T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

MONITORING AND OPTIMIZATION IN INTELLIGENT MANUFACTURING MANAGEMENT

MASTER THESIS

Dhafir Najim Abed

Engineering Management Department

Engineering Management Master in English Program

DECEMBER 2022

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Thesis Advisor: Assoc. Prof. Dr. Redvan GHASEMLOUNIA

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LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

Enstitümüz, Engineering Management Department İngilizce Tezli Yüksek Lisans Programı (201281014) Dhafir Najim Abed "in “Monitoring and Optimization in Intelligent Manufacturing Management” adlı tez çalışması Enstitümüz Yönetim Kurulunun 22.12.2022 tarihinde oluşturulan jüri tarafından ***Oy Birliği*** ile Yüksek Lisans tezi olarak ***Kabul*** edilmiştir.

Öğretim Üyesi Adı Soyadı

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DECLARATION

I, Dhafir Najim ABED, do hereby declare that this thesis titled as “Monitoring and Optimization in Intelligent Manufacturing Management” is original work done by me for the award of the master's degree in the faculty of Engineering Management. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (22/12/2022)

Dhafir Najim Abed

DEDICATION

To my mother's soul and our pride.

To my esteemed father..... may God prolong his life, and grant him health and wellness.

To my wife and life partner...

To my dear son...

To my dear brothers ....

To my friends.....

I dedicate my scientific research.

PREFACE

Foremost thanks to Allah, the most beneficent and merciful, who helped me to complete this study and to submit it in such a way.

I would like to express my thanks, appreciation, and gratitude to my supervisor Asst. Prof. Dr. Redvan GHASEMLOUNIA for his concern, guidance, and advice.

November 2022 Dhafir Najim Abed

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ABBREVIATIONS

AWS : Advanced Warning System
COE : Center of Excellence
CSF : Critical Success Factors
DPM : Development of Project Management
DR : Demand Response
HVAC : Heating, Ventilation, Air
LP : Linear Programming
MILP : Mixed Integer Linear Programming
MIP : Mixed Integer Programming
MIS : Management Information System
MPC : Model Predictive Control
PO : Project Office
PSO : Particle Swarm Optimization
SE : Smart Equipment
SEM : Smart Equipment Manufacturing
SSM : Supply Side Management
TQM : Total Quality Management
VFDs : Variable Frequency Drives

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MONITORING AND OPTIMIZATION IN INTELLIGENT MANUFACTURING MANAGEMENT

ABSTRACT

The world has had three important industrial revolutions, these resulting in enormous improvements in various elements of manufacturing and giving immense advantages to humanity and society. The year 2022 ushers in Industry 4.0, often known as the "fourth Industrial Revolution" and the "Internet of Things" Era.

The needs of the market's clients play a key influence in the evolution of manufacturing strategies. Personalization, which evolved from customization, is the emerging trend for satisfying every customer’s requirements. In order to be successful on the market and to achieve competitive benefits, manufacturers in many industries must adapt to difficult changes and overcome these obstacles.

In the last two seasons, rising energy prices, over consumption of natural resources, and growing CO2 emissions have emerged as some of the most pressing global issues. The consumption of energy by industry accounts for 22.4% of the total energy produced.

Because of this, it is an essential requirement that businesses develop and implement energy-efficient procedures in order to examine their energy consumption, power data, and their use of technology that is energy-efficient. Although customers of utility companies are offered financial incentives through Demand Response programs, there is no evidence that consumer energy management techniques are being successfully used.

In order to accomplish this, which is referred to as intelligent manufacturing, technical breakthroughs in monitoring, automation, management, and big data can be utilized.

In this study, we highlighted on the concepts of monitoring and optimization in intelligent manufacturing management.

The main purpose of this research is to spread the among specialists of manufacturing fields and automation projects, where the aim target of the research into indicating how important the referred the concepts of monitoring and optimization in intelligent manufacturing management as per the scientific standards in achieving the concept and ensuring the implementation of manufacturing fields and automation, to investigate if engineers that those working in manufacturing fields and automation projects are aware of the essential concepts of monitoring and optimization in intelligent manufacturing management.

The method of search followed for this study included a mix of a comprehensive literary review, and analysis of important literature.

After that, a questionnaire of (140) members of the manufacturing field specialists and automation project specialists. The findings of the research reveal (18) constituents that are critical to clarified the mail concepts of monitoring and optimization in intelligent manufacturing management, and the opinion regarding the importance of these concepts.

Keywords: *Automation, Optimization, Intelligent Manufacturing, Monitoring.*

AKILLI ÜRETİM YÖNETİMİNDE İZLEME VE OPTİMİZASYON

ÖZET

Dünya, imalatın çeşitli öğelerinde muazzam gelişmelerle sonuçlanan ve insanlığa ve topluma muazzam avantajlar sağlayan üç önemli sanayi devrimi yaşadı. 2022 yılı, genellikle "dördüncü Sanayi Devrimi" ve "Nesnelerin İnterneti" Çağı olarak bilinen Endüstri 4.0'ı başlatıyor.

Pazardaki müşterilerin ihtiyaçları, üretim stratejilerinin evriminde önemli bir etkiye sahiptir. Özelleştirmeden gelişen kişiselleştirme, her müşterinin gereksinimlerini karşılamak için ortaya çıkan bir trend. Pazarda başarılı olmak ve rekabet avantajı elde etmek için birçok sektördeki üreticilerin zorlu değişimlere uyum sağlaması ve bu engelleri aşması gerekiyor.

Son iki sezonda artan enerji fiyatları, doğal kaynakların aşırı tüketimi ve artan CO2 emisyonları, en acil küresel sorunlardan bazıları olarak ortaya çıktı. Sanayi tarafından tüketilen enerji, üretilen toplam enerjinin %22,4'ünü oluşturmaktadır.

Bu nedenle, işletmelerin enerji tüketimlerini, güç verilerini ve enerji verimli teknoloji kullanımlarını incelemek için enerji verimli prosedürler geliştirmeleri ve uygulamaları temel bir gerekliliktir. Kamu hizmeti şirketlerinin müşterilerine Talep Yanıt programları aracılığıyla finansal teşvikler sunulsa da, tüketici enerji yönetimi tekniklerinin başarılı bir şekilde kullanıldığına dair bir kanıt yoktur.

Akıllı üretim olarak adlandırılan bunu başarmak için izleme, otomasyon, yönetim ve büyük veri alanlarındaki teknik atılımlardan yararlanılabilir.

Bu çalışmada, akıllı üretim yönetiminde izleme ve optimizasyon kavramları üzerinde durduk.

Bu araştırmanın temel amacı, akıllı üretim yönetiminde izleme ve optimizasyon kavramlarının bilimsel standartlara göre ne kadar önemli olduğunu ortaya koyarak, üretim alanlarının ve otomasyon projelerinin uzmanları arasında yaygınlaştırılmasıdır. üretim alanları ve otomasyon projelerinde çalışan mühendislerin akıllı üretim yönetiminde izleme ve optimizasyonun temel kavramlarından haberdar olup olmadığını araştırmak.

Bu çalışma için izlenen araştırma yöntemi, kapsamlı bir edebiyat incelemesi ile önemli literatürün analizini bir arada içermektedir.

Ardından imalat saha uzmanları ve otomasyon proje uzmanlarından (140) üyeye anket uygulanmıştır. Araştırmanın bulguları, akıllı üretim yönetiminde izleme ve optimizasyonun posta kavramlarını netleştirmek için kritik olan (18) bileşeni ve bu kavramların önemine ilişkin görüşü ortaya koymaktadır.

Anahtar Kelimeler: *Otomasyon, Optimizasyon, Akıllı Üretim, İzleme.*

1. INTRODUCTION

Energy management and conservation have become a major challenge for the smart network due to the growing population and ongoing demand. Demand side management systems are implemented globally to lessen the total energy burden and pollutants that endanger nonrenewable energy sources and the environment. In recent years, there has been an exponential increase in interest in energy management studies. The purpose of this thesis is to investigate and introduce, through optimization and control, the potentially overlooked energy-saving strategies of main systems in production energy use.

Among the many steps in the value chain that go into making machinery and tools, smart equipment manufacturing (SEM) is an essential one. It's a good measure of a country's overall scientific and technological might. There will be national improvements in technology and industrialization as a result of this.

1.1 Smart Manufacturing

Smart manufacturing is a type of production in which procedures and processes are improved to create maximum profit with minimal energy use and expense. The increase in sophisticated modeling, controls, optimization, and big data during the past decade makes this conceivable. In fact, intelligent production is also considered part of the fourth industrial revolution.

Due to the National Institute of Standards and Technology, smart manufacturing systems are fully integrated, cooperative systems that respond in real time to changing production requirements, supply network conditions, and consumer needs. Using control and optimization in energy management approaches, this study aims to achieve just this objective.

The significance of the industry to national military and economic security is strategic. Smart equipment (SE) applies to a type of technical equipment with advanced technology, a substantial initial investment, and a lengthy service life. It is applicable in numerous fields, and its production must be structured using cross-domain, cross-industry, and cross-regional production facilities. SE can be categorized as fundamental, specialist, and outfit equipment.

1.2 Supply Side Management

Supply Side Management (SSM) applies to energy strategies adopted on the supply side (consumers) to reduce electricity costs and infrastructure expenses.

Typically, this is accomplished by shifting or timing energy usage from periods of high demand to periods of low demand. Customers might, for instance, use renewable resources or energy storage technologies like batteries to meet their energy demands during high demand periods. Prioritizing energy needs and scheduling low-priority energy needs during off-peak hours is a simple yet effective strategy.

SSM can also be implemented at the subsystem level by conducting energy audits to identify potential energy-saving strategies, installing energy-efficient equipment such as variable frequency drives (VFDs), improving machine schedules, and updating the control systems of energy-intensive systems such as HVAC (Dababneh et al. ,2016).

Figure 1.1 demonstrates how load shifting, one of the most extensively utilized SSM strategies, can be used to level out peak demand and consequently demand-based costs.

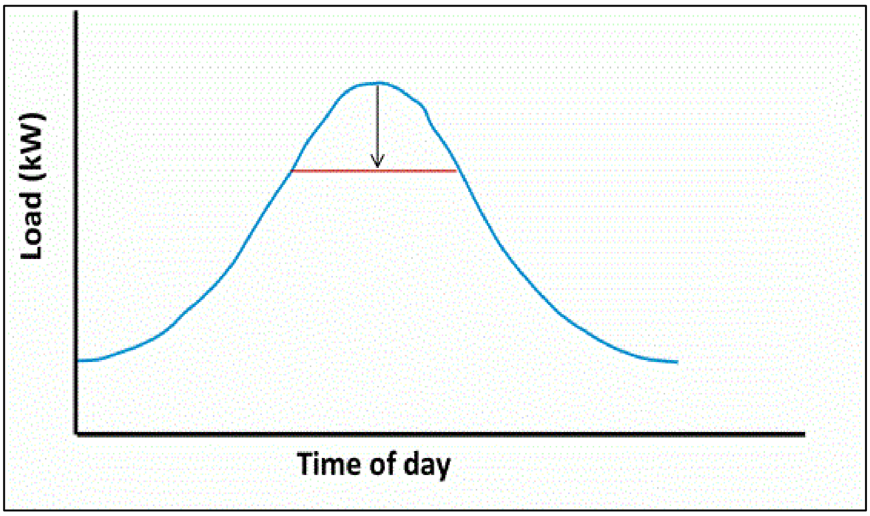

Figure 1.1: Supply Side Management by Load Shifting

Source: Dababneh et al., (2016)

The energy efficiency of air conditioners, compressors, and assembly lines can be improved with the help of demand response and other forms of smart manufacturing. The subset of smart production known as "smart systems" can benefit from control and optimization at both the system and part levels. Producing goods of the highest quality and efficiency in using energy is a priority for manufacturers keen on keeping costs down without sacrificing output.

1.3 Research Milestones

The sizeable amount of the demand for energy is the result of ineffective energy conservation techniques, which places a burden on the suppliers of utility services, as well as drives up the costs of utility services and the carbon footprint. Therefore, there is a pressing requirement to maximize energy efficiency through the use of energy management and control and optimization systems that are also friendly to the environment. The key objectives of this research are as follows:

- Methods for improving energy efficiency and cutting expenses are identified and chosen as part of energy management.
- Supply Side Management-assisted development of a mathematical framework that can plan flexible machines.
- Modeling of a manufacturing plant utilizing lumped parameter modeling and validation with actual data.

2. INTELLIGENT MANUFACTURING MANAGEMENT

2.1 Manufacturing in the Industrial Sector

Compared to residential and commercial customers, industrial consumers have less scheduling flexibility in terms of output and time limitations. Consequently, scheduling concerns that are flexible and those that are not must be taken into account. By efficiently scheduling the machines on the production line, peak energy consumption in manufacturing can be reduced.

Abdulaal and Asfour (2016) developed a model for energy management that adjusts the set points of controlled equipment in response to real-time pricing, i.e. demand shifting. Nevertheless, the price must be given to the buyer one hour beforehand, and a computationally intensive optimization issue must be addressed every two hours. In addition, it has been assumed that the anticipated data are dependable enough.

Utilizing a demand response model, (Dababneh et al., 2016) planned a production line taking into account its heat transfer characteristics and managing the “HVAC” system. The outcome is an optimal production line schedule and a complete reduction in peak production, without violating production or comfort limitations. While heat transport was accurately estimated, the “HVAC” system was merely approximated by converting temperature to heat load and ignoring other temperature disturbances. In addition, this application requires challenging building temperature predictions in a production environment. The objective of job shop scheduling is to assign n jobs to m machines with different processing times so that the make period is as short as possible (Kawaguchi and Fukuyama, 2018). This technique has been generalized to achieve minimal energy consumption by incorporating a secondary cost feature that accounts for system idle time, loading time, and startup time.

The authors of (Gu et al., 2020) utilized a similar method to maximize energy consumption and render time by employing a Particle Swarm Optimization algorithm affected by biology (PSO). Both of these publications lack a generic nature in the framing of the problem, which is required for diverse production line difficulties. Additionally, none of these efforts considered inflexible scheduling.

The authors of (Kawaguchi and Fukuyama, 2018) modeled machines and buffers in manufacturing environments using a discrete event model, and they offered Model Predictive Control as a means to decrease energy usage while achieving the make period requirement. They did not, however, illustrate how effective processing time may be assessed or any of the MPC implementation's results. Some research has sought to combine intelligent manufacturing and demand response. Demand side management is key to the smart manufacturing paradigm. A previous program that has been actively investigated and implemented for ten years. Renewable resource penetration is the most commonly suggested method for reducing peak demand. In order to optimize the usage of renewable resources during peak demand, the authors of (Daniel et al., 2018) utilized a hierarchical Model Predictive Control system as part of active demand side management.

In a home case study, they utilized the weather forecast, pricing signals, and the MPC to undertake load shifting for this purpose. In circumstances when there are additional renewable power producing units, such as solar panels and wind turbines, a Demand Response (DR) model has been developed (Nwulu, 2017). Using a model based on Mixed Integer Linear Programming, they were able to optimally relocate loads to decrease peak demand and use renewable energy to meet demands that could not be changed (MILP). The high construction and maintenance expenses and unstable electricity supply of these renewable resources overwhelm the energy savings costs in each of these projects.

Scheller, et al. (2020) utilized Particle Swarm Optimization to determine the optimal load distribution plan for the residential, commercial, and industrial sectors. This approach does not account for inflexible loads, which are prevalent in the manufacturing industry. Due to fluctuations and stochastic temperature interruptions in manufacturing, simulation and regulation of the thermal system in the manufacturing sector are significantly more complex than in the commercial and residential sectors. Consequently, a system-level modeling strategy that is sufficiently general to be used in all production contexts and captures the necessary heat transfer dynamics for control system design is required. The Resistor-Capacitor lumped parameter model is an example of a widely used model that is basic and robust enough to handle disturbances (Frias et al.,2017).

An investigation was conducted into the usage of Economic-MPC (MPC with custom cost feature involving price and energy) in building “HVAC” systems, where an RC thermal model was constructed and energy and pricing were minimized. Though Particle Swarm Optimization (PSO) and EMPC were successful in avoiding suboptimal solutions (energy optimal schedules) and quickly converging, the objective function minimized by “PSO” was dependent on time-varying prices rather than demand, which is not the case in states such as Indiana where customers are compensated based on peak demand. Combining real-time optimization based on economics and “MPC” to create “E-MPC” for a chemical plant with storage units (Huang, et al. (2019). Again, the “E-MPC” considered commodity market prices instead of the energy consumption of energy-consuming subsystems. According to (Woo, and Junghans, 2020), black box modeling (input-output data-based modeling) was employed extensively with the device identification approach in “MATLAB” to develop thermal state space models for “MPC”. Although this appears to be a promising alternative, in most businesses only energy data is easily available. Utilizing plant-wide optimization in conjunction with “MPC”, a supervisory architecture was utilized to enhance demand side management by minimizing peak demand in “HVAC” and refrigeration systems. The implementations described above are only based on one of the systems and do not account for the complete manufacturing facility.

2.2 Intelligent Manufacturing

MILP was used in conjunction with MPC for micro grid energy management (Woo, and Junghans, 2020). However, this only applies to micro grids with storage systems on a small scale. The majority of research on MPC for building energy efficiency has been conducted on residential and industrial buildings, as opposed to manufacturing facilities, where energy savings opportunities are large. This was demonstrated by modeling a genuine manufacturing facility using a common modeling process, validating it, and then using MPC in order to save energy and money. In production, many types of air compressors are utilized for a variety of applications. Compressor control strategies include Start/Stop, Load/Unload, Modulating, Variable

Displacement, and Variable Speed. The most effective control method is variable displacement control (Variable Speed Drive, VSD), which modulates motor activity based on load and prevents superfluous motor loads. According to GAMBICA (the UK's Trade Association for Instrumentation, Control, Automation, and Laboratory Technology), variable speed drives (VSDs) can lower air compressor energy usage by 50%.

2.3 Scheduling Problem

Optimizing the parallel scheduling of the already-powerful VSD compressors is an additional measure to lower the energy footprint. Kouvaritakis, and Cannon, (2013) proposed a novel MPC-based control approach for a VSD screw compressor that lowers the upper and lower pressure set points and conserves energy. The drawback of the implementation is that the air flow criteria for a given time period were left out of the potential scope. Using the MILP formulation, the authors of (Zhang, et al.,2022) created a method for optimally distributing load amongst parallel compressors. In this work, compressor maps were utilized to guarantee that compressors were functioning under optimal conditions, and MILP was utilized to transfer between compressors with the least amount of surge. Despite producing positive results, this solution is only suitable for applications using centrifugal compressors.

The authors of (Cataldo, et al., 2015) employed a comparable strategy to solve the compressor scheduling problem. The objective was to assign an N-number of compressors to various clients depending on their flowrate and pressure constraints in order to lower the overall cost of constructing and operating the compressors. This study examined compressors with Start/Stop operation, one of the least efficient compressor control systems.

He, et al. (2012) utilized evolutionary algorithms to plan compressors for different clients in gas pipeline operations. The objective is to choose the most efficient compressors so that the fuel, start-up, and gas costs are as low as feasible. Utilizing neural networks and genetic algorithms to determine the objective function's minimum for demand forecasting. In contrast, the research puts penalties on the objective functions as limitations, and genetic algorithms do not always produce optimal solutions, unlike MILP.

According to the knowledge of the author, no work has been done on the scheduling of VSD compressors in parallel mode. Prior research on energy management and energy efficiency for intelligent manufacturing reveals a notable absence of application of generic MPC in manufacturing, demand-based scheduling systems, and compressor load delivery. Utilizing an energy-oriented control and optimization technique that is well-suited to a manufacturing context, the thesis addresses this gap.

2.4 Linear Programming

The purpose of this chapter is to introduce readers to the concept of scheduling. Typically, the objective of a scheduling problem is to identify a set of machine assignments that reduces or maximizes a certain objective. This is a typical problem in the world of computer science and is referred to as Work Shop Scheduling (JSP). In such a scenario, "m" jobs must be done by "n" machines with variable processing speeds and capacities.

The objective is to outsource these tasks to robots in a manner that requires the least amount of time and labor (power consumption). Linear Programming (LP) is a typical mathematical optimization technique used to tackle scheduling issues (Jensen, 2004). A cost that is a function of a set of variables is minimized or maximized within the constraints of an LP issue. Linear constraints may be either inequalities or equality conditions, or both. The limits determine the area of feasibility. The "best" potential cost value is the solution to the linear programming issue. The first example problem illustrates the operation of LP.

$$\begin{aligned} &\text{Maximize } Z=3x+2y \\ &\text{Subject to } 4x+2y \leq 15 \\ &X+2y \leq 8 \\ &x-y \leq 2 \\ &x \geq 0 \\ &y \geq 0 \end{aligned} \quad \mathbf{(2.1)}$$

Integer Programming and Mixed Integer Programming are LP-related variants. As its name suggests, integer programming is an LP problem with variables that can only take integer values, whereas the MILP issue contains variables that can be integers of integers. The feasible solution space and optimal solution for MIP, LP, and IP problems are depicted in figure (2.1).

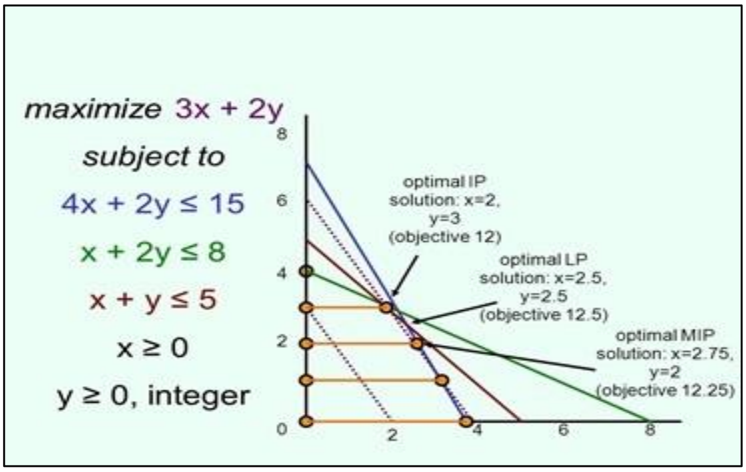

Figure 2.1: MIP, LP and IP Problems and Their Solutions

Source: Jensen, 2004

Maximum Z = 34 is observed at location (6, 4) while minimum Z = 34 is observed at point (6, 4). (-1, -3).

The preceding example is a straightforward instance of LP; however, when there are three or more variables, LP issues cannot be solved merely by charting since it is difficult to visualize spaces with greater dimensions. Such difficulties are resolved using Simplex, Big M, and other specialized LP approaches.

MIP was employed for scheduling difficulties in this study since it is used to identify machine status (integer) and power/capacity assignments (variable).

2.4.1 Algorithm with a brand and a boundary

MILP issues are NP-hard, meaning that no known algorithm can solve them in polynomial time, and their complexity grows exponentially with time. This type of problem is typically addressed using Branch and Bound, which searches for a solution by dividing the relaxed problem into smaller groups of problems rather than enumerating all potential solutions, hence significantly lowering the temporal complexity of the problem. This technique operates similarly to decision trees containing nodes and branches. The algorithm begins at the root node by computing the relaxed solution (solution with only equalities).

By increasing or reducing the value of the decision variables, further nodes (or sub problems) are branched off (or investigated) from the root node. When a node is determined to be infeasible (less optimum than its parent node) or to violate the decision variable's constraints, it is "fathomed" (the children nodes of that node are not explored and other adjacent nodes is explored). This process is repeated until the optimal (minimum or maximum) solution is discovered. By trimming, the algorithm will search the solution space without listing every possible solution. Branch and Bound is demonstrated using the following example (Lin, et al. ,2021) and figures (2.2) and (2.3). The second example problem explains the algorithm's operation in greater depth.

$$\text{Maximize } 13x_1 + 8x_2$$

$$\text{Subject to } x_1 + 2x_2 \ \leq 8 \tag{2.2}$$

$$x_1 \leq 8$$

$$x_2 \leq 0$$

As explained earlier, the solution starts with the relaxed problem IP^0 and then branches out by looking at the possible values x_1 can take. In the next level, the nodes IP^1 and IP^2 are the relaxed solutions for $x_1 \geq 3$ and $x_1 \leq 2$ without the remaining constraints violated respectively. IP^2 is fathomed as it is worse than IP^1 and the children nodes (IP^3 and IP^3) of IP^1 are explored for better solutions.

IP^3 is fathomed as it leads to a infeasible solution that violates constraints 2a and 2b ($x_1 \geq 3$ and $x_1 \geq 3$).

On the other hand, IP^4 is fathomed as it yields a cost that is worse than its parent node IP^1. IP^0 is the best solution that maximizes the cost function in case of inequality constraints.

This enables the Brand and Bound method to determine the optimal answer without examining all alternative possibilities.

MATLAB's MIP problems can be solved with the intlinprog function, which employs the brand and bind approach. This function's inputs are the cost function, inequality, and equality.

All of them are input as matrices, and the position of each matrix element corresponds to the corresponding equation/inequality/cost function decision parameter.

The Branch and Bound algorithm is then utilized to get the optimal solution for the problem. The major steps of this method are depicted in the flowchart in Figure (2.2);

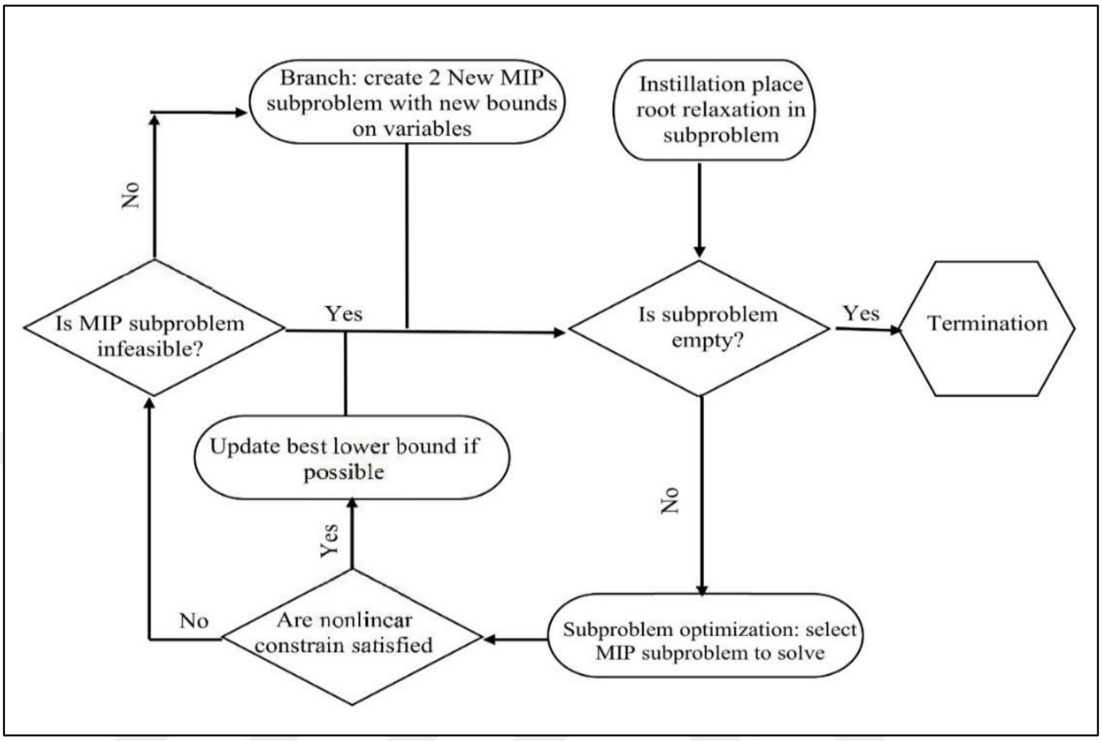

Figure 2.2: Branch and Bound Algorithm Flowchart

Source: Northwestern, (2019)

2.4.2 Enhancement of computerized control systems

Currently, the duty for controlling technical processes has increased substantially, and management information systems such as SCADA are partially responsible for production safety. These systems can be modified, notably SCADA trace mode v.6. Due to the likelihood of modernization, this leads one to view it as the most promising way for managing complex automated systems (Cox, et al., 2019).

As depicted in figure (2.3), investigations of such systems have demonstrated a predisposition to reduce the accident rate at metallurgical businesses resulting from technological malfunctions and growth accidents induced by the human element.

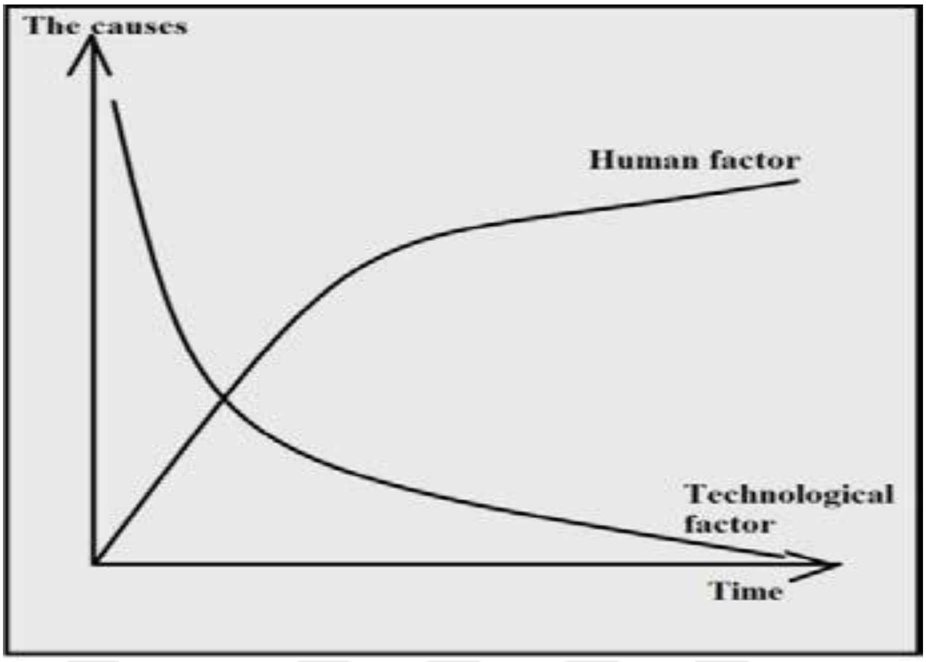

Figure 2.3: Frequency of Accidents Dependent on Human and Technological Elements

Source: Cox et al., (2019)

Large quantities of machinery, the continuity of technological processes, the instability of technological parameters, etc., contribute to the complexity of the technical process management in the metallurgical industry. Consequently, object management decision-making may be substantially impeded, and its effectiveness may be diminished (Cox et al., 2019).

The administrative level organizes the three-tier management process based on information processed by the management Information System (MIS) at the hardware and software layers (Figure 2.4). It should be emphasized that the employed MIS do not provide personnel with escape possibilities.

Contact with the corporate MIS system must be managed by a system that handles information from the start, i.e. at the technological level, and prevents emergency circumstances.

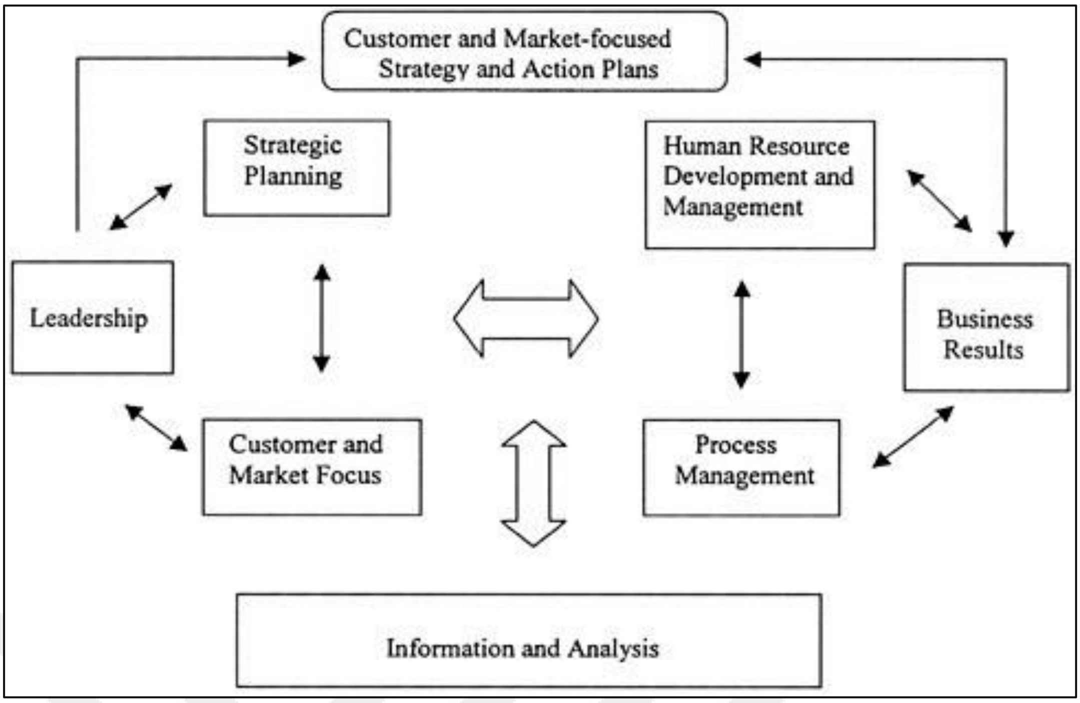

Figure 2.4: Dependence Three-Tiered Management Organization of Metallurgical Enterprises

Source: Cox et al., (2015)

The authors found that the idea of openness grounds of SCADA Systems (Rana and Abido, 2017) permits the introduction of additional modules without major human and financial expenditures, geared to address the following issues:

- Improve the enterprise's economic and environmental evaluation. Reduce the enterprise's environmental charges.
- Decrease in environmental expenses.
- Stable functioning of equipment and chemical constitution of raw materials within the parameters of the norms.
- Protection of the company's excellent standing on home and foreign markets.

It is recommended that these responsibilities will be accomplished by implementing a Smart Advanced Warning System (AWS) and integrating it into the ICS of the metallurgical company. The framework of the Technological Processes ICS and AWS is depicted in figure (2.5).

During the AWS development phase, the dynamic man-machine device manufacturing expertise from other industries, such as transportation protection and glass manufacturing, was considered (Kawaguchi and Fukuyama, 2018).

AWS enables the evaluation of current production conditions and the display of suitable solutions connected to the consequences on the technical situation, including pre-emergency and emergency scenarios. The developed AWS possesses intelligent qualities and considerably enhances the entire automation of metallurgical industries.

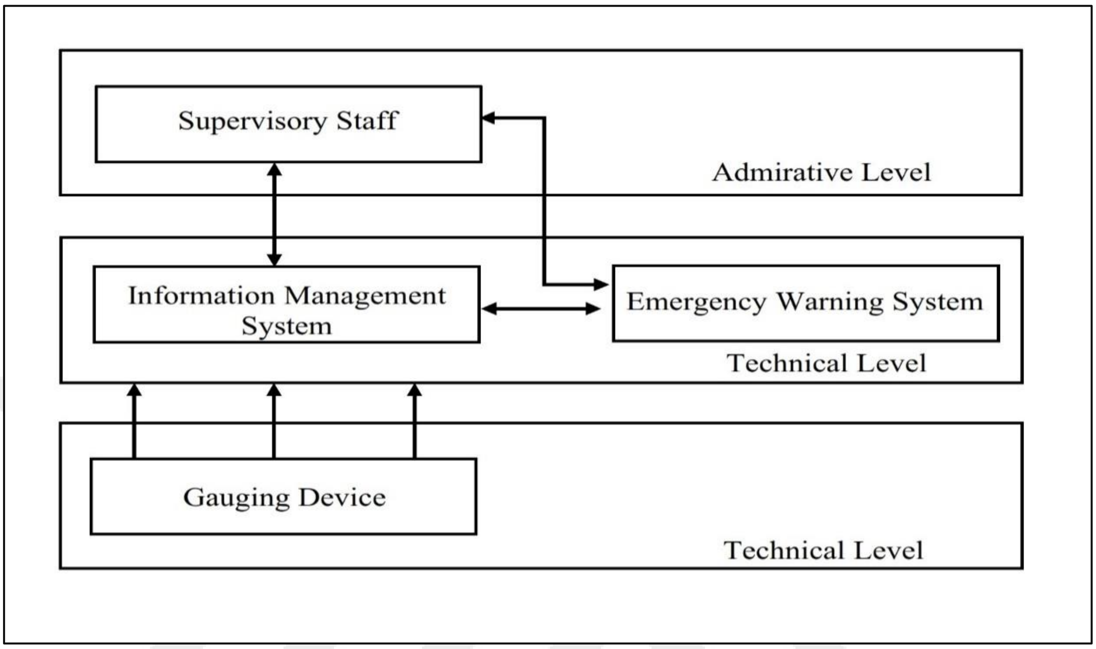

Figure 2.5: Schematic Structure of the Technological Processes ICS and AWS İnside the Metalworking Company

Source: Kawaguchi and Fukuyama, (2018)

2.4.3 Enhancing AWS operations

AWS includes numerous methodologies like, formation of the enterprise's bad situations database and information base. Clearly, the number of adverse circumstances can be substantial. Consequently, it is predicted that the checklist technique will be used to identify emerging and potentially bad circumstances more frequently. The method is based on the judgment of the authors' recommended expert group and is described in the literature; the critical factor is proposed to determine the risk of each condition (Dababneh and Sun, 2016). Knowledge processing based on the AWS components, including such:

- Condition assessment unit necessary to determine the present state of operations.
- Situations are separated into classes within this classification unit. Different approaches to influence the issue are determined by each class based on their respective priorities.

- The initial decisions processing element determines the optimal alternative solution from a variety of options.
- The decision-selection unit provides only one possible managerial response to a given event.

2.5 Profitability and Effectiveness

According to Tangen (2004), neither productivity nor efficiency has a single definition. There is also no clarity on the definition between academia and industry. As noted above, the concept of productivity is inconsistent and there is no logical understanding of the phrase. The phrase is believed to have been coined by French physio rats in the 18th century, who defined it as "productive capacity" (SOU 1991:82, 1991). According on whether the explanation is conversational or mathematical, the significance and depth of the term vary (Ghazzai, et al.2017). Following are descriptions of both mathematical and conversational explanations.

Table 2.1: Explanations of Productivity from Different Resources

Explanations	**Reference**
Productivity equals value added divided by production factor inputs	Chew 1988
Productivity Equals reality output divided by anticipated resource consumption	Fisher 1990
Productivity equals total income divided by (cost plus target profit).	Sink and Tuttle 1989
Productivity equals value added divided by production factor inputs.	Aspén 1991
Productivity is defined as the proportion of output to inputs required for production. Productivity is the ratio between outputs such as goods and services generated and inputs such as labor, capital, materials, and other factors.	Hill, 1993
Productivity is the capacity to satisfy market demands for goods and activities while consuming the fewest resources possible.	Moseng 2001
Productivity is the ratio between the real result of a conversion and the real resources employed.	Jan van Ree 2002

Source: Ghazzai, et al. (2017)

Hayes stated that "productivity, a difficult notion to describe and measure, is normally determined by dividing a country's (or an industry's) output, adjusted for inflation, by the number of labor hours necessary to produce it" (Ghazzai, et al., 2017).

2.5.1 Efficiency

The efficiency is defined as the relationship between delivering a value that is greater than the cost of creating the same value. Ghazzai, et al. (2017) explains the distinction between efficiency and efficacy. While there is no clear concept of productivity, there is productivity. Ghazzai, et al. (2017) concludes that efficiency is "doing things correctly" whereas effectiveness is "doing the right things."

Another production-oriented definition of efficiency is "the difference between the production line and the best applicable version of the same process."

Beloglazov, et al. (2012) also defines these two concepts and concludes that efficiency is the equilibrium between resource utilization and input, whereas effectiveness is the achievement of an organizational objective. This definition does not include the customer or value creation if they are not specified in the organization's aims.

2.5.2 Correlation link productivity and efficiency

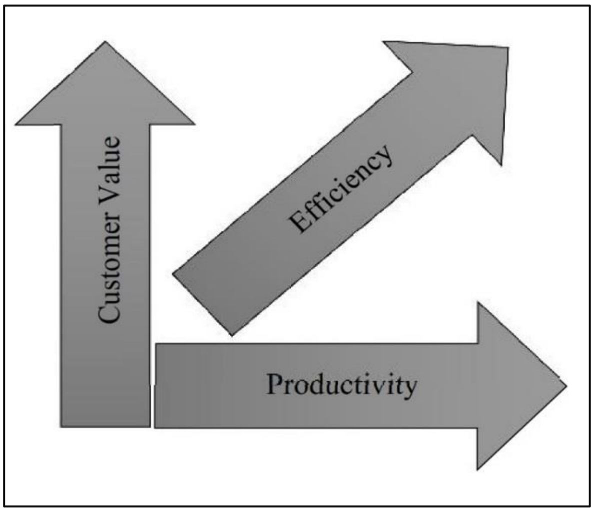

Figure 2.6: The 2 Components That Provide the Basis for Term Effectiveness

Source: (Beloglazov, et al., 2012)

As demonstrated previously, productivity measures the transformation of assets, whereas efficiency reflects how well this is done relative to an ideal condition. One aspect is client value, which is frequently characterized as customer perception. Customer value is the customer's willingness to make a sacrifice in exchange for the desired performance.

If the client pays a price at which the perceived value of the given quality matches the sacrifice, customer value has been increased (Beloglazov, et al., 2012).

According to the preceding definitions, productivity is a link between input and output and a measurement of how well inputs are utilised to achieve the intended result. During several years, there has been a great deal of emphasis on projects.

The rationale for this, according to Sheng, et al. (2015), is simple: projects align accountability and organizational objectives to individual and little group work tasks if their job is not a part of the company's usual work.

2.6 Projects

Several definitions of projects are offered in the next section. " A project is an organized effort to complete a unique, non-routine, or low-volume work" (Saha and Jindal, 2018).

Other meanings of projects include "a temporary endeavor that was undertaken to create a unique product or service (project management institute, 2004)" and "a project is limited in time, is unique in some sense, and have a specific and denoted deliverable" (Saha and Jindal, 2018). The fundamental characteristics of a project are that it has a time constraint, that it is unique in some sense, and that it has a specific and denoted deliverable (Mantel et al. Or, "The entire process required to produce a new product, new plant, new system or another specified result" (Arcibald 1976 in (Saha and Jindal, 2018). Or, "A narrowly defined activity which is planned for a finite duration with a specific goal to be achieved" (General electric 2007 in (Saha and Jindal, 2018)). Or, "The entire process required to produce a new product, new plant, new system or another specified result."

Frequently, projects are carried out as part of programs, in which a number of projects are carried out to meet a certain program objective. At TPPS, a program can be the development of a plant facility, and projects are subcomponents of this facility's construction, such as the automating or mechanical engineering portion.

There are various types of projects, ranging from those aimed to fulfill strategic objectives to those intended to increase project effectiveness (Saha and Jindal, 2018) It is necessary to be able to measure the success of a project regardless of its intended purpose. The sections of a project to be handled are defined by three interdependent and often contradictory criteria. The following are:

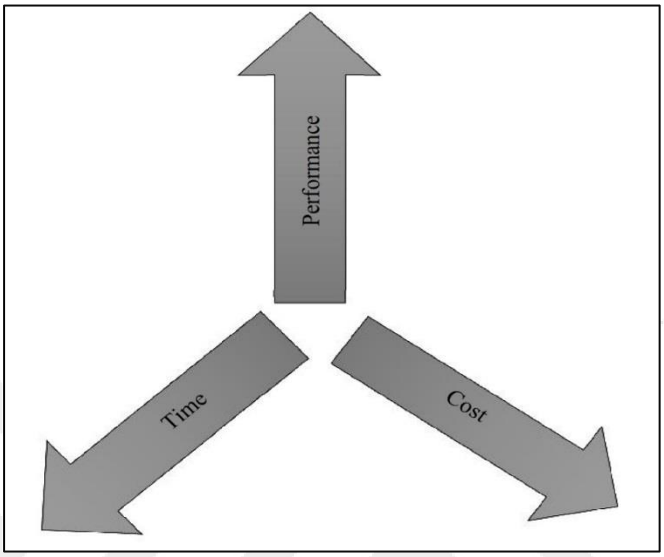

Figure 2.7: The Three Project Parameters of Management

Source: (Saha, and Jindal, 2018)

As per (Saha and Jindal, 2018), some contend that quality is one objective, whereas Mantel et al. claim that quality is an integral aspect of the project definition. The client has approved all project objectives. As previously said, projects are temporary endeavors designed to offer value to the client. However, does the project make this task simpler? If the future were predictable and determined, the response would be affirmative.

As that the world and the future are not entirely predictable and predetermined, the undertaking is marked by uncertainty (Saha, and Jindal, 2018). Managing uncertainty while meeting performance, cost, and time objectives requires planning and trade-offs. As the management of projects has been widely detailed in the literature, and as there are as many diverse project management methodologies as there are project managers, the following section provides some commentary on project management.

However, the question would be whether projects can be routine work, beginning with a set schedule. According to Mantel et al., projects must have some degree of flexibility. This is due to the fact that we do not live in a deterministic environment.

Occasionally, a senior manager (who is not required to oversee the projects) supplies the Project manager with a documentation that specifies deliverables, a budget, and a timeline.

2.6.1 Assessing the Project

Assessment of a project is an activity conducted to assess against the project's initial plan (Saha, and Jindal, 2018). The task is not to be completed only after the project is complete, but rather on an ongoing basis in order to generate information that can be used for decision-making and quality control. There are a variety of evaluation methodologies, and the purpose of this chapter is to provide a general overview of project assessment. To measure a project, it is necessary to establish what constitutes a successful project (Buyya, et al., 2010).

Saha, and Jindal, (2018) advise that assessments be conducted with the selection process in mind, i.e., why was this project funded and chosen? "A project evaluation is an assessment for use by upper management," Its criteria must include the management's requirements, the institution's declared and unstated objectives, the original entry requirements for the project, and the project's performance to accomplish of its efficiency, Effect and customer satisfaction, corporate performance, and future possibilities.

Measuring the success of a project based on its budget, schedule, and performance is more straightforward than measuring its revenues or qualitative, subjective criteria. Establishing the metrics at the onset of a project is advantageous, as is employing rigorously standardized assessment methodologies for subjective aspects.

2.6.2 Project Management

The qualities of a project are outlined above. Since a project is a transitory undertaking done by a cross-sectional workforce, a project manager is required to oversee its variables. The manager is responsible for managing project resources to fulfill budget, schedule, and performance objectives. Other responsibilities of the project manager include conflict resolution, general management negotiations, and motivating efforts (Saha, and Jindal, 2018).

Saha, and Jindal, (2018) describe the PM in terms of its distinction from a functional manager. The functional manager is responsible for a well-defined firm function, such as marketing, production, human resources, etc., and has experience and understanding of the controlled technology. The purpose of a functional manager is consequently supervision of the function. In contrast, the project manager is responsible for a cross-sectional team that has no functional location inside the organization.

Frequently managing a disparity in technological competencies in which the PM has only limited expertise. The PM can consequently be viewed as a facilitator.

Saha, and Jindal, (2018) identify the PM's responsibilities as acquiring resources, fighting fires and overcoming obstacles, providing leadership and creating trade-offs, and engaging in negotiation, resolving conflict, and convincing.

2.7 Project Assessment Frameworks

2.7.1 Framework of the development of project management (DPM)

To comprehend the application of a project management development model, one must comprehend the strategic advantages of a unified project management approach. "Although projects are not repetitious, they may require considerable time and, for our purposes, are sufficiently substantial or complex to be recognized and handled as independent activities" (Buyya, et al., 2010).

For the strategic planning of project management, Buyya, et al., (2010) argues why a standard project management methodology must be developed. The repetitious nature of a standard, consistent technique will aid in achieving the project's objectives. This approach is rather straightforward and provides an illustration of the actions that define a project management methodology.

The methodology includes the technical aspects and the organizational as well as the financial. Buyya, et al., (2010) outlines the opportunities of integrating project management trends with the current methodology. The trends listed includes; Total Quality Management (TQM) and concurrent engineering process among others. The benefits of the integration of this model include a tighter cost control, corporate resource models and efficiency/effectiveness. If an organization is to achieve success in strategic planning for PM, it must be aware of its Critical Success Factors (CSF).

There are a number of different CSFs but they can be divided in to three categories: qualitative, organizational and quantitative (Buyya, et al., 2010). To determine the success of a project, one must define success.

Historically, success has been defined as meeting the budget on time and achieving the desired performance (Buyya, et al., 2010), but Buyya, et al., (2010) argues that organizations experienced in project management have expanded the parameters to include limited amount of scope changes, not disrupting corporate cultures or values, and not disrupting the organization's typical work flow.

Buyya, et al., (2010) finds that "executive project sponsorship must exist and be evident for a balanced interface between the project manager and line manager". To assist the execution of technique, one must have the appropriate quantitative instruments. There are numerous tools, and although it is impossible to define them all, in order to achieve maturity, the following must be met: "Project management education must precede software knowledge." The types of resources are depicted in figure (2.8).

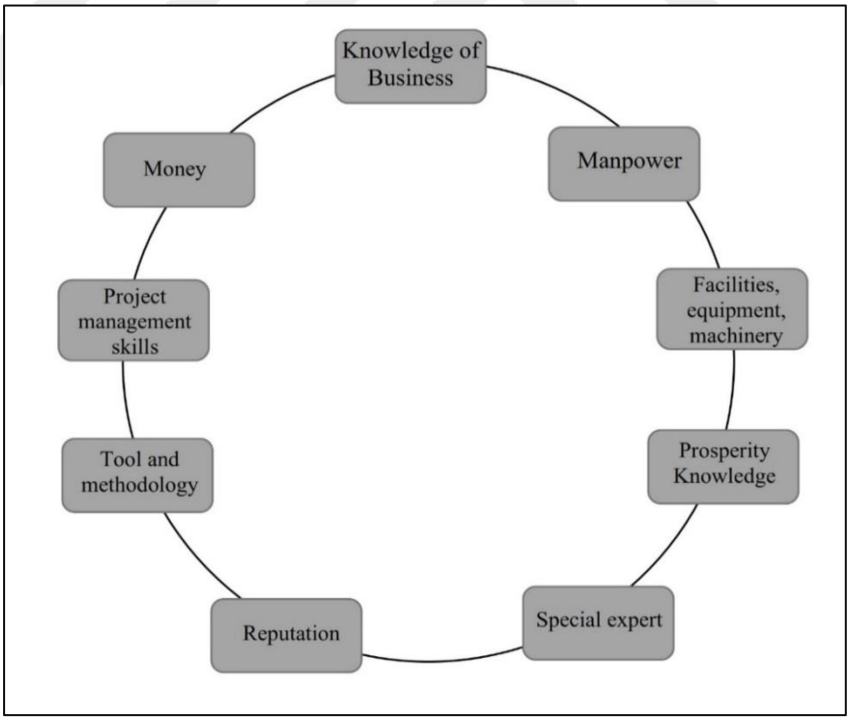

Figure 2.8: Project Components

Source: (Buyya, et al., 2010)

In summary, "for organizations to achieve excellence in project management, executives must learn to define project success in terms of what is good for both the project and the organization" (Buyya, et al., (2010).

Among the organizational factors is the balance of project manager, line manager, and project sponsor responsibilities. Buyya, et al., (2010) suggests that the following equation holds true in successful project management. To capitalize on the organization's strengths, it is essential to be aware of the project's resources. Rather than being a must, identifying the strategic resources upon which to grow demands knowledge and a can-do mentality from management, additionally, leaders must offer the same encouragement and support for software usage as they do for project management Buyya, et al., (2010).

The justifications for strategic planning in project management are outlined above, along with a number of instruments for developing a methodology and their justifications. The implementation of a project management maturity model can help organizations attain project management excellence more quickly (Buyya, et al., 2010).

Using the (DPM) framework, an organization can compare its project management performance to determine where to focus its improvement efforts. Below is a summary of the levels, including the features and obstacles for achieving success at each level.

2.7.1.1 Stage 1 standard language

The first stage denotes organizations lacking project management organization. Fear of changes in the power of authority and reluctance to change are prevalent characteristics of level one organizations. There may be an awareness that project management exists, but application of the concept is not widely accepted. The requirements for advancement include learning in project management, recruiting professionals in project management, and communicating in project management language.

The amount of time spent in level one can be counted in either months or years. This is not accomplished when management decides to advance to level two of a teambuilding exercise during a trip. This requires dedication, and the time required varies on prior experiences, the economic climate, and the type of business, the assessment tools consist of a questionnaire with 80 questions; each question contains many responses, but responders must choose just one (Buyya, et al., 2010).

2.7.1.2 Stage 2 standard process

When an organization has progressed from the level of knowledge about project management to the use of project management, it must understand the need to develop processes that utilize an organizational strategy that leverages the strengths of project management.

Importance is placed on the involvement of executives in level-two tasks. It is more likely that the entire organization will establish a shared procedure while focused on outward competition rather than internal power struggles with the backing and dedication of senior management (Buyya, and et al., (2010).

Buyya, and et al., (2010) estimates that the time it takes to progress from level two to level three ranges from six months to two years, depending on the strength of the corporate culture and the type of firm. Questions about the visible benefits of project management make up the bulk of the assessment tool for promotion to level two. Line managers' commitment to project management and how effectively leaders push for a unified procedure.

2.7.1.3 Stage 3 unique methodology

The stage three criterion builds on the areas of the hexagon of perfection, which are: Integrated processes, Culture, Behavioral greatness, unstructured project management, Training and learning, and Management support. Level three evaluates the successful application of project management, but does not ensure success in every project; "the successful implementation of project management does not guarantee that your projects will be handled well, hence increasing your chances of success". The completion time for level three is measured in years and is dependent on the adoption of a singular approach, informal project management, and the rate of cultural change Buyya, and et al., (2010).

2.7.1.4 Stage 4 benchmarking

Using Benchmarking as a Component of the DPM Process is outlined; this section will cover the application of benchmarking as presented by Buyya, and et al., (2010) in a development project management framework. The fourth stage builds on the understanding that there is always opportunity for methodological development.

In certain businesses, a project office (PO) or center of excellence (CoE) is responsible for this component. Frequently, these two phrases are used interchangeably to describe the same function. Buyya, and et al., (2010) describes the distinctions between them:

Table 2.2: Contrast Project Office and Centre of Expertise

Project Management Office	**Centre of Expertise**
Constant operational responsibility for project managers	May be an official or unofficial committee (may be a part-time)
Concentrate on internal lessons obtained	Concentrates on outward comparison
Advocate of the methodology's application	Advocate of incremental improvement and evaluation
Utilization of project management instruments	Expertise in identifying project management instruments

Source: Buyya, and et al., (2010)

As shown in table (2.2), the selection of function involves understanding of the function's purpose. Although there are distinctions between them, the offices also evaluate common factors.

The advantageous characteristics of this job include problem-solving, centralized scheduling, centralized cost monitoring and reporting, the development of a career path in strategic planning, and a controlled organization that processes lessons learned (Kerzner, 2001).

It is possible to undertake benchmarking using either an organizational or a process-based approach, both of which are qualitative and quantitative. The institutional approach emphasizes important success criteria, whereas the process is more directly tied to project management and emphasizes process enhancement (Kerzner, 2001).

1.7.1.5 Stage 5 continuous enhancement

As an organization reaches level five, it must not become complacent and unfocused. The fifth level is where the real benefits of the previous four levels are explored, as well as evaluating and continuously enhancing to ensure long-term achievement (Kerzner, 2001).

Kerzner (2001) identifies five areas for ongoing improvement, as depicted in Figure (2.9).

Consider these elements when analyzing the market for more convenient software, managing client relations, and managing the COE or the PO, to name a few examples.

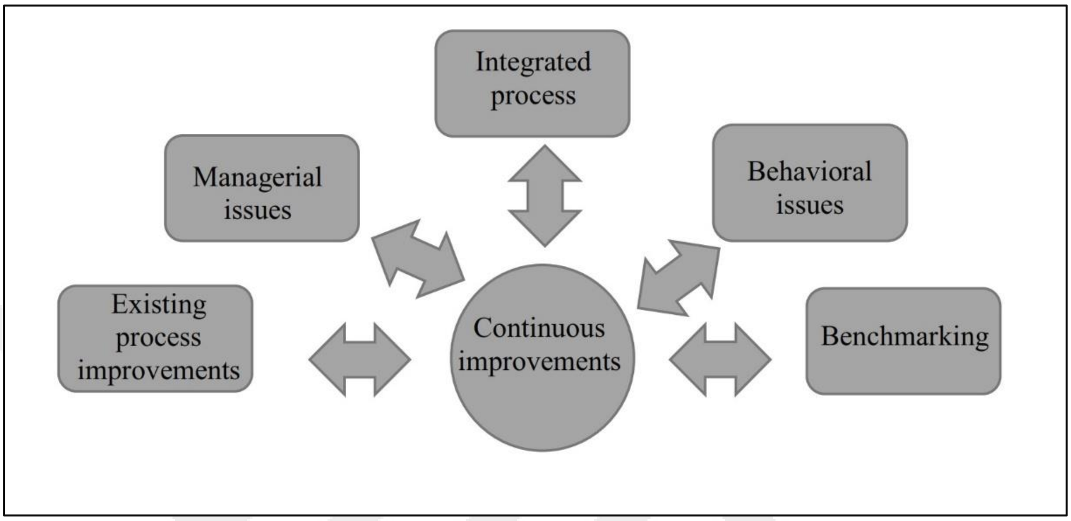

Figure 2.9: Factors to Consider for Continuous Improvements

Source: (Kerzner 2001)

2.7.2 Implementing capability maturity models (ICMM)

As technology has progressed, the complexity of the goods and services that businesses produce and provide has expanded. In addition to the increased complexity of the products, the market is becoming increasingly competitive, which drives businesses to produce items that are superior, faster, and less expensive (Software engineering institute SEI, 2010). That according SEI (2010), the majority of available methodologies for organizational growth tend to concentrate primarily on a portion of the business without understanding or resolving the system in that this portion occurs.

As per SEI, the difference is that CMMI tackles the complete lifetime of a product and hence all the components required to produce and sustain a product (Software engineering institute SEI, 2010). Figure (2.9) depicts the three dimensions that organizations according to the SEI tend to concentrate on when attempting to improve. The procedure is the key to the achievement of the three important dimensions. The procedure combines skills and expertise with procedures and corporate objectives to create business stability and concentration (Software engineering institute SEI, 2010).

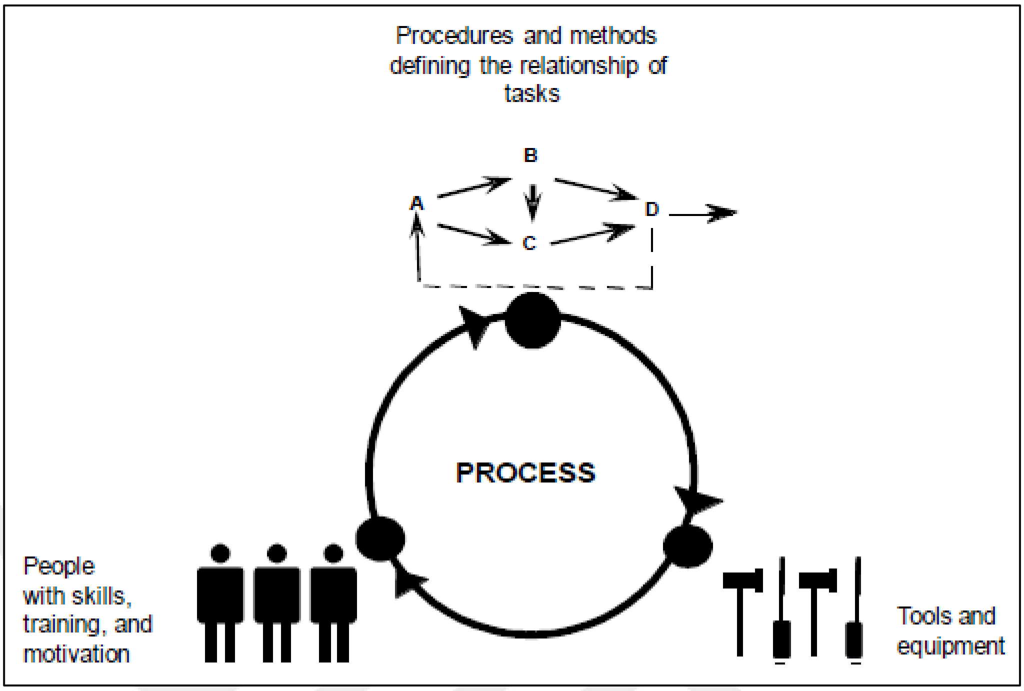

Figure 2.10: Three Fundamental Factors

Source: Software Engineering Institute SEI, (2010)

The focus of Capability Maturity Models (CMM) is on processes. The Capability Maturity Model (CMM) is not a set of processes that a corporation can use to improve. Instead, the SEI considers process design to be a complex operation requiring the evaluation of numerous organizational factors.

“CMMs focus on improving processes in an organization. They contain the essential elements of effective processes for one or more disciplines and describes an evolutionary improvement from adhoc, immature processes to disciplined, mature processes with improved quality and effectiveness” (Software engineering institute, SEI, 2010,).

Development stages are evolutionary plateaus, with each level focusing on a subset of processes, as this has been demonstrated to be the most effective way. (2010), Software Engineering Institute SEI (2010) proposes focusing on a certain process area inside an organization. After a decision has been made, choose the maturity level to aim for and concentrate resources and enhancements on reaching that level (Software engineering institute, SEI, 2010).

The process areas and their respective maturity levels are listed in the table below. This section discusses where effort should be directed and what should be prioritized in order to achieve the desired level of maturity in the organization's primary function.

2.8 Prerequisites

The majority of software project failures are not attributable to poor engineering or inept personnel, but instead to inadequate system requirements (Macaulay, 2012). As hardware prices have reduced and software complexity has increased, the cost of software has gradually increased as a proportion of the total system cost.

According to Achimugu et al., (2014), software projects are difficult to manage within budget, especially if customers' expectations are to be met. The solution to the issue is to set consumer expectations beforehand and communicate them to the programmers and finance managers.

To encompass all aspects of requirements, (Macaulay, 2012) advocate the phrase "requirements engineering," which provides a more holistic approach to the topic, as the term "engineering" implies that the job should be more repeated and methodical.

Since the majority of work performed at TPPS involves software development, it is crucial that the requirements for automation projects are pertinent. As project complexity develops and the design turns toward digital PLC instead of mechanical relays, the importance of software requirements grows. The relationship between software criteria and projects is described as follows: "...customer and supplier (or their representatives) typically draft requirements together; later, programmers and other specialists use them" (Achimugu et al., 2014).

Another method is to ask the following three questions: "What happens when the requirements are incorrect? What are the processes of requirement engineering? And is there an optimum process for requirement engineering?" (Macaulay, 2018). The answers to these questions are as follows: it has an impact on budget and planning, it is a series of structured actions during which the system specifications document is created, and there is no optimal requirements workflow.

Using the responses and Macaulay's assertion, one may identify the essential parts of requirements engineering. It aids in keeping projects within budget and on schedule, and provides developers, management, and customers with a coherent perspective of the deliverables.

However, there is no optimal requirements engineering method. Academically, requirements engineering is a reasonably new topic, yet there is a vast body of literature and concepts available. Several of these theories are discussed here.

Achimugu et al., (2014) gives the reasons from the customers' perspective. The reasons for drafting specifications vary amongst organizations, however a few frequent reasons are mentioned. Management of validation, verification, tracking, and specifications. Macaulay (2012) explain it using the essential phases of requirement engineering, including elicitation, evaluation, validation, discussion, documentation, and monitoring.

(Macaulay, 2018), with the exception of the managerial perspective, share this viewpoint. Regardless of whether the requirements are evaluated from the customer's or the organization's perspective, they share the characteristics of outlining the engineering process's route map and providing materials for verifying the functionality. In actuality, the requirements method is iterative; view figure (2.11). Which should be included in the requirement is not a uniform list of topics. "The software engineering research community contends that the more detailed and consistent a requirements document is, the more probable it is that the software will be dependable and delivered on time" (Macaulay, 2018). The documentation should contain descriptions of data needs, technical specifications, quality criteria, and other outputs (Lausen, 2002). Frequently omitted from the requirement specification are the customer's history and business objectives. Developing these sections might assist the developing organization make informed decisions and comprehend the customer's perspective (Achimugu et al., 2014).

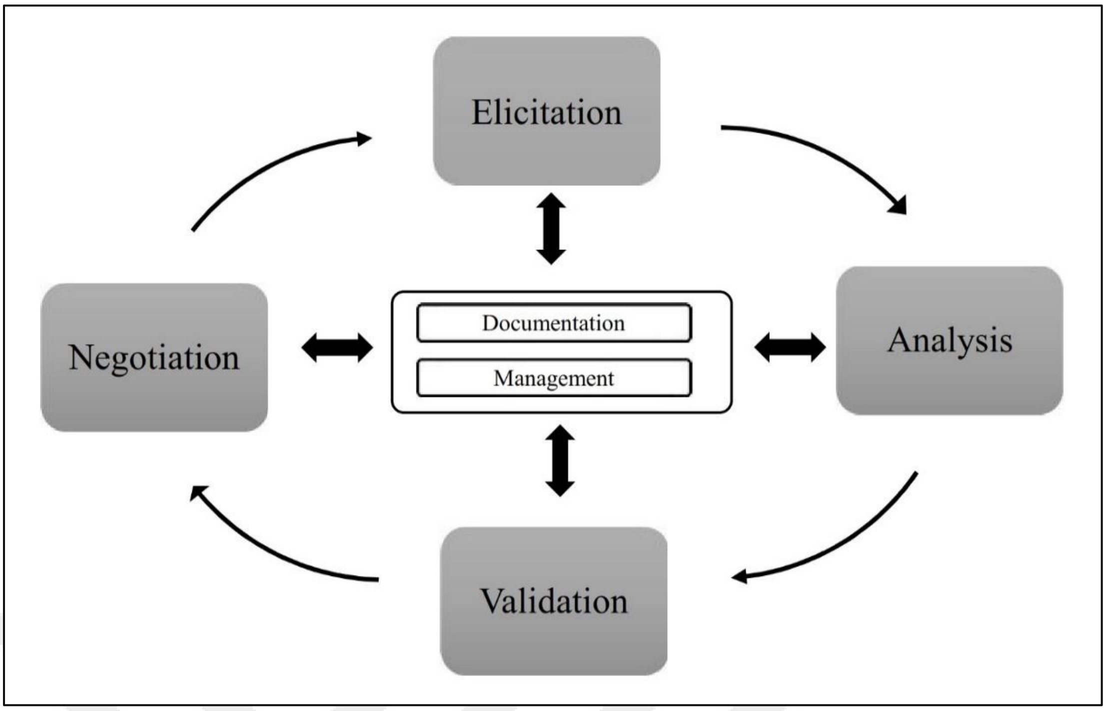

Figure 2.11: The Requirements Engineering Cycle Three Critical Dimensions

Source: Macaulay, (2018)

Essential to requirements engineering is the discussion of quality, as the client wants the provided solution to match her standards. The quality grid can graphically illustrate the significance of the functions. As defined by Achimugu et al., (2014), the objectives are divided into categories such as operations, modification, and transformation. Under each headline, list the objectives and their relative importance, from trivial or even ignorable to crucial. The objectives are not currently requirements, but they will become requirements upon completion of the procedure. The purpose of the quality grid is to give developers with a base from which to select specifications.

As described in the following section, requirements engineering isn't an easy undertaking. A faulty requirement engineering methodology has numerous potential issues, and the sooner the issue is recognized, the less it will cost to fix. Such requirements may result in budget overruns, missed deadlines, dissatisfied customers, unstable systems, and expensive upgrades (Macaulay, 2012). As previously said, there are a variety of stages to the requirement, ranging from the information to the styles of the technical specifications.

Representing and producing the needs for various levels has evolved over time, and numerous techniques are available. The criteria could be defined with a dataflow diagram, abstract code, step function, state changeover matrix, and so forth.

2.9 Benchmarking

Benchmarking as a component of the DPM is a technique for organizations at stage 4 in the model; for application in this thesis, the conceptual underpinning of benchmarking will be discussed, and it will thereafter be utilized for evaluation and intelligence provision against other businesses.

This methodology is however intended for usage within an organization whose learning process includes benchmarking. This thesis is not concerned with TPPS benchmarking framework development. Additionally, there is an emphasis on utilizing benchmarking methodologies to give a GAP analysis and perfect study based on the results of other firms performing major projects. This thesis describes benchmarking theory both in terms of a methodological strategy and as a technique for continuous development.

The benchmarking can be philosophically determined. Benchmarking is the skill of being humble enough to acknowledge that someone is greater than you while still possessing the intelligence to become as excellent or greater (Zeggini, et al., 2008).

Benchmarking is defined in this thesis as "a procedure to continuously evaluate and compare the company’s procedures with comparable practices in leading organizations to recover information that might aid its own organization to locate and apply improvement activities" (Zeggini, et al., 2008).

In the preceding definition, there are five crucial factors to consider when conducting benchmarking. The real work itself should be compared first. Second, benchmarking should be a structured process from which lessons are drawn. Third, rather than focusing solely on competition, seek for the finest in class. In addition, much can be learnt by monitoring the top students in a class. Lastly, the objective is not the evaluation itself; rather, it is improvement (Zeggini, et al., 2008).

As per Zeggini, et al., (2008), there are various sorts of benchmarking: system, operational, and strategic. Every one of these sorts of benchmarking provide various types of data to the organization. These data can then be utilized and compared to the company's own processes.

There are numerous benchmarking models that can be employed to represent the benchmarking approach as a whole. Zeggini, et al., (2008) propose the subsequent five-step procedure.

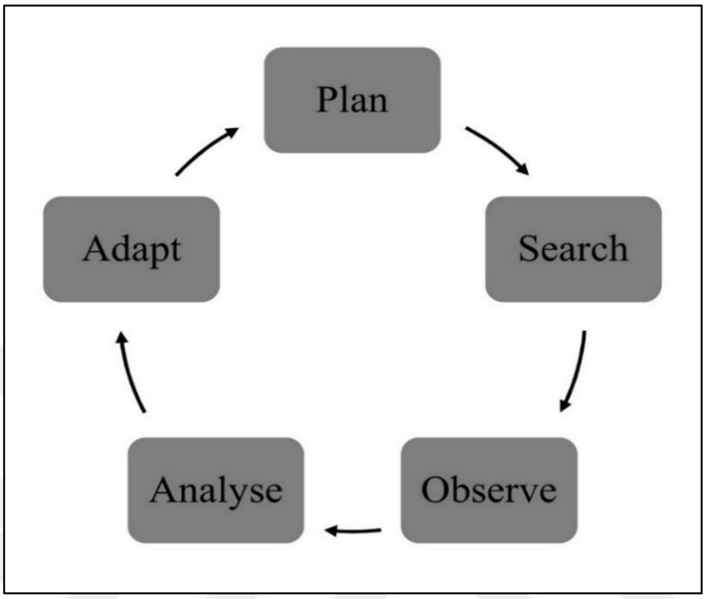

Figure 2.12: The Benchmarking Wheel

Source: Zeggini, et al., (2008)

Several steps are as follows: (Zeggini, et al., 2008);

1.Select and describe the process to be evaluated using benchmarking, and determine the measurement points.

2.Identify a benchmarking partner.

3.Map out and comprehend the partners process in terms of both achievement level and practice.

4.Identify distinctions in performance level, practice, and prerequisites.

5.Select the best approach and adapt it to the organization's needs.

Benchmarking can be used to accelerate continuous enhancements and is consequently a tool that is utilized in the contexts of DPM, LEAN, and theory of limitations software enhancement.

3. A UTOMATION PROJECTS

3.1 General Introduction

Henry Ford began using an automated assembly line to construct the Model-T in 1919. Since then, automation has progressed and become a vital component of the manufacturing sector. Automation delivers more efficient and precise labor than humans, while also reducing expenses (Sauter et al., 2011). As new approaches were introduced and investigated, the development of computers and numerically controlled equipment increased the degree of automated processes. In the 1960s, the development of the mainframe computer marked the beginning of the era that saw the introduction of software planning systems for manufacturing.

This has led to the development of numerous systems, including manufacturing resource management and, more recently, enterprise resource management. This seeks to disseminate information to more individuals in more locations and to coordinate processes (Richter, et al.,2022).

Digital PLCs have replaced coils to make automation more user-friendly. The introduction of LAN allowed for the centralized control of machinery in factories. And analog controllers were swapped out for programmable equivalents.

A lot has changed since the line assembly automation at the turn of the 20th century, as depicted in the image up top. Both the demand for and complexity of automation are rising all the time.

As was the case with computers, in which hardware was the most expensive component and software was relatively inexpensive, the ratio in automation is shifting toward software and management systems becoming costlier. This study will therefore regard the automation project as a software project with the intent of adopting software industry principles to automation initiatives.

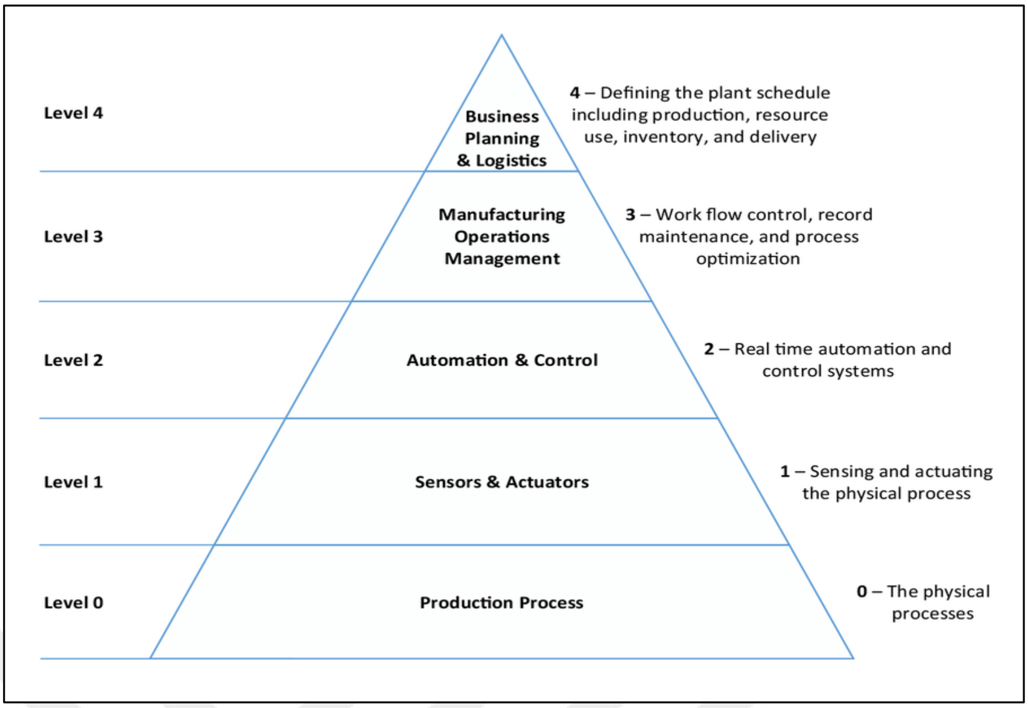

Figure 3.1: Progress of Automation Technologies

Source: Richter, et al.,(2022)

3.2 LEAN Technology Programs and LEAN Applications

This section provides a quick summary of the LEAN concepts so that readers unfamiliar with the philosophy can obtain a basic understanding. The philosophy of applying LEAN to software development initiatives is then discussed. The overview of LEAN will be based on Poppendieck's 22 proposed components.

3.2.1 LEAN generally

The revolutionary book "The machine that changed the world" popularized the phrase LEAN Operations. The term LEAN has two sides: production performance on one side and enhancements on the another (Womack, et al., 2007). The investigation at MIT that culminated in the previous section book examined Japanese production facilities in the United States and compared them to typical American automobile factories.

A revolutionary result was discovered. Japanese factories were astonishingly 40% more efficient than their American counterparts. Womack and his colleagues determined that this was a result of innovative approach in the following areas:

- Responsibilities of the employees.

- Accessibility.
- Collaboration with providers.
- Quality.
- Stocking reduction.
- Overall cost savings.

Since the initial formulation of LEAN production, others have not only revised it but also applied it to other sectors, such as healthcare, building, and software development. So, what is LEAN? Gabriel's case study indicates that the lean approach to project management has been successful in potentially challenging and complex sectors. It resulted in a high degree of team commitment and drive, as well as the satisfaction of the entire client organization (Carroll, B. J., 2007)".

“Lean thinking is important because it can reduce defect rates to 1 per million units (Middleton, 2001)”. “In a nutshell, a Lean system is achieved by eliminating waste and unnecessary actions and linking all steps that create value in a continuous sequence (Sremcev, et al., 2018)”.

3.2.2 LEAN Expansions; lean application development

Not just the industry and academic communities have discovered the benefits of LEAN thinking. McKinsey has implemented the lean approach in software projects. According to Kindler et al. (2007), applying the concepts of Lean manufacturing to application development management can enhance productivity by 20 to 40 percent while simultaneously enhancing quality and execution speed.

Poppendieck emphasizes the effectiveness of LEAN in both her publications that investigate the potential of LEAN software development and her conference proceedings. "When used appropriately, lean software engineering yields high-quality technology that is built rapidly and at the lowest possible cost" (Poppendieck, 2007)”.

Lean production has enhanced manufacturing focused on the premise that individuals represent the most flexible aspect of the system, thereby enhancing processes and focusing on the staff, without neglecting the bringing valuable in decision choices (Ebert, et al., 2012).

Poppendieck (2003) enumerates 22 tools that will assist businesses in implementing LEAN software development. The tools are described and shown with the aid of several examples.

3.2.3 The 22 instruments for implementing LEAN application development

3.2.3.1 Instrument 1 recognizing waste

This is the foundation of LEAN thinking, which is considered as the ultimate method for preventing waste (Ohno, 1988). In table (2.4) are given the seven categories of production waste. (Poppendieck & Poppendieck, 2003) translates them into the probable waste of software creation, and the conversion is presented in the table following.

Table 3.1: The Seven Wastes in Software Construction

Waste in Manufacturing	**Waste characterization**
Work performed in part	The greatest issue with incomplete work is that untested technology has the potential to fail. Before testing, it is impossible to determine whether the software actually functions. And without testing the entire system, there is no assurance that the code will solve the business issue. Reducing partially completed code is a strategy to eliminate waste and reduce risk.
Additional processes	Documentation that is superfluous is not a value-adding practice. "Is there someone awaiting these documents?" is a question that should be posed when examining required documentation.
Extra Attributes	Adding additional features increases complication; if the code is unnecessary at this time, it should not be implemented.
Task Changing	Beginning many projects simultaneously and switching between tasks introduces changeover times into the system. This results in an increase in the time spent on non-tasks.
Waiting	Common wastes in software development include waiting for manpower, project approval, and an extensive requirements document. A principle offered by Poppendieck (2003) is to "decide as late as possible," but if the implementation of the choice would take a lengthy time, the decision should be made early.
Motion	Is the distance to the customer service agent considerable? Exist circulating paperwork and relocating requirements?
Defects	Is a problem resolved immediately, or does it not become evident until late in the project? To reduce the impact of faults, it is necessary to detect and rectify them as quickly as feasible.

Source: Poppendieck and Poppendieck (2003)

To be able to recognize garbage is not as simple as one might believe; the list of seven sorts of waste has helped manufacturing locate waste in places they would not have otherwise explored. To be able to prevent and reduce waste, it is necessary to examine the aforementioned categories and identify non-value-adding operations (Poppendieck and Poppendieck, 2003).

3.2.3.2 Instrument 2 value flow mapping

When a business decides to use LEAN, a value stream map is an effective way to organize the identification of waste. The value stream map depicts the progression of a product from beginning to end along the value chain. And as a technique, it has proven to be effective: "in industry after industry, the process of mapping the value stream has invariably led to a greater understanding of how internal processes satisfy customer expectations" (Poppendieck and Poppendieck, 2003). As an example of the tool, a conventional value stream map is presented in figure (3.2).

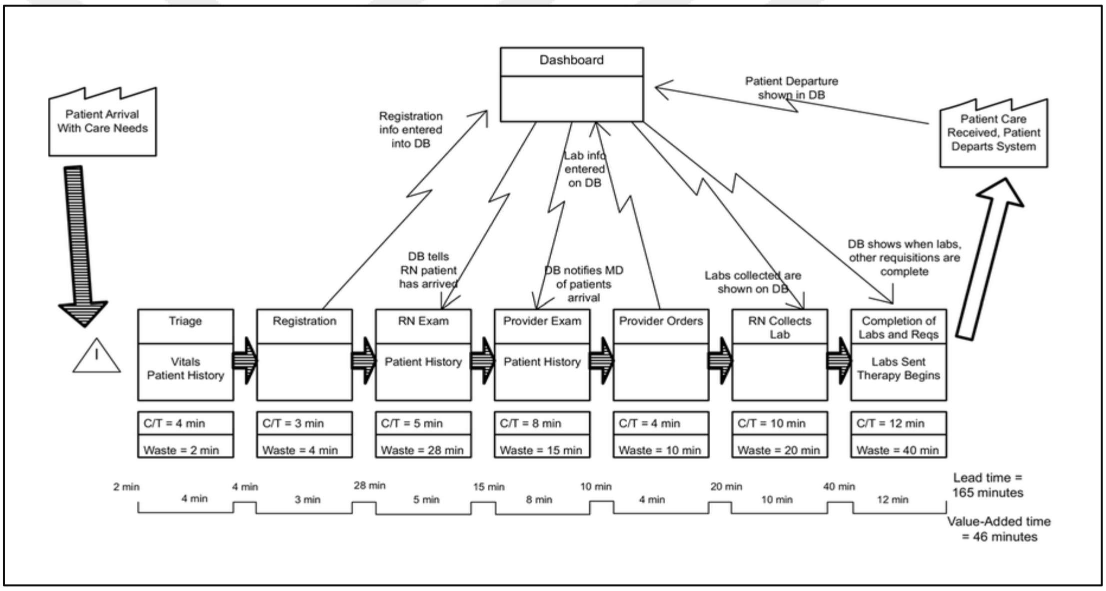

Figure 3.2: Conventional Value Stream Map

Source: Poppendieck and Poppendieck, (2003)

According to the preceding graph, just a third of time is spent on value-adding tasks. This is likely due to the fact that the customer does not receive a second opportunity to study the criteria (Poppendieck and Poppendieck, 2003).

The proposed method is to create a schedule and, as described above, map the activities as either work time or waiting time. Then, the longest delay will be halved (Poppendieck and Poppendieck, 2003).

3.2.3.3 Instrument 3 commentary

A lot of events can occur during the development process; consequently, ongoing feedback is required to accommodate these changes. Poppendieck and Poppendieck (2003) present an example in which they compare the use of a typical waterfall feedback model with deterministic feedback points to the feedback of a cruise control.

The conclusion is that a cruise control cannot function adequately on shifting terrain if the set point on the accelerator is fixed. To obtain the desired speed, one needs measure the speed and adjust the accelerator. (Poppendieck and Poppendieck, 2003) Propose increased input and a couple of tips, including: testing code as quickly as possible, attempting ideas through creating code rather than gathering requirements, and visualizing.

3.2.3.4 Instrument 4 iterations

The just-in-time idea is a cornerstone of the LEAN manufacturing methodology. Implementing just-in-time to the production system is an excellent starting point for transitioning to leaner manufacturing. This is translated to the software development process by establishing milestones and producing prototypes according to these milestones. This provides user feedback and design-related issues. Iteration is the method whereby a small chunk of software is built in a predetermined amount of time. This results in improved quality, more feedback, and earlier problem detection (Poppendieck and Poppendieck, 2003).

3.2.3.5 Instrument 5 synchronization

With separating the task and assigning feature-driven development or code ownership, the difficulty of synchronizing various chunks of code is created. Before, when the Software was a small part of the system, one programmer was responsible for one feature (Poppendieck and Poppendieck, 2003), but as the complexity of features has expanded, the demand for synchronizing builds has also increased.

3.2.3.6 Instrument 6 set-based development

Poppendieck & Poppendieck (2003) use a meeting-scheduling scenario to demonstrate the utility of this tool. Either party can propose a time frame and wait for a response, which could be a rejection of the proposed time frame and a new suggestion. It is hoped that convergence will occur as the iteration process progresses. Give a range of times rather than a set time, and the other person will be able to select a time that works with her schedule.

If we apply this principle to the software development process, we can avoid frustrating the client by letting him or her pick between multiple options and instead focus on providing what they need rather than trying to guess what they want. The customer can be given a range of options from which to make a final decision.

3.2.3.7 Instrument 7 optional planning

It is a tricky balancing act to plan for risk management in a project while also meeting client needs. The conventional strategy has been to require the customer to make an irrevocable decision regarding the system's specifications as soon as practicable. The agile methodology is characterized by creating possibilities and making decisions as late as feasible (Poppendieck and Poppendieck, 2003).

The difference between experts and amateurs is that amateurs try to get everything right the first time and attempt to tackle multiple problems at once, which leads them to make hasty decisions upon which they frequently rely. Experts' decisions are postponed until they have the facts and are aware of the limitations (Thimbleby, 1988).

3.2.3.8 Instrument 8 final responsible time

The aforementioned tools suggest that the best method is to begin development rapidly in short iterative increments as soon as some of the requirements are met, offering feedback and correcting problems along the way. This entails delaying decisions as long as possible. One may believe that delaying decisions makes the task simpler, but in reality, it makes the work more difficult and goes against some of our basic tendencies (Poppendieck and Poppendieck, 2003).

Last responsible moment was coined by the Lean Construction Institute. At the point of the last responsible instant, a decision must be taken; otherwise, it will be decided for you automatically (Poppendieck and Poppendieck, 2003).

As stated previously, decision postponement is not a natural instinct. Therefore, Poppendieck (2007) advises sharing incomplete information and establishing lines of contact between system users and system developers. Developing an understanding of what is significant and when and on what matters judgments should be taken.

3.2.3.9 Instrument 9 making choices

Individuals consider decision-making in a variety of ways, and various types of decisions necessitate distinct principles. There is no conventional decision-making template or set of principles that, when applied to a given decision situation, will guarantee a favorable outcome. The straightforward rules provided by Poppendieck and Poppendieck (2003) are to:

1.Get rid of garbage.
2.Enhance learning.
3.Determine as late as necessary.
4.As quickly as possible, please.
5.Give the team autonomy
6.Develop a sense of honesty.
7.View the totality.

Following seven principles are detailed in detail in the supplied resources (Poppendieck and Poppendieck, 2003).

3.2.3.10 Instrument 10 pulling devices

As opposed to the conventional push technique, the pull strategy is the foundation of the Just in time principle. This indicates that in manufacturing, rather than pushing a product through the production line in sequential order, production should not begin until there is a request from succeeding activities. This assures that nothing is generated or produced until a customer specifically requests it. In software development, the customer decides at the start of each iteration what will be delivered at the conclusion of that iteration; this is equivalent to a kanban card. The cards contain a narrative or an event.

This also solves one of the major development-related issues, scheduling. To prevent micromanagement and avoid wasting time waiting for instructions, one simply grabs the kanban card corresponding to the assignment and creates that feature (Poppendieck and Poppendieck, 2003).

3.2.3.11 Instrument 11 queuing theoretical instrument

The queueing theory has numerous applications. Poppendieck and Poppendieck (2003) propose calculating the cycle time of the processes using queuing theory. The cycle time is the time it takes for a person to go from joining the queue to exiting the queue. As discussed previously, the Lean philosophy emphasizes minimizing waste, which includes time spent in a wait.

Therefore, decreasing the wait time reduces waste (Poppendieck and Poppendieck, 2003). To manage the service time of a queue, there are two factors to modify. One may either increase the rate of service, which is the time it takes to accomplish the work for which you are queuing, or one can decrease the arrival rate, which reduces the average queue length.

When queueing theory is used to software development, testing should be conducted in small batches as opposed to big ones. This reduces cycle time as the usage rate rises (Poppendieck and Poppendieck, 2003).

3.2.3.12 Instrument 12 expense of delay

In traditional management, an investment in a technology intended to save time in manufacturing is justified by comparing the cost of the investment against the cost of the hours saved. Considering the advantages of rapid progress, the outcome would be different. The message is to not undervalue the advantages of rapid development (Poppendieck and Poppendieck, 2003).

By developing a profit-and-loss analysis and comparing the cost of development by examining the difference in production, with and without the employed tool, a profit-and-loss analysis may be conducted to determine whether the employed tool is cost-effective. Comparing the expenses will provide an estimate of how much the delay will cost in terms of market loss.

All development work involves tradeoffs. Typically, the tradeoffs in projects concern expense feature and launch schedule. Despite the fact that the perception that trade-offs are conceivable and permitted is rarely emphasized in project descriptions. According to Poppendieck (Poppendieck and Poppendieck, 2003), this causes each project participant to make ambiguous trade-offs. This leads in a compromise of every factor.

The proposed solution for this issue is to provide all team members with an economic model. This gives everyone the same point of reference and enables members to determine the business's objectives. Since members now understand what economic success entails, this is more likely to result in economic success (Poppendieck and Poppendieck, 2003).

In addition to the aforementioned tools, Poppendieck proposes discussing things in the same context. "How can a developer choose between saving a week, saving $10,000, or adding new capabilities?" (Poppendieck and Poppendieck, 2003). Therefore, it is appropriate to compare apples to apples and not apples to currency.

3.2.3.13 Instrument 13 autonomy

According to Poppendieck, transferring practice is frequently a mistake; instead, one should attempt to comprehend the system in which the implementation will occur. When you understand your own system and the underlying principles of the technique you desire to implement, your likelihood of success increases (Poppendieck and Poppendieck, 2003).

This is illustrated with reference to the bankrupt GM facility in Freemont, California, which reopened with Toyota in charge of production. With the same personnel, there were numerous indications of improvement. It is asserted that the rationale for these adjustments is faith in the employee's ability to determine the optimal work practices. Toyota brings the belief and foundation of their production method to the factory where employees run and recommend improvements, while concentrating on the employees (Poppendieck and Poppendieck, 2003).

3.2.3.14 Instrument 14 encouragement

The theory behind this tool is that individuals require more than a list of activities in order to get motivated. The following are recommendations for motivating individuals: Start with a distinct objective and express a distinct project vision. Upon defining a purpose that is realizable, ensure that the team possesses the necessary skills to realize that goal. Ensure that the team understands the product's goal and how it benefits the customer prior to gaining customer access.

When deciding what to commit to, the team should decide. Management's role in the process is to provide as a support for the team; the team should ask management for resources and assistance in resolving their practical issue. And finally, a skeptic who explains why and how the team will fail will reduce morale (Poppendieck and Poppendieck, 2003).

The following components are an excellent beginning point for motivating individuals: Make the team feel like they are a part of the team and give them credit, allow them to feel protected, make the team members more aware of their competency by motivating them and addressing their knowledge and skills, and ensure that the project is making development (Poppendieck and Poppendieck, 2003).

3.2.3.15 Instrument 15 leadership

Type of leader is a key factor in agile software development success. Often, a devoted leader stands in the shadows of a project's success. This leads to dedication. A leader must be able to adapt to change in addition to establishing direction, aligning people, and fostering motivation. At Toyota and 3M, the chief engineer participates in the entire process and oversees the product from inception to completion (Poppendieck and Poppendieck, 2003).

3.2.3.16 Instrument 16 competence

Poppendieck proposes that expertise should be localized into knowledge functions, and that these activities should set standards and offer the organization with expertise and knowledge. These individuals should form an internal community, analogous to the research community in which everyone contributes to the hunt for new information; this community should be centered on the success factors. When designing these communities, it is possible that the required critical mass to form a community is not met (Poppendieck and Poppendieck, 2003).

When realizing this, one should consider how these regions are or could be the company's blind regions.

3.2.3.17 Instrument 17 perceived purity

Customers' perception of the system, from marketing to installation, is its perceived integrity. The best experience for the client, according to Poppendieck, is the feeling that the developer must have been inside your head, i.e., the feeling that the system is the customer's preferred system at all times (Poppendieck and Poppendieck, 2003).

Knowing how to create such a system is not simple, as customer perceptions fluctuate and customers rarely know what they want at the outset of a process. Rather than a solution, the customer typically has a problem or a need that the program should fulfill. (Poppendieck and Poppendieck, 2003). To maintain a positive relationship between client and designer, the following models are applicable: (Poppendieck and Poppendieck, 2003).

To ensure that the user comprehends the domain, a conceptual domain model is created. This can be accomplished through the use of a matrix structure that lists the entities and the actions performed on the entities. The number of elements in the matrix represents the system's options (Poppendieck and Poppendieck, 2003). Describe the terms contained within the domain model. Construct use scenarios that capture usability characteristics. Also, be aware of the system's qualifications and what is essential for stakeholder engagement.

3.2.3.18 Instrument 18 conceptual precision

Conception integrity is the production of a high-quality final product by integrating and aligning all trade-offs made during the development phase to create a seamless and functioning whole. The product strikes a balance between adaptability, reactivity, effectiveness, and maintainability (Poppendieck and Poppendieck, 2003). Poppendieck describes two strategies employed in the automotive industry: minimizing the degrees of freedom by utilizing existing components and integrated issue solution. Integrated problem-solving entails early information release in tiny pieces and simultaneous comprehension and resolution (Poppendieck and Poppendieck, 2003).

Implementing the principles in the software industry entails utilizing existing components whenever possible, employing integrated issue solving, and beginning software development before design details are finalized, as well as consulting with clients and end users. Employ seasoned developers in all crucial areas. Utilize a Master developer who has leadership and oversees the technical team to guarantee they are in sync and their solutions can be integrated.

3.2.3.19 Instrument 19 refactoring

Customization is based on thought; nobody could have known everything from the start. As the project commences, there is limited opportunity to know how to design and program everything. And to dispel the notion that all good designs are created at the start of a project.

(Poppendieck and Poppendieck, 2003). In comparison to the continuous improvement-based lean production philosophy. A Toyota employee is encouraged to halt production if a problem becomes obvious. This is the fundamental tenet of lean: nothing is ever perfect. The same holds true for software development, which must also evolve over time. This involves using an iterative method to the software development process. Conceptual consistency is a realizable and desirable property of the final product. As indicated by Poppendieck (ibid), one must refactor if the fundamental integrity is compromised. A system with conceptual integrity possesses the following characteristics: Simplicity, lucidity, usability, absence of redundancy, and absence of supplementary features.

This signifies that good code is simple code, good code is easy to comprehend and utilizes understandable requirements and names, prototype so that it does what it is considered to do and does it easily, do not replicate code if a modification needs to be made in one location it is easier, if the mistake is copied to multiple places it is much more difficult.

Do not introduce unnecessary features based on the possibility that they might be utilized someplace, sometime (Poppendieck and Poppendieck, 2003). Maybe readers acquainted with the LEAN methodology will see this practice as rework and consequently waste.

Poppendieck and Poppendieck (2003) believe that this is neither waste nor rework, but rather improvement of design and learning as an individual grows. Poppendieck proposes the next curve view figure (3.3).

This is the opposite of the change cost curve. Changes will happen. If your routines and discipline keep the cost of change low, you will be able to maintain production even when changes occur (Poppendieck and Poppendieck, 2003).

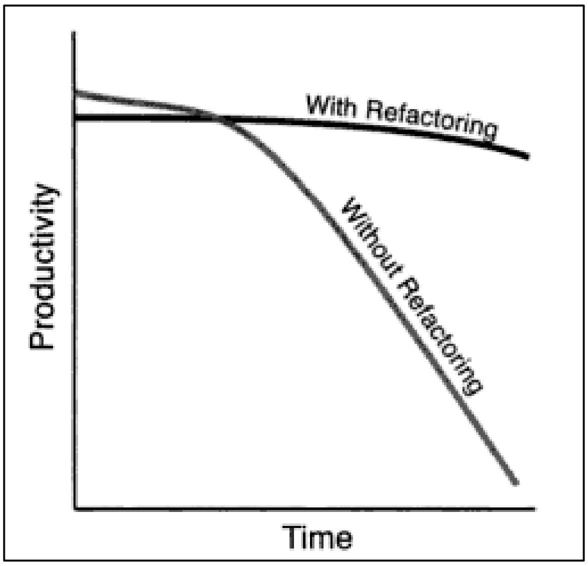

Figure 3.3: Constantly Enhancing Design Preserve Productivity

Source: Poppendieck and Poppendieck, (2003)

This suggests that a team's productivity will decline if they are not permitted to change the design as the project grows. Comparing this to the Toyota production line example in which a worker pauses the line to identify the root cause, Toyota is aware that this will ultimately result in a speedier production unit.

3.2.3.20 Instrument 20 evaluation

Checking guarantees that the customer receives what they require. In software engineering, each feature must be tested to ensure that it functions as the author intended and that the features work together (Poppendieck and Poppendieck, 2003). Developer tests and customer tests are suggested vocabularies for test.

Tests also provide a solid foundation for communication and feedback. The test is an excellent method of communicating with the client and with other developers, as the expected outcome of the test provides a solid foundation for understanding how the product is intended to function. Also, conduct tests in tiny groups; do not wait until the conclusion of the project to test everything. This increases complexity, and since large tests are complex, they will not be executed frequently (Poppendieck and Poppendieck, 2003).

If a test is conducted, it can also serve as the foundation for the software's documentation. The number of defects in each test is also a strong indicator of whether the system is convergence (Poppendieck and Poppendieck, 2003).

3.2.3.21 Instrument 21 measurements

Measuring and optimizing every component will suboptimize a system (Poppendieck and Poppendieck, 2003). This means that the individuals performing the activity will focus their performance and efforts on the criteria against which they are judged. And if the system does not capture the entire system and merely measures for the purpose of measuring, this will result in a suboptimal system (Poppendieck and Poppendieck, 2003).

3.2.3.22 Instrument 22 agreements

Although a fixed-price contract is the most common sort of contract, there are a number of other varieties. The fixed price contract permits the customer to get bids from multiple vendors and select the cheapest, or at least be more likely to do so (Poppendieck and Poppendieck, 2003).

Trust should serve as the foundation for the type of contract used in software development. Due to the scope of this thesis, Poppendieck's proposed contracts will not be discussed in detail.

3.2.4 The agile technology development methodology

As per Poppendieck (2003), there are two conditions for the successful implementation of a new idea: the idea must have been demonstrated to work in practice, and those adopting it must comprehend why it works. Then, how does LEAN technology development differ from conventional development? They're:

Table 3.2: A Comparison of Lean Architecture to Classic Software Architecture

LEAN Methodology	Traditional Systems Engineering
Suspends engineering	Contains engineering
Allows the craftsman "wiggle space" for alterations	Tries to minimize significant changes as "hazardous"
Postpones installation (delivers lightweight APIs and descriptions of relationships)	Contains many or no implementation(platforms, libraries) (documentation only)
A minimal amount of paperwork	Documentation-centric, to describe the implementation or substitute for its deficiency
People	Equipment and notations
Collaborative planning and teamwork	Project surveillance and management
Endpoint user mental modality	Cohesiveness and technical connection

Source: Coplien and Bjørnvig, (2010) LEAN implementation is not a recipe that can be followed (Poppendieck and Poppendieck, Lean software development: An agile toolkit, 2003). And yes is the answer to the question "is LEAN software development feasible?" (Raman, 1998). In an article about the application of lean principles to a company, the authors conclude, "We see that implementation of a lean production system in knowledge work is possible and that it changes how the organization learns through hypothesis-driven problem-solving, streamlined communication, simplified process architecture, and, to a lesser extent, specified tasks" (Stauter et al., 2011).

This article also provides a fair overview of the issues involved in determining whether an effort is in reality LEAN. Furthermore, the question emerges as to whether or not wipros is genuinely practicing lean manufacturing, given that no agreed definition of lean software exists. We rely on the fact that Wipro consciously attempted to develop a lean software services system. Regardless, their proposal was inspired by Lean thinking, so we can benefit from their attempted mapping" (Stauter et al., 2011).

One cannot definitively conclude that there is no Hawthorne effect based on these observations. Moreover, case studies provide scant evidence that the implementation of LEAN software development has yielded enduring outcomes. However, research shows that production concepts may be applied to software development, and in manufacturing lean has proven to give organizations a competitive opportunity.

Table 3.3: The Seven LEAN Systems Development Concepts

7 Concepts of LEAN systems	Instruments utilized
Get rid of waste	1. Viewing Waste
	2. Value chain mapping
Enhance learning	3. Review
	4. Repetitions
	5. Synchronization
	6. Predetermined growth
Make a decision as late as you can.	7.Options-based reasoning
	8.Logic based on alternatives
	9.Making choices
The price of delay	10. Pull techniques
	11. Principle of Waiting
	12. The price of delay

Table 3.3: (Cont.) The Seven LEAN Systems Development Concepts

7 Concepts of LEAN systems	**Instruments utilized**
Enable the team	13.Self-motivation
	14. Inspiration
	15. Leadership position
	16. Ability
Create reliability in	17. Perceived honesty
	18. Conceptual consistency
	19. Restructuring
	20. Evaluation
View the entire	21. Measurements
	22. Agreements

Source: Poppendieck and Poppendieck, (2003)

In a case study conducted by Middleton (2001), two teams were evaluated during the development phase. LEAN software was found to be effective during development, despite organizational hurdles and a fear of revealing flaws limiting its longevity.

Although there was a great deal of dissatisfaction in the beginning due to the high number of obvious faults, which led to some demotivation, the error rate eventually decreased (Middleton, 2001).

Parneel-Klabo (2006) identified three challenging obstacles: collocation space, executive assistance, and change curve influence. When implementing LEAN, there are many myths associated with the seven steps outlined in table (3.3). These beliefs include the following: early specification minimizes waste, haste creates waste, the purpose of testing is to uncover faults, and there is one ideal way (Poppendick and Poppendick, Implementing LEAN software development: From concept to cash, 2007).

The 2007 sequel to Poppendieck's book Implementing Lean software development: from concept to cash describes a 24-frame LEAN development approach. They've divided the frames into six categories: systems thinking, technical excellence, dependable delivery, unrelenting improvement, Great people, and Aligned Leaders. Each of these groups is assigned a leader accountable for the creation of the frames (Poppendick and Poppendick, Leading LEAN software development: Results are not the point, 2010).

And as Naftnalia et al. observed, "there is currently a paucity of research that can aid organizations in adopting modern software development processes, particularly when it comes to LEAN concepts and concepts" (Ebert, et al., 2012). There is much more to write and present on LEAN system development and Agile processes; for additional reading and installation, please consult the references. This thesis will not address the implementation methodology and the instruments and support required to succeed with LEAN application.

3.3 Project-Based TQM

Total quality management (TQM) is a productivity and process technique that was established to enhance organization performance (Jung and Wang, 2006). However, the application of TQM principles to projects has not been as straightforward and simple as one might assume. The primary reason for this is the measurement element; in a manufacturing process, one can measure rework and the number of clients served, among other metrics. But in a project, defining a measurement is far more difficult (Jung and Wang, 2006.).

Table 3.4: The Concepts of TQM

Concept	**Description**
Get rid of waste	Total quality must be the foremost concern of the organization/company/person.
Description of quality	Any definition of quality must encompass meeting/satisfying/conforming to negotiated/agreed-upon customer needs/requirements/wants/expectations.
Customer classification	Customers encompass investors/employees/stakeholders/suppliers/community as well as all interpersonal relationships.
Customer contentment	Long-term client happiness will be the objective of any high-quality firm.
Target	A high-quality organization will have a clearly articulated, broadly understood, and widely approved mission or purpose.
Communication	A whole quality organization will convey its quality principles/beliefs/values/mission statement/policy in an open and transparent manner.
Ethos	Total quality management embraces the organization's principles, beliefs, and ethos; therefore, total quality permeates every operation, decision, and performance.
Benefit	Integrity, honesty, trust, and candor at the highest levels are fundamental components of overall quality management.

Table 3.4: (Cont.) The Concepts of TQM

Concept	**Description**
Appreciation and rewards are shared	All stakeholders in a comprehensive quality organization implicitly respect one another, presuming that long-term business is supposed to be mutually beneficial.
Health and safety	The welfare of all investors/employees/suppliers/community members, as stakeholders in the enterprise, is fundamental to the long-term success of the organization, making health, safety, and environmental concerns a major priority in a complete quality institution.
Commitment	The leadership of overall quality management emanates from the top of the organization and solicits the participation of every individual and team.
Ownership and involvement	Total quality management entails continual and quantifiable improvements at all organizational levels. From the performance of a corporation to the performance of an individual person, constant process improvement is an indispensable element of success.
	Total quality management necessitates consistent performance to high standards in every aspect of an organization; hence, measurement, evaluation, and auditing are typical TQM operations.
	The objective of every overall quality organization is to maximize resource utilization to achieve higher financial and/or nonfinancial performance.
	Total quality management will always necessitate adequate/adequate expenditure in order for planned activity to happen.

Source: Choppin, (1995)

A set of TQM's guiding principles is provided below to facilitate comprehension (Choppin, 1995). According to (Tippett and Waits, 1994), "... evaluating project efficiency is a far more subjective and complex job" (table 3.4), measurement is one of the fundamental components of Total Quality Management. One of the claims made by (Jung and Wang, 2006) is that the emphasis on performance, time, and money causes project managers to concentrate on attaining success in these fields. Not maximizing the organization and project, but achieving short-term success. The solution is a long-term evaluation of team performance, motivation, and attitudes, among other factors (Jung and Wang, 2006).

From the above table, it can be deduced that one of the main components of TQM is measurement, and according to (Jung and Wang, 2006), "... quantifying project efficiency is a considerably more subjective and challenging endeavor."

One of the claims made by (Jung and Wang, 2006) is that the emphasis on performance, time, and money causes project managers to concentrate on attaining success in these areas.

Not maximizing the organization and project, but producing a successful outcome in the short term. The solution is a long-term evaluation that includes team effectiveness, motivation, and attitudes, etc. (Jung and Wang, 2006).

3.4 Risk Management in Projects

As a project is characterized as a transitory endeavor and its hazards are unknown, a risk assessment must be conducted.

PMI (2008) outlines six steps for controlling project risks.

1. Establish risk management
2. Evaluate Risks
3. Conduct qualitative risk evaluation
4. Conduct quantitative risk assessment
5. Define risk response
6. Assess and manage threats

All of this may be summed up as outlining how to plan for the risk assessment, identifying the risk, and determining how to respond if an incident occurs (PMI, Project Management Institute, 2008).

Plan risk management is a technique that is intended to identify and manage project hazards. Detailing the risk management procedure increases the likelihood of a successful risk assessment (PMI, Project Management Institute, 2008). Below is a listing of the program's risk management inputs, objectives, and instruments.

After completing the risk management strategy, it is necessary to identify the risks. Similar to figure (2.18), this process includes inputs, tools, and outputs. Examining essential papers, like the risk management strategy, activity cost estimates, activity length estimates, and other planning documents, is part of the inputs (PMI, Project Management Institute, 2008).

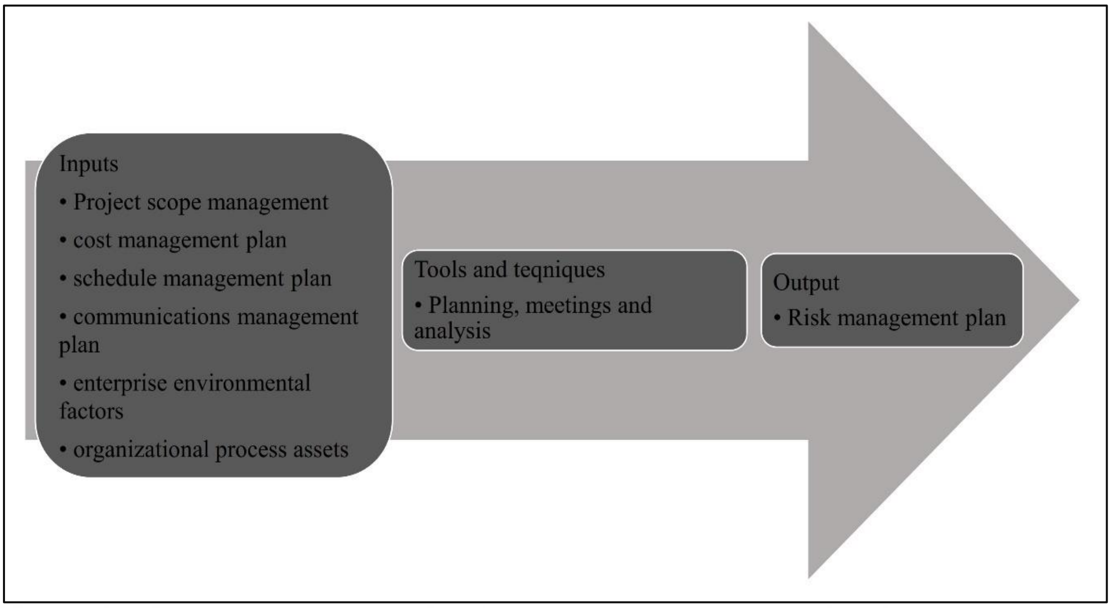

Figure 3.4: Establish İnputs, İnstruments and Techniques, and Outputs for Risk Management

Source: PMI, Project Management Institute, (2008)

SWOT assessment, expert opinion, and checklist assessment are among the tools utilized for this project. The output of this process is a risk register (PMI, Project Management Institute, 2008).

The third and fourth phases consist of a risk matrix and ways for displaying and computing impact factors for the hazards identified in the second phase (PMI, Project Management Institute, 2008). After identifying the risks, tools and strategies are built to be able to respond should a danger occur. And determining how to manage these risks can be viewed as a process with risk register, project management plan, work performance indicator, and performance reports as inputs (PMI, Project Management Institute, 2008). Then, through meetings, audits, and document analysis, one may review the project's status and determine if risks are increasing or even becoming a reality. This procedure results in the update of project papers and the risk register, as risks tend to evolve as a project develops (PMI, Project Management Institute, 2008).

3.5 Procedures and Process-Oriented Thinking

Every endeavor a person undertakes is controlled by procedures (Emmert-Streib, et al., 2020). There are several types of processes, however they can typically be divided into three classifications: Management, financial, and administrative operations (Karlf and Helgi Lvingsson, 2007). Various definitions of Processes exist, the ISO 9000 definition being: "A process is a set of interrelated or interacting actions that turn inputs into outputs" (Karlf and Helin Lvingsson, 2007).

Frequently, processes are defined within the context of Business process management (BPM), as defined by Van Der Alst in (Emmert-Streib, et al., 2020): "Supporting business processes utilizing methods, techniques, and software to design, enact, control, and analyze overall operations involving humans, institutions, applications, paperwork, and other sources of information" BPM is developed to govern process orientation. According to (Karlf and Helin, 2007), the purpose for a process focus in an organization is to focus on the customer and synchronize functions. The traditional institutional strategy centers the organization on a matrix structure in which resources are located in the functions and processes are cross-functional and customer-centric (Karlf & Helin, 2007).

As processes represent a flow of activities within an organization, which is essentially a division of labor, the term process organization has been questioned (Karlf and Helin Lvingsson, 2007).

Processes are widely employed in industry, and a number of challenges related to the introduction of a process-centric perspective can be observed. They can essentially be characterized as ambiguous responsibilities in both the economic and choice contexts (Karlf and Helin, 2007). One might conclude that a process is more of a concern of management and accountability than of organizational structure (Karlf and Helin, 2007).

3.6 KPI

KPI is a set of measurements designed to assess and analyze the most important indication for the organization's future success (Al Dakheel, et al., 2020).

As per (Al Dakheel, et al.,2020), few organizations measure their true KPI, citing a lack of investigation into what KPI actually is as the explanation. To classify and fully comprehend what a KPI is (Al Dakheel, et al.,2020), a few additional performance indicators must first be defined.

And to define KPI, one must understand the distinction between KPI, KRI, and PI (Al Dakheel, et al., 2020). They are described in the following manner:

1. Key result indicators (KRIs) provide an overview of your performance.

2. Efficiency indicators (PIs) provide direction.

3. KPIs tell you what to do to substantially improve productivity.

Examples of KRI that are frequently misinterpreted as KPIs are customer satisfaction, net profit before taxes, and employee satisfaction. They are a measurement of numerous actions that indicates whether the organization is moving in the right path, but they do not tell you what has to be improved (Al Dakheel, et al.,2020).

They only measure the symptom, not the underlying reason. Between the KRI and the KPI should be a set of complimentary measurements that provide extra insight into the KPIs. Examples of KPIs include the profitability of the top 10% of customers and the net profit on the most important product lines (Al Dakheel, et al.,2020). When these have been clarified and understood, the attention can shift to comprehending the organization's KPI.

The seven characteristics of a key performance indicator (Al Dakheel, et al., 2020);

1. Nonfinancial.

2. Regularly measured (daily or 24/7).

3. Implemented by the CEO and top leadership team

4. All personnel understanding the measure and corrective action

5. assigns accountability to an individual or group.

6. Significant effects (affects the majority of fundamental important success elements and many balanced scorecard perspectives).

7. Positive influence (affects all other performance measures in a positive way).

The measurement's selection time indicates whether the measurement qualifies as a key performance indicator (KPI). Frequent measurement is required since monthly or annual measurements are not crucial to the business (Al Dakheel, et al., 2020). Consequently, it does not qualify as a KPI.

(Al Dakheel, et al., 2020) Recommends a 10/80/10 method, in which a company has 10 KRI, 80 PI, and 10 KPIs (Al Dakheel, et al., 2020). The following is suggested in the specific situation of performance measures for project control.

Table 3.5: Measuring for Project Management

Principle	**Definition**
Critical tasks not started on time	schedule
Critical tasks not finished on time	schedule
Non critical task becoming critical	schedule
Milestones missed	schedule
Due date changes	schedule
Price changes	Cost
Cost overruns	Cost
Insufficient cash flow	Cost
High overhead rates	Cost
Long supply lead time for material required	Resources, Schedule
Low utilization of resources	Resources, Cost
Resource availability problems	Resources, Schedule, Cost
Change in labour cost	Resources, Cost
Changes in scope of project	Performance, Cost, Schedule, Resources
Changes in scope of project	Performance, Cost, Schedule
Lack of technical information	Performance, Cost, Schedule
Failure in test Performance, schedule	Performance, Schedule
Delays in client approvals on configuration changes Performance, schedule	Performance, Schedule
Errors in records (inventories, configuration, etc.) Performance, cost, schedule	Performance, Cost, Schedule

Source: Al Dakheel, et al.,(2020)

3.7 Pareto Concept

The Pareto concept, sometimes known as the 80/20 rule, was introduced by the Italian economist Vilfredo Pareto (Reh, 2017). Pareto observed that 20% of the population possessed 80% of the wealth and subsequently discovered that same rule extended to a variety of other situations.

Joseph Juran expanded the principle in 1930 by naming it "essential few, trivial many" (Reh, 2017).

There is no official definition of the principle, but Rozenberg (2017) provides a clear understanding of its fundamentals: "80% of all consequences originate from 20% of all causes" (Rozenberg,2017).

Today, the Pareto principle is applicable in a variety of contexts and can therefore be considered an effective method for enhancing your business. If 80% of your revenue comes from 20% of your customers, the question is whether it is necessary to focus on 80% of the customers when focusing on 20% will result in a far greater revenue rise.

4. RESEARCH METHODOLOGY

4.1 General Introduction

This chapter explains the research methodology used to reach the research's objective, as well as the data collection and analysis techniques. This chapter describes the research structure for this study, which is comprised of three major parts. The initial phase consists of three steps: an assessment of intelligent production management and automation projects. The second stage consists of a questionnaire survey of manufacturing fields and automation projects specialists. The third stage comprises the development and confirmation of questionnaire data presented to manufacturing field specialists and automation project specialists. The subsequent sections concentrate on the aforementioned research methods.

4.2 Research Design

The research design is a structured overview of how the research study will be conducted, where the overall approach is chosen to systematically and logically combine the various components of a study to solve the research question and provide a foundation for data collection, computation, and analysis.

According to Denscombe (2014), an investigator should have explanations to the what, why, and when questions of his study, as these answers provide emphasis and purpose to a research effort. As per Kerlinger and Pedhazur (1973), referenced by Blaikie (2010), the creation of a research design aids in answering these research objectives.

Denzin and Lincoln (2011) define research design as a comprehensive plan for conducting a research project. Bailey (1997) defines it as the overarching plan adopted to combine the many elements of a study in a consistent and logical manner, thus effectively resolving the research issue and serving as the template for the gathering, measurement, and evaluation of data. The instructions technique can be qualitative, quantitative, or a combination of the two, offering precise guidance for research activities (Creswell, 2018).

Creswell (2018) emphasizes moreover that researchers must give careful consideration to the philosophical implications they embrace in a study, the methodology of inquiry that relates to these principles, and the particular research methodologies that put the approach into reality. To direct research activities, the chosen method can be qualitative, quantitative, or a combination of the two. It must adhere to certain philosophical beliefs, design methodologies, and research methods (Creswell, 2018). The definition of a study design is depicted in figure (4.1).

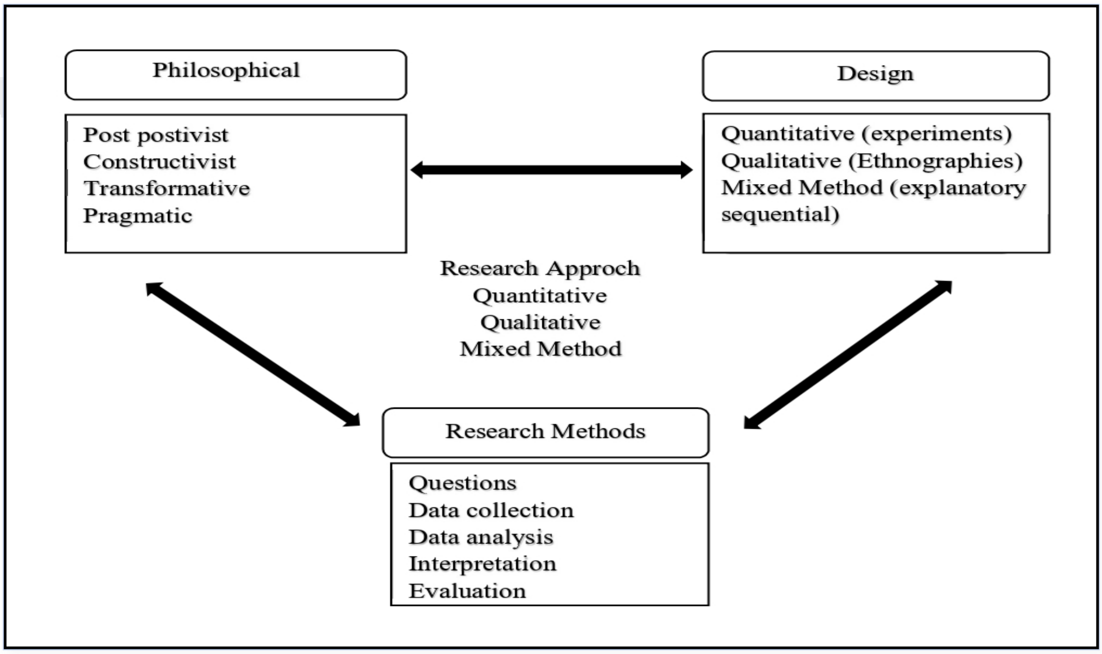

Figure 4.1: Framework for Research Design

4.3 Philosophical Theories

Philosophical theories may be described as overall guidelines and understanding of the world or the purpose of a study carried out by the researcher (Creswell, 2018).

Usually, the author uses those principles and theoretical concepts in a research paper. However, some people might never agree that they should accept a particular assumption or agree on the role these hypotheses play in the study process (Mertens, 2015). Philosophical assumptions include ontology, epistemology, axiology, methodology, and philosophical assumptions of rhetoric (Creswell, 2018).

Figure (4.2) demonstrates these philosophic assumptions according to Gunatilake (2013), focusing on particular issues like what is the method of the study? How does the investigator relate to the examined person? Which are the principles that contribute to the study? What was the study's reality? What's learning communication?

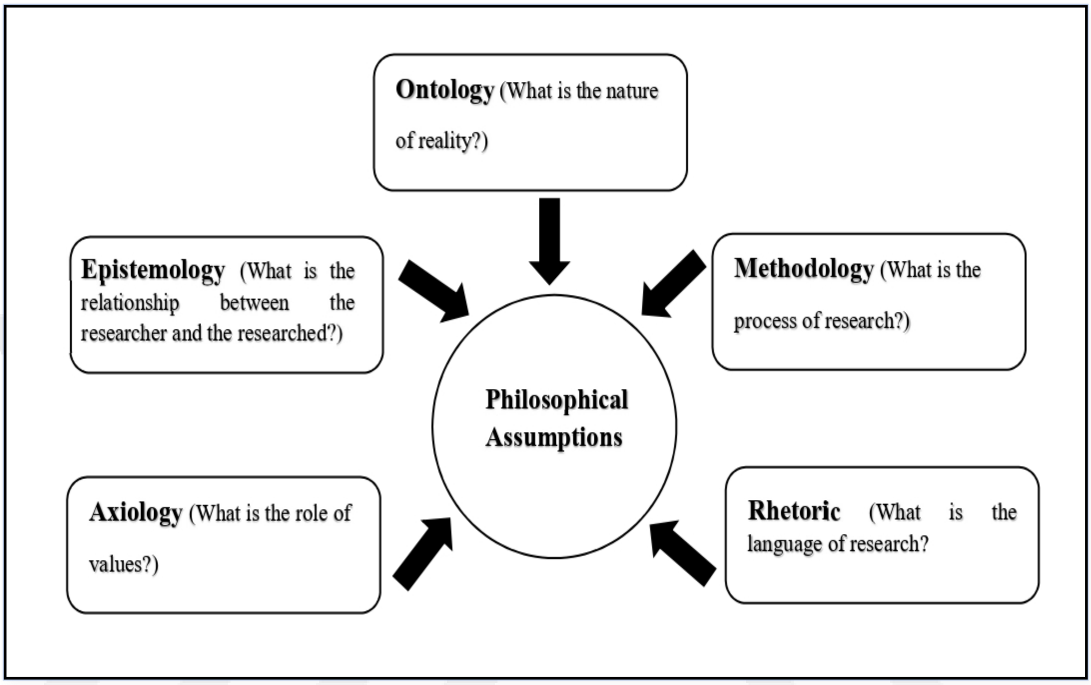

Figure 4.2: Philosophical Theories

Ontology is a philosophical assumption regarding the essence of truth in which the investigators believe the multiple reality of their subjects and this is illustrated by the use of various themes using the technique (What is the study process?) Rhetorical tale (What is the language of research?). Epistemology is a metaphysical theory of the relation between the researcher and the known and how empirical knowledge has been gained.

Axiology is an assumption philosophy on the role of ethics in science. The methodology is a logical theory of the research process and method, which is defined as inductive by the expertise of the scientists in data collection.

Rhetoric is the practice of language study and the practice of convincing the public. This study utilizes a mixed methods strategy, integrating qualitative and quantitative techniques in order to comprehend and identify the components of monitoring and optimization in intelligent manufacturing management.

In accordance to Johnson and Duberly (2000), it is vital to establish a clear philosophical stance that is congruent with the personal approach of the investigator, the nature and method of the research, and the potential for productive learning regarding the object of the research.

At this point, it is vital to discuss the types of research, which may be regarded from three different angles: the implementations of the research's conclusions, the goals of the study, and the method of inquiry utilized to perform the investigation.

4.4 Types of Research

From the viewpoint of research goals, a research plan can be categorized as descriptive, correlational, illustrating, or exploratory. The aim of the study will decide the kind of research to be implemented from a perspective of the study goals (Neuman, 2014):

- Research is known as descriptive research when attempting to explain a situation, practice, service, or procedure in a systematic manner, or when attitudes regarding certain problems are identified, and how to study issues.

- Research includes a correlation between several parts of a situation if the study focuses on attempting to find or assessing the nature of an interaction, interdependence, or partnership.
- Research is defined as explaining when the main goal of explaining why events happen and constructing, creating, extending, or testing the theory. It helps to explain why and how two parts of a phenomenon are related.
- Research can be exploration if the purpose of a study is to either explore a field where minimal research needs to be done or to explore possibilities for specific research and to establish preliminary concepts and research issues.

The study is descriptive in concept as it aims to explain the various practices of monitoring and optimization in intelligent manufacturing management. The study is also considered an exploration of the method of inquiry, where the study takes both qualitative and quantitative methods into account, and the synthesis between the two methods to sufficient to accomplish the purpose of the study.

4.5 Choice of Research Methodology

The approaches of the analysis adopted by the study are based on the research researcher's philosophical concepts, research design, and fundamental research procedures for gathering, analyzing, and interpreting information according to Creswell (2018).

Study approaches are defined as the kind of qualitative, quantitative, and mixed techniques that guide the research design processes (Mertens, 2015).

Quantitative research as per Aliaga and Gunderson (2005) is effective at generating knowledge from a wide range of units in the broadest possible field, but quantitative methods can be very shallow when a topic or idea is to be studied in depth.

The qualitative method is best for a detailed investigation of a study issue. It is a system, which studies subjects in their natural environment, which attempts to explain or perceive a phenomenon with regard to the meanings that people bring to them, where data are inductively analyzed in this method based on details to general concepts, and the researcher interprets the importance of the information (Creswell, 2018).

Qualitative study can define an approach to analysis and try to understand the significance of individuals that are dedicated to social issues, where the qualitative study is intended to examine the real circumstances in their time-based and local circumstances (Flick, 2018).

On the other side, mixed methods given the quantitative and the qualitative benefits. Researchers regarded the selection between the quantitative and qualitative approaches as important. Nevertheless, they are no better than the other because they both have distinct traits and have their strengths and limitations (Mertens, 2015).

4.6 Choosing a Mixed Method

This study uses a mixed-methods approach because the study aims to get a detailed understanding of the significance of the monitoring and optimization in intelligent manufacturing management. Regarding Creswell (2018), if a practice or theory requires to be investigated and clarified since few studies have been done, then a mixed approach is needed.

Valen and Olsson (2012) conducted a study to determine the extent of the importance of the occupational service management career for the owners of buildings in relation to their buildings in the fine, functional, and up to date conditions, by performing the questionnaire investigation and thorough interviews.

The qualitative approach was the first proposed, due to limited the literature in this field, the research analysis is exploratory and required explanatory studies to validate findings.

The quantitative approach was then used to verify and generalize results for a population and to analyze the results of the qualitative process by means of a questionnaire survey. In order to corroborate and generalize the qualitative technique's conclusions to a community and to further investigate their findings, the quantitative approach was then applied via a questionnaire assessment.

4.7 Selection of Research Methods

This section describes effective research approaches by choosing mixed approaches for this study analysis as an acceptable methodology. The search method is the technique for the gathering of observation research information and may be classified into four main topics: documentation, interviews, analysis, and questionnaires (Denscombe, 2010).

The selected methods used for gathering information in this research include documentation and questionnaires. The study mandated an exploratory development approach involving the collection first of qualitative information and then quantitative data.

The study began with gathering qualitative information from related literature and documentation to collect as much knowledge about sustainable building components, it was the first step of the study. The second step of the study involved the acquisition of quantitative data. The results of the documentation gathered were used for designing a questionnaire that was created and then bring up to members of the manufacturing fields and automation project specialists.

4.8 Framework of Study

The study approach implemented in this study could be shown by means of a three stages research framework as shown in figure (4.3).

Stage one consists of the literature review and study of manufacturing fields and automation projects documents and their concepts. Literature review on manufacturing fields and automation projects was involved in the literature review and document study, stage one also included the highlight on the manufacturing fields and automation projects specialists.

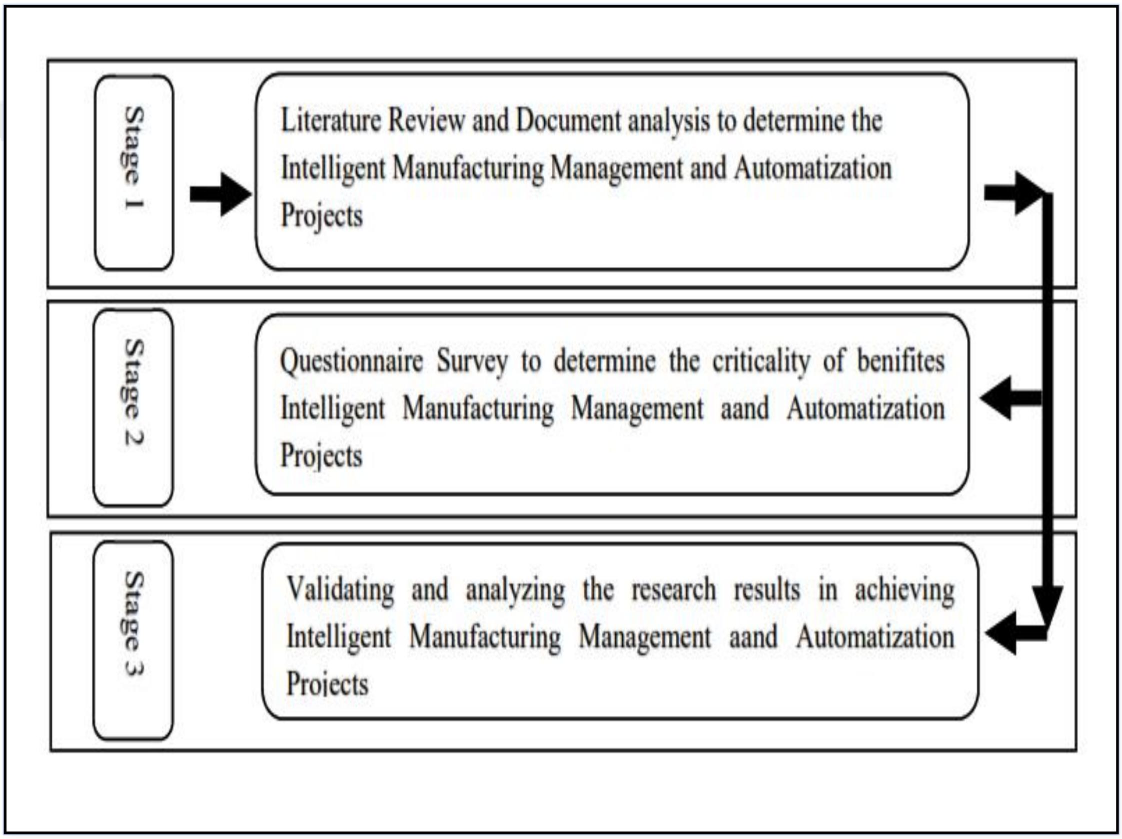

Figure 4.3: Framework of Research Stages

4.8.1 Literature review

The literature review in the study was presented to provide a strong theoretical structure for the field of research and to promote the study's aims and purpose. When findings were made, the literature review proceeded to the latter stages of the study process.

A review of the relevant literature positions of a study defines the information gaps, provides a structure for establishing the value of the study, and thus provides an explanation for the problem statement (Creswell, 2018).

Figure (4.4) clarify the steps of background review in the study as displayed in chapters 1 to 3. The literature review provided the study regarding the theoretical framework intelligent manufacturing management and automation projects.

Denscombe (2014) suggests that such a method aims at arriving at a result on the proposed information of a subject depended on a detailed and impartial review of studies carried out on the topic. This method was helpful, where numerous publications on the study subject were identified, but these publications needed to recognize to define manufacturing management and automation projects concepts.

The study was included selecting the literature from several sources including books, seminars, blogs, and databases, in addition to several journals like Journal of Building and Environment, Journal of Construction, Engineering and Management, and Journal of manufacturing management and automation projects.

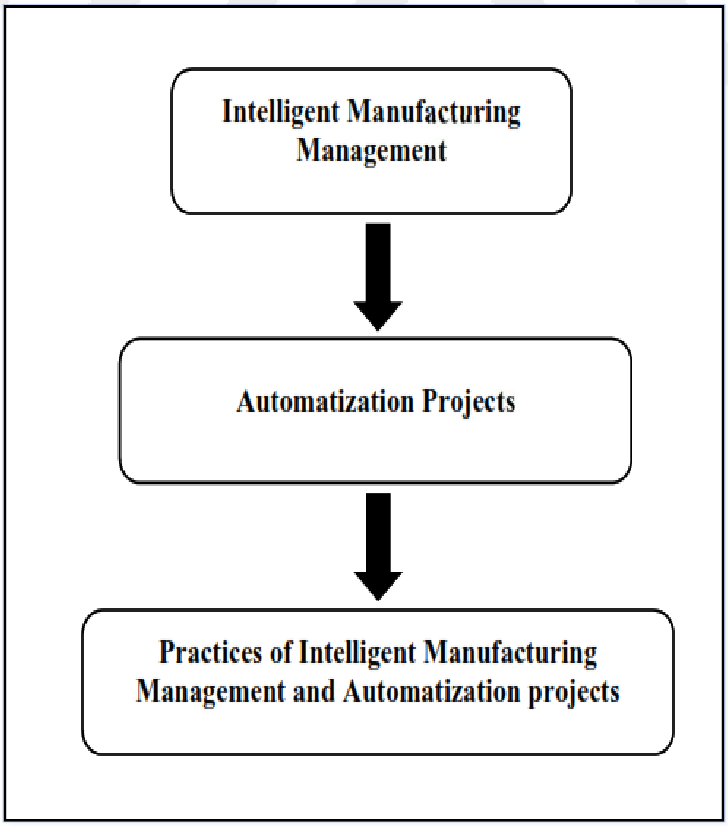

Figure 4.4: Framework of Literature in Research

The principle of the literature gathering was a keyword study for ' intelligent manufacturing management and automation projects'. The choice of literature has been dependent on background pertinence to the research, paper currency, and material quality.

Figure (4.5) shows the stages followed in this study to define intelligent manufacturing management and automation projects.

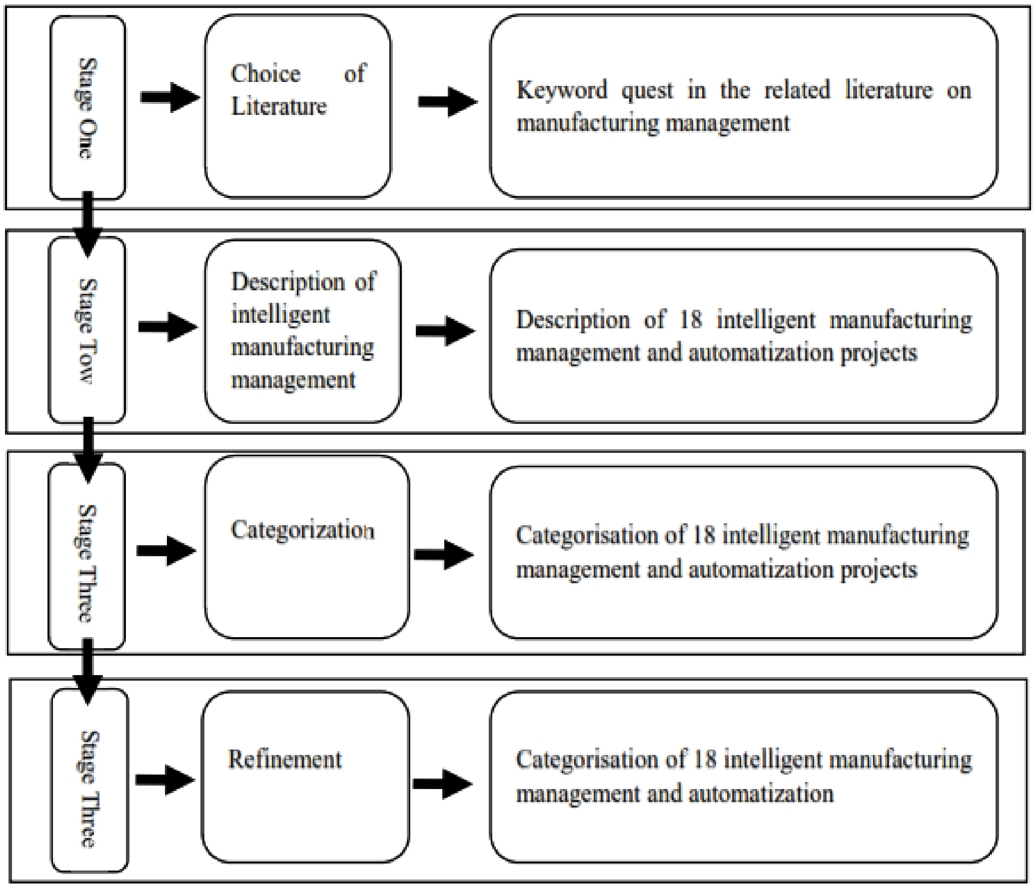

Figure 4.5: Steps of Literary Review

Relevance of the analysis included results from earlier studies on the components that establish a manufacturing management and automation projects, while this consistency of the contents involved concern of the rich data on research objectives available in the literature, the results and suggestion are typically set out in the abstracts.

A total of (18) concepts for intelligent manufacturing management and automation projects were described. Each concept has been refined to meet the ingredients detected in the analysis of information. Described are eighteen concepts of factory management and automation programs. Each concept has been modified to conform to the information analysis's identified components.

4.8.2 Questionnaire Survey

Scientists have designed a questionnaire survey to offer a quantitative or mathematical explanation of population patterns, behaviors, or views by analyzing a sample of that population (Creswell, 2018).

Figure (4.6) shows the research process at this point, where this part is dedicated to designing and processing the survey questionnaire and evaluating the survey results.

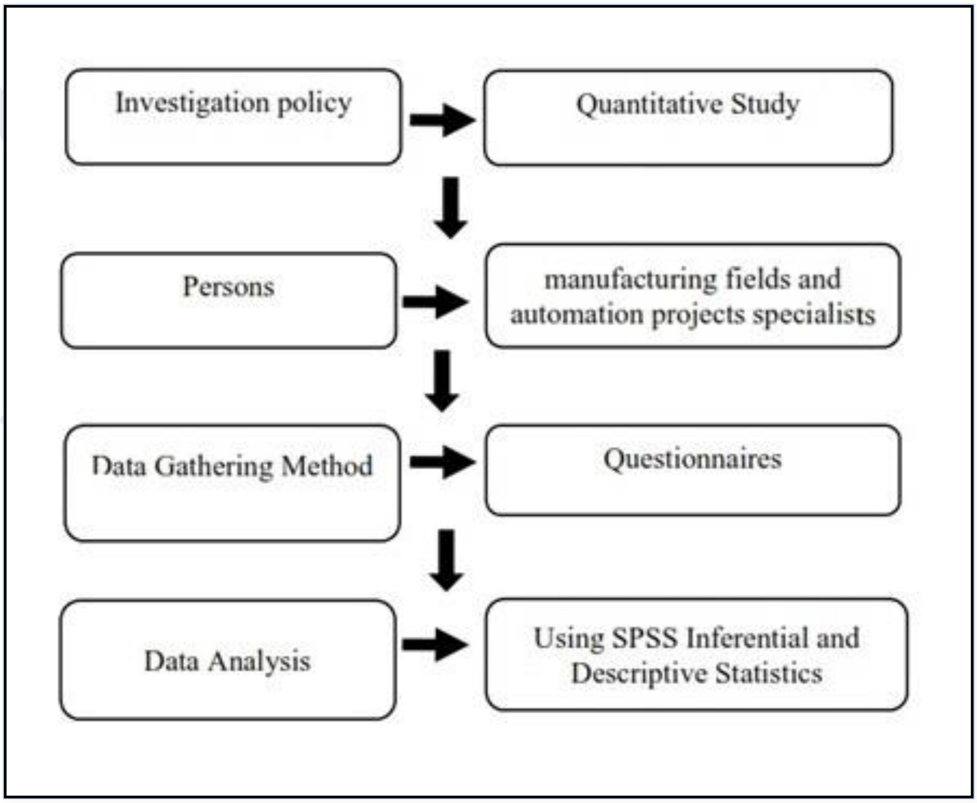

Figure 4.6: Steps of Questionnare Survey

The questionnaire aims to evaluate the ingredients of intelligent manufacturing management and automation projects and the challenges of implementing this concept.

Questionnaires are a documented set of queries designed to specifically gather details from persons and gather details utilized for information analysis. Questionnaires must be designed in a method that may be completed easily method and not need any help.

They can be difficult because respondents cannot speak in their own words and sometimes the researcher has no chance to verify if the responses are valid. However, these are very simple to organize and all participants have required essentially the same queries and chosen from the recorded responses, it's suitable for quantitative study (Denscombe, 2014).

4.8.2.1 Questionnaires Sample

The questionnaire study includes a quantitative approach specifically to the use of the sample primarily, which selects individuals, choosing a number for several and generalizing findings that might represent a wider population.

According to Bryman, (2016) the degree to which a specimen is a community depending on specimen volume, the basic design of choice processes, and the specimen structure, where the specimen volume is the number of persons from the community through which the investigator gets data, the specimen design or sampling the strategy be referred to the

basic plan choice process, where specimen structure is a list representing persons in a community. The questionnaires were targeted at (105) registered members of the manufacturing fields and automation projects specialists. The participants were contacted by printing the questionnaire and distributing it in papers, social media numbers, and email addresses obtained from the register of the manufacturing fields and automation projects specialists as stated above. Where participants have been required to answer the questionnaires and send them back through the same receipting method, and then questionnaires (105) have been returned after given them specific duration (14) days.

4.8.2.2 Questionnaires design

The questionnaires should be designed to gather data that could be used for evaluation, provide a list of questions, and must ask people for data on identified research matters (Denscombe, 2014). where four key criteria must be met while questionnaires are designed:

- Theoretical awareness of the study conducted and obtained by analyzing submitted literature, or other qualitative study methods that may function as a pilot approach.

- The validity of the questionnaire, how the question tests what it has been designed to test, and the reliability of the questions whether these are consistent or relevant.
- Experience in writing a questionnaire, and the utilization of a broad variety of questionnaires published.
- Knowledge of the target demographic.

A sample of the questionnaire is included in appendix A. The questionnaire includes a group of specific questions designed to gather the knowledge that will assist in achieving the aims and objectives of the study.

Specific questions are designed with answers that only permit the answers to match into categories defined by the researcher in advance.

The questionnaire includes a group of specific questions designed to gather the knowledge that will assist in achieving the aims and objectives of the study.

Specific questions are designed with answers that only permit the answers to match into categories defined by the researcher in advance.

The questionnaire also included the scales defined as measurement levels, which are a method for arranging information in the measurement of indicators into the nominal

and ordinal level, and also scales to determine the intensity, direction, amount, or power of a variable measuring in quantitative data.

Scales include Likert, Thurstone, the social distance of Borgadus, semantic differential, numerical ranking, and the scale of Guttman.

They are utilized by social scholars to provide strong data quality, high precision and reliability, compare data sets, and improve data collection and analysis (Neuman, 2014).

The scale of measurements utilized for this study is nominal and ordinal (numerical and Likert) measurement scales. The nominal measurement scale is used in section 1 of the questionnaire it's required from the respondent to select the specialty of his/her occupation and years of experience.

Section 2 (part 1 and part 2) deal with issues by using the ordinary measurement scale (Likert scales), Where they included a 5-point scale Likert, which requires respondents to indicate to what extent they agree or disagree about the effects and criticality of the ingredients listed for achieving a monitoring and optimization in intelligent manufacturing management.

Where; No.5=Strongly Agree, No.4=Agree, No.3=Disagree, No.2=Neither agree nor disagree, and No.1= Strongly disagree. Due to its simplicity, flexibility, and reliability, the Likert scale is the most widely used form of scaling (Neuman, 2014).

4.8.2.3 Data collection

The response ratio for the data collection is beneficial in assessing the efficiency of the questionnaires returned in the study. Table (4.1) displays the distribution of the questionnaire for the survey method. 140 questionnaires were distributed directly either by printed papers or by sent questionnaire link (google format) through the social media numbers and email addresses, and then (105) completed questionnaires were then returned, which resulted in an (75%) of participants.

Table (4.2) displays the number of responses depending on the various backgrounds.

Table 4.1: Response Rate

Questionnaire		**No.**
The questionnaires distributed directly	10	140
The questionnaires sent by social media numbers	102	
The questionnaires sent by email	28	
Overall number of returned completed questionnaires		105
Responses%		75 %

Table 4.2: Questionnaire Distribution

Questionnaire	**Rate %**	**No.**
Mechanical	56.2	59
Control and Systems	13.3	14
Production	4.8	5
Electrical	8.6	9
Others	17.1	18
The total number of completed questionnaires returned	100	105

4.8.2.4 Data analysis

The study followed initial steps to insert data gathered in the program SPSS 22, after which the data inserted were reviewed and errors verified. It was a required practice to verify the data input process was correct. SPSS 22 was used descriptively and differentially to analyze the data from the survey.

Calkins (2005) reports that descriptive statistics typically define or identify a collection of data elements and attempt to deduct information obtained by sampling by graphically presenting the information or explaining its key patterns and how it is distributed when inferential statistics are presented.

The primary purpose of a pilot study is to identify issues prior to the main study, allowing the researcher to undertake steps to improve the research methodology.

In addition, researchers conduct pilot tests to determine how long it will take participants to submit questionnaires while addressing all relevant topics without becoming dissatisfied. Patton (2002) opines that pilot experiments should be a standard component of excellent research methodology because they can save investigators both time and money by identifying logistical difficulties and other design flaws prior to the actual study and allowing for corrections and improvements prior to the execution of the main investigation.

Addressing research obstacles in advance is beneficial. Despite the benefits listed above, a pilot research does not ensure the success of the major study and can even result to its termination. There may be further flaws that were not disclosed in the pilot.

A significant value of (5 %) was used in the study. The study involved the analysis of the percentile form, Cronbach's Alpha, and relative important index. The study also involved the engineering specialization of the different participants in the questionnaire survey as shown in figure (4.7).

The results show that (56.2%) have a mechanical engineering background that carries the highest percentage of engineers that they working in the field of manufacturing and production projects, the results also show that (13.3%) have a control and systems engineering background, while the result shows (4.8 %) have a production engineering background, the results also showed (8.7%) have an electrical engineering background, and (17.1%) have other engineering specialization background.

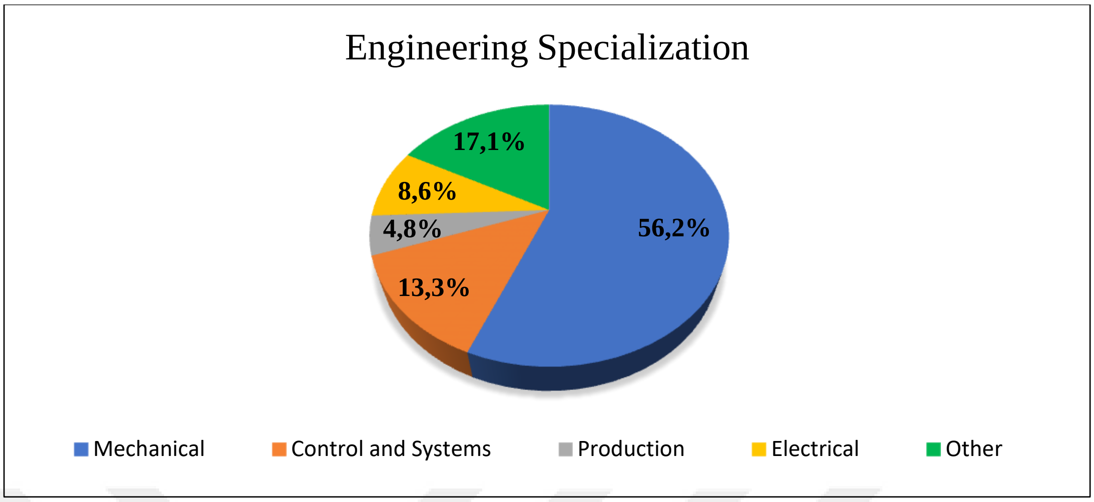

Figure 4.7: Engineering Specialization

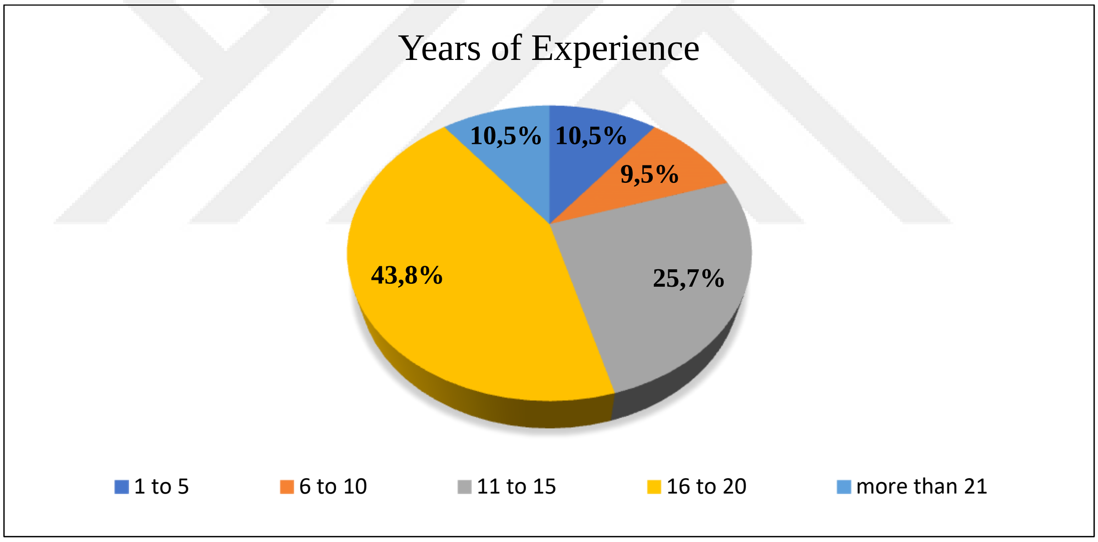

Figure 4.8: Years of Experience

The study shows years of experiencing the of the different participants as per figure (4.8), where (10.5%) of participants from 0-5 years of professional experience, (9.5%) of participants from 6 -10 years of working experience, (25.7%) with 11-15 years of professional experience, (43.8%) of participants from 16 -20 years of professional experience, and (10.5%) for more 21 years of professional experience.

Also the analysis shows different engineering occupation as per figure (4.9), where (36.2%) they working in the field of project management, the results also show that (7.6%) they working as product engineer, while the result shows (25.7 %) as site engineer, the results also showed (25.7%) working supervisor engineer, and (4.8 %) working other engineering occupation.

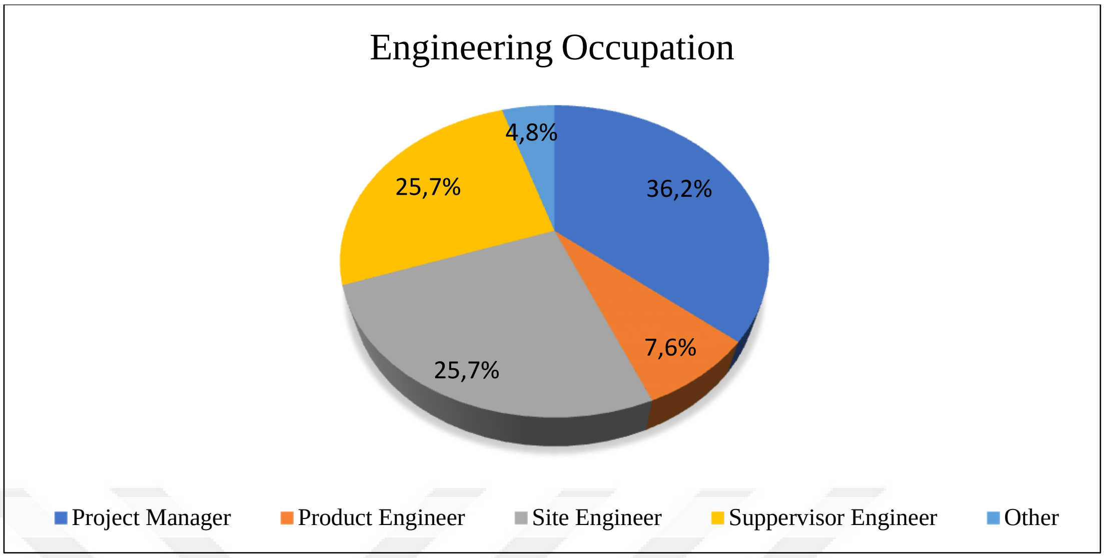

Figure 4.9: Engineering Occupation

The study also shows different of education level from the participants as per figure (4.10), where (64.8%) of participants they have BSC degree, (18.1%) of participants they have MSC degree, while (11.4%) they have PHD degree, and (5.7%) they have other degrees of education.

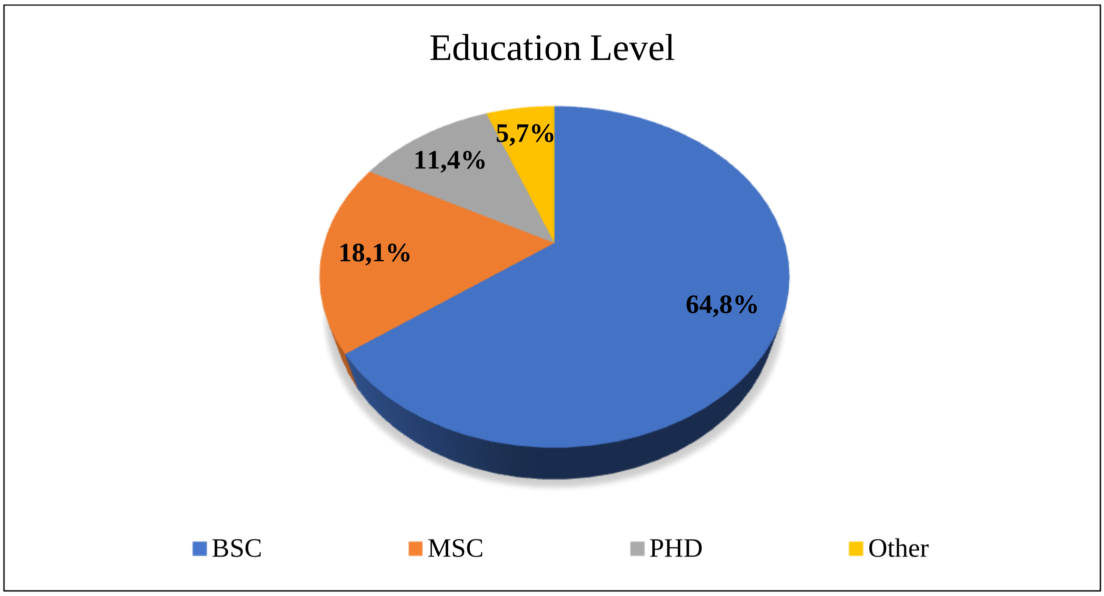

Figure 4.10: Education Level

Table 4.3: Concepts of Monitoring and Optimization in İntelligent Manufacturing Management

No.	**Items**	**Code**
1	The intelligent manufacture of high-tech equipment is crucial to the safety of our national economy.	IM1
2	Engineering management for technology Intelligent manufacturing is a creative, cutting-edge process that combines scientific method, technology, operational research, social scientific knowledge, and the individual element.	IM2
3	The production of high-end machinery is an essential component of the value chain that comprises the fabrication of industrial and commercial equipment.	IM3
4	The term high-end equipment describes to a category of sophisticated pieces of machinery that need a sizable initial investment and are designed to last for an extended period of time.	IM4
5	Intelligent manufacturing is becoming increasingly vital to the growth and modernization of the Higher manufacturing as it encourages the transition toward smart, internet-connected, and provider products.	IM5
6	Modern information technology is crucial to the expansion of the high-end manufacturing sector, which has been propelled by technological innovation.	IM6
7	All stages of the intelligent equipment manufacturing process life cycle, from research and development to manufacture to use to maintenance and reprocessing, are infused with cutting-edge information technology.	IM7
8	The production process for intelligent equipment shortens the time it takes to make a product and cuts down on the costs associated with doing so while simultaneously increasing the intelligence of the equipment's development, manufacturing, and maintenance processes.	IM8
9	Improved innovation design skills, increased production intelligence, and reduced manufacturing risk are all results of the intelligent equipment production procedure.	IM9
10	The technologies of artificial intelligence represent a significant technical assistance for tackling present engineering management issues.	IM10
11	The industrial internet is a significant technical resource for managing contemporary engineering manufacturing issues.	IM11
12	Digital revolution, intellectualization, communication, and servitization are on the rise in the higher manufacturing sector as a result of the new creation of IT infrastructure.	IM12
13	Intelligent production of sophisticated machinery necessitates the application of engineering management and process optimization techniques	IM13
14	Quality and dependability management are affected by the optimization of intelligent industrial engineering management operations.	IM14

Table 4.3: (Cont.) Concepts of Monitoring and Optimization in İntelligent Manufacturing Management

No.	Items	Code
15	Intelligent production of high-end equipment relies on data management and calculated choices made by trained professionals in the field of engineering.	IM15
16	Professional, evidence-based engineering management of Modern intelligent manufacturing using state-of-the-art machinery is capable of achieving a wide range of ecological, societal, economic, scientific, and technological goals simultaneously.	IM16
17	Scientifically credible engineering management on The intelligent production of high-end equipment can effectively combine different talent objectives and cultural concepts at the degree of strategic management.	IM17
18	The assessment of issues in the management of smart manufacturing engineering requires giving careful thought and consideration to the actions associated with that management from a broad perspective.	IM18

In order to apply the SPSS software for data assessment, re-coded were assigned for the questions from (1 to 18) of respondent’s opinion on the concepts of monitoring and optimization in intelligent manufacturing management to code to (IM1 to IM18), as shown in table (4.3).

2.8.2.4 Evaluation of the components of the questionnaire's reliability

The reliability analysis was conducted to establish the dependability of scales used to determine the importance of monitoring and optimization concepts in intelligent manufacturing management. The reliability test is used to assess the consistency of the selected scale and the alpha in Cronbach is the most popular reliability test as shown in equation (4.1).

The reliability test carried out to demonstrated the reliability of the scales to determine what important concepts of monitoring and optimization in intelligent manufacturing management;

$$\alpha = \frac{n}{(n-1)}\left[1 - \frac{\sum_{i=1}^{n} \sigma_{yi}^2}{\sigma_x^2}\right] \qquad \textbf{(4.1)}$$

Where:

α = alpha Cronbach

n = refer to the number of scale items

σ_{yi}^2 = refer to the variance associated with the item i

σ_x^2 = refer to the variance associated with observed total scores

Where the values of (0.70) or larger are accepted. Table (4.4) indicates that all values more than (0.70) value, its acceptable Cronbach's alpha value meaning that the scales are reliable for this analysis.

Table 4.4: The Cronbach's Alpha Values

Components	**No. of Items**	**Value**	**Cronbach's Alpha**	**Internal Reliability**
Concepts of monitoring and optimization in intelligent manufacturing management	18	0.875	$0.9 > \alpha \geq 0.8$	Good

Table 4.5: Levels of Concepts of Monitoring and Optimization in Intelligent Manufacturing Management

No.	**Concept**	**Mean**		**Std. Deviation**	**Variance**	**Level**	
		St.	**Std. Error of Mean**				
1	IM1	4.31	0.053	0.543	0.295	2nd	
2	IM2	4.26	0.057	0.589	0.347	4th	4.37
3	IM3	4.18	0.055	0.568	0.323	6th	
4	IM4	4.37	0.064	0.654	0.428	1st	
5	IM5	4.10	0.073	0.746	0.556	9th	
6	IM6	4.16	0.080	0.822	0.675	7th	
7	IM7	4.06	0.065	0.663	0.439	11th	
8	IM8	3.99	0.071	0.727	0.529	16th	
9	IM9	3.98	0.082	0.843	0.711	18th	
10	IM10	3.99	0.073	0.753	0.567	17th	
11	IM11	4.09	0.072	0.735	0.541	10th	
12	IM12	4.00	0.065	0.665	0.442	15th	
13	IM13	4.03	0.066	0.672	0.451	13th	.634
14	IM14	4.29	0.064	0.661	0.437	3rd	
15	IM15	4.21	0.081	0.829	0.686	5th	
16	IM16	4.10	0.062	0.634	0.402	8th	
17	IM17	4.04	0.074	0.759	0.575	12th	
18	IM18	4.02	0.068	0.693	0.480	14th	

Where table (4.5) describes the level of the benefits of monitoring and optimization in intelligent manufacturing management. It shows IM4 ‘The term high-end equipment describes to a category of sophisticated pieces of machinery that need a sizable initial investment and are designed to last for an extended period of time’ as the maximum value with a level index of (4.37).

This is followed by IM1 ‘The intelligent manufacture of high-tech equipment is crucial to the safety of our national economy' 2nd level with an index of (4.31).

IM14 ‘Quality and dependability management are affected by the optimization of intelligent industrial engineering management operations’ level the 3rd with an index of (4.29), and IM2 'Engineering management for technology Intelligent manufacturing is a creative, cutting-edge process that combines scientific method, technology, operational research, social scientific knowledge, and the individual element' ranked with level 4th with an index (4.26).

While the IM9 'Improved innovation design skills, increased production intelligence, and reduced manufacturing risk are all results of the intelligent equipment production procedure’ ranked lowest with an index of (3.98).

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The conclusion can be separated into two sections: first, conclusions on factors that immediately impact projects, and second, organizational characteristics that impact efficiency. The immediately influencing parameters are separated into four subtopics: a coherent information stream, a well process, the availability of the right instruments, and a well-executed understanding stage. The organizational characteristics consist of three subtopics: organizational knowledge, project success, and management assistance.

5.1.1 Immediately impact projects

When evaluating the analysis, a number of projects are affected by certain criteria. The most influential characteristics are the pattern plant master, the components, the customer benefit, and the operation design. As the study of the questionnaire progresses, the mentioned characteristics form part of a larger dependency. When examining detailed answers, four aspects are determined to be influential:

1. A properly executed Understand stage.
2. Appropriate technical equipment.
3. An emphasis on internal cooperation rather than on seller/buyer.
4. Cohesive project-process characterized by collaboration on the project as a whole rather than sub-optimization of its pieces.

5.1.2 Organizational characteristics

The fact that the projects are provided partly on time and within budget is not attributable to a well-designed methodology or an organizational learning perspective. This feat is the result of the engineers' expertise and experience in designing huge, complicated control structures.

In addition, my research revealed that many projects have not even conducted a lessons gathered session. Whenever the lessons observed session has been conducted, management has provided little input on the outcomes, and little improvements can be extrapolated from the resulting reports. In globalization projects, organizational development and maturity in plan management and project methodologies are not a priority.

Throughout this thesis, it has been evident that there is a shortage of a tool that measures project performance, as the KPI does not reflect the underlying project's performance. I believe the primary issue is the absence of a clear definition of a productive project, which would give project managers with a baseline.

The management assistance, namely support from field managers, was also mentioned. I firmly believe that line managers have wonderful intentions and ideals, but somewhere along the line, these concepts become corrupted. One of the primary comments was that there are too many suggestions for management organizations, measuring instruments, and processes, and that the working groups do not believe they can influence their implementation.

Here are a few of the areas that I believe need to be addressed in order to improve customer value delivery and increase productivity. I would think that one of the findings is the most important, and that is the collaboration with automation technology and module manufacturers regarding a better pattern system for the applications.

5.2 Recommendation

5.2.1 Recommendations for enhancements

This section provides three recommendations for implementing theoretical concepts and philosophies in order to evaluate the influential parameters identified in the previous section.

These recommendations investigate the possibilities of implementing “LEAN”, “TQM”, and “CMMI” to effectively establish a mature project approach that aligns responsibilities and delivers a transparent value stream. Furthermore, some broad advice is presented.

In this thesis, the characteristics have been investigated and subsequently grouped into improvement regions. Follow below three recommendations for evaluating some of the identified improvement regions. The primary objective is to boost project productivity by identifying applicable concepts from the literature and applying them to global initiatives.

1. Utilize “LEAN” concepts to identify waste and profit from the non-waste organization ethos. As the projects are comparable to software projects, additional emphasis should be placed on “LEAN” technology development principles.

Applying the “LEAN” principles of visualizing the work, the development process and development could be visually represented with a board or a system that publicly displays the project 's performance. Poppendieck provides examples of this in the “LEAN” section, where he offers a Kanban approach for software development. In addition, the motivating part of this hypothesis is deemed to be an intriguing component. During interviews, it has been stated that the project lacks a distinct vision and goals.

This lack of purpose focus has been cited as an issue. “LEAN” technology development describes the exploration of theories on how to evaluate and how to measure the appropriate thing, essentially stating, "What you measure is what you get." In additional to or as part of the measurement process, the contract structure must be examined. Although considerable effort is expended in locating other kinds of contracts, it is strongly advised that this strategy be pursued.

“LEAN” evaluates a distinct value stream, and the technology theory in particular offers practical examples and advice for creating the workflow. By using “LEAN”, it is possible to achieve a better alignment among automation solutions, and it also provides a mindset that encourages every person to contribute enhancement recommendations.

Accordingly, the proposal is to investigate the “LEAN” technology development philosophy, with a particular emphasis on the aforementioned sectors, in order to evaluate the efficiency-affecting characteristics discovered in the previous section.

2. Researching the concept of “Total Quality Management” in order to identify a clear and coherent complementary approach compatible with “LEAN”, ability advanced model integrating, and process improvement.

According to the tenets of “Total Quality Management”, everyone is responsible for quality. To be able to direct individuals towards a quality objective, a set of quality standards must be developed and established as the objective. Consistently concentrating on the consumer is one of the prospective improvement opportunities. The current organization lacks a clear emphasis and concentration of resources on providing quality to the final consumer.

By employing TQM concepts and incorporating the entire value chain in providing quality to the client, a greater degree of alignment is achieved.

As previously explained, there is no unified perspective of who the client is; several say it is the industry company, while others claim it is the end consumer. There is a requirement for defining who your client is and harmonizing this perspective across the whole value cycle.

Collaboration is also crucial in “TQM”, although the emphasis is not as collaborative as it could be; rather, the emphasis is on corporate relationships that discourage cooperation. The commitment element of “TQM” is other component. In a “TQM” organization, the entire organization must commit to providing a quality product that meets customer requirements. In addition, both the “LEAN” and ability advanced model integrating models incorporate an emphasis on continual development.

“TQM” also stresses the necessity of evaluating performance and conducting auditing operations, a highlighted area of weakness for multinational initiatives. The suggestion to implement the “TQM” philosophy is based on the framework's suitability and the fact that it aligns with and measures the organization's ability to produce quality and fulfill customer expectations. Lastly, it provides the organization with a shared focus and stimulates development.

3. Enhancing project maturation by evaluating the ability advanced model integrating for innovation framework and the required process stages to attain level 3.

The ability advanced model integrating is based on a series of process development procedures that, when evaluated, are intended to identify and enhance company processes. Importantly, the processes outlined in ability advanced model integrating are not a set of operations that can be adopted and used to eliminate the company's current operations. The techniques discussed entail evaluating a variety of steps to determine, based on the organization's maturity level, the measures required to increase development. Both the development of project management (DPM) and the capability advanced prototype integrating are dependent on the same theory of organizational maturity; however, the degrees indicated in the models are distinct. The global initiatives should evaluate the steps required to reach development level 3 according to this approach. This requires an integrating project management approach, a focus on organizational processes, and a definition of organizational processes.

The advantages of this approach are that it offers global initiatives with a process prototype design that can simultaneously raise project maturity and concentrate process emphasis. Several areas for improvement are discussed in the conclusion chapter, with the adoption of the ability advanced model integrating as a viable solution. These areas include identifying the appropriate project tools as maturity is included into the process, establishing a cohesive project process that facilitates phase handoffs, and fostering a broader project-wide collaboration.

It has been stated that the project procedure is not effective and does not provide an efficient method of functioning. As a result, it is expected that evaluating procedures based on technology industry knowledge and methodologies will provide useful direction. To improve organizational learning and promote efficiency, resolving the capacity advanced model integrating for innovation model will equip the global initiatives with the tools and methods necessary to develop procedures that will amplify organizational education. This must be done both in terms of gathering lessons experienced and conducting lessons acquired sessions, as well as generally gathering project documentation that can be examined to provide knowledge and a teaching perspective to the organization.

5.2.2 Limitation of study

The study focuses on the factors influencing the productivity of automation engineering. Operations are analyzed in terms of their immediate and indirect effects on the operation. After analyzing the potential effect attributes may have on a project, the influence on either duration, money, or scope will be used to determine whether or not to include the element. Global Projects executes a variety of projects, among which are as such Greenfield projects, during which a factory is developed from scratch, as opposed to Brownfield and Revamping projects, which involve the renovation and expansion of existing facilities. The automation component is a subproject inside the building of a plant; other subprojects include process development and electrical design. As this thesis focuses on the factors influencing the productivity of automation engineering, the research will be conducted from an automation approach.

5.2.3 Typical recommendations

Throughout the course of writing this thesis, a few areas for development have been identified; these observations and findings are provided here. Some emphasis was placed on the management assistance features, but most of the remarks concerned the accessibility of project managers. Accessibility and perceptiveness should be increased in order to offer a better knowledge of management monitoring systems and gather information. There is no indication of scope creep in the examined projects, while there is indication of scope creep in the initial set of interviews. It is claimed that this is due to a vague explanation of the project's scope and deliverables. Another recommendation is to discover a method for communicating the effects of scope creep.

The absence of a definition of project performance is another discovery discovered during the course of this research. Identifying success will give teamwork with a clear objective and match available resources with the performance of the project. According to the frequent revisions of the pattern plant master and the absence of a consistent framework on the project server, the utilization of code is not investigated, and no code is recycled. Creating an inside team of seasoned engineers with the purpose of providing examples and proposals for code reuse is encouraged.

5.2.4 Researched recommendation

Utilizing software and services like PLC, SCADA, ERP, DCS, HMI, PLM, and MES has enabled enterprises to collect real-time data and base decisions on it. This software has assisted the industry in minimizing product downtime, scheduled maintenance, and the transition from reactive to predictive, educational, and decision-making stages.

In recent years, the adoption of international standards for environmental management systems, particularly the ISO 50001 standard, has increased dramatically. This also compels manufacturers to engage in energy-saving measures, allowing the market under consideration to expand. In addition to using big data analytics to improve complicated operations and supply chain management, smart manufacturing also makes use of big data. Big data analytics enables a company to convert from regressive to predictive manufacturing techniques, hence enhancing process efficiency and product performance.

In addition, the emergence of Industry 4.0 and the Internet of Things has made the market more accessible, since it is simple to convert production machinery into a form of intelligence and connectivity. It has enabled production processes and stages to be managed through a centralized control center and wearable devices, enhancing their accessibility, enhancing operational procedures, and facilitating their use.

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APPENDICES

Appendix-A: Reliability Analysis

```
RELIABILITY
  /VARIABLES=MI1 MI2 MI3 MI4 MI5 MI6 MI7 MI8 MI9 MI10 MI11 MI12
MI13 MI14 MI15 MI16 MI17 MI18
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA.
```

Reliability

Notes

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Comments		
Input	Data	C:\Users\Toshiba\Desktop\Dhafir SPSS analysis\MI.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	105
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=MI1 MI2 MI3 MI4 MI5 MI6 MI7 MI8 MI9 MI10 MI11 MI12 MI13 MI14 MI15 MI16 MI17 MI18 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA.
Resources	Processor Time	00:00:00.03
	Elapsed Time	00:00:00.03

Scale: All Variables

Case Processing Summary

		N	%
Cases	Valid	105	100.0
	Excluded[a]	0	.0
	Total	105	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.875	18

```
FREQUENCIES VARIABLES=Specialaztion Experience Occupation Education
MI1 MI2 MI3 MI4 MI5 MI6 MI7 MI8 MI9 MI10 MI11 MI12 MI13 MI14 MI15
MI16 MI17 MI18
  /NTILES=4
  /STATISTICS=STDDEV VARIANCE RANGE MINIMUM MAXIMUM
SEMEAN MEAN MEDIAN MODE SUM
  /PIECHART PERCENT
  /ORDER=ANALYSIS.
```

Frequencies

Notes		
Output Created		12-NOV-2022 22:57:20
Comments		
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	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	105
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Specialaztion Experience Occupation Education MI1 MI2 MI3 MI4 MI5 MI6 MI7 MI8 MI9 MI10 MI11 MI12 MI13 MI14 MI15 MI16 MI17 MI18 /NTILES=4 /STATISTICS=STDDEV VARIANCE RANGE MINIMUM MAXIMUM SEMEAN MEAN MEDIAN MODE SUM /PIECHART PERCENT /ORDER=ANALYSIS.
Resources	Processor Time	00:00:06.63
	Elapsed Time	00:00:06.63

Statistics

Statistics

		Engineering Specialization	Years of Experience	Engineering Occupation	Education Level
N	Valid	105	105	105	105
	Missing	0	0	0	0
Mean		2.17	3.34	2.55	1.58
Std. Error of Mean		.154	.110	.130	.089
Median		1.00	4.00	3.00	1.00
Mode		1	4	1	1
Std. Deviation		1.578	1.125	1.337	.907
Variance		2.490	1.266	1.788	.823
Range		4	4	4	3
Minimum		1	1	1	1
Maximum		5	5	5	4
Sum		228	351	268	166
Percentiles	25	1.00	3.00	1.00	1.00
	50	1.00	4.00	3.00	1.00
	75	4.00	4.00	4.00	2.00

Statistics

Statistics

		The intelligent manufacture of high-tech equipment is crucial to the safety of our national economy.	Engineering management for technology Intelligent manufacturing is a creative, cutting-edge process that combines scientific method, technology, operational research, social scientific knowledge, and the individual element.	The production of high-end machinery is an essential component of the value chain that comprises the fabrication of industrial and commercial equipment.	The term high-end equipment describes to a category of sophisticated pieces of machinery that need a sizable initial investment and are designed to last for an extended period of time.
N	Valid	105	105	105	105
	Missing	0	0	0	0
Mean		4.31	4.26	4.18	4.37
Std. Error of Mean		.053	.057	.055	.064
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.543	.589	.568	.654
Variance		.295	.347	.323	.428
Range		2	3	2	3
Minimum		3	2	3	2
Maximum		5	5	5	5
Sum		453	447	439	459
Percentiles	25	4.00	4.00	4.00	4.00
	50	4.00	4.00	4.00	4.00
	75	5.00	5.00	5.00	5.00

Statistics

Statistics

		Intelligent manufacturing is becoming increasingly vital to the growth and modernization of the Higher manufacturing as it encourages the transition toward smart, internet-connected, and provider products.	Modern information technology is crucial to the expansion of the high-end manufacturing sector, which has been propelled by technological innovation.	All stages of the intelligent equipment manufacturing process life cycle, from research and development to manufacture to use to maintenance and reprocessing, are infused with cutting-edge information technology.	The production process for intelligent equipment shortens the time it takes to make a product and cuts down on the costs associated with doing so while simultaneously increasing the intelligence of the equipment's development, manufacturing, and maintenan
N	Valid	105	105	105	105
	Missing	0	0	0	0
Mean		4.10	4.16	4.06	3.99
Std. Error of Mean		.073	.080	.065	.071
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.746	.822	.663	.727
Variance		.556	.675	.439	.529
Range		3	4	2	3
Minimum		2	1	3	2
Maximum		5	5	5	5
Sum		431	437	426	419
Percentiles	25	4.00	4.00	4.00	3.50
	50	4.00	4.00	4.00	4.00
	75	5.00	5.00	4.50	4.50

Statistics

Statistics		Improved innovation design skills, increased production intelligence, and reduced manufacturing risk are all results of the intelligent equipment production procedure.	The technologies of artificial intelligence represent a significant technical assistance for tackling present engineering management issues.	The industrial internet is a significant technical resource for managing contemporary engineering manufacturing issues.	Digital revolution, intellectualization, communication, and servitization are on the rise in the higher manufacturing sector as a result of the new creation of IT infrastructure.
N	Valid	105	105	105	105
	Missing	0	0	0	0
Mean		3.98	3.99	4.09	4.00
Std. Error of Mean		.082	.073	.072	.065
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.843	.753	.735	.665
Variance		.711	.567	.541	.442
Range		3	3	3	3
Minimum		2	2	2	2
Maximum		5	5	5	5
Sum		418	419	429	420
Percentiles	25	3.00	4.00	4.00	4.00
	50	4.00	4.00	4.00	4.00
	75	5.00	4.50	5.00	4.00

Statistics

Statistics		Intelligent production of sophisticated machinery necessitates the application of engineering management and process optimization techniques	Quality and dependability management are affected by the optimization of intelligent industrial engineering management operations.	Intelligent production of high-end equipment relies on data management and calculated choices made by trained professionals in the field of engineering.	Professional, evidence-based engineering management of Modern intelligent manufacturing using state-of-the-art machinery is capable of achieving a wide range of ecological, societal, economic, scientific, and technological goals simultaneously.
N	Valid	105	105	105	105
	Missing	0	0	0	0
Mean		4.03	4.29	4.21	4.10
Std. Error of Mean		.066	.064	.081	.062
Median		4.00	4.00	4.00	4.00
Mode		4	4	4	4
Std. Deviation		.672	.661	.829	.634
Variance		.451	.437	.686	.402
Range		3	3	3	3
Minimum		2	2	2	2
Maximum		5	5	5	5
Sum		423	450	442	431
Percentiles	25	4.00	4.00	4.00	4.00
	50	4.00	4.00	4.00	4.00
	75	4.00	5.00	5.00	4.50

Statistics

Statistics

		Scientifically credible engineering management on The intelligent production of high-end equipment can effectively combine different talent objectives and cultural concepts at the degree of strategic management.	The assessment of issues in the management of smart manufacturing engineering requires giving careful thought and consideration to the actions associated with that management from a broad perspective.
N	Valid	105	105
	Missing	0	0
Mean		4.04	4.02
Std. Error of Mean		.074	.068
Median		4.00	4.00
Mode		4	4
Std. Deviation		.759	.693
Variance		.575	.480
Range		3	3
Minimum		2	2
Maximum		5	5
Sum		424	422
Percentiles	25	4.00	4.00
	50	4.00	4.00
	75	5.00	4.00

Frequency Table

Engineering Specialization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mechanical	59	56.2	56.2	56.2
	Control and Systems	14	13.3	13.3	69.5
	Production	5	4.8	4.8	74.3
	Electrical	9	8.6	8.6	82.9
	Other	18	17.1	17.1	100.0
	Total	105	100.0	100.0	

Years of Experience		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	11	10.5	10.5	10.5
	6-10	10	9.5	9.5	20.0
	11-15	27	25.7	25.7	45.7
	16-20	46	43.8	43.8	89.5
	more than 21	11	10.5	10.5	100.0
	Total	105	100.0	100.0	

Engineering Occupation		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Project Manager	38	36.2	36.2	36.2
	Product Engineer	8	7.6	7.6	43.8
	Site Engineer	27	25.7	25.7	69.5
	Supervisor Engineer	27	25.7	25.7	95.2
	Other	5	4.8	4.8	100.0
	Total	105	100.0	100.0	

Education Level		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BSC	68	64.8	64.8	64.8
	MSC	19	18.1	18.1	82.9
	PHD	12	11.4	11.4	94.3
	Other	6	5.7	5.7	100.0
	Total	105	100.0	100.0	

The intelligent manufacture of high-tech equipment is crucial to the safety of our national economy.		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	4	3.8	3.8	3.8
	Agree	64	61.0	61.0	64.8
	Strongly agree	37	35.2	35.2	100.0
	Total	105	100.0	100.0	

Engineering management for technology Intelligent manufacturing is a creative, cutting-edge process that combines scientific method, technology, operational research, social scientific knowledge, and the individual element.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	5	4.8	4.8	5.7
	Agree	65	61.9	61.9	67.6
	Strongly agree	34	32.4	32.4	100.0
	Total	105	100.0	100.0	

The production of high-end machinery is an essential component of the value chain that comprises the fabrication of industrial and commercial equipment.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	9	8.6	8.6	8.6
	Agree	68	64.8	64.8	73.3
	Strongly agree	28	26.7	26.7	100.0
	Total	105	100.0	100.0	

The term high-end equipment describes to a category of sophisticated pieces of machinery that need a sizable initial investment and are designed to last for an extended period of time.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	7	6.7	6.7	7.6
	Agree	49	46.7	46.7	54.3
	Strongly agree	48	45.7	45.7	100.0
	Total	105	100.0	100.0	

Intelligent manufacturing is becoming increasingly vital to the growth and modernization of the Higher manufacturing as it encourages the transition toward smart, internet-connected, and provider products.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	2.9	2.9	2.9
	Neutral	15	14.3	14.3	17.1
	Agree	55	52.4	52.4	69.5
	Strongly agree	32	30.5	30.5	100.0
	Total	105	100.0	100.0	

Modern information technology is crucial to the expansion of the high-end manufacturing sector, which has been propelled by technological innovation.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.0	1.0	1.0
	Disagree	3	2.9	2.9	3.8
	Neutral	13	12.4	12.4	16.2
	Agree	49	46.7	46.7	62.9
	Strongly agree	39	37.1	37.1	100.0
	Total	105	100.0	100.0	

All stages of the intelligent equipment manufacturing process life cycle, from research and development to manufacture to use to maintenance and reprocessing, are infused with cutting-edge information technology.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	20	19.0	19.0	19.0
	Agree	59	56.2	56.2	75.2
	Strongly agree	26	24.8	24.8	100.0
	Total	105	100.0	100.0	

The production process for intelligent equipment shortens the time it takes to make a product and cuts down on the costs associated with doing so while simultaneously increasing the intelligence of the equipment's development, manufacturing, and maintenan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	25	23.8	23.8	24.8
	Agree	53	50.5	50.5	75.2
	Strongly agree	26	24.8	24.8	100.0
	Total	105	100.0	100.0	

Improved innovation design skills, increased production intelligence, and reduced manufacturing risk are all results of the intelligent equipment production procedure.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	2.9	2.9	2.9
	Neutral	29	27.6	27.6	30.5
	Agree	40	38.1	38.1	68.6
	Strongly agree	33	31.4	31.4	100.0
	Total	105	100.0	100.0	

The technologies of artificial intelligence represent a significant technical assistance for tackling present engineering management issues.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	2.9	2.9	2.9
	Neutral	21	20.0	20.0	22.9
	Agree	55	52.4	52.4	75.2
	Strongly agree	26	24.8	24.8	100.0
	Total	105	100.0	100.0	

The industrial internet is a significant technical resource for managing contemporary engineering manufacturing issues.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	2.9	2.9	2.9
	Neutral	15	14.3	14.3	17.1
	Agree	57	54.3	54.3	71.4
	Strongly agree	30	28.6	28.6	100.0
	Total	105	100.0	100.0	

Digital revolution, intellectualization, communication, and servitization are on the rise in the higher manufacturing sector as a result of the new creation of IT infrastructure.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	20	19.0	19.0	20.0
	Agree	62	59.0	59.0	79.0
	Strongly agree	22	21.0	21.0	100.0
	Total	105	100.0	100.0	

Intelligent production of sophisticated machinery necessitates the application of engineering management and process optimization techniques					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	19	18.1	18.1	19.0
	Agree	61	58.1	58.1	77.1
	Strongly agree	24	22.9	22.9	100.0
	Total	105	100.0	100.0	

Quality and dependability management are affected by the optimization of intelligent industrial engineering management operations.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	9	8.6	8.6	9.5
	Agree	54	51.4	51.4	61.0
	Strongly agree	41	39.0	39.0	100.0
	Total	105	100.0	100.0	

Intelligent production of high-end equipment relies on data management and calculated choices made by trained professionals in the field of engineering.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	6	5.7	5.7	5.7
	Neutral	9	8.6	8.6	14.3
	Agree	47	44.8	44.8	59.0
	Strongly agree	43	41.0	41.0	100.0
	Total	105	100.0	100.0	

Professional, evidence-based engineering management of Modern intelligent manufacturing using state-of-the-art machinery is capable of achieving a wide range of ecological, societal, economic, scientific, and technological goals simultaneously.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.0	1.0	1.0
	Neutral	13	12.4	12.4	13.3
	Agree	65	61.9	61.9	75.2
	Strongly agree	26	24.8	24.8	100.0
	Total	105	100.0	100.0	

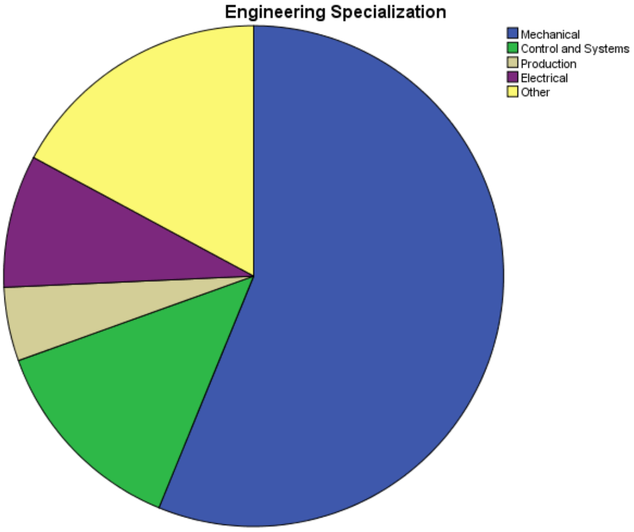
Scientifically credible engineering management on The intelligent production of high-end equipment can effectively combine different talent objectives and cultural concepts at the degree of strategic management.

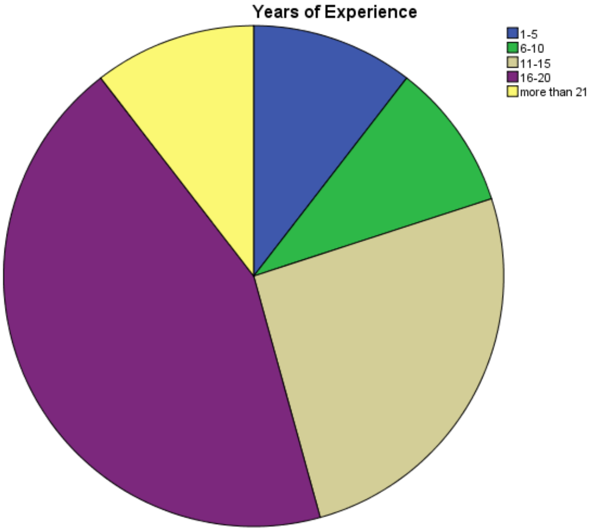
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	4	3.8	3.8	3.8
	Neutral	16	15.2	15.2	19.0
	Agree	57	54.3	54.3	73.3
	Strongly agree	28	26.7	26.7	100.0
	Total	105	100.0	100.0	

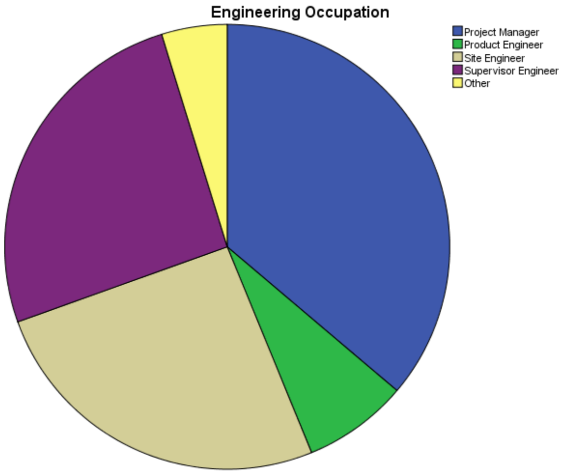
The assessment of issues in the management of smart manufacturing engineering requires giving careful thought and consideration to the actions associated with that management from a broad perspective.

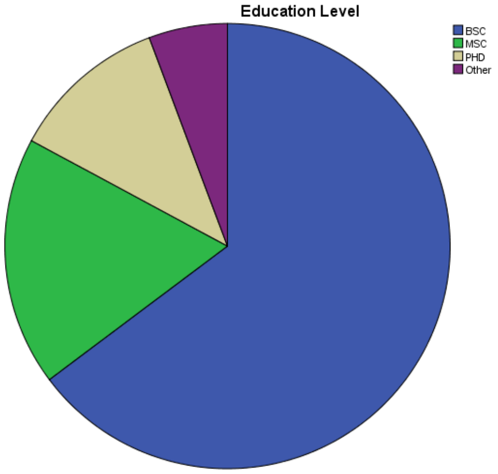
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	2.9	2.9	2.9
	Neutral	15	14.3	14.3	17.1
	Agree	64	61.0	61.0	78.1
	Strongly agree	23	21.9	21.9	100.0
	Total	105	100.0	100.0	

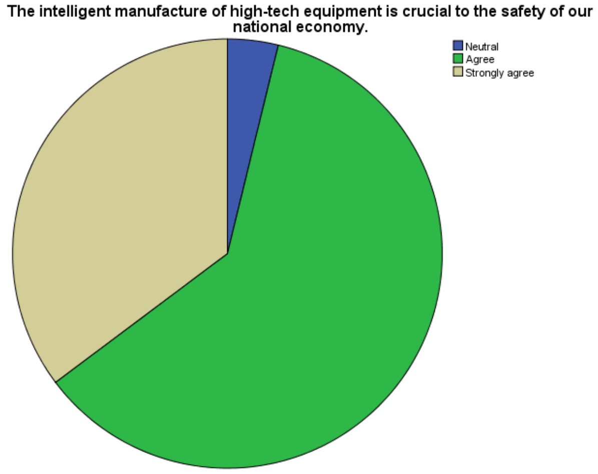
Pie Chart

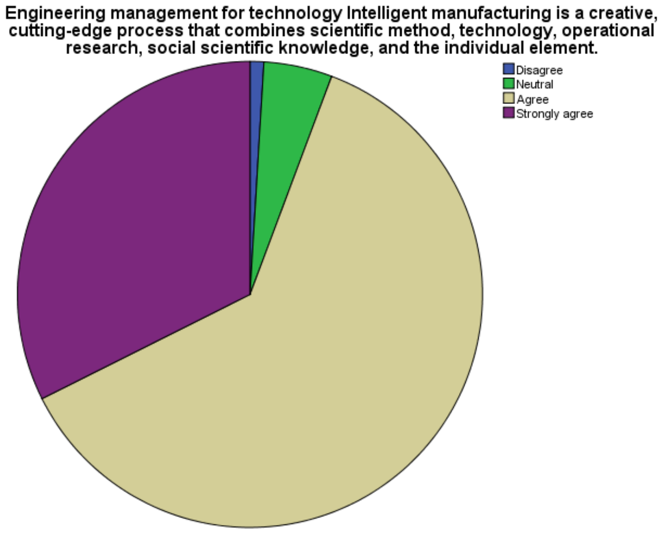


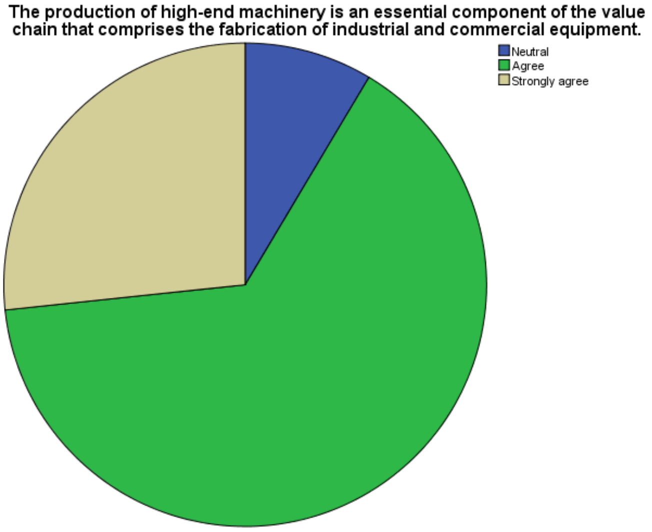


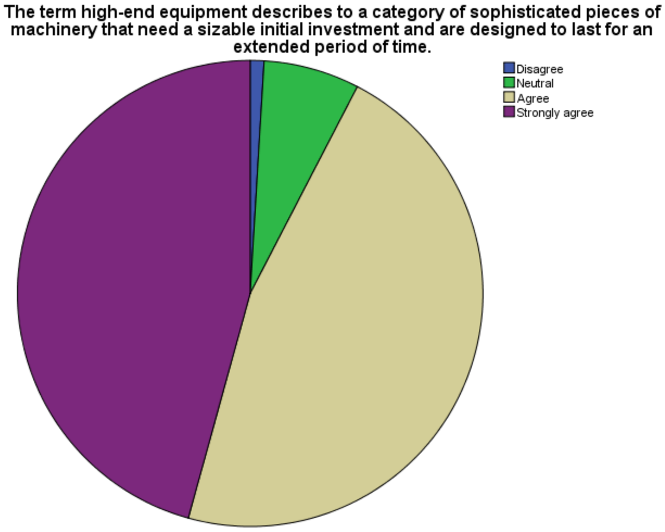

Engineering Occupation
Project Manager
Product Engineer
Site Engineer
Supervisor Engineer
Other

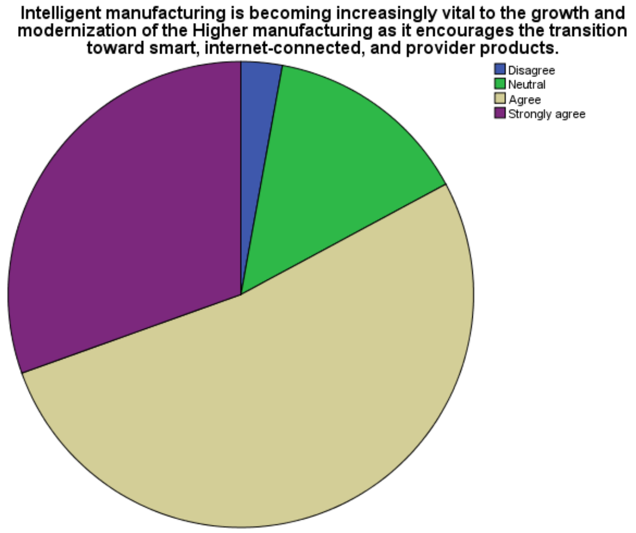

Education Level
BSC
MSC
PHD
Other

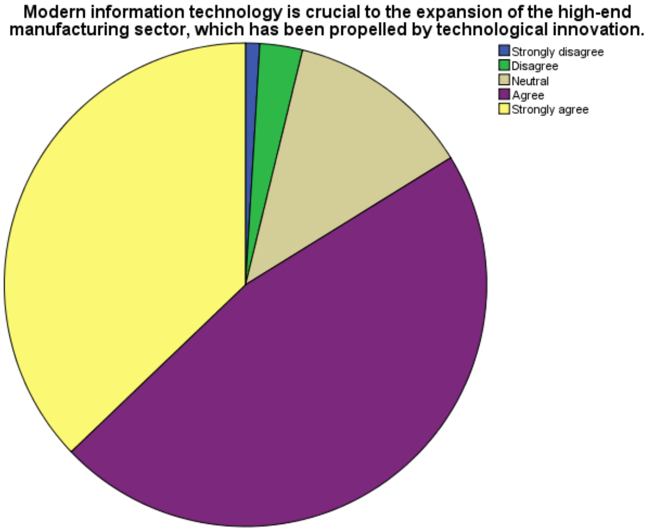

The intelligent manufacture of high-tech equipment is crucial to the safety of our national economy.
Neutral
Agree
Strongly agree

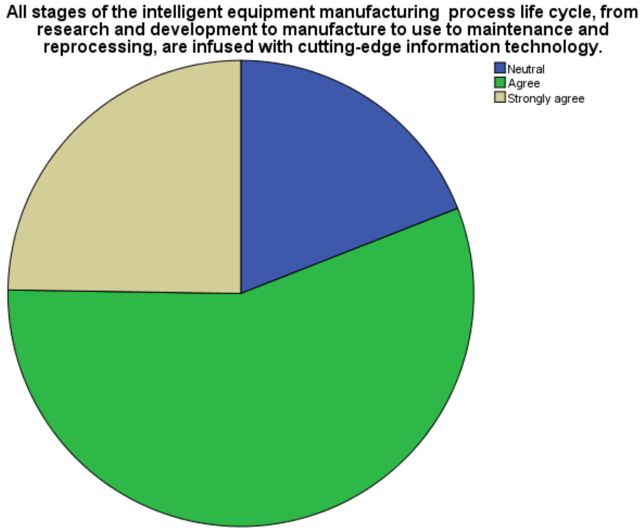

Engineering management for technology Intelligent manufacturing is a creative, cutting-edge process that combines scientific method, technology, operational research, social scientific knowledge, and the individual element.

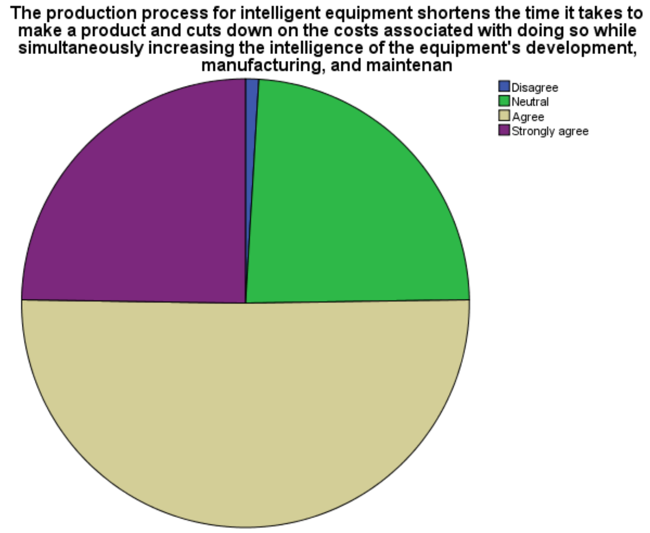

The production of high-end machinery is an essential component of the value chain that comprises the fabrication of industrial and commercial equipment.

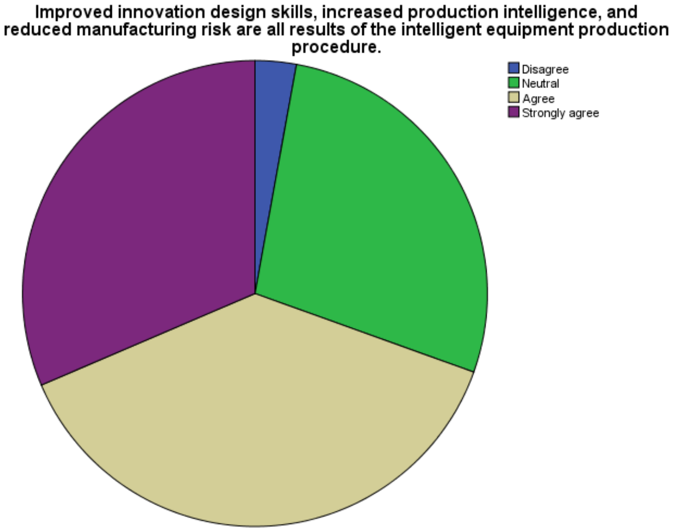

The term high-end equipment describes to a category of sophisticated pieces of machinery that need a sizable initial investment and are designed to last for an extended period of time.

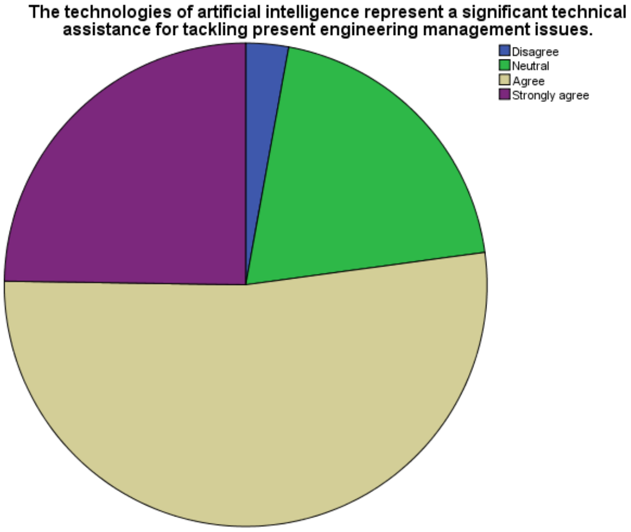

Intelligent manufacturing is becoming increasingly vital to the growth and modernization of the Higher manufacturing as it encourages the transition toward smart, internet-connected, and provider products.

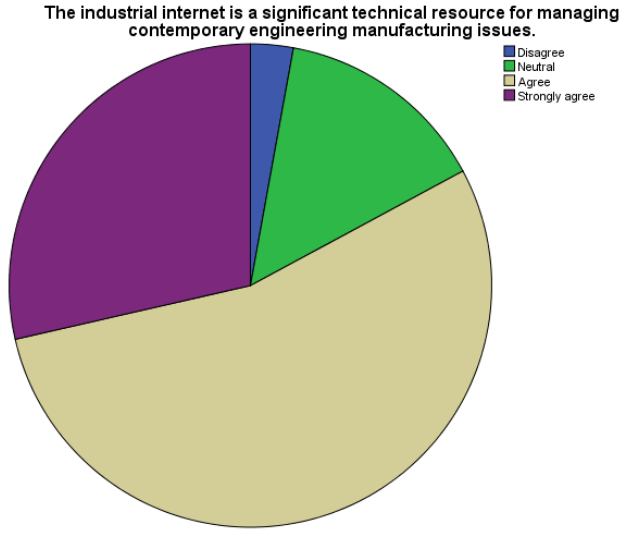

Modern information technology is crucial to the expansion of the high-end manufacturing sector, which has been propelled by technological innovation.


All stages of the intelligent equipment manufacturing process life cycle, from research and development to manufacture to use to maintenance and reprocessing, are infused with cutting-edge information technology.


The production process for intelligent equipment shortens the time it takes to make a product and cuts down on the costs associated with doing so while simultaneously increasing the intelligence of the equipment's development, manufacturing, and maintenan
Disagree
Neutral
Agree
Strongly agree


Improved innovation design skills, increased production intelligence, and reduced manufacturing risk are all results of the intelligent equipment production procedure.
Disagree
Neutral
Agree
Strongly agree


The technologies of artificial intelligence represent a significant technical assistance for tackling present engineering management issues.
Disagree
Neutral
Agree
Strongly agree


The industrial internet is a significant technical resource for managing contemporary engineering manufacturing issues.
Disagree
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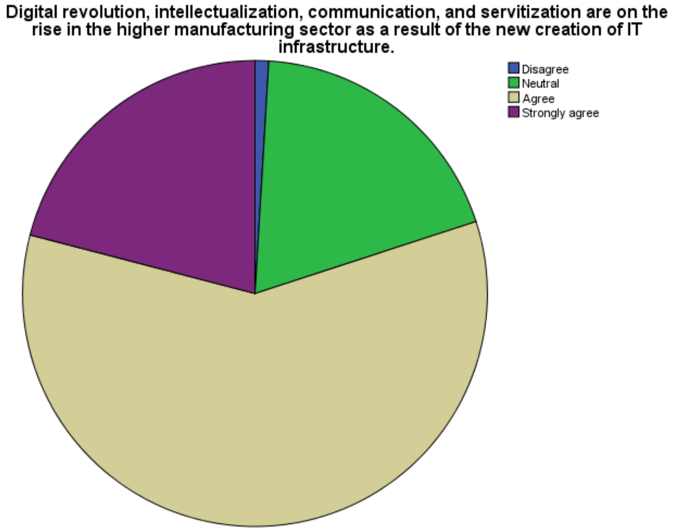
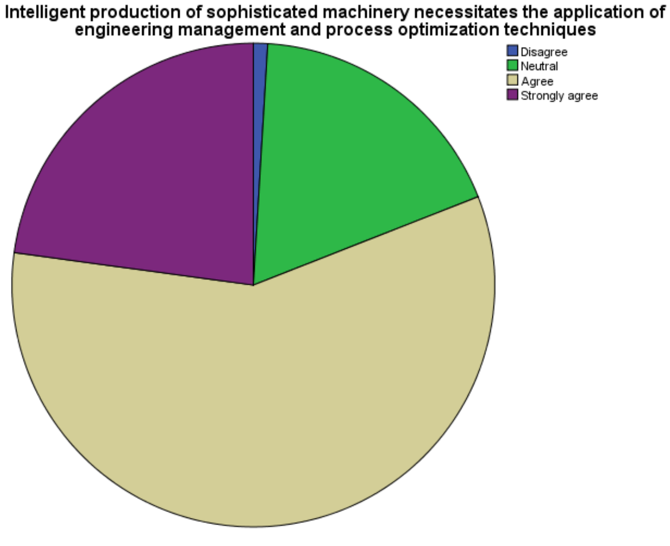
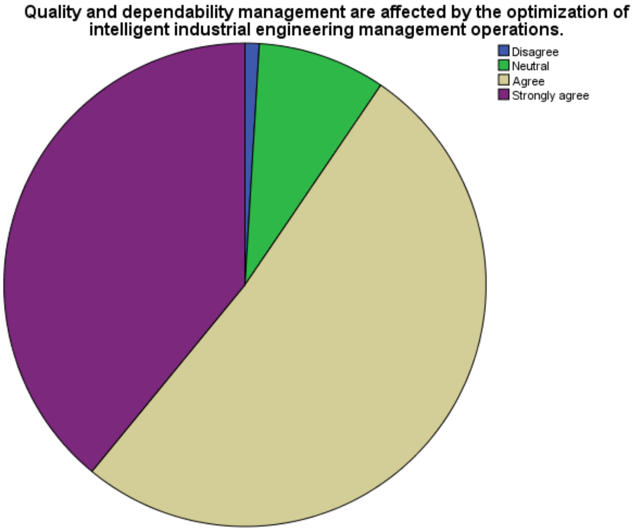
Agree
Strongly agree


Digital revolution, intellectualization, communication, and servitization are on the rise in the higher manufacturing sector as a result of the new creation of IT infrastructure.
Disagree
Neutral
Agree
Strongly agree


Intelligent production of sophisticated machinery necessitates the application of engineering management and process optimization techniques
Disagree
Neutral
Agree
Strongly agree


Quality and dependability management are affected by the optimization of intelligent industrial engineering management operations.
Disagree
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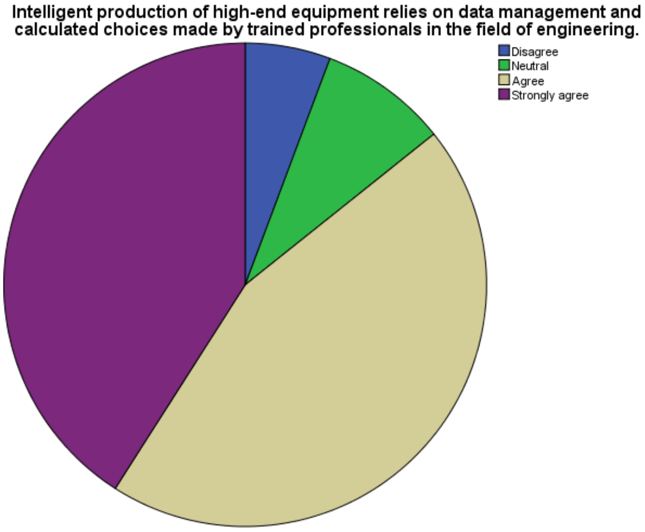
Agree
Strongly agree


Intelligent production of high-end equipment relies on data management and calculated choices made by trained professionals in the field of engineering.
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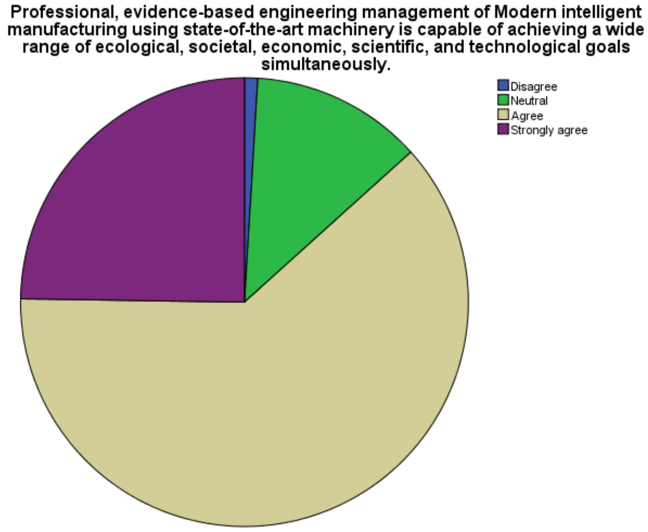
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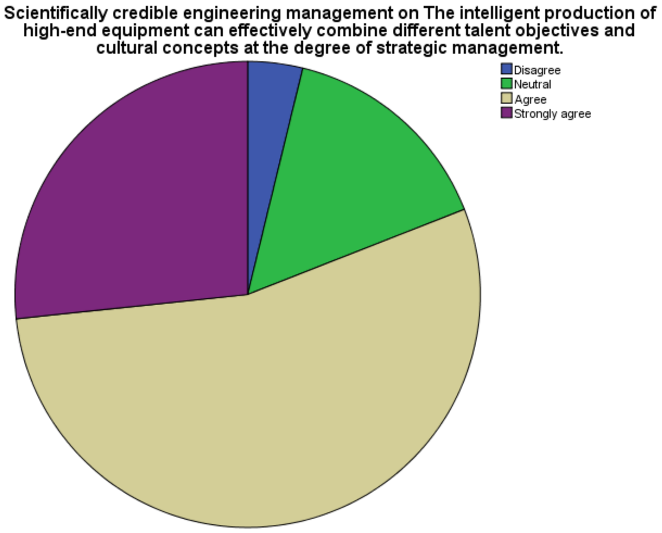
Scientifically credible engineering management on The intelligent production of high-end equipment can effectively combine different talent objectives and cultural concepts at the degree of strategic management.
Disagree
Neutral
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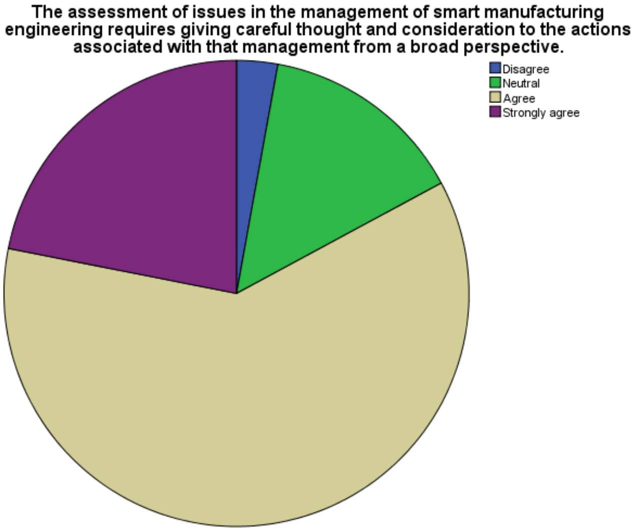
Strongly agree


The assessment of issues in the management of smart manufacturing engineering requires giving careful thought and consideration to the actions associated with that management from a broad perspective.
Disagree
Neutral
Agree
Strongly agree

RESUME

Dhafir Najim Abed

EDUCATION:

- **Master** 2021 – 2022 : Istanbul Gedik University - Engineering management master’s degree.
- **Bachelor** 2001 – 2006 : Al- Mustansiriyah University - Baghdad \Iraq B.SC Mechanical engineer.

LANGUGES:

- Arabic : Mother Tongue
- English: Proficient in Speaking and Writing.

SKILLS:

Ability to work under pressure, work with a team, positive attitude, self- directed and confident decision maker, strong work ethic, ability to prioritize, multitasked and exceptional management.

COMPUTER SKILLS:

- Computer Use
- Internet User
- Emails
- Microsoft office (Word, PowerPoint, Excel)
- Microsoft power BI
- Microsoft MS project
- Adobe (Photoshop, Illustrator, After Effects, Premiere)
- AUTOCAD
- primavera p6

COURSES & CERTIFICATE:

- Project Management Certificate.
- Healthy and Safety Induction Certificate.
- Primavera P6 Certificate (Basic Levels, Advance Levels).
- Principles of Project Management.
- Management for a Competitive Edge.
- Mining Engineering Certificate.
- Oil reservoir management.
- Feasibility Study in Project Management.

EXPERIENCE POSITION

1. Project managers.

2. Technical Office engineering.

3. Bids & contract management.

a) TECHNICAL PROPOSAL

- Execution Plan
- Quality Plan
- HSE Plan
- Risk Plan
- Warehousing, mater management, transportation. Logistics.

b) Commercial Proposal

4. planning & monitoring engineering.

5. Cost engineering.

- Cost Estimation and pricing.
- Cost Controlling.
- Contract and claims.

6. Invoices and payments management.

WORKS EXPERIENCE

1- (2020 – 2022)

Position: project manager.

Project: Developing electricity network(transformers, pols and cable) to center city.

Company: Wadiy AL-Eamre company Trade And General Contracting.

Clint: Karbala Governorate.

2. (2020 – 2021)

Position: project manager.

Project: Developing electricity network (transformers, pols and cable)to AL-handea district.

Company: Wadiy AL-Eamre company Trade And General Contracting.

Clint: Karbala Governorate.

3.(2018 – 2019)

Position: cost control engineer/ Planning Engineer.

Project: Water injection boosting station project.

Company: NOOR BAGHDAD & RAECO .

Clint: PetroChina International Iraq FZE Iraq Branch.

4.(2018 – 2019)

Position: cost control engineer/ Planning Engineer .

Project: brick wall project.

Company: NOOR BAGHDAD & RAECO .

Clint: PetroChina International Iraq FZE Iraq Branch.

5.(2017 – 2018)

Position: project manager.

Project: Staff camp project.

Company: RAECO .

Clint: PetroChina International Iraq FZE Iraq Branch

6.(2013 – 2015)

Position: Technical project manager.

Project: Abu Al Khasib sewer project.

Company: Pamposh Constructions India private limited .

Clint: Bl-Basra Governorate.

7.(2009 – 2010)

Position: QC.

Project: Tunnel Square Almuqatel Iraqi project.

Company: Albarajim company.

Clint: Baghdad Governorate.

8.(2007 – 2008)

Position: site engineer.

Project: Development of the south Baghdad gas power station.

Company: MEE company (American company).

Clint: Ministry of Electricity.