MANUFACTURING EXECUTION SYSTEM

MASTER'S DEGREE THESIS

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ABSTRACT

Today manufacturing units face several challenges, such as the growing complexity of their processes and supply networks, cost pressures, increasing customer expectations for quality, lead time, and customization. To gain a profitable production processes and improve competitiveness, many actions can be undertaken. Among them, one of the approaches is the deployment of information tools, to better manage and control the production process. Manufacturing execution system (MES) are the critical part that form a connecting link between the preceding and following in enterprise hierarchical structure. This project was carried out in GAI GIACOMO SRL. In this project the purpose is to evaluate the Manufacturing execution system practices of the employees working in the company. And to explore the relationship between the Manufacturing execution system and demographic characteristics of employees and firms. This project is conducted among 100 employees and results suggest that the status of Manufacturing execution system practices of the employees in the company. No significant relation between gender, marital status, dependents, age, nature of job, departments, position in the organization has a significant association with manufacturing execution system. Study also conducted to find out the association between firm demographical factors and MES of the employees it revealed that educational qualification and experience of the employees has a significant association between MES of the employees. Correlation analysis is done to find out whether the eight components selected are correlated significantly with each other. Multiple regression analysis was applied to identify the influences of eight components of MES on MES of employee. Through these analyses are performed to ensure that manufacturing operations are executed efficiently and improves output of production.

ACKNOWLEDGEMENT

An endeavor can be successful only when it is packed with proper guidance and blessings. I hereby take pleasure in acknowledging all those who have enabled us to complete this project. I express my sincere and humble thanks to Professor ELISA UGHETTO and Engineer DANIELE GAI, Professor and Head, DIGEP for creating an excellent learning atmosphere in the College. I express my sincere thanks to all other professors, university authorities, family and friends for there encouragement, guidance and support in every step of my project.

ATIF MUNIR

CHAPTER 1

Introduction

The Industrial Revolution began in Great Britain and was spread throughout the world quickly, which has different phases, started from goods crafting by hand or manual production and dominated by machine manufacturing units during the eighteenth century in Great Britain and spread throughout the world to modern era of digital and Internet technologies. Industrial Revolution as times passed the current revolution which is called industry 4.0. Industry 4.0 defines the organizations motivation and objectives.

A great challenge is represented by the Industry 4.0 for businesses in general and for SMEs. The study at hand will observe and document SMEs´ awareness, readiness and capability to meet this challenge. To study this further a part of industrial 4.0 is considered that is Manufacturing Execution Systems to study the improvement of the competitive priorities of companies. The framework on the information technologies (IT) and its business highlights, the contributions of the organizational factors for the implementation of the MES, the main concepts and the possible applications of this tool. The built theoretical framework was to subsidize the research performance in the studied company. The verification of MES significantly contributed to the manufacturing units are related to improvement of factors like cost, quality, flexibility, conformity and reliability. MES also enriches information quality generated in the plant floor, information that makes it fast, standardized, reliable and precise. When integrated to the Enterprise Resource Planning (ERP) of the company, the MES fills the gap, offering information to other functional areas of the organization. The interviews and surveys, were conducted in businesses departments in the company, showed the importance of the products tracking, and the MES implementation was decisive to improve that issue, concluding that the dimension is considered as a competitive priority of the manufacturing. Finally, analyzing the data which can be extracted after implementing the system and studying to which extent this data can be used for optimization to draw a conclusion.

1.1: Industrial Revolutions:

Industrial Revolutions that occurred about 200 years ago has major turning points in industrial development towards mankind. Industrial revolution impacted every industry and the way human beings lived and affected almost every aspect of their actions and functions in their businesses.

In the period of 1760 to 1830 first industry revolution occurred through the transition from manual work to the first manufacturing processes mostly in textile industry. An improved quality of life was a main driver of the change.

The Second Industrial Revolution began at the end of 19th century and 1st half of 20th century through discovery of electricity that enabled industries and mass production.

The Third Industrial Revolution which is also known as Digital Revolution, started in the 70s in the 20th century where microelectronics and automation was introduced. The main players in the initial phase are the US based IT and Internet companies. The manufacturing units facilitate flexible production, whereas variety of products is manufactured on the basis of flexible production lines with programming of machines. Such production systems still do not have flexibility towards production quantity.

The Fourth Industrial Revolution. Machines are characterized by the application of information and communication technologies to industry and is also known as "Industry 4.0". It builds on the developments of the Third Industrial Revolution. The consequence of this new technology for industrial production systems is reorganization of classical hierarchical automation systems to self-organizing cyber physical production system that allows flexible mass custom production and flexibility in production quantity.

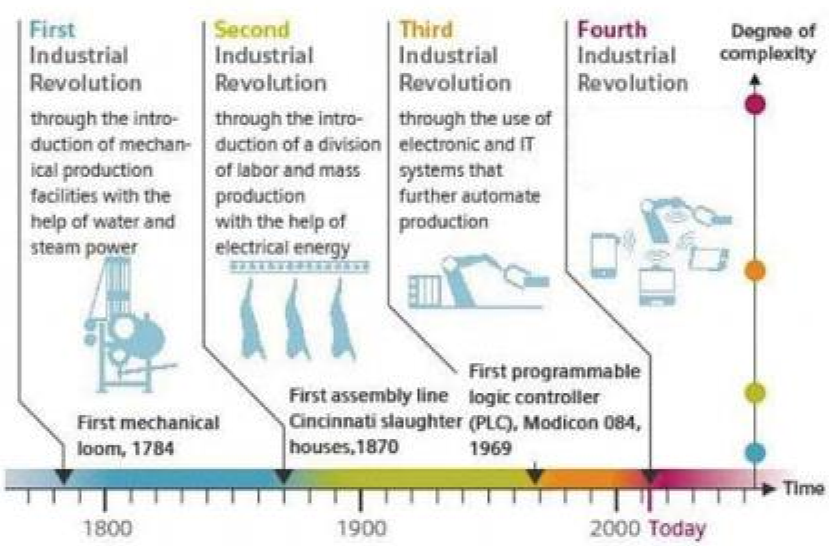


Figure 1: The industrial revolution

1.2 Introduction industry 4.0:

Traditional manufacturing industry has been accelerated through digital revolution (robots, 3D printing, sensors and other IT sources) across the world and competition has been increased globally so its compulsory for manufacturing units to adapt this change to remain the competitive in a globalized environment. The term used for the development and the management of the whole value chain in manufacturing industry is the "fourth industrial revolution" or "Industry 4.0". Now a days manufacturing and production system are attached with information technology support devices, because it's difficult to control the complex task in the manufacturing industry, the certain Information Technology at companies that transforms both working conditions and efficiency. The purpose of Industry 4.0 is to achieve improvements in terms of automation and operational efficiency and effectiveness.

The concept of the industry 4.0 was emerged last years due to technological advancements and the industrial revolution in the global industrial sector. The term "Industry 4.0" appeared firstly in an article published in November 2011 by the German government that resulted from an initiative regarding high-tech strategy. The concept depends on earlier concepts and perspectives that evolved over the years or evolved from third industrial revolution.

Industry 4.0 is an approach integrated to the business and manufacturing units, and integration of all actors in the company's value chain (suppliers and customers). Technical aspects of these requirements are addressed by the application of the generic concepts of Cyber-Physical Systems (CPS) and industrial Internet of Things (IoT) to the industrial production systems. The Industry 4.0 'execution system' is therefore based on the connections of CPS building blocks. These blocks are embedded systems with decentralized control and advanced connectivity that are collecting and exchanging real-time information with the goal of identifying, locating, tracking, monitoring and optimizing the production processes. Furthermore, an extensive software support based on decentralized and adapted versions of Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP) is needed for a seamless integration of manufacturing and business processes. The third important aspect is handling of a big amount of data collected from the processes, machines and products. Typically, the data is stored in a cloud storage. This data requires immense analytics that lead from the 'raw' data to the useful information and, finally to the concrete actions which support an adaptive and continuously self-optimizing industrial production process. Due to this significant transition for the position of a country in a global market, some government-led initiatives were introduced around the globe to support the transition. Industry 4.0, as the first such initiative and inspiration for other initiatives, comes from

Germany and will be addressed in detail in this paper. Similar concepts that were initiated in other countries are shortly presented in the continuation. The concept of Industrial Internet has been brought up in North America by the General Electric company in late 2012. It is seen as a tight integration of physical and digital worlds that combines big data analytics with the Internet of Things. The concept assumes a much broader application area as the Industry 4.0 and covers power generation and distribution, healthcare, manufacturing, public sector, transportation and mining. Within the Industrial Internet consortium that was founded by General Electrics and some other companies, it has been estimated that 46% of the global economy can benefit from the Industrial Internet. In France, the concept ‘Industrie du futur’ was introduced as a core of the future French industrial policy. It is based on cooperation of industry and science and built on five pillars. cutting edge technologies including additive manufacturing, virtual plant, IoT, and augmented reality, supporting the French companies, especially small to middle ones, to adapt to new technologies, extensive employees training, strengthening international cooperation around industrial standards and promotion of French industry of the future. Next similar initiative ‘Made in China 2025’ was introduced in 2015. It was initiated by the China Ministry of Industry and Information Technology in cooperation with many experts from the China Academy of Engineering. The main goal of this initiative is to comprehensively upgrade Chinese industry by drawing direct inspiration from Germany's Industry 4.0 concept and adapting it to the China needs. The transformed manufacturing should be innovation driven. Also, other elements like sustainable development and green energy are considered. Ten priority sectors were identified starting from information technology, robotics and automated machine tools. The long-term goals are to reform China manufacturing industry, to move from the high number of low-cost products to high-quality products and to take over Germany and Japan dominance in manufacturing until 2035, in order to evolve into the industry world superpower until 2049.In the fourth industrial revolution that was triggered by the development of Information and Communications Technologies (ICT). Its technological basis is smart automation of cyber-physical systems with decentralized control and advanced connectivity (IoT functionalities). The consequence of this new technology for industrial production systems is reorganization of classical hierarchical automation systems to self-organizing cyber physical production system that allows flexible mass custom production and flexibility in production quantity. 2.2 Origin of Industry 4.0 concept That the Industry 4.0 concept comes from Germany is not surprising, since Germany has one of the most competitive manufacturing industries in the world and is even a global leader in the sector of manufacturing equipment. Industry 4.0 is a strategic initiative of the German government that traditionally heavily supports development of the industrial sector. In this sense, Industry 4.0 can be seen also as an action towards sustaining Germany's position as one of the most influential countries in machinery and automotive manufacturing. The basic concept was first presented at the Hannover fair in the year 2011. Since its introduction, Industry 4.0 is in Germany a common discussion topic in research, academic and industry communities at many different occasions. The main idea is to exploit the potentials of new technologies and concepts such as availability and use of the internet and IoT, integration of technical processes and business processes in the companies, digital mapping and virtualization of the real world, 'Smart' factory including 'smart' means of industrial production and 'smart' products. Besides being the natural consequence of digitalization and new technologies, the introduction of Industry 4.0 is also connected with the fact that many up to now exploited possibilities for increasing the profit in the industrial manufacturing are almost exhausted and new possibilities must be found. Namely the production costs were lowered with introduction of just-in-time production, by adopting the concepts of lean production and especially by outsourcing production to countries with lower work costs. When it comes to the decreasing costs of industrial production, Industry 4.0 is a promising solution. According to some sources, Industry 4.0 factory could result in decrease of production costs by 10-30%, logistic costs by 10-30%, quality management costs by 10-20%. There are also several other advantages and reasons for the adoption of this concept including:

(1) a shorter time-to-market for the new products

(2) an improved customer responsiveness

(3) enabling a custom mass production without significantly increasing overall production costs,

(4) more flexible and friendlier working environment

(5) more efficient use of natural resources and energy.

The core process is digital to physical conversion in a reconfigurable manufacturing system. Reconfigurable manufacturing systems are the latest advance in the development of a manufacturing system. First step were fixed production lines with the machines dedicated to the performance of specific tasks so only one product could be produced. Next step were flexible production systems with programmable machines that allowed production of a variety of different products but offered no flexibility in the production capacity. As the results of the latest development are reconfigurable manufacturing systems able to adapt their hardware and software components to follow ever-changing market requirements of type and quantity of the products. Machines in Industry 4.0 factory are Cyber-Physical Systems, physical systems integrated with ICT components. They are autonomous systems that can make their own decisions based on machine learning algorithms and real-time data capture, analytics results, and recorded successful past behaviors. Typically, programmable machines (CNC and NC) are used, with a large share of mobile agents and robots able of self-organization and self-optimization.

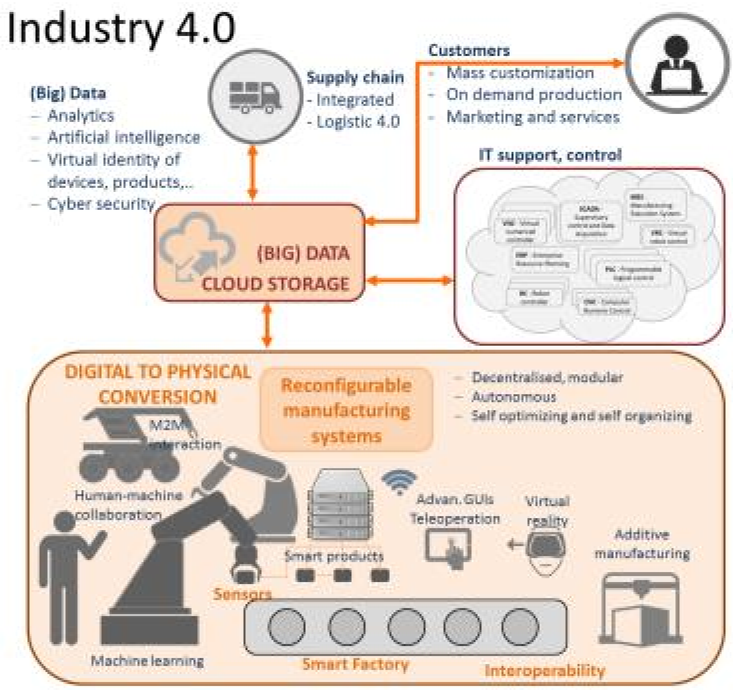


Fig. 2. Industry 4.0 smart factory

Products in such factory are also ‘smart’, with embedded sensorics that is used via wireless network for real-time data collection for localization, for measuring product state and environment conditions. Smart products also have control and processing capabilities. Thus, they can control their logistical path through the production and even control/optimize the production workflow that concerns them. Furthermore, smart products can monitor their own state during the whole life cycle, including during their lifetime/application. This enables proactive, condition-based maintenance that is especially valuable for products embedded in larger systems (like for example power converters in electric grids). In Industry 4.0, the production elements have beside their physical representation also virtual identity, a data object that is stored in the data cloud. Such virtual identity can include a variety of data and information about the product, from documents, to 3-D models, individual identifiers, current status data, history information and measurement/test data. Important elements of the Industry 4.0 concept are also interoperability and connectivity. A continuous flow of information between the devices and components, Machine-To-Machine interaction (M2M), manufacturing systems and actors should be established. Hereby the machines, products and factories can connect and communicate via the Industrial IoT (mostly based on wireless network). Another important topic is Human-To-Machine (H2M) collaboration that is necessary as some production tasks are too unstructured to be fully automatized. A lot of research effort is currently also invested in so called collaborative robotics. Here human workers and especially designed compliant robots work together in the execution of complex and unstructured work tasks at the manufacturing production line. Such tasks were done completely manually before. Advanced user interfaces are developed for new forms of M2H communication. They often include teleoperation and are based on augmented reality environments. Between the Industry 4.0 manufacturing technologies, additive manufacturing, such as 3D printing, is often mentioned as one of the key technologies. In combination with rapid prototyping methods including 3D modelling, a direct digital thread can be established from design to production, facilitating a shorter time from the idea to the product. Until now, however, additive manufacturing processes cannot always reach the same quality as a conventional industrial process and some new materials still need to be developed.

When considering the current state of the Industry 4.0, it is important to understand the preconditions that must be fulfilled so that a new concept can be introduced in industrial manufacturing system. At least the following must be fulfilled:

• Stability of the production must be guaranteed also during the transition phase.

• Stepwise investment should be possible as most of the industrial processes cannot bear big one-time investments.

• A good know-how protection is necessary. Closely connected is the cybersecurity issue. Furthermore, the industry concept is not limited just to the production system, but it includes the complete value chain (from suppliers to the customers of one enterprise towards the 'Connected Word' of all enterprises) and all enterprise's functions and services. It is not easy to fulfil these criteria, therefore only some 'islands' of the Industry 4.0 concept currently exist.

1.3 Manufacturing execution systems

MES was developed in 70s to assist the execution of production, with the concept of online management of activities on the shop floor. It bridges the gap in-between planning system (such as ERP) and controlling systems (such as sensors, PLCs) and uses the manufacturing information (such as equipment, resources and orders) to support manufacturing processes. Like any enterprise information systems tool, MES too has evolved with time to integrate several extensions to perform various manufacturing activities using the sophistication of the computer technology advancements. In the past, production departments of many companies preferred tailor-made information systems for the shop floor and were locally collecting the production data in spreadsheets or other databases, which made it difficult for software maintenance and data consolidation. MES was developed with a purpose to integrate multiple point systems and consequently software providers were able to package various production execution functions in the form of a MES software. However, the next generation manufacturing is in the need for process improvement by further leveraging automation tools and real-time systems to completely avoid the paperwork. This vision leads to the concept of smart factories (with industrial internet), where wireless technology and mobile information & communication technologies (ICT) become the key enablers for industrial internet. But such digitization in manufacturing is still at a nascent stage. The future factories will rely on real-time compliant software and ICT, where MES will have a greater role in smart factories than just providing features for manufacturing management Customers demanding less expensive, yet customized, products are driving manufacturers to make Industry 4.0 a reality. Fortunately, technology exists today that allows not only lower cost, but higher quality, faster processing, and shorter time to market for personalized products. The obvious technologies include the Internet of Things (IoT), mobile computing, cloud storage, software and service availability, big data, advanced analytics, machine learning, robotics and virtual and augmented reality (VR and AR). However, much like the nerves, limbs, and head of a person, these new technologies need a backbone connecting and coordinating them. The only way to guarantee quality, ensure productivity, manage cost, and have reliable delivery dates is with a manufacturing execution system (MES). The success of Industry 4.0 rests on a new generation of MES that is Industry 4.0 ready.

CHAPTER 2
COMPANY PROFILE

2.1 GAI GIACOMO SRL:

During the writing the thesis, the study was made in Gai Giacomo S.R.L during six months of internship with the following duties:

- Follow the implementation of the MES project.
- Collection and analysis of data generated by the system.
- Proposals for optimization and improvement.

The internship helped me a lot in this dissertation as it gave me the opportunity to study the hypothesis and to have a practical real-life case study. In a company which considered to be under the SMEs category.

2.2 The story of GAI GIACOMO SRL:

It was founded in 1967, GAI GIACOMO SRL is an automated turning shop able to offer its customers both specialized technical support and high-level production technologies. The characteristics that make the company a leader in its sector are: competence, more than 50 years of experience in the sector; sophisticated, cutting-edge technology, machinery and equipment; reliability, high technical profile and punctuality; flexibility, maximum efficiency for every kind of need, small, medium and large series.

GAI GIACOMO has consolidated its position internationally in the production of small precision metal parts from 3 mm diameter to 65 mm diameter based on the customer's design, thanks to the commitment, enthusiasm and competence shown in all these years.

The company operates on a total area of over 6,300 m2 and makes use of the collaboration of highly specialized and constantly updated technicians and staff. The careful research of the highest quality standard of the product has pushed the Company towards continuous technological innovations thanks to which it can now count on productive machinery and cutting-edge control instruments.

Recently company production takes place in two departments one is Gai Giacomo srl and other is Gai servizi which is also located on villarbasse via Rivoli 134 and company is producing for the following departments:

- AUTOMOTIVE
- OLEODINAMIC
- MEDICAL TECHNOLOGY
- COMMUNICATIONS
- NAVAL INDUSTRY
- HYDRAULICS
- PNEUMATIC
- BUILDING INDUSTRY OR CONSTRUCTION
- INDUSTRIAL ENGINEERING

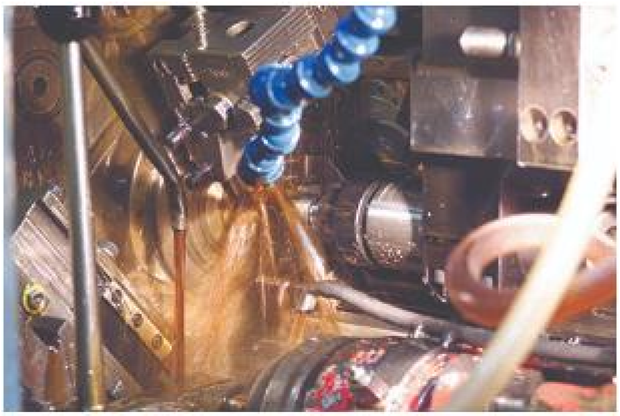
PRODUCTIONS

C.N.C Machines

CNC controlled machine which has double spindle with fixed head and sliding headstock with automated lathes bar which has 4 to 10 controlled axes with mechanical tools. These tools helps in highly precise and complex machining from diameter 3 mm to 65 mm machining capacity for small and medium production runs.

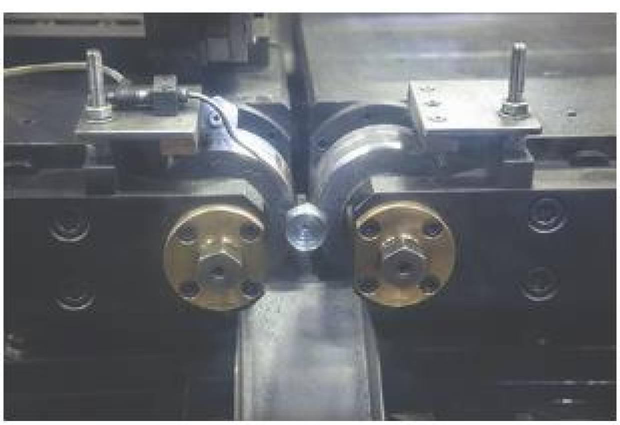
Multi spindle machines

Multi spindle machine is used for large production runs from 6mm to 42 mm. it contains automated bar lathes with six or eight mechanical spindles and CNC.



Secondary Machining and Finishing

A vigorous and technically suitable shop signifies or represents the ideal assistance for the finishing of some processes carried out in the company. Transfer, rolling machines, milling machines, drills and camera selection machines allow the definition and fine-tuning of the pieces made.



Treatments

Using the collaboration of qualified external suppliers, Gai Giacomo srl offers details finished with thermal and galvanic surface treatments, complete with external and internal adjustments, always according to the specifications requested by the customer.

CHAPTER 3

LITERATURE REVIEW

Most MES research papers report the construction of a single MES and rarely consider its interactions with multiple MESs that represent multiple shop floors. Now, collaborative business has become common and outsourcing functions in enterprises gradually play a significant role. Terms such as extended enterprises, contracting organisation and virtual enterprises have been originated for investigating the special cooperative behaviours among companies. One of the most productive and extensive approaches formalising the use of agents in manufacturing systems has been developed in the Holonic Manufacturing Systems (Valckenaers et al.1994), in the paper 'holon' is defined as the association of a software agent with a physical device or a set of physical devices. Although the cooperation of holons do not use either worldwide or consolidated procedures, their architecture maintains a hierarchical structure based on a functional decomposition. Multiagent architectures generally use hierarchical and heterarchical structures (Dilts et al. 1991, Leita˜o and Restivo 1999). In the hierarchical architecture, there are different levels of master–slave agent type relationships, in contrast heterarchical architecture, agents communicate as 'peer-to-peer' without a predefined master-slave relationship. Agents are locally autonomous and cooperate in a negotiation procedure which helps them to reach their objective. The advantages anticipated from heterarchical structures are their reduced complexity, increased modularity, scalability, and their intrinsic robustness and fault tolerance. When there is a need only then decisions can be made locally. The PABADIS project (Plant Automation Based on Distributed Systems) (PABADIS Group 2001, Diepet al. 2003) aims at developing an MES based and a networked adaptable manufacturing system and designed according to a distributed and de-centralised framework and executed with autonomous agents. It addresses flexible manufacturing units with small production batches and will enable future plants to be highly reactive to an unstable market. Holons are also used in a MES architecture dedicated to pile of customised manufacturing (Simao et al. 2006). SEMATECH (SEMATECH Inc. 1998) is another open framework for the incorporation of MES running in semiconductor industries and focused on the control at the shop level of manufacturing systems. It integrates basic manufacturing functionalities at the factory engineering level, which comprise product design, process planning and material requirement planning (Harhalakis et al. 1994, 1995). It comes along with analysis and design tools constructed usig UML diagrams and Petri nets (Lin et al. 2005, Lin and Jeng 2006). In the same frame of thought, we can have a talk about NIIIPSMART (Barry et al. 1998) architecture design with a standards-oriented configurable object model that represents the manifold exposure of MES in order to reduce design costs, or Open MES (Hori et al. 1999) which is basically an object-oriented framework with a modular organisation to attain open connectivity not only with other software systems, but also with manufacturing devices.

Sl No	Title	Author	Country	Method	Results
1	Manufacturing execution system-a literature review	B. Saenz de Ugartea, A. Artibab and R. Pellerina	France	Literature review	This article aspires to narrate what MES have become, present their relationships with other enterprise information systems, and to point out major issues related to MES. In this paper authors have discussed research areas that need to be explored in order to resolve the increased complexity of execution systems and to carry out the continuing customer needs for faster real-time response and expanded functionality coverage.
2	An Overview of Next-generation Manufacturing Execution Systems: How important is MES for Industry 4.0	Soujanya Mantravadi,Charles Møller	Denmark	Survey	This paper provide mapping for the current MES research pertaining to Industry 4.0 into key groups to highlight its significance in digital manufacturing.
3	Smart Manufacturing Execution Systems for Small	Sherwin Menezes,Savio Creado,Ray Y. Zhong	New Zealand	Literature review	A case study indicates the feasibility and practicality of the designed and developed system.

	and Medium-sized Enterprises				
4	A business repository enrichment process: A case study for manufacturing execution systems	Ikbal Arab-Mansour,Pierre-Alain Millet,Valérie Botta-Genoulaz	France	Survey	With the use of multiple applications and driven by business processes. Through the study of semantic heterogeneities, in this survey we have used enrichment-based alignment for business applied to ISO/IEC 62264.Ultimately, we evaluate the contribution of this approach to enterprise maturity in the application of standards and reference models
5	Implementation of a Message-driven Manufacturing Execution Workflow System	Meilin Wang,Jarvis N. Jiang,Jiao Wang	China	Survey	This paper proposed a mechanism for message-driven manufacturing execution workflow. This mechanism packages the tasks generated in the MES through the custom Manufacturing Transaction Protocol(MTP) and Instant Messaging Protocol (IMP) and sends them to the process participants in the IMC to drive the execution of the whole process .On the one hand, the mechanism can merge with ERP to improve the efficiency of business processing .On the other hand ,as a workflow product, it can solve the business diversity or reconstruction problems that occur in enterprises.

6	Manufacturing Execution Through e-FACTORY System	E. Tekin, A. Köksal	Turkey	Literature review	This paper provides a Manufacturing Execution System (e-Factory) developed to integrate manufacturing engineering, procurement, production planning, manufacturing and quality functions. e-Factory System supports the production devising process. The main input of this process is data related with the three dimensions of Production. “Product Data”, “Project Parameters” and “Plant Data”.
7	Manufacturing execution systems: A vision for managing software development	Martin Naedele, Hong-Mei Chen, Rick Kazman, Yuanfang Cai, Lu Xiao,Carlos V.A. Silva	USA	Survey	This paper, introduced the principles and functional areas of a MES. We then examine the gaps between MES-vision driven software development and current practices. These gaps comprise of: 1. Lack of a unified data collection infrastructure 2. Lack of integrated people data 3. Lack of common conceptual frameworks driving improvement loops from development data, 4. Lack of support for projection and simulation. 5. Finally, we illustrate the feasibility of leveraging MES principles to manage software development, with the use of Modularity Debt Management Decision Support System prototype developed.

8	The Industry 4.0 revolution and the future of Manufacturing Execution Systems (MES)	Francisco Almada-Lobo	USA	Literature review	Industry 4.0 dictates the end of conventional centralized applications for production control. Its sight of ecosystems of smart factories with sharp and autonomous shop-floor entities is inherently decentralized. Responding to customer demands for tailored products, these plants charged by technology enablers such as 3D printing, Internet of Things, Cloud computing, Mobile Devices and Big Data, between others create a totally new environment. The manufacturing systems of the future, covering manufacturing execution systems (MES) will have to be built to support this model shift.
9	TOWARDS COOPERATING PLANNING ANDMANUFAC TURING EXECUTION SYSTEMS	Paul Verstraete, Paul Valckenaers	Belgium	Survey	This paper proposes holonic manufacturing execution system that collaborate with a planning system. This collaboration allows to integrate the robustness and flexibility of the holonic MES with the optimization performed by the planning system. The Holonic MES is implemented as a situated multi-agent system.
10	A critical review of manufacturing & Industry4.0 maturity models : Implications For Small And medium-sized enterprises (SMEs)	Sameer Mittal, Muztoba Ahmad Khan, David Romero, Thorsten Wuest	USA	literature review	The main objective of this paper is to critically review currently available Smart Manufacturing (SM) and Industry 4.0 maturity models, and evaluate their fit recognizing the specific requirements of Small and Medium-sized Enterprises (SMEs). To this end, this paper provides features that are characteristic for SMEs and identify research limits needed to be addressed to successfully support manufacturing SMEs in their progress towards Industry 4.0.

11	Part data integration in the Shop Floor Digital Twin: Mobile and cloud technologies to enable a manufacturing execution system	Pedro Daniel Urbina Coronado, Roby Lynn, Wafa Louhichi, Mahmoud Parto, Ethan Wescoat, Thomas Kurfess	USA	Survey	This survey is essential to realizing a complete digital model of the shop floor, known as the Shop Floor Digital Twin, that can be used for production control and optimization.
12	Cyber-physical production systems retrofitting in context of industry 4.0	Theo Lins , Ricardo Augusto Rabelo Oliveira	Brazil	literature review	This paper described, the standardization of the retrofitting process to transform old equipment into a CPPS. The standardization is done with the support of a platform that has features to work independently of the model or type of equipment provided. To implement the proposed platform, we define the requirements, components, and technologies necessary to retrofit industrial equipment. The entire process is based on Reference Architectural Model for Industry 4.0 (RAMI 4.0) an extensive architecture of Industry 4.0
13	Implementation of the Manufacturing Execution System in the food and beverage industry	Xinyu Chen, Tobias Voigt	Germany	literature review	This study intends to present the characteristics of the food and beverage manufacturing process, analyze the prospective benefits and hurdles of the MES implementation in the food and beverage industry through literature review. The solutions to solve the MES implementation issues and the research areas that need to be examined in order to meet the MES requirements from the food and beverage industry are also discussed in this study.
14	A Conceptual Model of Smart Manufacturing Execution System	Tae Hyun Kima, Jongpil Jeongb, Yeasang Kim	Korea	literature review	This article, will introduce a new design of state of the art smart MES (or S-MES) for rolling stock manufacturer by collaborating various

	for Rolling Stock Manufacturer				functions and To-Be model is provided for comparison with As-Is model.
15	Manufacturing execution systems: A vision for managing software development	Martin Naedele,Hong-Mei Chen, Rick Kazman,Yuanfang Cai, Lu Xiao,Carlos V.A. Silva	USA	Survey	The manufacturing concept, it highlighted the use of the feedback principles of system dynamics to structure and simplify the complex web of dynamically interacting variables that influence management decisions (Abdel-Hami and Madnick, 1991). This paper takes the scheme of learning from manufacturing one step further: to directly adapt the principles of a manufacturing execution system (MES) to software engineering. We claim, it will help to manage and expand the predictability of software development by more fully integrating information, and will provide a base for automated tool support for improved decision.

CHAPTER 4

RESEARCH DESIGN

4.1 PROBLEM DEFINITION

Today manufacturing units face several challenges, such as the growing complexity of their processes and supply networks, cost pressures, increasing customer expectations for quality, lead time, and customization. To gain a profitable production processes and improve competitiveness, many actions can be undertaken. Among them, one of the approaches is the deployment of information tools, to better manage and control the production process. Manufacturing execution system (MES) is an information system comprise with a critical part that forming a connecting link between the preceding and following in enterprise hierarchical structure.

4.2 OBJECTIVE OF THE STUDY

The objectives of this study are as follows:

- Identifying the different Indicators Leading to MES.
- To Develop a comprehensive reliable and valid MES questionnaire to assess the level of MES practices at the workplace.
- To investigate the relationship between the MES with the demographic characteristics of Employees.
- To investigate the relationship between MES and components of MES.

4.3. SCOPE OF THE STUDY

The scope of the study is that the research is confined to Gai Giacomo Srl. The company profile is discussed in Chapter 2.

4.4. RESEARCH DESIGN

A research design is a logical and systematic plan prepared for directing the research study. Its specific to the objective of the study, methodology and techniques to be adopted for achieving the objectives. It constitutes blueprint for the collection, measurement and analysis of data. It is a planned structure and strategy for investigation program of research. A research design is the program that guides the investigator in the process of collecting, analysing and interpreting the observation. It provides a systematic plan of procedure for the researcher to follow.

CHAPTER 5

METHODOLOGY

5.1. IDENTIFY THE COMPONENTS:

The extensive literature survey has been carried out. About 15 research papers on MES study has been collected and the various indicators by the different researchers has been observed and based on the frequency of repeated components 8 indicators are chosen for this study. The components chosen as shown in the Table 4.1. Initially a draft instrument covering the areas has been designed and discussed with MES experts, HR Managers and Project Guide about validity of the instrument and finally the final MES measuring instrument has been designed.

Table 5.1: MES Components

COMPONENT NUMBER	COMPONENT
TM	TOP MANAGEMENT AND COMMITMENT
ET	EDUCATION AND TRAINING
HRM	HUMAN RESOURCE AND TRANING
CF	CUSTOMER FOCUS AND TRAINING
SQM	SUPPLIER QUALITY MANAGEMENT
PM	PROCESS MANAGEMENT
CI	CONTINOUS IMPROVEMENT
TQM	TOTAL QUALITY MANAGEMENT

5.2.DESIGN OF MES MEASURING INSTRUMENT

Based on the literature survey and the instrument has been taken as reference and modified to suit the local condition. The final structured questionnaire was prepared by incorporating some qualitative modification based on the feedbacks of the safety experts and internal guide. The questionnaire was designed in English language. The structured questionnaire for this study is "close ended" by nature. This questionnaire had following 2 important elements:

1. Employees demographic information
2. Employees perception towards MES

Each section has multiple questions to cover different parameters with a 5-point Likert scale with "1" being "strongly disagree" and "5" being "strongly agree". The questionnaire consists of 9 demographic parameters of employees and 40 questions on MES components.

5.4 DATA COLLECTION

The questionnaire was distributed to 120 employees after explaining the purpose of study and requested them to fill the questionnaire without any biasing about their opinion on various MES systems and practices. Out of 120 employees 106 were returned out of which 6 questionnaires were not having full information and hence they are omitted from the study from further analysis. The data was segregated and fed in MS Excel software for further analysis.

CHAPTER 6

HYPOTHESIS

Framework of MES and workplace structure was developed and relevant hypothesis for the present research was prepared by considering the research objectives. The section below shows the formulated research hypotheses.

Cooper and Schindler described the purpose of hypothesis testing is to determine the correctness of the study, since the researchers have collected a sample of data, not a census.

6.1 Hypothesis for Manufacturing execution systems and Demographical factors of employees:

Hypothesis H01a: There is no significant relation between MES and Gender.

Hypothesis H01b: There is no significant relation between MES and Marital Status

Hypothesis H01c: There is no significant relation between MES and Dependents

Hypothesis H01d: There is no significant relation between MES and Qualification

Hypothesis H01e: There is no significant relation between MES and Age

Hypothesis H01f: There is no significant relation between MES and Position

Hypothesis H01g: There is no significant relation between MES and Nature of Job

Hypothesis H01h : There is no significant relation between MES and Total Experience

Hypothesis H01i: There is no significant relation between MES and Departments

6.2 Association between demographical factors of employees and Manufacturing executions of systems of employees

To find out the association between demographical factors of employees and MES, ten hypotheses H_01_a, H_01_b, H_01_c, H_01_d, H_01_e, H_01_f, H_01_g, H_01_h, H01i, and H01j were setteled. Using Chi Square analysis, hypothesis was tested for independency. The employees were classified into satisfied and unsatisfied based on their perception towards MES for all demographical characteristics and alike is presented in Table. Further, the values of χ^2 and their importance levels (if significant) for testing the association between MES along with demographic characteristics of employees are also shown as follows:

Table 6.1 Relationship between Demographical Factors of employees and Manufacturing Execution System Based on employees.

Sl No	Demographical Factors of Employees		Status of MES		χ^2 Table Value	χ^2 Calculated Value	P value	Significance Level
			Satisfied	Unsatisfied				
1	Gender	Male	50	43	3.84	0.532	0.466	NS
		Female	4	3				
2	Marital Status	Married	11	18	3.84	0.424	0.515	NS
		Unmarried	43	38				
4	Qualification	ITI	4	3	9.49	10.414	0.034	5%
		Diploma	13	13				
		Graduate	29	27				
		PG	8	3				
		Others	4	3				
5	Age group	18-30Years	12	19	7.82	6.067	0.108	NS
		31-40Years	24	13				
		41-50Years	6	4				
		More than 50Years	12	10				
6	Position in the organization	Worker	31	22	7.82	7.398	0.060	NS
		Supervisor	7	6				
		Middle Management	8	10				

		HOD	8	8				
7	Nature of job	Office job	24	18	7.82	1.919	0.589	NS
		Site job	16	22				
		Both a&b	4	2				
		Prod job	12	2				
8	Experience	Less than 5Years	27	32	7.82	9.175	0.027	5%
		6-10Years	11	6				
		11-20Years	10	3				
		More than 20Years	7	5				
9	Department	Production	9	6	7.82	6.566	0.000	NS
		Maintenance	2	3				
		HR	14	4				
		Others	29	33				

6.3 INFERENCES

1. Employee's gender ($p>0.005$, χ^2 calculated < χ^2 table) and marital status ($p>0.005$, χ^2 calculated < χ^2 table) of the employees is not associated with the manufacturing execution of systems. This shows MES is independent of gender and marital status of employees
2. Qualification of the employees ($p>0.005$, χ^2 calculated > χ^2 table) has a significant association with MES of the employees. Manufacturing executions of systems of employees is dependent on Qualification of the employees.

3. Age ($p>0.005$, χ^2 calculated < χ^2 table), Position in the Organisation ($p>0.005$, χ^2 calculated < χ^2 table), nature of the job ($p>0.005$, χ^2 calculated < χ^2 table) and departments($p>0.005$, χ^2calculated < χ^2 table) of the employees is not associated with the manufacturing execution of systems. That is MES is independent of age, position in the organization, job nature of the employees, departments.
4. Experience of employees ($p>0.005$, χ^2calculated > χ^2 table) has a significant association with MES of the employees. Manufacturing execution of systems of employees is conditional on experience of the employees.

   Status of MES of employees is dependent on qualification and experience.

CHAPTER 7

DATA ANALYSIS

This chapter presents the analysis of the information collected from 100 employees from Gai Giacomo SRL on different demographic characteristics of the employees. The status of MES depends on employee demographical characteristics. Employee demographical characteristics include gender, marital status, dependents, age, education, experience, departments etc. Hence an attempt is made in this chapter to present a profile of the respondents of the sample in terms of demographical characteristics.

Statistical Tools

It is very important to ensure that the data collected for research analysis are correctly coded. To ensure the same, data was fed to the computer with the help of a well-structured data entry format. Once the data entry was completed, random checks were made to the entries to find out whether the data was entered correctly or not. After editing, the entire data was transferred to MiniTab 14 for further data processing and analysis. Simple statistical techniques such as percentages, average, etc were applied to analyse the quantitative data.

The data was screened in order to study about the perception of employees towards MES. Inferences, results and conclusion have been drawn out from the analysis of data. The following analysis has been used in the study to obtain results from data analysis.

Percentage Analysis: One of the straightforward procedures of data analysis is the percentage analysis procedure. It is one of the most important traditional statistical tools. By using this procedure, data are lessening in the standard form with the base equal to 100, which provides an easy comparison.

Chi Square Test: In statistics learning, a likelihood ratio test is a statistical test used to differentiate the fit of two models, one of which (the null model) is a special case of the other (the alternative model). The chi square test is built on the probability ratio, which indicates how many times more likely the data are under one model than the other.

Pearson's Correlation Coefficient: Correlation analysis is an approach for investigating the relationship between two quantitative, continuous items, usually labelled as X and Y. In correlation analysis the emphasis is on the degree to which a linear model may represent the association between two items. The Pearson's correlation coefficient (r) may take on any value between +1 to -1.

The sign of the Pearson's correlation coefficient (+, -) interprets the direction of the relationship, either positive or negative. Positive Pearson's correlation coefficient means that as the value of one variable increases, the value of the other variable also increases as one decreases the other also decreases. A negative Pearson's correlation coefficient specifies that as one variable increases, the other decreases, and vice-versa.

Multiple regression analysis: The basic purpose of multiple regressions is to learn more about the relationship between various independent and dependent variable. The multiple regression based on analysing the three or more variables, one is dependent and two or more independent variables. Conventionally, the degree to which two or more independent variables are related to the dependent variable is revealed as the correlation coefficient R. In multiple regressions, R can presume values between 0 and 1. To clarify the direction of the relationship between variables, have a look at the signs (plus or minus) of the regression or beta coefficient. If beta coefficient is positive, then the relationship of this variable with the dependent variable is positive; if the B coefficient is negative then the relationship is negative. Certainly, if the B coefficient is equal to 0, then no relationship exists between the variable.

7.1 STATUS OF MES WITH RESPECT TO GENDER

The gender of an employee is always considered as one of the important variables and Based on gender, respondents are classified into two groups. Table below presents The Gender wise distribution of surveyed employees.

TABLE 7.1 showing the satisfactory level of different gender

GENDER		
GENDER	SATISFIED	UNSATISFIED
MALE	50	43
FEMALE	4	3

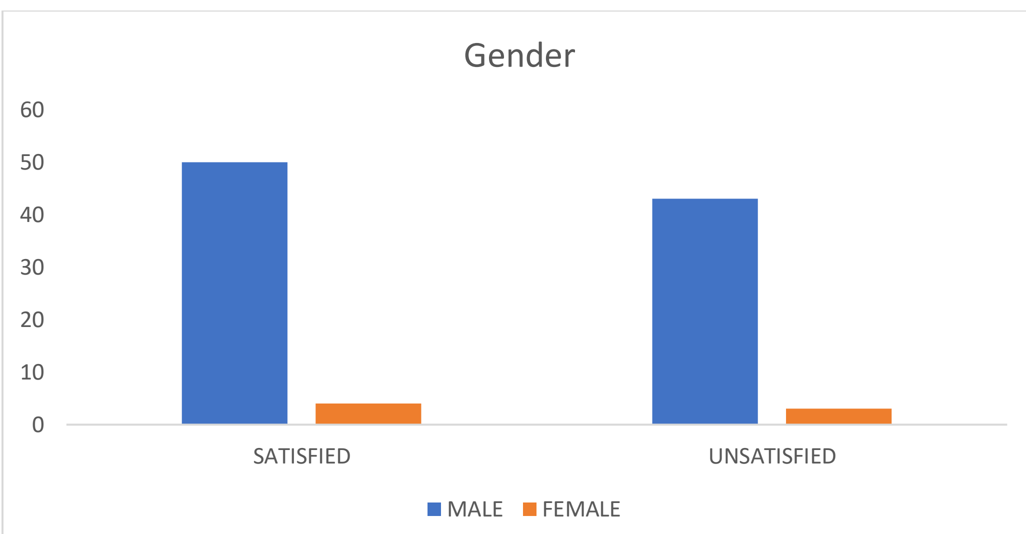


FIGURE 7.1 showing the satisfactory level of different gender

Analysis: From the above Table 7.1 it is evident that, out of 100 employees, 93 of the male employees and only 7 female employees considered in this survey. It is found that 54% of the male and 57% of female employees are satisfied with the present status of MES practices.

Whereas 46% of male and 43% of female employees are unsatisfied with present status of MES practices.

Interpretation: From the above analysis it can be inferred that male employees are more satisfied with the present status of MES practices compared to the female employees.

7.2 STATUS OF MES WITH RESPECT TO MARITAL STATUS

The marital status of an employee is always considered as one of the important factors and based on marital status, respondents are classified into two groups. Table below presents the marital status of surveyed employees.

TABLE 7.2 status of MES based on marital status

MARTIAL STATUS		
STATUS	SATISFIED	UNSATISFIED
MARRIED	11	18
UNMARRIED	43	38

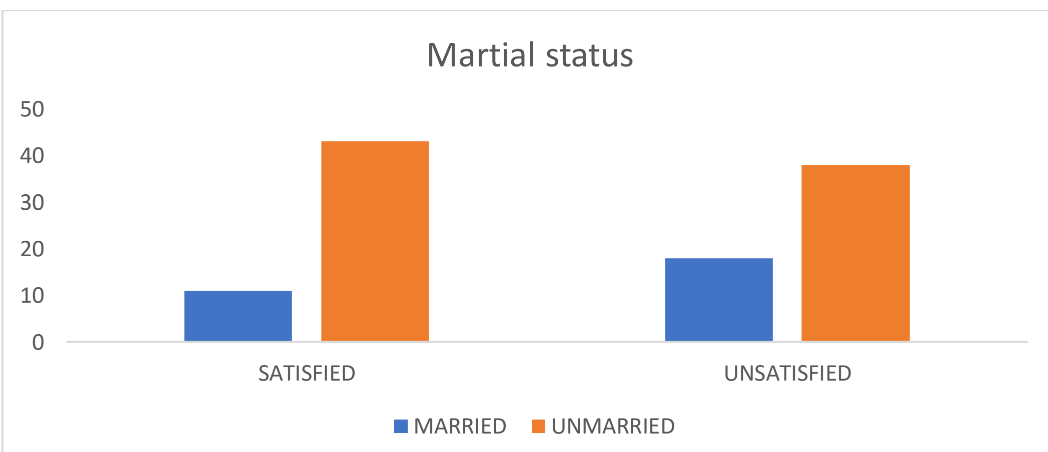


FIGURE 7.2 status of MES based on marital status

Analysis: From the above Table 7.2 it is found that, out of 100 employees, 29 are married and 71 are unmarried employees in the surveyed population. From which 38% of married and 61% of unmarried employees are satisfied with the present status of MES practices. Whereas 62% of married and 39% of unmarried employees are unsatisfied with the present status of MES practices.

Interpretation: From the above analysis it can be inferred that unmarried employees are more satisfied than married employees with the present status of MES practices.

7.3 STATUS OF MES WITH RESPECT TO THE NUMBER OF DEPENDENTS OF EMPLOYEES

Based on Dependents, employees are classified into four groups. Table below shows the distribution of respondents based on the dependents.

TABLE 7.3 status of MES based on dependent of employees

DEPENDENTS		
DEPENDENT	SATISFIED	UNSATISFIED
NIL	30	20
1-2 DPNDS	24	26
3-4 DPNDS	0	0
5+ DPNDS	0	0

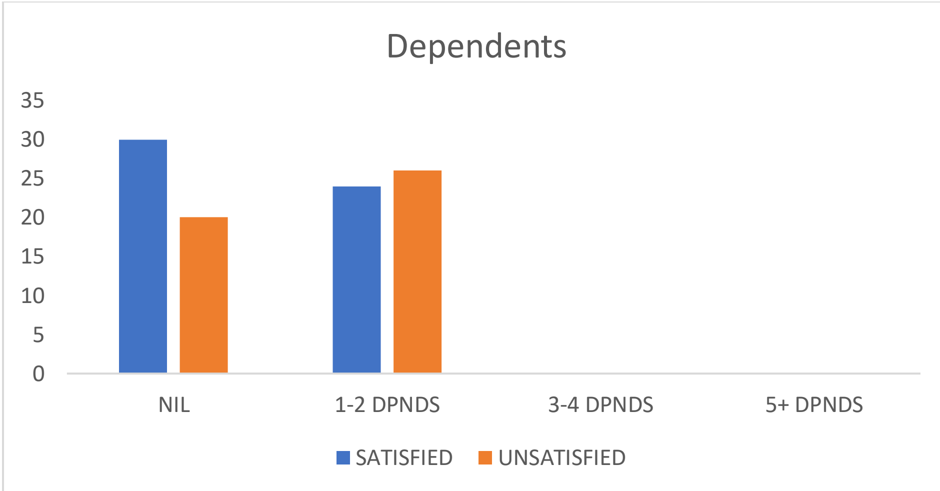


FIGURE 7.3 status of BBS based on dependent of employees

Analysis: From the above table 7.3, out of 100 employees, only 50 employees have no dependents, 50 employees have 1-2 dependents, No employees have 3-4 dependents and employees have 5 and above dependents .In which 25% of No dependents, 55% of 1-2 dependents, 52% of 3-4 dependents, 80% of 5 and above dependent employees are satisfied with the status of BBS practices. Whereas 60% of No dependents, 48% of 1-2 dependents, employees are satisfied with the status of MES practices.

Interpretation: From the above analysis it can be inferred that maximum employees who have no dependent employees are more satisfied of MES practices.

7.4 STATUS OF MES WITH RESPECT TO THE EDUCATIONAL QUALIFICATION

Educations enrich skill, ability and effectiveness of the employees. Respondents are classified into five groups on basis of their Educational qualification. Table below shows the distribution of respondents based on their educational qualification.

TABLE 7.4 status of MES based on educational qualification

EDUCATIONAL QUALIFICATION		
QULIFICATION	SATISFIED	UNSATISFIED
ITI	4	3
DIPLOMA	13	13
GRADUATE	29	27
PG	8	3

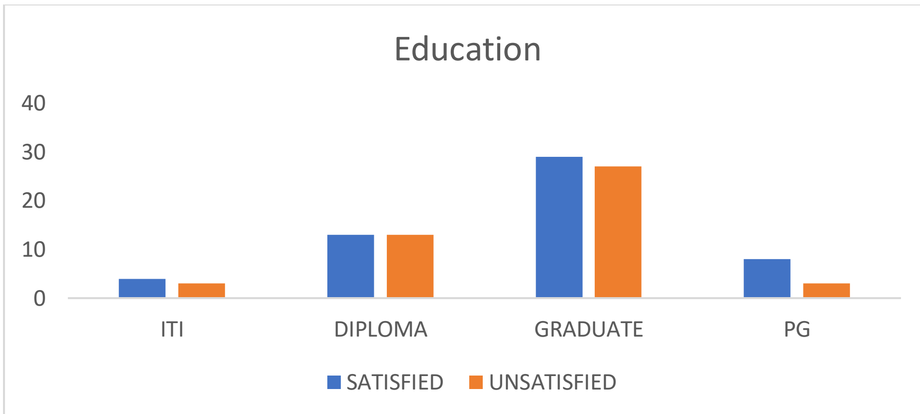


FIGURE 7.4 status of MES based on educational qualification

Analysis: From the above table 7.4, out of 100 employees, only 56 employees are graduates, 11 employees are postgraduates, 26 employees diploma holders, 7 employees are ITI holders. In which 57% ITI holders, 50% diploma holders, 51% graduates, 81% postgraduates of the employees are satisfied with the status of MES practices. Whereas 43% ITI holders, 50% diploma holders, 49% graduates, 19% postgraduates' employees are unsatisfied with the status of MES practices.

Interpretation: From the above table it is inferred that, maximum employees are postgraduates. And these employees are more satisfied and other educational qualification employees are least satisfied with the status of MES practices.

7.5 STATUS OF MES WITH RESPECT TO DIFFERENT AGE GROUP

Age of the employees is an important factor having a direct bearing on the success of industrial units. Classification of respondents based on age is shown in the Table below

TABLE 7.5 showing the satisfactory levels of different age group

AGE GROUP		
AGE GROUP	SATISFIED	UNSATISFIED
18-30Y	12	19
31-40Y	24	13
41-50Y	6	4
50+Y	12	10

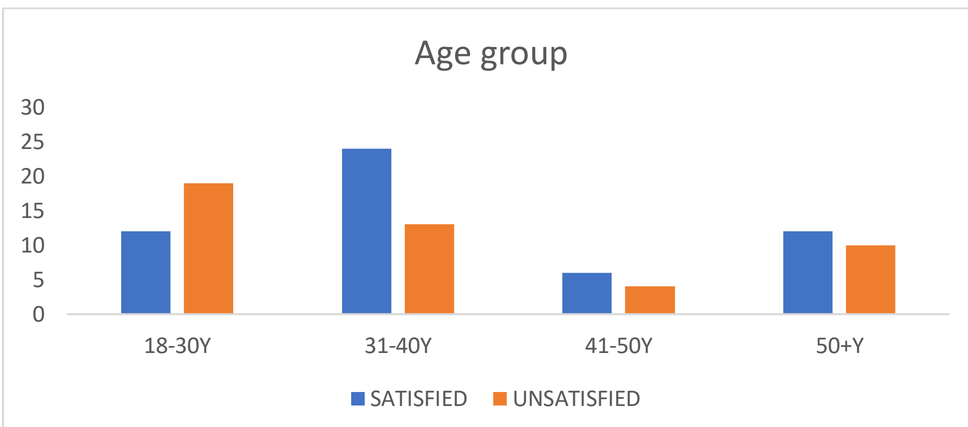


FIGURE 7.5 showing the satisfactory levels of age group

Analysis: From the above table 7.5, out of 100 employees, only 22 employees are aged above 50 years, 37 employees are aged between 31-40 years, 10 employees are aged between 41-50 years and 31employees are aged between 18-30 years. In which 38% 18-30 years, 64% 31-40 years, 60% 41-50 years and 54% are above 50 year of aged employees are satisfied with the status of MES practices. Whereas 62% 18-30 years, 36% 31-40 years, 40% 41-50 years and 46% are above 50 year of aged employees are unsatisfied with the status of MES practices.

Interpretation: From the above table it is inferred that, maximum employees are aged between 18-30 years. Employees aged between 31-40 years of age are more satisfied and employees above 50 years of age are least satisfied with the status of MES practices.

7.6 STATUS OF MES WITH RESPECT TO THEIR POSITION IN ORGANIZATION

Table below shows the classification of employees based on their job designation. Based on the sample data the profile of the data has been classified as worker, Supervisor/Manager, middle management and HODs.

TABLE 7.7 showing the satisfactory levels of different of position in the organisation

POSITION IN THE ORGANISATION		
POSITION	SATISFIED	UNSATISFIED
WORKER	31	22
SUPERVISOR	7	6
MIDDLE MNGT	8	10
HOD	8	8

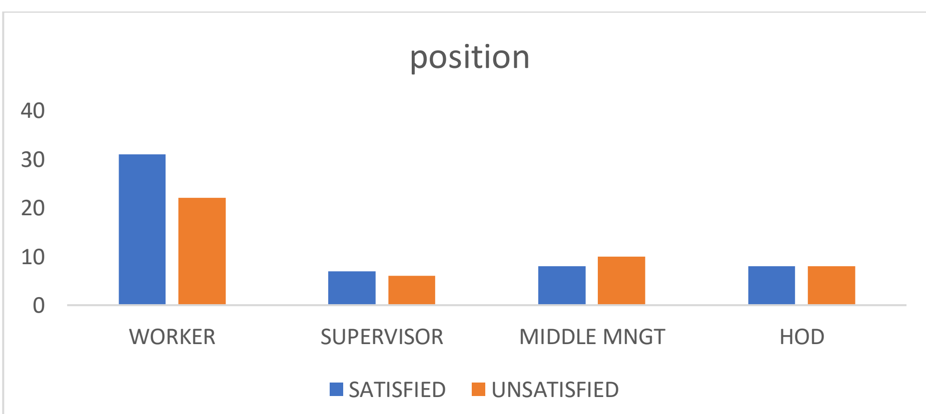


FIGURE 7.7 showing the satisfactory levels of different of position in the organisation

Analysis: From the above table 7.7, out of 100 employees, only 16 employees are Head of the Department, 18 employees are Middle Management, 13 employees are Supervisors and 53 employees are workers. In which 58% Worker, 54% Supervisor, 44% Middle Management and 50% Head of Department are satisfied with the status of MES practices. Whereas which 42% Worker, 46% Supervisor, 66% Middle Management and 50% Head of Department are unsatisfied with the status of MES practices.

Interpretation: From the above table it is inferred that, maximum employees are Workers. Employees who are Head of the Department are more satisfied and workers least satisfied with the status of MES practices.

7.7 STATUS OF MES WITH RESPECT TO THE NATURE OF JOB

Based on nature of job, employees are classified into three groups namely office job, site job and production job. Table below shows the distribution of respondents based on the nature of job.

TABLE 7.8 showing the satisfactory levels of different of nature of job

NATURE OF JOB		
NATURE	SATISFIED	UNSATISFIED
OFFICE JOB	24	18
SITE JOB	16	22
BOTH A&B	4	2
PRODUCTION JOB	12	2

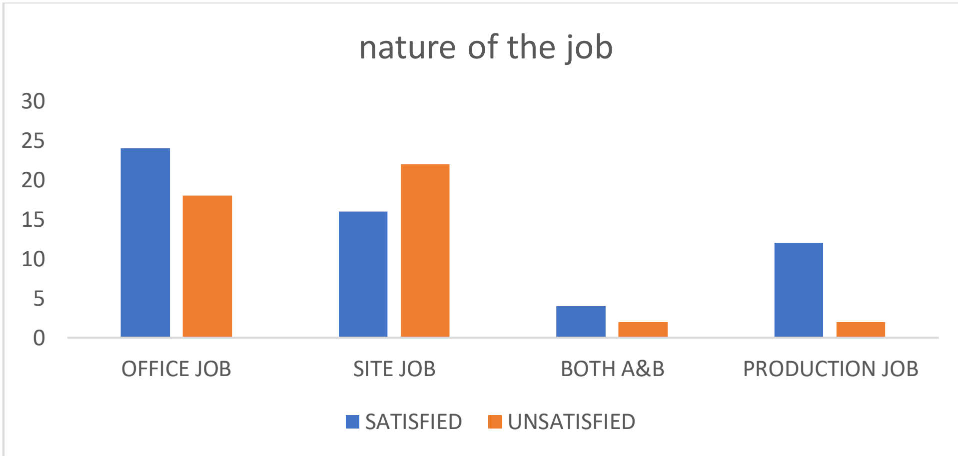


FIGURE 7.8 showing the satisfactory levels of different of nature of job

Analysis: From the above table 7.8, out of 100 employees, only 38 employees are in Site Jobs, 42 employees are in Office Jobs, 6 employees are both in Site and Office jobs and 12 employees are in Production Jobs. In which 57% office job, 42% site job, 66% of both office and site job and 78% production job employees are satisfied with the status of MES practices. Whereas 43% office job, 58% site job, 44% of both office and site job and 22% production job employees are unsatisfied with the status of MES practices.

Interpretation: From the above table it is inferred that, maximum employees are in site Job. Employees who are production are more satisfied and employees in site job are least satisfied with the status of MES practices.

7.8 STATUS OF MES WITH RESPECT TO THE TOTAL WORK EXPERIENCE

Experience of the respondents in the present organizations is considered for the present study. The Table below categorized the respondents based on years of experience.

TABLE 7.9 showing the satisfactory levels of different of work experience

TOTAL WORK EXPERIENCE		
EXPERIENCE	SATISFIED	UNSATISFIED
>5Y	27	32
6-10Y	11	6
11-20Y	10	3
<20Y	7	5

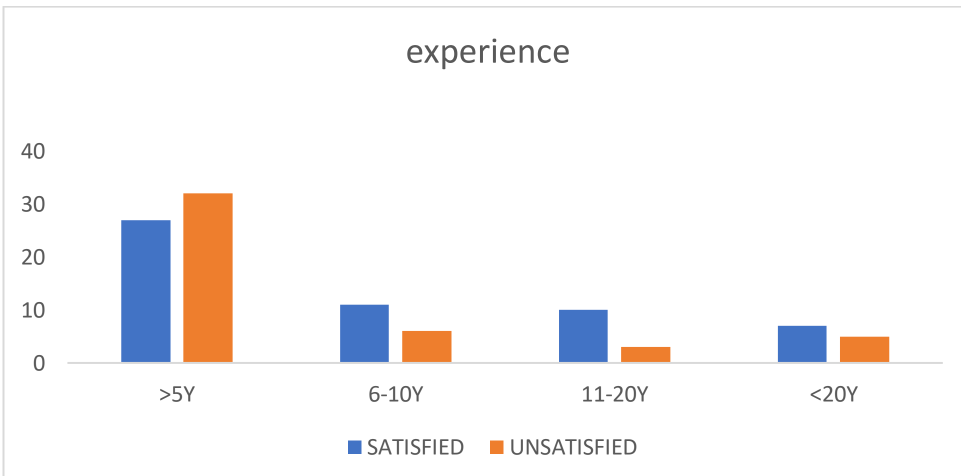


FIGURE 7.9 showing the satisfactory levels of different of work experience

Analysis: From the above table 7.9, out of 100 employees, only 17 employees have 6-10 years of experience, 13 employees have 11-20 years of experience, 12 employees have more than 20 years of experience and 59 employees have less than 5 years of experience. In which 46% less than 5 years, 65% 6-10 years, 76% 11-20 years and 58% more than 20 years of experienced employees are satisfied with the status of MES practices. Whereas 54% less than 5 years, 35% 6-10 years, 24% 11-20 years and 42% more than 20 years of experienced employees job employees are unsatisfied with the status of MES practices.

Interpretation: From the above analysis it is inferred that, maximum employees have less than 5 years of experience. Employees who have experience between 11-20 years are more satisfied and employees who have more than less than 5 years of experience are least satisfied with the status of MES practices.

7.9 STATUS OF MES WITH RESPECT TO THE DEPARTMENTS

Table below shows the classification of employees on the based on the department of the employees has been classified has production/process, Maintenance, HR and other departments.

TABLE 7.10 showing the satisfactory levels of different of departments

DEPARTMENT		
DEPARTMENT	SATISFIED	UNSATISFIED
PRODUCTION	9	6
MAINTENANCE	2	3
HR	14	4
OTHERS	29	33

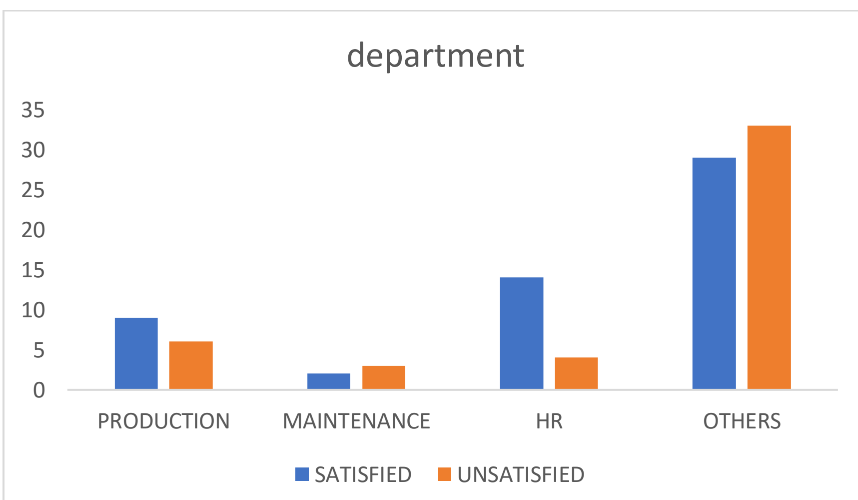


FIGURE 7.10 showing the satisfactory levels of different of departments

Analysis: From the above table 7.10, out of 100 employees, only 18 employees are in HR department, 5 employees are in Maintenance Department, 15 employees are in Production

Department and 62 employees are in another Department. In which 60% Production, 40% Maintenance, 77% HR and 46% of the employees are in other departments are satisfied with the status of MES practices. Whereas 40% Production, 60% Maintenance and 33% HR and 64% of the employees are in other departments unsatisfied with the status of MES practices.

Interpretation: From the above table it is inferred that, maximum employees are in another department. Employees in HR Department are more satisfied and employees in maintenance Department are least satisfied with the status of MES practices.

7.10 Status of MES components

The 7 MES components selected are shown in the table.

TABLE 7.11 showing the satisfactory levels of different of MES components

COMPONENTS CONSIDERED		
COMPONENTS	SATISFIED	UNSATISFIED
TOP MANAGEMENT AND COMMITMENT	56	44
EDUCATION AND TRAINING	56	44
HUMAN RESOURCE AND MANAGEMENT	60	40
CUSTOMER FOCUS AND SATISFACTION	59	41
SUPPLIER QUALITY MANAGEMENT	57	43
PROCESS MANAGEMENT	57	43
CONTINOUS IMPROVEMENT	57	43
TOTAL QUALITY MANAGEMENT	51	49

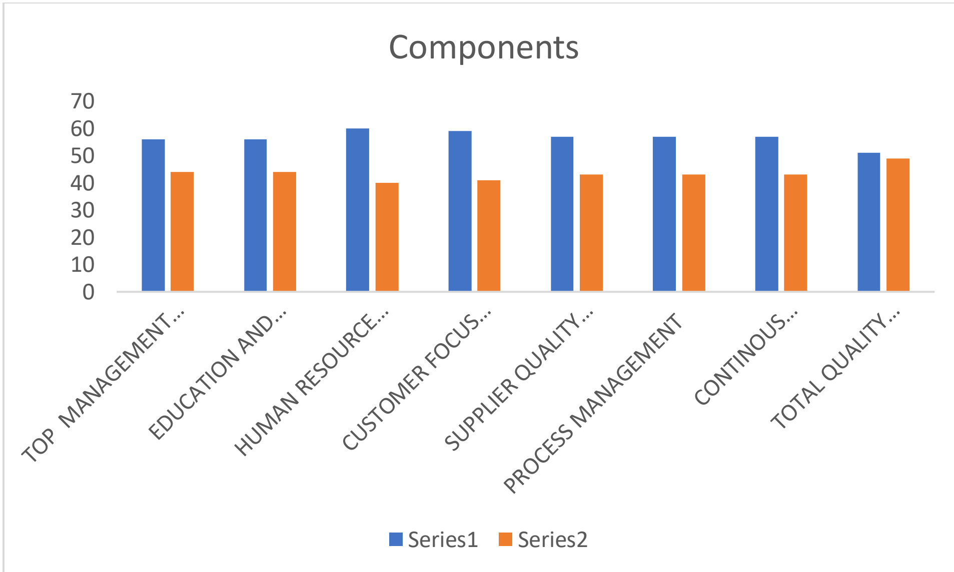


FIGURE 7.11 showing the satisfactory levels of different of MES components

Analysis: From the above table 7.11, It is found that top management and commitment, education and training by 56%, human resource management by 60%, customer focus and satisfaction by 59%, Supplier quality management, process management and continuous improvement by 57%, and total quality management by 51% are satisfied with the status of MES components.

Interpretation: From the above analysis it is inferred that even though the satisfaction level is high for all components it is important for the authority to stress more on the unsatisfied respondents, find the root causes, make the changes in the policy and work on these factors to improvise the MES practices in the organization.

CHAPTER 8

CORRELATION & REGRESSION ANALYSIS

8.1. CORRELATION ANALYSIS

Correlation analysis is done to find out whether the seven selected MES components are correlated significantly with each other.

8.1.1 Correlation between MES and components of MES of employees

To test the sub hypotheses and to determine the magnitude of impact of MES components on employees MES, Pearson correlation test conducted for 5% level of significance and it reveals that value of $p<0.05$ for all the components. The results of hypotheses test have presented in the Table below. From this, it was deduced that there is a positive correlation between Components of MES and employees MES in surveyed Manufacturing Industry and the relationship between them is statistically significant.

TABLE 8.1 Correlation between MES and components of MES of employees

MES Components	Correlation Coefficient	Result
TOP MANAGEMENT AND COMMITMENT	1	Significance
EDUCATION AND TRAINING	0.85	Significance
HUMAN RESOURCE AND MANAGEMENT	0.87	Significance
CUSTOMER FOCUS AND SATISFACTION	0.82	Significance
SUPPLIER QUALITY MANAGEMENT	0.76	Significance
PROCESS MANAGEMENT	**0.97**	Significance
CONTINOUS IMPROVEMENT	**0.63**	Significance
TOTAL QUALITY MANAGEMENT	0.94	Significance

P value = 0.000 for all parameters

From the above Table, it reveals that there exists a high correlation between MES and process management (r= 0.97) and there exists less correlation between MES and Continuous Improvement (r = 0.63). That is process management has high influence on MES of employees and continuous improvement has less influence on employee in MES.

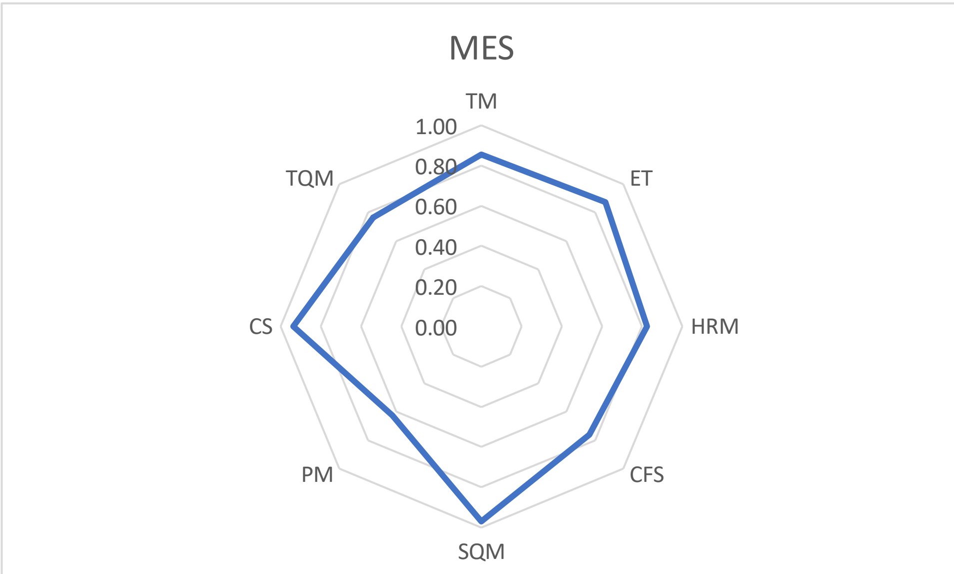


FIGURE 8.1 Correlations between MES and Components of MES

TABLE 8.2 Correlation between MES and components of MES

	TM	*ET*	*HRM*	*CFS*	*SQM*	*PM*	*CS*	*TQM*
MES								
TM	1							
ET	0.79	1						
HRM	0.68	0.72	1					
CFS	0.62	0.58	0.62	1				
SQM	0.90	0.90	0.87	0.80	1			
PM	**0.36**	0.49	0.54	0.37	0.53	1		
CS	0.75	0.79	**0.91**	0.81	0.94	0.73	1	
TQM	0.54	0.59	0.57	0.55	0.67	0.47	0.66	1

P value = 0.000 for all parameters

Above table illustrates the correlation between the components of MES, out of the Eight components, there exists a high correlation (r=0.91) between customer focus and satisfaction and Human resources and there is a less correlation(r=0.36) between process management and top management and commitment.

8.2.REGRESSION ANALYSIS:

This statistical approach that demonstrates the relationship between two or more variables in the form of equation to approximate the value of a variable, formed on the given value of another variable, is called regression analysis. The variable whose value is approximated using the algebraic equation is called dependent variable and variable whose value is used to approximated this value is called independent variable. The linear algebraic equation used for demonstrating a dependent variable in terms of independent variable is called linear regression equation

In this study, Manufacturing execution of system (MES) is a dependent variable and eight components of MES are the independent variables.

TABLE 8.3 components of MES with respect to symbols

SYMBOLS	COMPONENTS OF MES
TM	TOP MANAGEMENT AND COMMITMENT
ET	EDUCATION AND TRAINING
HRM	HUMAN RESOURCE AND TRANING
CF	CUSTOMER FOCUS AND TRAINING
SQM	SUPPLIER QUALITY MANAGEMENT
PM	PROCESS MANAGEMENT
CI	CONTINOUS IMPROVEMENT
TQM	TOTAL QUALITY MANAGEMENT

The regression equation is

MES = 0.3594 +0.1965 TM +0.1754 ET +0.09625 HRM +0.15898 CF+0.6910SQM +0.1967CI+0.1360 PM+.1604 TQM

It is identified by regression equation, that for one value of MES in supplier quality management 0.6910(regression coefficient), this is the maximum contribution and minimum contributor is human resource management of 0.09625. The value of R^2 is 0.9687, $P < 0.00$ that specifies that MES accounts 96.87% dissimilarity in the dependent variable.

TABLE 8.4

Coefficients						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
		B	**Std. Error**	**Interval**		
1	**(Constant)**	.3594	.076618	0.5116365	4.69	0.2073
	TM	.1965	.022043	0.2402986	8.92	0.1527
	ET	.1754	.026606	0.1226566	6.60	0.1226
	HRM	0.09625	.021190	0.0541711	4.54	0.0541
	CF	0.1589	.022176	0.1149507	7.17	0.1149
	SQM	0.691	.0638609	0.5643182	10.82	0.5643
	PM	.1360	.0184147	0.1726281	7.39	0.0994
	CI	0.1967	0.068524	0.3327783	2.87	0.2974
	TQM	0.1604	.0184468	0.1970999	4.69	0.0123
a. **Dependent Variable**: MES						

8.2.1. Regression equation for MES and components of MES of employees

Multiple regression analysis was applied to find out the impact of eight components of MES on MES of employees. In the present research, eight MES components are taken as independent variables and MES of employees are the dependent variables. The relevant results have been shown in the table

TABLE 8.5 Regression Analysis between components of MES and MES of employees (Model summary)

Model	R	R^2	Adjusted R^2	Standard Error of the Estimate
1	1.000a	.9687	.9687	.093
a. Predictors: (Constant), TQM, PM, TM, CF, HRM, ET, SQM				

From the Above Table, it is found that R^2 value = .09687 and adjusted R^2 value =0.9687. This specifies that all the seven MES components create 96.87 percent variance on the employees MES. The regression fit is confirmed through the following ANOVA Table given below:

TABLE 8.6 Regression Analysis between components of MES and MES of employees (ANOVA)

Model		Sum of	Df	Mean	F	Sig.
	Regression	25.19591	6	4.1993	480.23	$.000^b$
	Residual	.813233	93	.0087		
1	Total	26.00915	99			
a. Dependent Variable: MES						
b. Predictors: (Constant), TQM, PM, TM, CF, HRM, ET, SQM						

The table shown above shows us that the F value = 480.23, p =0.000 which are statistically significant at 5% level. Hence, the regression's fitted value is suitable which leads to individual influences of these variables through the coefficient. Above table indicates the regressions coefficients for each independent variable and significance level.

CHAPTER 9

RESULTS AND DISCUSSION

Based on the Literature survey the questionnaire was designed containing eight components MES containing 40 questions averaging more than 3 questions for each component with 9 demographic factors. The data was collected from 100 respondents from different departments. Out of which 60 workers, 30 supervisors and 10 top management personnel. The data was fed into MS Excel and status of MES has been derived by taking the grand average 4.04. Above the grand average is taken as Satisfied and below the grand average is taken as Not Satisfied. Thus, out of 100 employees, 54 were found satisfied and 46 were found not satisfied with manufacturing execution systems. The status of MES has been compared with demographic parameters such as gender, marital status, dependents, qualification, age, nature of the job, position, experience, department etc. Hypothesis has been derived and inferences are drawn and analysed the data through the chi square test and found that qualification and experience have significance with MES, and all other demographic factors have no significance. Relationship between MES with Components of MES and between components of MES are established by carrying out correlation analysis for the survey data and it reveals that there exists a high correlation between MES and process management ($r = 0.97$) and there exists less correlation between MES and Continuous Improvement ($r = 0.63$). That is process management has high influence on MES of employees and continuous improvement has less influence on employee in MES. Out of the Eight components, there is a high correlation ($r=0.91$) between customer focus and satisfaction and Human resources and there is a less correlation($r=0.36$) between process management and top management and commitment. Multiple regression analysis was applied to recognize the influence of seven components of MES on MES of employees. In the current research, seven MES components are considered as independent variables and MES of employees is the dependent variable. The final regression equation has been acquired as below:

The regression equation is

MES = 0.3594 +0.1965 TM +0.1754 ET +0.09625 HRM +0.15898 CF+0.6910SQM +0.1967CI+0.1360 PM+.1604 TQM

By using regression equation, it is spotted that for one value of MES in supplier quality management 0.6910(regression coefficient), this is the maximum contribution by supplier quality management and minimum contributor is human resource management of 0.09625. Value of R^2 is 0.9687, $P < 0.00$ that indicates that MES accounts 96.87% dissimilarity in the dependent variable.

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