

## **EFFECTIVE APPLICATION OF LEAN MANUFACTURING IN LEADING INDUSTRIAL COMPANY – A CASE STUDY**

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### **ABSTRACT**

*The main objective of this study is to assess the application of Lean Manufacturing in the companies adopting Lean management in order to improve its effectiveness, in addition to develop a track for other companies planning to adopt Lean management. This study explored key literature resulting in the development of a new model of application. Moreover, a special questionnaire developed as tool for gathering information gapping the bridges toward the effective application and problem solving. Additionally, the newly designed model and tool were used in a case study to assess the application in one of the leading Jordanian manufacturing companies. Descriptive statistics were used in this study, the study sample included (125) participant. Moreover, SPSS software was used in the data analysis. The results showed that the general arithmetic mean of sample answers on the statements which evaluates the effective application of Lean Manufacturing, has reached (3.203) of (4) with standard deviation of 0.725 representing high degree of estimation. This success is justified by satisfying the critical requirement of application.*

**KEYWORDS:** *Lean Manufacturing, Management, Statistical Analysis, Employees, Questionnaire, New Application Model*

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### **Article History**

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## **1. INTRODUCTION**

Nowadays, Lean manufacturing is one of the most important industrial management systems used by successful companies all over the world. It has proved its effectiveness when properly implemented. For competitive companies, who lagged the utilization of this system or did not implement it in an effective manner, they lost their market share and left behind. Effective lean manufacturing application is an answer to growing challenge of competitive global market, addressing the continual customer demand of customization, lack of resources and increased production cost. This system has developed over the years, since 1950 by manufacturing pioneers; most of them came from automobile industries. The joint efforts of those pioneers who developed Lean manufacturing system, which is proved to be key factor of industrial management development and leading manufacturing companies business success. For centuries before World War I, manufacturing relied on craft production; tools and equipment developed piece by piece at the European countries, which were leading the industries. Then, Henry Ford and General Motors Alfred Sloan revolutionized the industrial world by introducing Mass Production concept setting the United States of America on the track of being the world dominating economy. The roots of

Lean originated from the Japanese culture. After World War II, Eiji Toyoda and Taii Chi Ohno at Toyota Motor Company in Japan pioneered the concept of Lean production, the rise of Japan to its current economic preeminence quickly followed as other Japanese companies and industries copied this remarkable system (Womack, Jones, Roos, 1991). We are considering automobile industry in this introduction about Lean management, since it is the cradle of development of lean manufacturing. Moreover, it is described as "The Industry of Industries" by Peter Drucker, who is considered "the founder of modern management" Denning, Steve (Forbs, 2014). Automobile industry is one of the largest capitals all over the world, with nearly 50 million vehicles produced every year. The huge capital, high competitive edge and extremely high level of development required by customers each year, placed top manufacturers around the world in an extreme race toward manufacturing development and optimization. A Major result was Lean manufacturing, which was followed by other industries all over the world, after seeing the amazing results achieved by this system. In Jordan, there is few evidence of applying Lean management as a total management system in industrial companies. It is true; there are few companies, which are familiar with the system and using many of its tools such as Jordan Bromine Company, Hikma Pharmaceutical Company and Japan Tobacco International Company. However, the majority of the companies still did not even hear about it. In addition, many companies all over the world are facing the critical situation of being in the transient state of fully applying lean management system. The problem is the misconception between only using lean system tools and fully adopting lean management system by creating truly lean culture within the company. Moreover, in Jordan, the academic effort at the universities, colleges and vocational training centers did not match the needs of providing the graduates with Lean management essential knowledge. Accordingly, in present work will develop lean management effective application and enhance the academic field with this knowledge

## **2. PROBLEM STATEMENT**

The world started to realize the power of LEAN manufacturing on the beginning of the 1980s after seeing the amazing achievement done by the Japanese industry. Since then, many researches, studies, books, articles have been exploring LEAN world and still the need more as this system key feature is continuous development and improvement. Nevertheless, many companies failed to apply effective Lean management. Such companies were stuck in a transient state between old systems and the new Lean system. Most of them returned the old systems after facing some problems or not achieving dramatic improvement. (Liker, 2004). In fact, the effective application of lean management is critically challenged by failing to fully understand the essence of Lean management concept and philosophy. (Balle, 2005). Moreover, to deal with the cultural differences issues either national or organizational. (Fairris, and Tohyama, 2002), (Herron, and Braiden 2007), (Liker, and Hoseus, 2008). In this work, an effort is made to explore LEAN manufacturing definitions, defining its related terms, explore the common Lean models, tools, and discuss the major challenges during applications

## **3. RESEARCH OBJECTIVES**

The main objective of this work is to study the effective application of Lean manufacturing within a manufacturing company. Accordingly, the scope of this study will achieve the following objectives:

- Highlight the historical background.
- Define Lean manufacturing and its associated terms and tools.
- Develop new holistic model tracking effective lean management application.

- Evaluate the effective application of Lean manufacturing using a questionnaire
- Evaluate the utilization of Lean process and tools by employees and within the company.
- Evaluate the problem solving resulting from effectively applying lean management practices.
- Based on the fieldwork and survey results a set of recommendations will be developed to bridge the gaps between effective true Lean enterprise and transient Lean enterprise.

#### 4. RESEARCH HYPOTHESIS

The main hypothesis of this study is:

**H<sub>0</sub>:** There is no evidence with statistical significance at the level of significance ( $\alpha \leq 0.05$ ) of the effective application of lean management within the case study company.

**H<sub>1</sub>:** There is evidence with statistical significance at the level of significance ( $\alpha \leq 0.05$ ) of the effective application of lean management within the case study company.

#### 5. RESEARCH METHODOLOGY

The method of the study is based on exploring the existing lean manufacturing literature and focus on the various models describing lean management. Accordingly, a new model is developed focusing on the effective application of lean management. This model is composed of sequence of major steps and factors which is proved to have key effect on effective Lean manufacturing application. Most of the factors in the new model are proved to have significant impact on lean application by previous studies. In addition, Lean experts holding key positions in successful Lean enterprises emphasized on the importance of those factors within their books and statements. However, most of the studies were focusing on single isolated factor or a couple of factors, in addition not showing the sequence of application and interrelations between the factors. Moreover, a questionnaire is designed to test the extent of effective lean application within the case study company. Additionally, the results of the questionnaire will be statistically analyzed showing the extent of each factor application and the result of problem solving.

**Study Population:** The population will be the employees of Case Study Company, which is a Jordanian joint venture company, established in 1999 between the American Albemarle Corporation and the Jordanian Arab Potash Company (APC). It is classified as limited private free zoon company. The actual operation and production activities started on 2002. Its main business is extracting, manufacturing and exporting derivatives form the Dead Sea. Both of Albemarle and APC, this company is considered the most successful joint ventures in the history of both companies. It is considered a large size company with 341 directly hired employees. In addition to 100 full times nested contractor working at company site. Its products are exported to more than 30 countries all over the world. This company is certified to be complying with a group of international standards, they are:-

- Quality Management System QMS ISO 9001:2009.
- Environment Management System EMS ISO 14001:2004.
- Occupation Health and Safety Assessment Series for health and safety management systems OHSAS 18001.
- Voluntary Emissions Control Action Program VECAP.

Albemarle, the mother company of the case study company has many sites and joint ventures distributed all over the world. In order to increase its competitive edge and make advantage of Lean manufacturing benefits it provided the support and commitment to all of its branches to start the effective application of Lean Manufacturing. A group of internal subject matter experts were developed to be involved in the application process. The below techniques and tools were involved:

- 5S.
- Kaizen.
- Gemba Audits.
- Just in time Manufacturing.
- Value Stream Mapping.
- Visual control and Dashboard.
- Pull Production System.
- Waste recognition and elimination.
- Other tools

The present study aims to evaluate the effective application of Lean tools and the whole system, in order to detect any problems and develop a set of recommendations to improve the performance and gap the bridge toward efficient and effective lean application. The employees represent the total population of the case study. There are 11 departments divided into 25 sections. Employees' distribution is shown below in figure (1.1) and the total population is 400 employees.

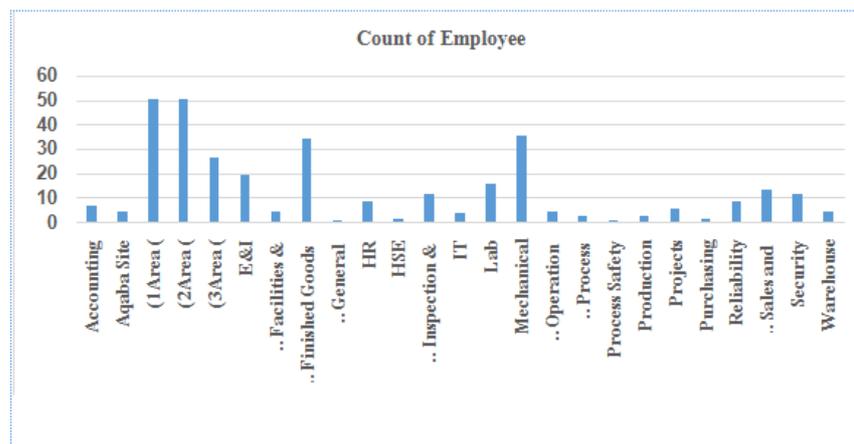
### **Waste Reduction Effect on Product Cost, Product Value and Profit Margin Demonstrative Figure**

Product cost (price) can be simply defined as the amount of money required to purchase that product (what is paid by the customer). Product value is the usefulness of the product or what really satisfies the customer needs and meets his expectation. Because of the waste included in the production process, the product cost increases and the customer had to pay for the waste even though he doesn't need it, and there is no added value for the customer. One of the most important pillars of Lean manufacturing is waste identification. In a real Lean enterprise, there is always a ruthless effort to identify and eliminate all kinds of wastes. After identifying the waste and implementing the necessary measures to eliminate it, it is possible to increase the profit or reduce the product price in the market, thereby increasing the competitive edge of the company. Figure (2) below is developed to highlight the advantages of waste minimization according to Lean manufacturing philosophy. As can be seen, there are two options:

- Reducing the product cost while maintaining the product real value. Thereby, we have a more desirable product because of the less price and same real value.
- The second option is maintaining the same product price and cutting waste cost. The result is increasing the profit margin.

The most challenging aspect of Lean manufacturing is its effective application within the organization. This is due to its vast scope and the various factors associated with its application. Many companies failed in its application, because

of thinking of lean as a tool or an equipment that can be purchased and get it to be running overnight. Other companies contracted experts or hired new staff for its application and failed too, because of rushing the application process missing the essential concept of the necessity of creating lean culture among the existing staff. Lean application can be described as a journey, which requires the joint efforts of everybody in the organization. The challenging questions of where to start? What to do? Who need to do it? And what is the sequence of application? Accordingly, this study is presenting a new model to address these questions and present a road map for lean manufacturing effective application.



**Figure 1: Count of Employees by Section.**

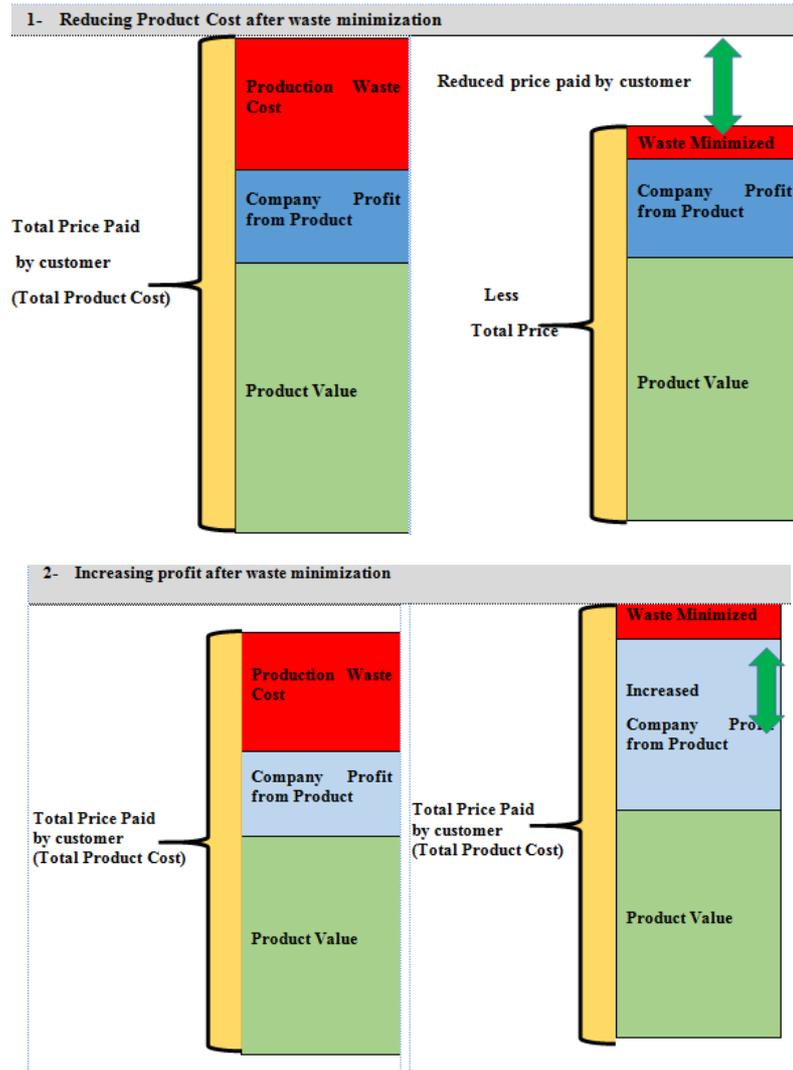
This model is connecting the most important factors and shows the sequence and interrelations between these factors. This model is shown in figure (3) below.

**Development of Lean Application Model**

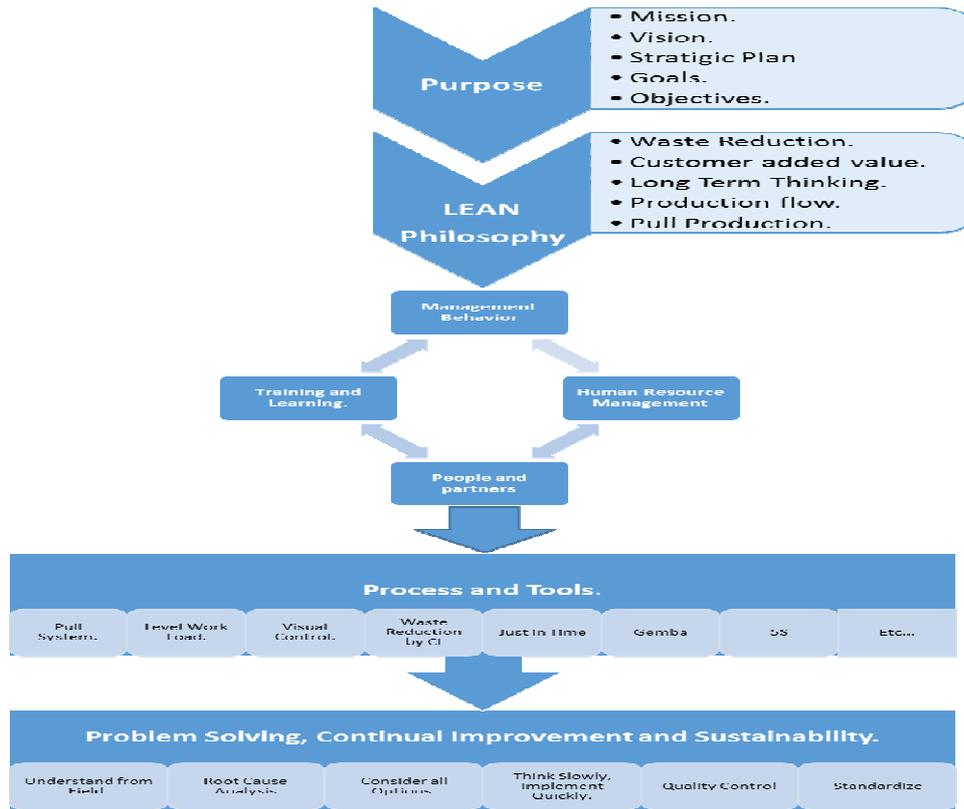
A special effective lean application questionnaire was designed according to lean philosophy and validated by many experts in the field. This questionnaire was carefully developed based on the literature review, field experience, the effort associated with the field study and the advice of the field experts. It is developed to evaluate the extent of application of each step within the new module. The results of the questionnaire were statistically analyzed to develop the necessary recommendations to bridge the gaps toward the effective application of lean management. It is important to highlight that during the study, the advice and comments provided by Lean experts and field practitioners were taken in great consideration. The model and questionnaire were discussed with them and modified accordingly. The model and questionnaire can be used in any corporate during any stage of applying lean

**Study Sample:** The study was performed over a random sample of (132) participants, forming the percentage of (33%) of the study population. Seven questionnaires were excluded for non-suitability of statistical analysis. So, the total number of questionnaires subjected to statistical analysis is (125) forming (31.25%) of the study population and the rate of (94.7%) of the study sample, table (2) shows the characteristics of the sample:

**Tools Validity:** The questionnaire and its associated model were presented to a group of the specialists, who are deeply involved in applying lean management. Several modifications and improvements were discussed to deliver the optimum outcome related to the actual case study. Also, a group of researchers and academics were consulted, who agreed on the validity of the questionnaire and the model.



**Figure 2: Waste Reduction Effect on Product Cost, Product Value and Profit Margin Demonstrative Figure.**



**Figure 3: Effective Lean Application Model.**

**Study Tools:** A questionnaire was developed for data collection. It is composed of 2 parts; the first part for identifying the personal information of the participant, the second part for questioning his point of view and evaluating the questionnaire statements. The total number of statements is 68. Each statement was carefully designed to satisfy two main conditions:

- Evaluate the steps of Lean manufacturing application based on the extensive literature review and the new model of application.
- Clarity and ability of understanding by the participant

The following weights: Totally Agree (4) degrees, Agree (3) degrees, Disagree (2) degrees and Totally Disagree (1) degree, and it were dealing with the arithmetic averages of the answers to single sample in accordance with the frequency distribution grouping of the arithmetic average of the answers was created according to the below steps:

- Determine the largest and smallest value: Largest value: 4 , smallest value: 1.
- Computing the range:  $4-1=3$
- Selecting the number of classes: It is selected to be three: High, Medium and low.
- Calculating the class (interval) width:  $(\text{Highest Value} - \text{Smallest Value}) / \text{No. of intervals} = (4-1)/3 = 3/3 = 1$

**Tool Stability:** The stability of the tool was verified using (SPSS) Software by identifying the stability of the reality of Cronbach's alpha for internal consistency equation. As the value of the overall reliability coefficient (0.950) and this percentage is high and demonstrates the consistency and coherence between the paragraphs of the tool, and stability coefficients values ranged between (0.703 - 0.919), the following table (1) shows the values of reliability coefficients.

**Statistical Method:** Both descriptive statistics and inferential statistics are used in this study. They are used in analyzing the questionnaire results and drawing the conclusions. Descriptive statistics used to describe the basic features of the data in a study in a meaningful manner. Using tables and graphs, descriptive statistics provide simple summaries about the responses of the study sample, in addition to calculating the mean and standard deviation of the sample responses to provide summarized meaningful information about the sample. Additionally, inferential statistics used the statistical data to develop the statistical hypothesis and the significance test in order to develop the required conclusions, the t-test method was used.

**Table 1: Stability Coefficients Values**

No.	Filed	Stability Coefficients Values (Cronbach's alpha)
1.	Evaluates the compliance of company mission and goals with Lean management basic requirements.	0.846
2.	Evaluates the commitment to lean management philosophy	0.748
3.	Evaluates management behavior and its compliance with Lean management	0.919
4.	Measures human resource management function and its impact on lean management	0.703
5.	Evaluates the compliance with lean management requirement related to people and partners	0.711
6.	Evaluates the function of training and learning in the company to satisfy lean management needs	0.842
7.	Evaluates the process of lean application and its associated tools within the company	0.705
8.	Evaluate the result of applying lean management and its impact on problem solving.	0.841
<b>Total Questionnaire Overall Reliability Coefficient</b>		<b>0.950</b>

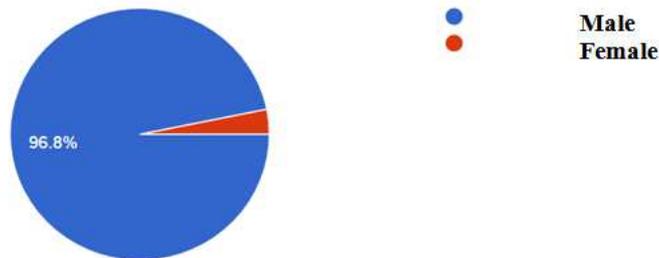
**Table 2: The Distribution of the Study Sample**

Variable	Variable Categories	Number	Percentage %
Gender	Male	121	96.8
	Female	4	3.2
Age	less than 25	11	8.8
	25 -35	44	35.2
	36-45	55	44
	More than 45	15	12
Years of Experience	Less than 5 years	19	15.2
	5 - 10	26	20.8
	11 – 15	44	35.2
	More than 15	36	28.8
Employment	Direct Hire Employee	112	89.6
	Contractor	5	4
	Intern	8	6.4
Job Level	Skilled labor.	7	5.6
	Technician.	39	31.2
	Foreman.	10	8
	Supervisor.	12	9.6
	Engineer.	35	28
	Senior Engineer.	4	5.6
	Manager.	12	9.6
	High Level Manager.	1	.8
Other	5	4	

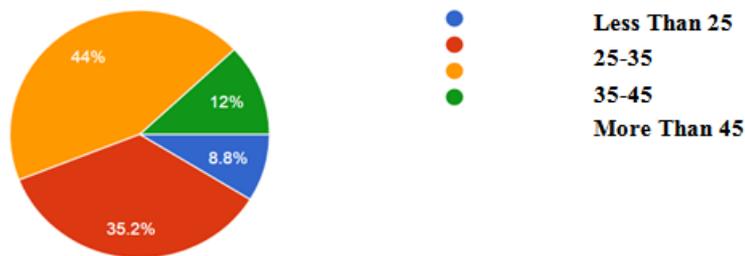
<b>Table 2 Contd.,</b>			
Work Department	Finance.	5	4
	Human Resources.	6	4.8
	IT	3	2.4
	Security.	4	3.2
	Operation.	43	34.4
	Maintenance.	30	24
	Logistics & Supply Chain.	4	3.2
	Packaging.	2	1.6
	Projects	5	4
	Laboratories	9	7.2
	Process and CIT	8	6.4
	Others.	6	4.8

**6. RESULTS AND DISCUSSIONS OF PARTICIPANT’S PERSONAL DATA**

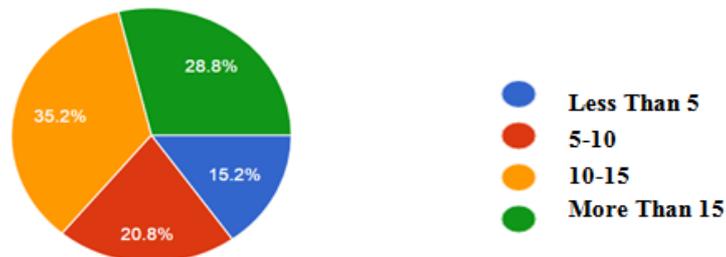
Figures 4-9 show the gender percentage distribution of the sample according to Gender, Age, Work experience, Employment, Job Level and Department.



**Figure 4: The Distribution of the Study Sample According to Gender.**



**Figure 5: The Distribution of the Study Sample According to Age.**



**Figure 6: The Distribution of the Study Sample According to Years of Work Experience.**

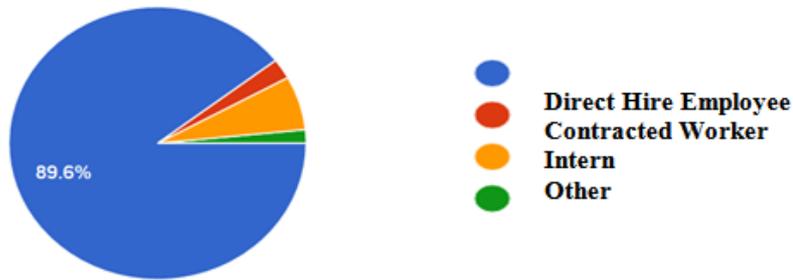


Figure 7: The Distribution of the Study Sample According to Employment.

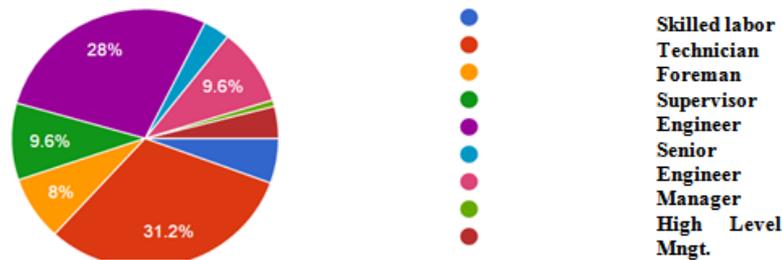


Figure 8: The Distribution of the Study Sample by Job Level.

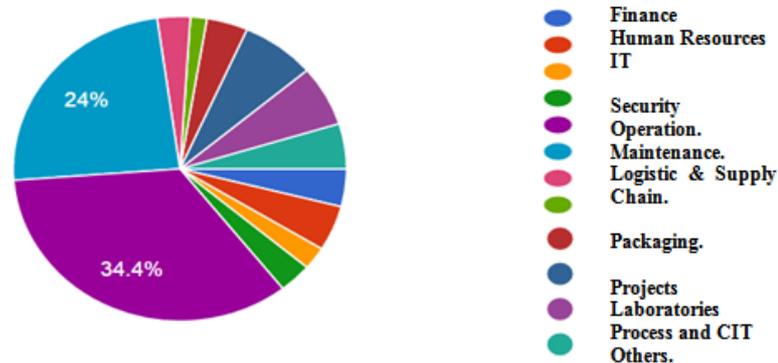


Figure 9: The Distribution of the Study Sample According to Department.

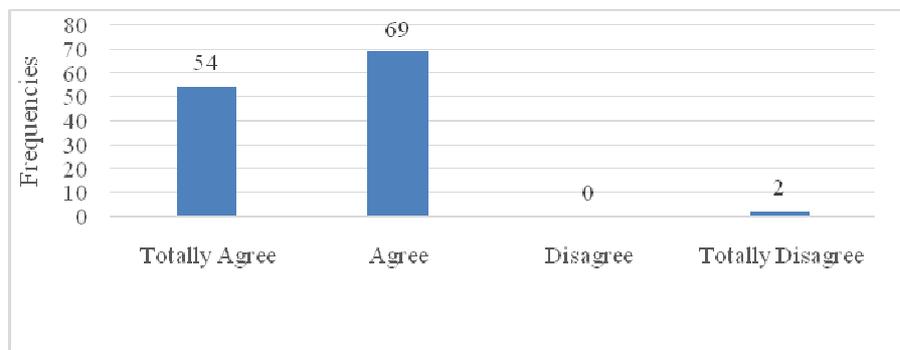
**7. STATISTICAL ANALYSIS OF THE QUESTIONNAIRE RESULTS**

This section discusses the results of the questionnaire and the statistical analysis related to the hypothesis, aiming to develop the correct conclusions and recommendations related to this study.

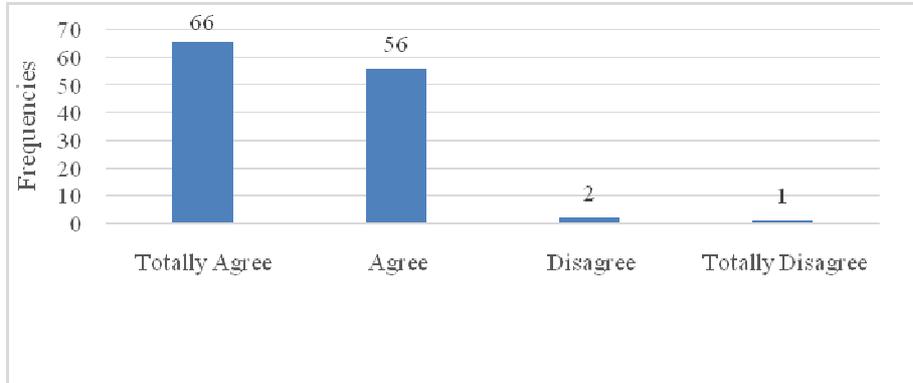
**A: Results Analysis of Questions (statements 1-7): Evaluating Company Mission and Goals Compliance with Lean Management Basic Requirements:**

Statement number (1) stated “In our company, employees understand the mission and goals of the company”. The frequencies and the percentage of the Respondent Answers to this statement shown in the figure (10) below, is it can be clearly seen, the majority of the employees with the percentage of 55.2% agree on understanding the mission and goals of the company. Moreover, 43.2% totally agree on this. Only 2 participants totally disagrees this point of view. This result shows strong compliance with Lean management principals. Statement number (2) stated “We seek understanding and aligning with our customer’s mission and goals”. The frequencies and the percentage of the respondents answer to this

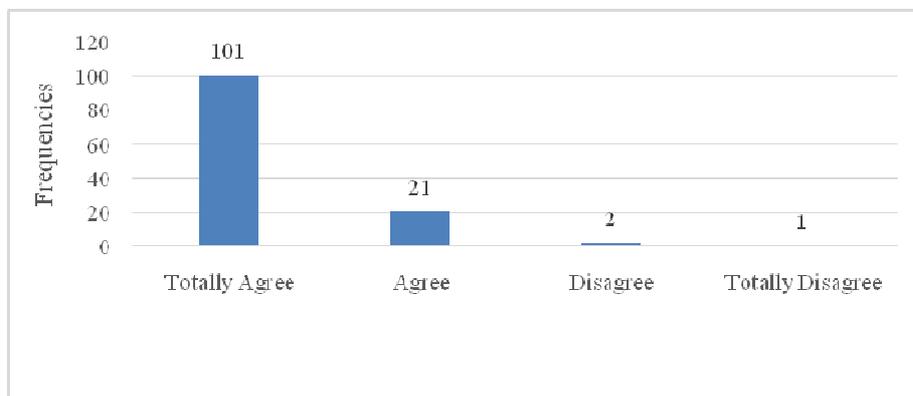
statement shown in the figure (11) below. The majority of the employees with the percentage of 52.8% totally agree on this. Additionally, 44.8% agree on seek understanding and aligning with our customer’s mission and goals. Only 2 employees disagree and 1 totally disagrees. This result shows strong compliance with Lean management principals. In the questionnaire, statement number (3) stated “We focus on providing high quality service to our customers”. The frequencies and the percentage of the respondents answer to this statement shown in the figure (12) below. 80.8% totally agree on the statement, 16.8% agree, 1.6% disagree and only 0.8% totally disagree. This proofs strong compliance with Lean management principles regarding focusing on providing high quality service to customers. In the questionnaire, statement number (4) stated “We focus on minimizing waste and cost as part of our mission and goals”. The frequencies and the percentage of the respondents answer to this statement shown in the figure (13) below. 64% totally agree, 32.8% agree, 2.4 disagree and only 0.8% disagree. These results show clear compliance with Lean management requirements regarding the focus on waste and cost reduction.



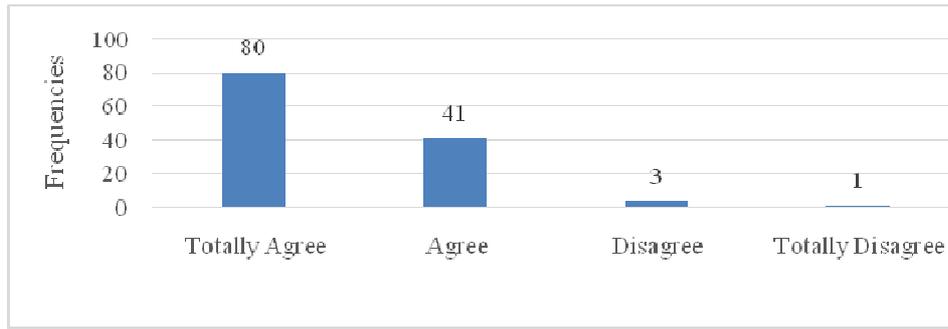
**Figure 10: Respondent Answers to Statement (1).**



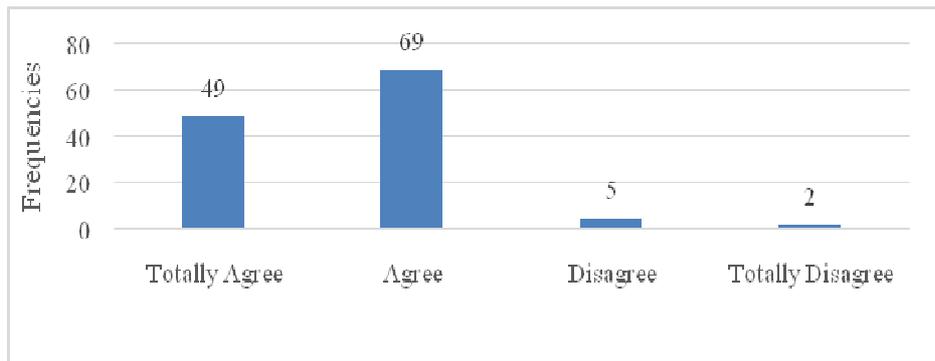
**Figure 11: Respondent Answers to Statement (2).**



**Figure 12: Respondent Answers to Statement (3).**



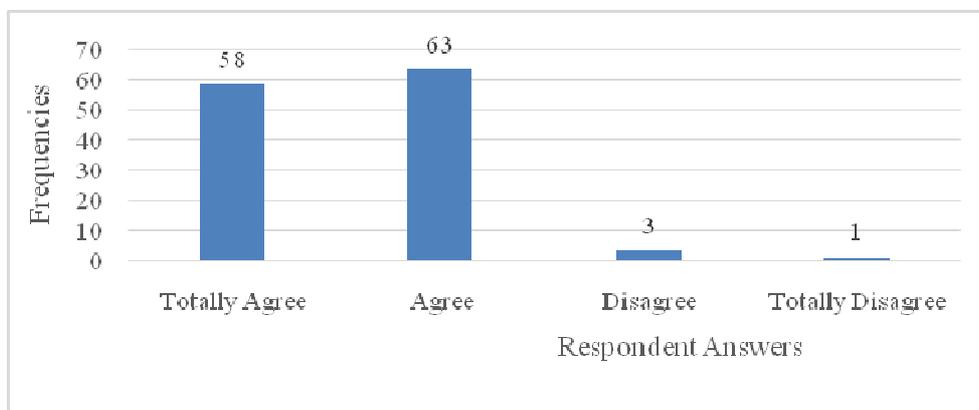
**Figure 13: Respondent Answers to Statement (4).**



**Figure 14: Respondent Answers to Statement (5).**

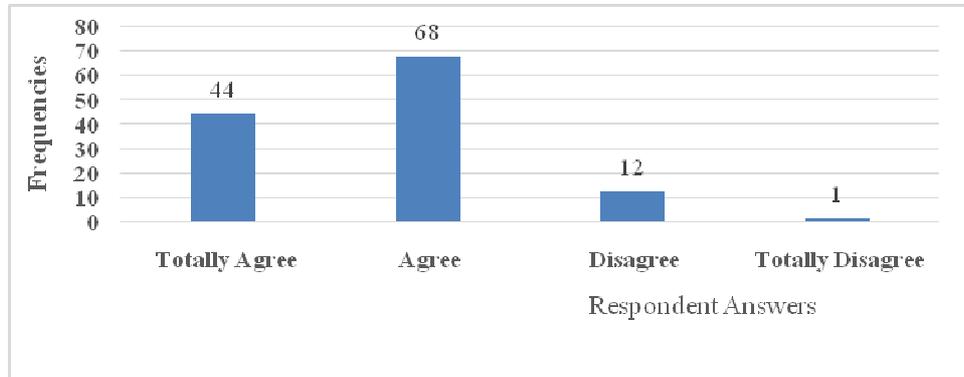
Statement number (5) stated “In our company, we communicate our mission and goals with our suppliers”. The frequencies and the percentage of the respondent’s answers to this statement shown in the figure (14), the majority of the employees with the percentage of 55.2% agree on this, 39.2% totally agree, 4% disagree and only 1.6% disagree. The results show strong compliance with Lean management principles regarding the communication of goals and mission with suppliers.

Statement number (6) stated “We focus on the added value for our customers as part of our mission and goals”. The frequencies and the percentage of the respondent’s answers to this statement shown in the figure (15) below. The majority of the respondent's answers with the percentage of 50.4% agree on the statement. Furthermore, 46.4% totally agree. Only 2.4% disagree and 0.8% totally disagrees. These results show clear compliance with Lean management principles regarding the focus on added value for customers.



**Figure 15: Respondent Answers to Statement (6).**

Statement number (7) stated “It is a priority to apply effective Lean manufacturing in our mission and goals”. The frequencies and the percentage of the respondent’s answers to this statement shown in the figure (16), the majority of the respondent’s answers with the percentage of 54.4% agree on this. Moreover, 35.2% totally agree on this. Only 9.6% disagree and 0.8% totally disagrees. This clearly complies with Lean management principles.



**Figure 16: Respondent Answers to Statement (7).**

**B: Results Analysis of Questions (statements 8-12): Evaluating the Understanding and Compliance with Lean Management Philosophy:**

The results questions statements 13-68 can be shown in tables 4 to 10.

**Table 3: T-Test Result of Evaluating Company Mission and Goals Compliance with Lean Management Basic Requirements**

#	Statement	Mean	Standard Deviation	Level Based On Mean	T - Value	Statistical Significance
1.	In our company, employees understand the mission and goals of the company.	3.4	0.582	High	17.290	0.000
2.	We seek understanding and aligning with our customer’s mission and goals.	3.49	0.576	High	19.307	0.000
3.	We focus on providing high quality service to our customers.	3.77	0.505	High	28.203	0.000
4.	We focus on minimizing waste and cost as part of our mission and goals.	3.6	0.582	High	21.132	0.000
5.	In our company, we communicate our mission and goals with our suppliers.	3.32	0.630	High	15.554	0.000
6.	We focus on the added value for our customers as part of our mission and goals.	3.42	0.585	High	17.640	0.000
7.	It is a priority to apply effective Lean manufacturing in our mission and goals.	3.24	0.653	High	12.679	0.000
<b>Total Field</b>		<b>3.46</b>	<b>0.610</b>	<b>High</b>	<b>17.595</b>	<b>0.000</b>

Table (4) clearly shows that the general arithmetic average of sample answers on the statements which evaluates the commitment to lean management philosophy, has reached (3.438) with the standard deviation of (0.695) which represents high degree of estimation. As all the statements in the table have high estimates, and it is supported by the

values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states: There is evidence with statistical significant at the level of significance ( $\alpha \leq 0.05$ ) of the understanding and compliance with Lean management philosophy within the case study company

**Table 4: T-Test Result to Evaluate the Effect of Questions (8-12); Evaluating the Understanding and Compliance with Lean Management Philosophy**

#	Statement	Mean	Standard Deviation	Level based on Mean	T - Value	Statistical Significance
8.	In our company, we are committed to waste minimization.	3.544	0.602	High	19.374	0.000
9.	In our company, production process is running based on customer's orders.	3.488	0.702	High	15.719	0.000
10.	In our company, production flow stops whenever a problem is detected	3.528	0.690	High	16.641	0.000
11.	In our company, there is high level of respect for the employees.	3.216	0.799	High	10.019	0.000
12.	In our company, we are committed to long-term improvement.	3.416	0.624	High	16.398	0.000
	<b>Total Field</b>	<b>3.438</b>	<b>0.695</b>	<b>High</b>	<b>15.089</b>	<b>0.000</b>

**C: Results Analysis of Questions (13-23): Evaluating Management Behavior and Its Compliance with Lean Management Principles:**

Table (5) clearly shows that the general arithmetic average of sample answers on the statements which evaluates management behavior and its compliance with Lean management, has reached (3.090) with the standard deviation of (0.746) which represents high degree of estimation. As all the statements in the table have high estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states: There is evidence with statistical significant at the level of significance ( $\alpha \leq 0.05$ ) of management behavior compliance with Lean Management principles within the case study company.

**Table 5: T-Test Result to Evaluate the Effect of Questions (13-23) Evaluates Management Behavior and its Compliance with Lean Management**

#	Statement	Mean	Standard Deviation	Level based on Mean	T - Value	Statistical significance
13.	Managers are in contact with the field and employees.	3.216	0.690	High	11.589	0.000
14.	Managers understand the details of the daily work.	3.088	0.751	High	8.748	0.000
15.	Managers encourage new ideas and suggestions provided by field employees.	3.112	0.732	High	9.348	0.000
16.	Managers set challenging goals and ask for improvement.	3.152	0.636	High	11.467	0.000

**Table 5 Contd.,**

17.	Managers closely monitor the daily work progress and compare with the plan.	3.200	0.660	High	11.860	0.000
18.	Managers involve reports in setting department work plans and objectives.	2.976	0.847	Medium	6.284	0.000
19.	Managers support providing resources for achieving goals.	3.024	0.653	High	8.967	0.000
20.	Managers award positive work accomplishments and attitudes.	2.864	0.919	Medium	4.429	0.000
21.	Negative work activities are investigated and disciplined.	3.312	0.734	High	12.366	0.000
22.	Managers use discussion and convincing with employees for goal achievements.	3.000	0.783	High	7.141	0.000
23.	Managers support effective Lean Application.	3.048	0.670	High	9.141	0.000
<b>Total Field</b>		<b>3.090</b>	<b>0.746</b>	<b>High</b>	<b>8.842</b>	<b>0.000</b>

**D: Results Analysis of Questions (24-28); Evaluating Human Resource Management Function and Its Compliance with Lean Management Requirements within the Case Study Company:**

Table (6) clearly shows that the general arithmetic average of sample answers on the statements which evaluates human resource management function and its compliance with lean management requirements, has reached (2.766) with the standard deviation of (0.969) which represents medium degree of estimation. The statements in the table has high and medium estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states: There is evidence with statistical significant at the level of significance ( $\alpha \leq 0.05$ ) of Human resource management compliance Lean Management requirements within the case study company.

**Table 6: T-Test Result to Evaluate the Effect of Questions (24-28), Evaluate Human Resource Management Function and its Compliance with Lean Management Requirements**

#	Statement	Mean	Standard Deviation	Level based on Mean	T - Value	Statistical significance
24.	Recruitment process delivers and retains talented employees.	3.048	0.727	High	8.416	0.000
25.	Employees holding leadership positions are internally promoted.	3.040	0.787	High	7.671	0.000
26.	Outstanding employees are developed and promoted.	2.816	0.817	Medium	4.324	0.000
27.	There is low level of turnover in the company.	2.248	0.876	Medium	-3.214	0.002
28.	It is easy to find successors within the company after employee resignation.	2.680	0.885	Medium	2.273	0.025
<b>Total Field</b>		<b>2.766</b>	<b>0.869</b>	<b>Medium</b>	<b>3.422</b>	<b>0.0054</b>

**E: Results Analysis of Questions (29-40): Evaluating Compliance with Lean Management Requirement Related to People and Partners.**

Table (7) clearly shows that the general arithmetic average of sample answers on the statements, which evaluates compliance with lean management requirement related to people and partners, has reached (3.12) with the standard

deviation of (0.802) which represents high degree of estimation. The statements in the table has high and medium estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states: There is evidence with statistical significant at the level of significance ( $\alpha \leq 0.05$ ) of focusing on people and partners to achieve effective lean application within the case study company.

**Table 7: T-Test Result to Evaluate the Effect of Questions (29-40), Focusing on People and Partners to Achieve Effective Lean Application**

#	Statement	Mean	Standard Deviation	Level	T - Value	Statistical Significance
29.	Within the company, people and human resources are very important priority.	3.144	0.810	High	8.886	0.000
30.	It is difficult to find suppliers and contractors with skills and knowledge matching what we have at our company.	3.136	0.776	High	9.162	0.000
31.	In our company, we help developing our contractors and suppliers.	3.232	0.540	High	15.132	0.000
32.	I believe lean application can be helpful for our company and is a high priority.	3.528	0.603	High	19.047	0.000
33.	People at the company believe Lean application is a priority.	2.832	0.895	Medium	4.144	0.000
34.	There is high level of self-awareness and commitment among employees.	3.488	0.562	High	19.638	0.000
35.	When production problem happens, it is solved by teamwork not individually.	3.304	0.732	High	12.280	0.000
36.	When a team member in vacation, it is easy to cover for him.	3.040	0.919	High	6.567	0.000
37.	It is easy to deliver work suggestions improvement and implement it.	3.048	0.705	High	8.685	0.000
38.	Workload is evenly distributed over employees within the section.	2.552	0.846	Medium	0.687	0.494
39.	It is important to have dedicated unit and employees to work full time on lean application.	3.320	0.757	High	12.099	0.000
40.	Good performing employees are promoted.	2.816	0.817	Medium	4.324	0.000
<b>Total Field</b>		<b>3.12</b>	<b>0.802</b>	<b>High</b>	<b>8.643</b>	<b>0.041</b>

**F: Results Analysis of Questions (41-46): Evaluating the Function of Training and Learning in the Company to Satisfy Lean Management Needs:**

Table (8) clearly shows that the general arithmetic average of sample answers on the statements, which evaluates the function of training and learning in the company to satisfy lean management needs, has reached (3.508) with the standard deviation of (0.590) which represents high degree of estimation. The statements in the table has high estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which

requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states: there is an evidence with statistical significant at the level of significance ( $\alpha \leq 0.05$ ) of utilizing training and learning to achieve effective lean application within the case study company.

**Table 8: T-Test Result of questions (41-46), Evaluating the Utilization of Training and Learning to Achieve Effective Lean Application**

#	Statement	Mean	Standard Deviation	Level Based on Mean	T - Value	Statistical Significance
41.	Other employees participate in providing training for their colleagues.	3.496	0.590	High	18.856	0.000
42.	There is a lot to learn from the daily work practices.	3.544	0.560	High	20.811	0.000
43.	It is easy to get work instructions and information when I need it.	3.560	0.573	High	20.661	0.000
44.	During my study period before being employed, I did not get knowledge about Lean Manufacturing.	3.496	0.590	High	18.856	0.000
45.	During my work at this company, I was trained on Lean manufacturing principles	3.496	0.590	High	18.856	0.000
46.	There is a need for more training on lean application within the company.	3.456	0.641	High	16.665	0.000
<b>Total Field</b>		<b>3.508</b>	<b>0.590</b>	<b>High</b>	<b>19.100</b>	<b>0.000</b>

**G: Results analysis of questions (47-60): Evaluating applying lean process and tools within the case study company:**

Table (9) clearly shows that the general arithmetic average of sample answers on the statements, which evaluates the process of lean application and its associated tools within the company, has reached (2.97) with the standard deviation of (0.806) which represents medium degree of estimation. The statements in the table has high estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states:There is evidence with statistical significant at the level of significance ( $\alpha \leq 0.05$ ) of applying lean process and tools within the case study company.

**Table 9: T-Test Result to Evaluate the Effect of Questions (47-60). Evaluates Applying Lean Process and Tools within the Case Study Company**

#	Statement	Mean	Standard Deviation	Level	T - Value	Statistical Significance
47.	There is low level of inventory in my section.	2.288	0.791	Medium	-2.996	0.003
48.	At the section where I work, we have low level of rework.	2.832	0.811	Medium	4.579	0.000
49.	There is low level of overproduction in my section.	2.984	0.793	Medium	6.824	0.000
50.	When a problem happens, short time needed to solve it.	3.184	0.734	High	10.422	0.000
51.	It is easy to spot any quality problem at my section.	3.096	0.807	High	8.252	0.000
52.	I need to ask few questions and spend short time to solve problems.	2.824	0.824	Medium	4.398	0.000

53.	Flow of raw materials and inventory is smooth and continuous.	3.072	0.674	High	9.487	0.000
54.	Production process is linked together in efficient manner.	3.272	0.614	High	14.057	0.000
55.	It is easy to get information and data about the production process.	3.208	0.699	High	11.324	0.000
56.	Workload is evenly distributed over time within the section.	2.440	0.827	Medium	-0.811	0.419
57.	There is work instruction and procedures to control work activities.	3.088	0.672	High	9.780	0.000
58.	Work reports are short and efficient.	3.112	0.638	High	10.729	0.000
59.	IT resources are well involved in work activities.	3.328	0.619	High	14.949	0.000
60.	Elective application of lean is better than mandatory application.	2.848	0.968	Medium	4.021	0.000
<b>Total Field</b>		<b>2.97</b>	<b>0.806</b>	<b>Medium</b>	<b>6.52</b>	<b>0.03</b>

### **H: Results Analysis of Questions (61-68): Evaluating Problem Solving and Continuous Improvement with in the Case Study Company**

Table (10) clearly shows that the general arithmetic average of sample answers on the statements which evaluates the result of applying lean management and its impact on problem solving and continual improvement, has reached (3.274) with the standard deviation of (0.688) which represents medium degree of estimation. The statements in the table has high estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the first study hypothesis in their nihilism form and acceptance of alternative hypothesis, which states: There is evidence with statistically significant at the level of significance ( $\alpha \leq 0.05$ ) of achieving problem solving and continuous improvement with in the case study company.

**Table 10: T-Test Result to Evaluate the Effect of Questions (61-68). Evaluating the Result of Applying Lean Management and its Impact on Problem Solving and Continual Improvement**

#	Statement	Mean	Standard Deviation	Level Based on Mean	T - Value	Statistical Significance
61.	I go to the field for understanding the cause of problems.	3.488	0.691	High	15.982	0.000
62.	I usually participate in problem`s root cause analysis.	3.312	0.777	High	11.686	0.000
63.	We have the required time and resources for problems root cause analysis.	3.032	0.761	High	7.813	0.000
64.	Usually we consider all options in problem solving.	3.384	0.579	High	17.070	0.000
65.	The resulting Corrective actions prevent the reoccurrence of the problem.	3.344	0.610	High	15.458	0.000
66.	Once identified and agreed, corrective actions are implemented quickly.	3.184	0.665	High	11.507	0.000
67.	Corrective actions and incident investigations are well documented.	3.320	0.643	High	14.267	0.000
68.	It is easy to know the root causes of previous problems.	3.128	0.660	High	10.644	0.000
<b>Total Field</b>		<b>3.274</b>	<b>0.688</b>	<b>High</b>	<b>12.577</b>	<b>0.000</b>

### Evaluating the Total Aspect of the Effective Application of Lean Management

Now, will use the same statistical approach to prove the main null hypothesis, table (11) clearly shows that the general arithmetic average of sample answers on the statements, which evaluates the effective application of Lean Management, has reached (3.203) with the standard deviation of (0.725) which represents high degree of estimation. The statements in the table has high estimates, and it is supported by the values of (t) calculated function is statistically significant at the level of significance ( $\alpha \leq 0.05$ ). Which requires a rejection of the main first study hypothesis in their nihilism form and acceptance of alternative main hypothesis, which states: There is evidence with statistical significance at the level of significance ( $\alpha \leq 0.05$ ) of the effective application of lean management within the case study company.

**Table 11: T-Test Result to Evaluate the Overall Effective Application of Lean Management within the Case Study Company**

#	Statement	Mean	Standard Deviation	Level	T - Value	Statistical Significance
1.	Results of Evaluating Company Mission and Goals Compliance with Lean Management Basic Requirements.(1 - 7)	3.46	0.610	High	17.595	0.000
2.	Results of evaluating the understanding and commitment with lean management philosophy. (8 - 12)	3.438	0.695	High	15.089	0.000
3.	Results of evaluating management behavior and its compliance with Lean manage. principles. (13 - 23)	3.090	0.746	High	8.842	0.000
4.	Results of evaluating human resource management function and its compliance with lean management req. (24-28)	2.766	0.869	Medium	3.422	0.0054
5.	Results of evaluating the focus on people and partners to achieve effective lean application (29- 40)	3.12	0.802	High	8.643	0.041
6.	Results of evaluating the utilization of training and learning to achieve effective lean application (41-46)	3.508	0.590	High	19.100	0.000
7.	Result of evaluating applying lean processes and tools within the case study company (47-60)	2.97	0.806	Medium	6.52	0.030
8.	Result of applying lean management and its impact on problem solving and continual improvement. (61-68)	3.274	0.688	High	12.577	0.000
	<b>The Average of Total Result</b>	<b>3.203</b>	<b>0.725</b>	<b>High</b>	<b>11.18</b>	<b>0.009</b>

## 8. CONCLUSIONS

According to study results, the below conclusions are drawn:

The newly developed model of effective lean application succeeded in describing a general road map of applying lean manufacturing application. In addition, the questionnaire succeeded in evaluating the extent of application. This was confirmed by:

- The high value of the reliability coefficient of Cronbach`s Alpha, reaching the value of 0.950.
- Compliance with literature review.

- The validity and positive feedback confirmed by the field practitioners and experts, who were involved in the study.
- About 27.2% of the study sample indicated that managers do not include reporting employees in setting department`s plans and objectives.
- 32% of the study sample indicated that managers do not award positive work accomplishments and attitudes.
- 32.8% of the study sample indicated that outstanding employees are not developed and promoted.
- 59.2% of the study sample indicated that there is high turnover rate in the company.
- 36% of the study sample indicates that there is a difficulty in finding competent successors within the company.
- 82.4% of the study sample indicates that there is a difficulty in finding suppliers and contractors with skill and knowledge matching those in the company.
- 32% of the study sample indicates that lean management application is not a first priority.
- 42.4% of the study sample indicates that workload is not evenly distributed over employees within work section.
- 87.2% of the study sample indicates that it is important to have a dedicated unit and employees to work full time on lean application.
- 96.8% of the study sample indicates that employees before graduating were not educated at the universities or collages about lean manufacturing.
- 95.2% of the study sample indicates that there is a need for additional training within the company.
- 48% of the study sample indicates that there is high level of inventory within the company.
- 34.4% of the study sample indicates that there is considerable amount of rework within the company.
- 53.6% of the study sample indicates that workload is not evenly distributed over time within work sections.
- There is disagreement about enforcing lean management application or make it elective. 42.4% of the sample thinks, mandatory application is better than elective. On the other hand, 57.6% think elective application is better.
- In general, there is a strong evidence of effectively applying Lean management within the case study company, the general arithmetic average of sample answers on the statements, which evaluates the effective application of Lean Management, has reached (3.203) with the standard deviation of (0.725) which represents high degree of estimation.

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