression coefficient ( $\beta_i$ ) is the expression of a certain increase in the independent variable corresponding to the dependent variable.
- (F) Test for testing the effect of the independent variable on the dependent variable.
- (T) Test to test the effect of the independent variable on the dependent variable.

#### 8. Hypothetical Model

The researchers have put the research model as in Figure (1-1) below, according to their perception of the problem of research and its objectives, benefiting from previous research and studies as they are considered the biggest supporters of the lean production system, both in terms of reliability of the supplier or synchronization of production with the requirements of the customer and thus requires long-term relationships with a distinct set of proven suppliers that meet the required quality standards.

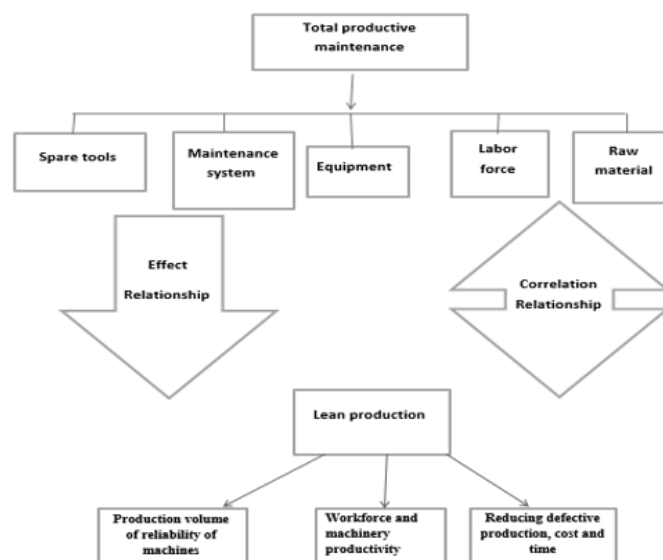


Figure 1: Virtual model

### 3. THEORETICAL FRAMEWORK: TOTAL PRODUCTIVITY MAINTENANCE AND LEAN PRODUCTION

#### 1- The concept of total productivity maintenance :-

Total productivity maintenance is understood as "a set of administrative and technical activities aimed at preserving the machine or restoring it to the normal state of operation to achieve its desired goal at the lowest possible cost" [10]. While [12] sees it as activities carried out by employees of the organization and shared by everyone from the top of the organizational pyramid to the operators. Ref. [14] state that it is the main activity that emphasizes the need to achieve the efficiency and effectiveness of the productive system in the facility through the involvement of employees and take their views and suggestions in the development of maintenance policies. Ref. [4] refer to the program as the idea of maintaining the whole plant and its equipment. The researchers understand total productivity maintenance as a preventive maintenance made by a series of improvements and went through a series of developmental stages to the extent of access to the total productivity maintenance. Therefore, it can be said that an activity is equivalent to the importance of productive activity and at the same time not considered purely engineering work but a set of activities (administrative, engineering and economic because it aims to achieve the best exploitation of the material elements and the optimal operation of the workforce and represented by resources, machinery and equipment, spare tools, systems and manpower in order to reduce the cost of the product (a commodity and / or service besides maintaining the quality of the specific product specifications.

#### 2- Objectives of Total Productivity Maintenance:-

Through a review of a set of references and relevant sources, the researchers concluded that the objectives of total production maintenance can be limited to the following: -

A- Manufacturing of the highest quality products through the use of high-quality raw materials and the operation of a qualified workforce with high training in addition to machines and equipment with solid structures.

B- Reducing costs by working to reduce wastes.

C- Small batch production in the shortest possible time.

D- Delivery of products without defects [11].

E-Reducing the percentage of wastes (time, money, effort and space) to improve the efficiency of machinery and equipment.

F- Allowing operators to take responsibility for certain activities and encourage maintenance team to achieve self-maintenance [10].

G- Providing a production environment free of technical and mechanical breakdowns, especially sudden breakdowns and maintaining clean and tidy working environment [8].

#### 3- Benefits and advantages of the application of total productivity maintenance.

We can limit the benefits and advantages of the application of total production maintenance with a number of scopes set by specialists as follows:

A- Increasing reliability of equipment: Making machinery and equipment work until the end of its design life and in times required by industrial processes.

B- Reducing damage accidents and employee injuries through the use of industrial safety means and providing the requirements for dealing with such accidents.

C- Increasing the experience of employees by involving them in training courses.

D- A measure of pollution control by adopting international standards of cleanliness of the working environment.

E- Creating trust among workers [11].

#### 4 -The requirements for the application of total production maintenance

Total production maintenance requirements can be summarized as follows:

A- Raw materials: The use of high quality raw materials for the purpose of ensuring the quality of the product.

B- Manpower: It is necessary to increase the skills of operators and workers in maintenance departments through training programs and focus on predictive maintenance how to use information and data in order to detect defects in equipment. Training production workers is required also to do basic maintenance work such as cleaning and lubrication and other jobs [11].

C- Tools: total productive maintenance is concerned with the cleanliness of equipment in order to detect early breakdowns and make the work environment clean, tidy and safe in order to reduce accidents and maintaining the significance of workers and facilitate handling of equipment [8].

D- Maintenance system: through the maintenance of the equipment operators by being responsible for carrying out simple maintenance work such as linking a nail, arranging the machine, adding oil or greasing and some other maintenance to the convergence of the operator and the machine and thus enabling him to detect a lot of malfunctions early. Thus, total productivity maintenance has created a sense of ownership by the operator and is proud to maintain it [4].

E- Spare Tools: Using backup tools that match the origin of the machine in order to ensure efficient performance. The researchers believe that these requirements cannot be considered individually, but rather as an integrated group because it is not possible to use high-quality raw materials without the presence of skilled well trained workforce to be in line with international standards of total production maintenance.

### 3.1 Lean production

#### 1- The concept of lean production

The roots of lean production are traced to the automaker Toyota, where the losses have been avoided in all episodes. At the time of repairing defective products and investing money of resulted from maintaining a large quantity of storage and effort due to the use of unskilled workers, lean production is considered a distinct engineering and manufacturing system that includes all the whole system from the first steps of until the arrival of the product (commodity and / or service) to the customer. This includes sales flow, final assembly, product design and all processing chains of supply including raw materials and processes. Researchers disagreed on a common concept of lean production. Slack, et.al. (2005: 519) note that lean production means moving towards eliminating waste in all its forms, developing processes quickly and reliably, and producing high quality and low cost products in order to win competition and achieve customer satisfaction.

(kerper, 2006: 2) (Schroeder, 2007: 14) (Sowords, 2009: 1) (Turban, et, al, 2011: 683) (krajewski & Ritzman, 2013: 297) have agreed that lean production system is a production methodology focused on maximizing the value of each activity of the organization by removing all sources of waste that do not add value to the product or customer. The concept of lean production focuses on reducing unproductive time in processes through continuous improvement and downsizing activities that do not add significant value to the system. [2]. According to [17], the most production that can be produced is by minimizing wastes and providing the customer with the required flexibility [6] understands that it is a method that employs highly trained workers at all stages of production who take a problem attitude to remove wastes and improve productivity. The researchers believe that the concept of lean production is based on reducing defects, costs, mistakes and space in order to improve quality and consumer satisfaction.

#### 2- Lean production characteristics

Believes that the characteristics of lean production can be limited to the following points [9]:

- A- Reducing storage through the use of modern production such as (Just in time).
- B- Empowering employees by increasing job satisfaction and thus loyalty to the company and love of work.
- C- Reducing space using modern production systems in production management like (lay out).
- D- Improving processing service through the use of processing chains.
- E- Reducing costs by getting rid of unjustified wastes.
- F- Multi-skilled staff.

#### 3- The objectives and advantages of lean production

(Slack, et.al. 2004: 774) indicate that lean production system aims to exclude all forms of waste and loss and remove them from the production processes (Real-time production).

While Bell (2006: 37-38) asserts that this system goes through three stages:

- A- Lean operations: At this stage waste is eliminated and continuous improvement is made on the productive processes of the commodity and / or service.
- B- Lean| project: At this stage, continuous improvement in all activities and transactions in the fields of production, marketing, distribution, service, quality and management.
- C- Lean network: within this phase wasted is eliminated and continuous improvement is made in the scope of the global electronic network.

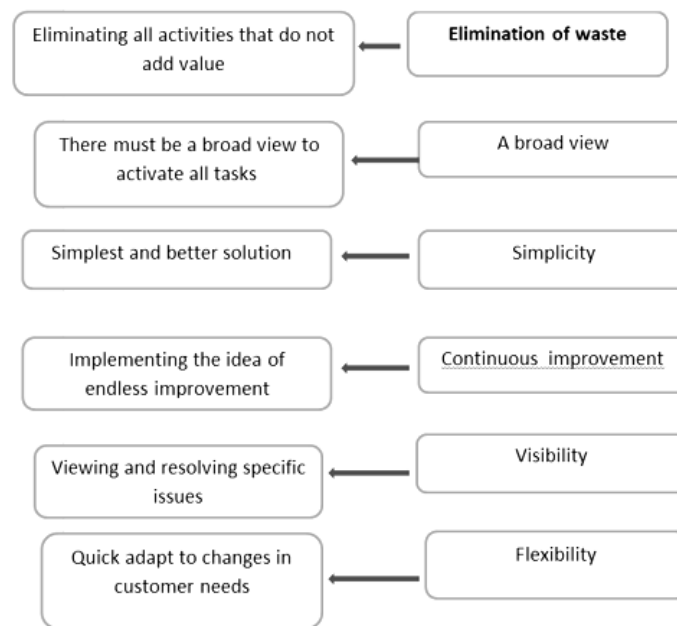
[13] adds that lean production system through continuous improvement (Kaizen) aims at eliminating surplus through a set of principles:

- A- Increase or decrease is the enemy and must be eliminated immediately.
- B- Improvement must be made continuously because the goal is not to make sudden adjustments.
- C- Everyone should participate in the process of improvement from senior management until workers.
- D- The philosophy of continuous improvement (Kaizen) focuses on an inexpensive strategy and does not require spending a lot of money on technology and experts, it benefits are:
  - Can be applied in all areas of work.
  - Focused on value creation.
  - Supported by an optical system i.e. full transparency in procedures, processes and values, which make problems and surplus visible to all.
  - The main effort in the process of improvement comes from a new way of thinking and a new way of working.
  - The essence of organizational learning is learning through work.

The advantages of lean production include:

According to [1] the advantages of lean production can be summarized as follows:

- Increasing the productivity of workers through the optimal use of production elements.
- The speed of decision-making through the adoption of electronic means of communication between all sections and divisions of the organization.
- Developing relations between personnel and processors.
- Developing the workforce in the performance of business by using some of the modern personnel management systems, including loyalty to the company resulting from fair distribution.
- Maximizing leadership. The pillars of lean production philosophy can be expressed in Figure 2.



**Figure 2:** The pillars of lean production philosophy [14]

#### 4- The basic elements of lean production system

The basic elements of lean production system are ten elements:-

A- Flexible resources: These systems require a multifunctional workforce to change the capacity of workers between stations and work cells that have different machines in their functions and are rearranged according to the size and design of production to eliminate bottlenecks [7].

B- Cellular arrangement: It is the organization of the plant into production cells or manufacturing cells. The work group is a group of different machines that come together to process a family of products in similar forms. These machines are assembled into a small assembly line in the form of a letter (U). Because the cell produces identical elements, the initialization and setup time will be slightly lowering the batch size [19].

C- Pull system for work flow Pull system must be distinguished from the push system. The push system starts by preparing the production schedule in advance before knowing the needs of customers. The pull system begins with an understanding of the needs and demands of customers and then begins production [18].

D.- Kanban system A signal used in pull system expressing the production of a specific quantity or batch of a particular component or product [5].

E- Small batches Quantity of items and parts produced together before being transported to a later workstation by offering high quality products in small batches, which helps reduce batch size by reducing inventory levels and costs [15].

F- Quick configuration and setup

The relationship between configuration and setup is strong in terms of costs and time of initialization, if it rises, it will be due to the higher time it takes to neglect the initialization between batches, and reducing the volume of the batch helps reduce the average inventory [16].

G- Equal burdens for workstations

In order for the lean production system to function properly, the load per workstation must be relatively equal, as it is difficult to maintain the flow of production through the pull system, Kanban and others without a fixed production volume [19].

H- Quality at the source. It is one of the basic requirements of lean production that enables it to meet the needs and requirements of customers continuously, and to ensure the provision of response to those expectations. It is the philosophy of detecting defects and correcting where they occur [18].

I- Preventive maintenance or total productive maintenance lean production system adopts the concept of total production maintenance (TPM) for the purpose of reducing costs, waste, utilization of equipment, controlling the organization of work flows accurately and reducing stock levels between workstations through carrying out maintenance activities that prevent machine failure and maintain it from the risks of stoppages [1].

J-Close relationships with suppliers. It is considered the largest supporter of lean production system, both in terms of reliability of the equipment or synchronization of production with the requirements of the customer and thus requires long-term relationships with a distinct group of suppliers who have proven their performance meets the required quality standards [3].

#### 4. THE PRACTICAL PART (STATISTICAL ANALYSIS) DESCRIPTIVE DATA ANALYSIS:

**1- Specialization variable:** The results of the questionnaire show that the geometric specialization rate has been the largest with 22 which constituted 49%, followed by administrative specializations with 14 which constituted 31% and finally the other with 9 which constituted 20% and this is normal due to the nature of that company, as shown in the following diagram:

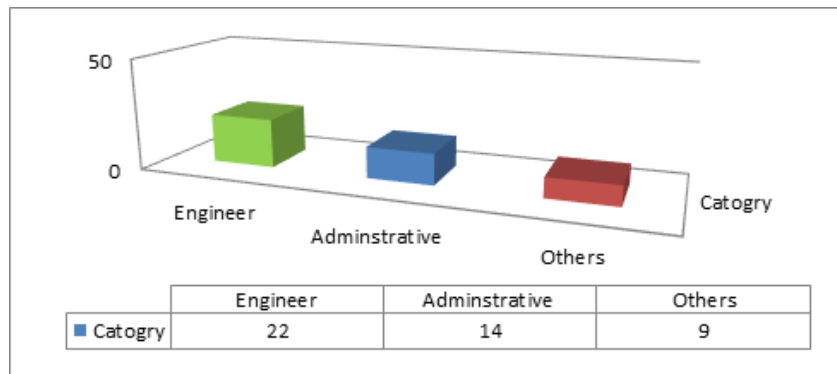


Figure 3: The results of the questionnaire

**2 -Age Variable:** The results show that most of the respondents are aged 25 to 35 years, who are 25 and who accounted for 56%, followed by category 35 to 45 years, who numbered 20 and who made up 44%. Finally, there is no person under the age of 25 and more than 45, as shown in the following Diagram:

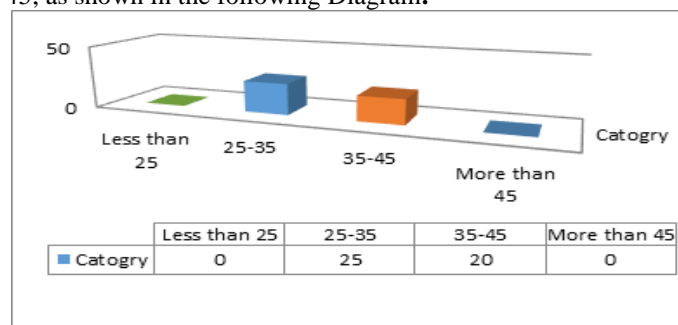
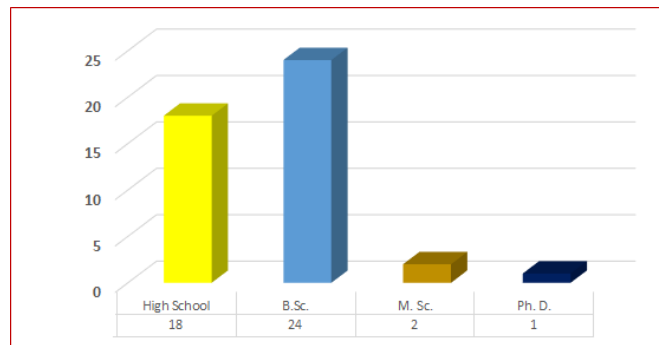


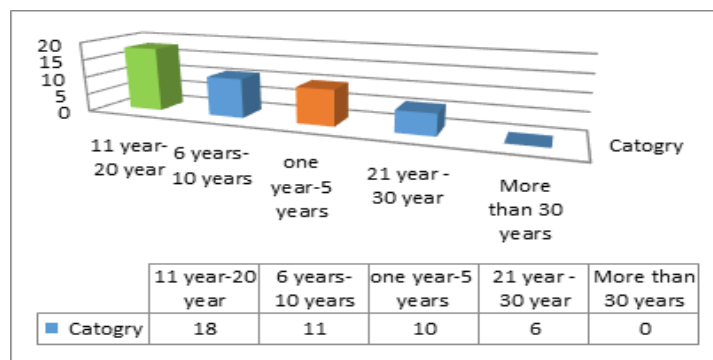
Figure 4: The distribution of sample data according to age

**3- Qualification:** The results show that the majority of those who are included in the questionnaire have been 24 Bachelor degree holders, who accounted for 53%, followed by high school degree holders, whose number is 18, which constituted 40%, then master degree holders, whose number is 2, who formed 4%, and finally PhD holders, whose number is 1 and who made up percentage of 1%, As shown in the following diagram:



**Figure 5:** The distribution of the sample data according to the qualifications

**4- Years of service:** The results show that most of the people who are included in the questionnaire have a service of 11 to 20 years, their number has comprised 18, which constituted 40%, followed by 6 to 10 years, who are 11, which constituted 24%, then from 1 to 5 years, are 10 who constituted 22% and finally from 21 to 30 years, are 6 and constituted 13%, while more than 30 years did not exist, as shown in the following diagram:



**Figure 6:** The distribution of the sample data according to the years of service

**Conducting the consistency and reliability test for the questions of the questionnaire used in all data:-**

Consistency means measuring the stability of the scale as not contradicting itself. It means that the scale gives the same results with a probability equal to the value of the parameter if re-applied to the same sample. It also measures the degree of data reliability from reflecting the results of the sample on the study population, and this is done through the use of one of the reliability factors such as Cronbach's Alpha or Split-Half, and the reliability factor takes values between zero and the correct one. If there is no reliability in the data, then the value of the parameter will be zero. On the contrary, if there is complete reliability in the data, then the value of the parameter will equal the correct one.

As for validity, it means that the scale measures what was set to measure it, and the validity coefficient can be calculated by calculating the root of the coefficient of reliability.

From the following table, it turns out that the value of the Cronbach's Alpha coefficient is 0.902, which is very high, meaning that the scale gives the same results with a probability of 0.902885 if it is reapplied to the same sample and for all questions. There is also a confidence level of 0.949 that the scale measures what was set to measure it.

<b>Reliability Statistics</b>	Cornbrash's Alpha	0.902
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Third: Calculating the weighted average for knowing the direction and agreement of respondents 'opinions and for each question in the form: This analysis includes calculating the weighted mean and the standard deviation for each question for the purpose of knowing the direction of the answer, and because the answers are one of three options they have been given the numerical coding as in the following table:

Opinion	Strongly disagree	Disagree	Normal	Agree	Strongly agree
Code	1	2	3	4	5

The weighted mean is then calculated and the direction is found according to the weighted average values as in the following table:



Opinion	Strongly disagree	Disagree	Normal	agree	Strongly agree
Weighted average	From 1 to 1.79	From 1.8 to 2.59	From 2.6 to 3.39	From 3.4 to 4.19	From 4.2 to 5

It is noticed that the length of the period used here is (4/5), that is, about 0.8, and the length of the period has been calculated on the basis that the five numbers (1,2,3,4,5) which are surrounded by four spaces between them. Also knowing the agreement on those opinions through the fact that the values of the standard deviation are greater than one (lack of agreement) or less than one (presence of agreement), and the results are shown in the following tables

**Table 1: Human resources**

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
There is an agreement	Strongly agree	0.49	4.37	0%	0	0%	0	2%	1	62%	28	36%	16	1
There is an agreement	Strongly agree	0.58	4.27	0%	0	0%	0	4%	2	58%	26	38%	17	2
There is an agreement	Agree	0.31	4.10	0%	0	0%	0	0%	0	84%	38	16%	7	3
There is an agreement	Strongly agree	0.50	4.43	0%	0	0%	0	0%	0	56%	25	44%	20	4
There is an agreement	Strongly agree	0.53	4.30	0%	0	0%	0	4%	2	62%	28	33%	15	5
There is an agreement	Agree	0.65	4.17	0%	0	2%	1	4%	2	62%	28	31%	14	6
There is an agreement	Strongly agree	0.30	4.27											

**Table 2: Spare parts**

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
There is an agreement	Strongly agree	0.49	4.37	0%	0	0%	0	0%	0	51%	23	49%	22	1
There is an agreement	agree	0.63	4.13	0%	0	2%	1	4%	2	60%	27	33%	15	2
There is an agreement	Agree	0.53	3.83	0%	0	2%	1	11%	5	76%	34	11%	5	3
There is an agreement	Agree	0.34	4.11											

**Table 3: Maintenance materials**

Agreement	Direction	standard deviation	Arithmetic mean	Opinion							
				Strongly disagree		disagree		Normal		agree	
				Rate	Number	Rate	Number	Rate	Number	Rate	
There is an agreement	agree	0.75	4.17	0%	0	4%	2	0%	0	64%	1
There is an agreement	Strongly agree	0.48	4.33	0%	0	0%	0	0%	0	62%	1
There is an agreement	Strongly agree	0.49	4.37	0%	0	0%	0	0%	0	62%	1
There is an agreement	Strongly agree	0.53	4.30	0%	0	0%	0	2%	1	62%	1
There is an agreement	Strongly agree	0.35	4.29								

**Table 4: Tools**

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
No agreement	Disagree	1.30	2.43	40%	18	27%	12	13%	6	18%	8	2%	1	1
No agreement	Disagree	1.30	2.40	24%	11	20%	9	16%	7	24%	11	16%	7	2
There is an agreement	Agree	0.97	3.77	4%	2	0%	0	13%	6	62%	28	20%	9	3
There is an agreement	Agree	0.61	4.03	0%	0	0%	0	11%	5	60%	27	29%	13	4
There is an agreement	Neutral	0.53	3.16											

**Table 5: Maintenance systems**

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
There is an agreement	Agree	0.74	4.00	2%	1	0%	0	4%	2	62%	28	31%	14	1
There is an agreement	Agree	0.59	4.17	0%	0	0%	0	7%	3	53%	24	40%	18	2
There is an agreement	Agree	0.68	3.87	0%	0	4%	2	11%	5	71%	32	13%	6	3
There is an agreement	Agree	0.43	4.13	0%	0	0%	0	2%	1	76%	34	22%	10	4
There is an agreement	Agree	0.38	4.04											

There is an agreement	Agree	0.26	3.98	Total ratios of total productivity maintenance items
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**Second: The part of lean production items**

**Table 6:** Reducing defective production, costs and time

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
There is an agreement	Agree	0.56	4.03	0%	0	0%	0	9%	4	69%	31	22%	10	1
There is an agreement	Agree	0.55	4.20	0%	0	0%	0	4%	2	60%	27	36%	16	2
There is an agreement	Agree	0.58	4.07	0%	0	0%	0	13%	6	67%	30	20%	9	3
There is an agreement	Agree	0.49	4.03	0%	0	0%	0	7%	3	82%	37	11%	5	4
There is an agreement	Agree	0.48	4.10	0%	0	0%	0	4%	2	69%	31	27%	12	5
There is an agreement	Agree	0.40	4.09											

**Table 7:** Workforce production

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
There is an agreement	Strongly agree	0.53	4.30	0%	0	0%	0	4%	2	62%	28	33%	15	1
There is an agreement	Agree	0.43	4.13	0%	0	0%	0	4%	2	71%	32	24%	11	2
There is an agreement	Agree	0.68	4.13	0%	0	2%	1	4%	2	64%	29	29%	13	3
There is an agreement	Agree	0.67	4.03	0%	0	2%	1	11%	5	69%	31	18%	8	4
There is an agreement	Agree	0.41	4.15											

**Table 8:** Production volume and machine reliability

Agreement	Direction	standard deviation	Arithmetic mean	Opinion										Question or item
				Strongly disagree		disagree		Normal		agree		Strongly agree		
				Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	
There is an agreement	Agree	0.52	4.07	0%	0	0%	0	7%	3	62%	28	31%	14	1
There is an agreement	Agree	0.52	4.07	0%	0	0%	0	7%	3	60%	27	33%	15	2
There is an agreement	Agree	0.48	4.10	0%	0	0%	0	4%	2	69%	31	27%	12	3
There is an agreement	Agree	0.55	4.10	0%	0	0%	0	7%	3	64%	29	29%	13	4
There is an agreement	Agree	0.38	4.08	0%	0	0%	0	2%	1	33%	15	4%	2	reliability
There is an agreement	Agree	0.35	4.11	Table No. (8): Production volume and machine reliability										

In general, it can be noticed that the responses are centered around the agree opinion, as most of the answers are centered around the answer "agree", and the values of the standard deviation have been less than the correct one, and this indicates that there is agreement on those opinions and that there is no dispersion of opinions.

### 1- Correlation Analysis:

In this chapter, the correlation between all the study items is studied and an attempt is made to know the existence of a relationship between the items to know which of the two cores are most closely related. Moreover, which items are the least correlated and whether the relationship is significant or not, and this is done by calculating the simple linear correlation coefficient.

Linear Correlation Coefficient between the items, as the value of the correlation coefficient ranges between (1 +, 1\_) and the positive value indicates the direct relationship between the two variables, "meaning one of the two variables increases with the increase of the other variable, and vice versa" and the negative value of the inverse relationship "that is, one of the two variables increases with an increase of the other variable and vice versa." And whenever the parameter approaches one, this indicates the strength of the relationship. The sign (\*) or (\*\*) indicates a statistical confidence and significance of 95% and 99% in the index, respectively, and from the data analysis it shows the following:"i.e. one of the two variables decreases with the increase of the other variable and the opposite is true" and whenever The coefficient is close to one, indicating the strength of the relationship, and the sign (\*) or (\*\*) indicates the presence of statistical confidence and significance of 95% and 99% in the index, respectively, where \*:significant at 0.05 level and also and \*\*:significant at 0.01 level, Table 9, shows the analysis of the Spearman correlation coefficient as represented below:

**Table 9:** Spearman correlation coefficient

Spearman correlation coefficient				
Variables	Reducing defective production, cost and time	Workforce and machinery productivity	Production volume and reliability of machines	Lean Production
Human Resources	.375*	0.176	.372*	.423**
Maintenance materials	.526**	.385**	.447**	.515**
Spare parts	.390**	.414**	.514**	.591**
Tools	.372*	0.099	.462**	.373*
Maintenance systems	.655**	.397**	.699**	.711**
Maintenance Quality	.674**	.433**	.747**	.764**

A-The existence of a medium-strong direct relationship with significant trust of 99% between human resources and lean production, that is, we reject the null hypothesis that "there is no correlation between human resources and lean production" and we accept the alternative hypothesis that "there is an association between human resources and lean production" Thus, the more interest in human resources increases, lean production increases, as the simple linear correlation coefficient \*\* 0.423.

B- The existence of a direct relationship of medium strength and significant confidence with a sum of 99% between the materials and lean production, meaning that we reject the null hypothesis that "there is no correlation between the materials of maintenance and lean production" and we accept the alternative hypothesis that "there is an association between the materials and lean production" thus, the more interest in materials increases, lean output increases, as the simple linear correlation coefficient \*\* 0.515.

C- The existence of a strong and significant correlation with 99% confidence between the reserve tools and lean production, that is, we reject the null hypothesis that "there is no correlation between the tools and lean production" and we accept the alternative hypothesis which states "that there is an association between the tools and lean production". Thus, the more interest in tools increases, lean output increases, as the simple linear correlation coefficient \*\* 0.591.

D- The existence of a direct relationship of weak strength and significant confidence with a 95% between the tools and lean production, meaning that we reject the null hypothesis that "there is no correlation between the tools and lean production" and we accept the alternative hypothesis which states "that there is an association between the tools and lean production". Thus, whenever interest in tools increases, lean output increases, as the simple linear correlation coefficient is \* 0.373.

E- There is a very strong and significant direct relationship with 99% confidence between the systems of maintenance and lean production, that is, we reject the null hypothesis that "there is no correlation between the systems of maintenance and lean production" and we accept the alternative hypothesis that "there is an association between the systems of maintenance and lean production". Thus, the more interest in maintenance systems increases, lean production increases as the simple linear correlation coefficient \*\* 0.711.

F- There is a very strong and significant direct relationship with 99% confidence between the quality of maintenance and lean production, meaning that we reject the null hypothesis that "there is no correlation between the quality of maintenance and lean production" and we accept the alternative hypothesis that "there is an association between the quality of maintenance and lean production". Thus, the greater the interest in maintenance quality, the more lean production increases, as the simple linear correlation coefficient \*\* 0.764.

## 2- Regression Analysis:-

This analysis aims to know the effect and significance of the explanatory variable "quality of maintenance" total productivity with its items (human resources, maintenance materials, tools, maintenance systems) on the approved variable "lean production" with its items (reduce defective production, cost and time, labor force, productivity, machinery, production volume and reliability of machinery and equipment), and includes the following indicators:

A- Explanation coefficient R<sup>2</sup>: It represents the percentage of explanation of the explanatory variable from the changes taking place in the dependent variable and the remaining percentage which is due to other factors that the researcher did not take into consideration.

B- Associated probability of the calculated value of F (p-value of F): The test uses the significance of the independent variables as a whole on the adopted variable, if its value is less than 0.05 we reject the null hypothesis (no significant effect) and accept the alternative hypothesis (the presence of a significant effect of the explanatory variable on the dependent variable) and vice versa.

C- Regression coefficient parameter: represents the amount of change in the dependent variable if the explanatory variable changes by one unit, so if the signal is positive then the increase in the explanatory variable causes an increase in the dependent variable and if the signal is negative then the increase in the explanatory variable leads to a decrease in the dependent variable and vice versa.

D- The accompanying probability of the calculated value of t (p-value of t): the test uses the significance of the explanatory variables individually on the dependent variable, if its value is less than 0.05 we reject the null hypothesis (no significant effect) and accept the alternative hypothesis (the presence of a significant effect of the explanatory variable on the dependent variable) and vice versa. From the data analysis it is found:

By taking the influence of the explanatory variable human resources on the dependent variable (lean production)

- It is found that the explanatory variable contributes 15% to the existing changes in lean production, while the other variables contribute 85%, which reflects the importance of that variable.

- The calculated value of F is (7.875) and it is greater than the tabular value of F of (4.07). Thus, we reject the null hypothesis which states that there is no significant effect of the explanatory variable and we accept the alternative hypothesis which states that there is a significant effect of the explanatory variable on lean production.

- The marginal slope value of the explanatory variable is 0.452, and this indicates that interest in human resources by one unit causes an increase in lean production by 0.452, and by testing t the calculated test value is "2.803" which is greater than the tabular value of "1.68" and this indicates that there is a significant effect of the explanatory variable on the dependent variable, and thus the estimated equation is as follows:

$$y = 2.249 + 0.452 X_1$$

The results are shown in the following table:

**Table 10:** The indicators of regression analysis of the causal relationship between human resources and lean production

comment	Tabular T values	Calculated t values	$\beta_i$	The value of the constant sharpness a	comment	Tabular F value	Calculated F value	Coefficient of explanation $R^2$
Significant effect	1.68	2.803	0.452	2.249	Significant effect	4.07	7.875	15%

By taking the effect of the explanatory variable, maintenance materials on the dependent variable (Lean Production)

- It is found that the explanatory variable contributes to 25% of the existing changes in lean production, while the other variables contribute 75%, a ratio that reflects the importance of that variable.

- The calculated value of F is (14,534) which is greater than the tabular value of F of (4.07), thereby rejecting the null hypothesis stating that there is no significant effect of the explanatory variable and we accept the alternative hypothesis which states that there is a significant effect of the explanatory variable on lean production.

- The value of the marginal slope of the explanatory variable is 0.462, and this indicates that interest in maintenance materials by one unit causes an increase in lean production by 0.462, and by testing t the calculated test value is "3.812" which is greater than the tabular value of "1.68" and this indicates that there is a significant effect of the explanatory variable on the dependent variable, and thus the estimated equation is as follows:

$$y = 2.193 + 0.462 X_2$$

The results are shown in the following table:

**Table 11:** the indicators of regression analysis of the causal relationship between maintenance materials and lean production

comment	Tabular T values	Calculated t values	$\beta_i$	The value of the constant sharpness a	comment	Tabular F value	Calculated F value	Coefficient of explanation $R^2$
Significant effect	1.68	3.812	0.462	2.193	Significant effect	4.07	14.534	25%

By taking the effect of the explanatory variable of the tools on the dependent variable (lean production)

-It is found that the explanatory variable contributes 36% of the changes in lean production, while the other variables contribute 44%, which is a large percentage that reflects the importance of that variable.

- The calculated value of F (23,651) is greater than the tabular value of F of (4.07), thereby rejecting the null hypothesis stating that there is no significant effect of the explanatory variable and we accept the alternative hypothesis which states that there is a significant effect of the explanatory variable on lean production.

- The marginal slope value of the explanatory variable has been 0.506, and this indicates that interest in tools by one unit causes an increase in lean production by 0.506, and by testing t the calculated test value is "4.863" which is greater than the tabular value of "1.68" and this indicates the presence of significant effect of the explanatory variable on the dependent variable. Thus, the estimated equation is as follows:

$$y = 2.051 + 0.506 X_3$$

The results are shown in the following table:

**Table 12:** the indicators of regression analysis of the causal relationship between tools and lean production

Comment	Tabular T values	Calculated t values	$\beta_i$	The value of the constant	comment	Tabular F value	Calculated F value	Coefficient of explanation

				sharpness a				$R^2$
Significant effect	1.68	4.863	0.506	2.051	Significant effect	4.07	23.651	36%

Through taking the effect of the explanatory variable (tools) on the dependent variable (lean production)

- It has been found that the explanatory variable contributes 14% to the existing changes in lean production, while the other variables contribute 86%, a ratio that reflects the importance of that variable.

- The calculated value of F (7.209) is greater than the tabular value of F of (4.07), thereby rejecting the null hypothesis stating that there is no significant effect of the explanatory variable and we accept the alternative hypothesis which states that there is a significant effect of the explanatory variable on lean production.

- The value of the marginal slope of the explanatory variable is 0.249, and this indicates that interest in the number by one unit causes an increase in lean production by 0.249, and by testing t the calculated test value has been "2.685" which is greater than the tabular value of "1.68" and this indicates the presence of significant effect of the explanatory variable on the dependent variable. Thus, the estimated equation is as follows:

$$y = 3.373 + 249 X_4$$

The results are shown in the following table:

**Table 13:** the indicators of regression analysis of the causal relationship between tools and lean production

Comment	Tabular T values	Calculated t values	$\beta_i$ The values of the marginal parameters	The value of the constant sharpness a	comment	Tabular F value	Calculated F value	Coefficient of explanation $R^2$
Significant effect	1.68	2.685	0.249	3.373	Significant effect	4.07	7.209	14%

- Through taking the effect of the explanatory variable, maintenance systems on the dependent variable (lean production) As:

- It has been found that the explanatory variable contributes 84% of the changes in lean production, while the other variables contribute 16%, which is a very large percentage that reflects the importance of that variable.

- The calculated value of F (232.398) has been greater than the tabular value of F of (4.07), thereby rejecting the null hypothesis stating that there is no significant effect of the explanatory variable and we accept the alternative hypothesis which states that there is a significant effect of the explanatory variable on lean production.

- The marginal slope value of the explanatory variable has been 0.883, and this indicates that interest in maintenance by one unit causes an increase in lean production by 0.883, and by testing t the calculated test value is "15.245" which is greater than the tabular value of "1.68" and this indicates the presence of significant effect of the explanatory variable on the dependent variable. Thus, the estimated equation is as follows:  $y = 0.499 + 0.883 X_5$

The results are shown in the following table:

**Table 14:** the indicators of regression analysis of the causal relationship between maintenance systems and lean production

comment	Tabular T values	Calculated t values	$\beta_i$	The value of the constant sharpness a	comment	Tabular F value	Calculated F value	Coefficient of explanation $R^2$
Significant effect	1.68	15.245	0.883	0.499	Significant effect	4.07	232.398	84%

6- By taking the effect of the explanatory variable, the quality of maintenance on the dependent variable (lean production)

$$y = a + b_6 X_6 + E \text{ As:}$$

y: represents the dependent variable (lean production) a: constant term

$\beta_i$ : Marginal slope of the explanatory variable, maintenance quality. Demonstration variable quality of maintenance.

E: represents random error (includes all variables not taken into account).

- It turned out that the explanatory variable contributes to 90% of the existing changes in lean production, while the other variables contribute 10%, which is a very large percentage that reflects the importance of that variable.

- The calculated value of F (427.201) has been greater than the tabular value of F of (4.07), thereby rejecting the null hypothesis stating that there is no significant effect of the explanatory variable and we accept the alternative hypothesis which states that there is a significant effect of the explanatory variable on lean production.

- The marginal slope value of the explanatory variable is 1.020, and this indicates that attention to maintenance quality by one unit causes lean production by 1.020, and by testing t the calculated test value has been "20.669" which is greater than the tabular value of 1.68 and this indicates that there is a significant effect of the explanatory variable on the dependent variable, and thus the estimated equation is as follows:

$$y = 0.049 + 1.020 X_6$$

The results are shown in the following table:

**Table 15:** the indicators of regression analysis of the causal relationship between the items of total productivity maintenance and lean production

comment	Tabular T values	Calculated t values	$\beta_i$	The value of the constant sharpness a	Comment	Tabular F value	Calculated F value	Coefficient of explanation $R^2$
effect	1.68	20.669	1.020	0.049	significant effect	4.07	427.201	90%

## 5. CONCLUSIONS AND RECOMMENDATIONS

### First: Conclusions:

By analyzing the questionnaire data, the following conclusions have been reached at:

1- Most of the people included in the questionnaire have been from engineering majors, where their percentage reached 48%, and this is a good indication that the nature of the organization's production is engineering. The administrative specializations are, then, amounted 33%. The other specializations comprised 20%. The ages are in the category 25 to 35 and within the specialty of management and economics and holders of a bachelor's degree and they have a service from 6 to 10 years, meaning they are from the youth category.

2- General, it is noticed that for all the items of the questionnaire, the responses have been centered around the opinion agreed, where most of the answers are centered around the answer "agree", and the values of the standard deviation have less than the correct one, and this indicates that there is agreement on those opinions and that there is no dispersion of opinions.

3- The presence of a very strong and significant direct relationship with 99% reliability between the reserve tools and the lean production, as the strongest relationships are among the other explanatory variables, knowing that all the other explanatory variables have less significant and direct relationships.

4- The presence of a very strong and significant direct relationship with 99% reliability between the systems of maintenance and lean production, as the strongest relationships have been among the other explanatory variables, knowing that all the other explanatory variables have less significant and direct relationships.

5- The explanatory variable has achieved the backup tools and maintenance systems the highest clarification factor to explain the changes in the dependent variable of lean production.

### Second: Recommendations:

1-The necessity of Iraqi industrial companies adopting the total productivity maintenance to avoid the various losses in materials, time and energies.

2-Training the workers continuously on this approach in practice by looking at the actual practices in the companies of the countries that follow it.

3- Linking the incentives of workers in companies to the level of reducing waste and wasting and not adopting profits and revenues, the only determinant of the incentive system.

4- Urging companies to adopt lean production because it is the only way to make Iraqi companies competitive in the market and develop their products and obtain an appropriate market share.



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