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Summer Internship Report

"Implementation of Industry 4.0"

at

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Submitted to:

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Date of Submission: 05th July, 2020

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Date of Submission	05th July,2020
Purpose	Submitted as a part of Summer Internship Program, 2020

DECLARATION

I hereby declare that this project titled "**Implementation of Industry 4.0**" at **Bosch Rexroth India Pvt Ltd** is a record of authentic work carried out by me under the guidance of **Mr. Vivek Kumar**, AhmP/PT, Active GSP Candidate, Bosch Rexroth & **Prof. Rajwinder Kaur**, Institute of Management, Nirma University, Ahmedabad. This project has been submitted to Institute of Management, Nirma University, Ahmedabad, in partial fulfilment of academic requirement for the Summer Internship Program (2020).

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191225

ACKNOWLEDGEMENT

I would like to take this opportunity to thank firstly **Institute of Management, Nirma University** for giving me this platform to step into corporate world and get first-hand experience on the same.

I am highly grateful to **Mr. Vivek Kumar**, AhmP/PT, Active GSP Candidate, Bosch Rexroth for all his precious knowledge sharing, time and valuable insights throughout my project- **"Implementation of Industry 4.0"**. Moreover, I would like to extend my gratitude to **Prof. Rajwinder Kaur** for mentoring and guiding me during this journey. I would also like to mention **Bosch Rexroth India Ltd** for providing such an opportunity to associate in an ongoing project amidst this pandemic and allowing me to Work from Home, providing training to carry out the tasks included in the project and enhance my knowledge base.

Last not but the least, I would like to thank each and every one who supported me and guided me for making my endeavours fruitful.

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Executive Summary

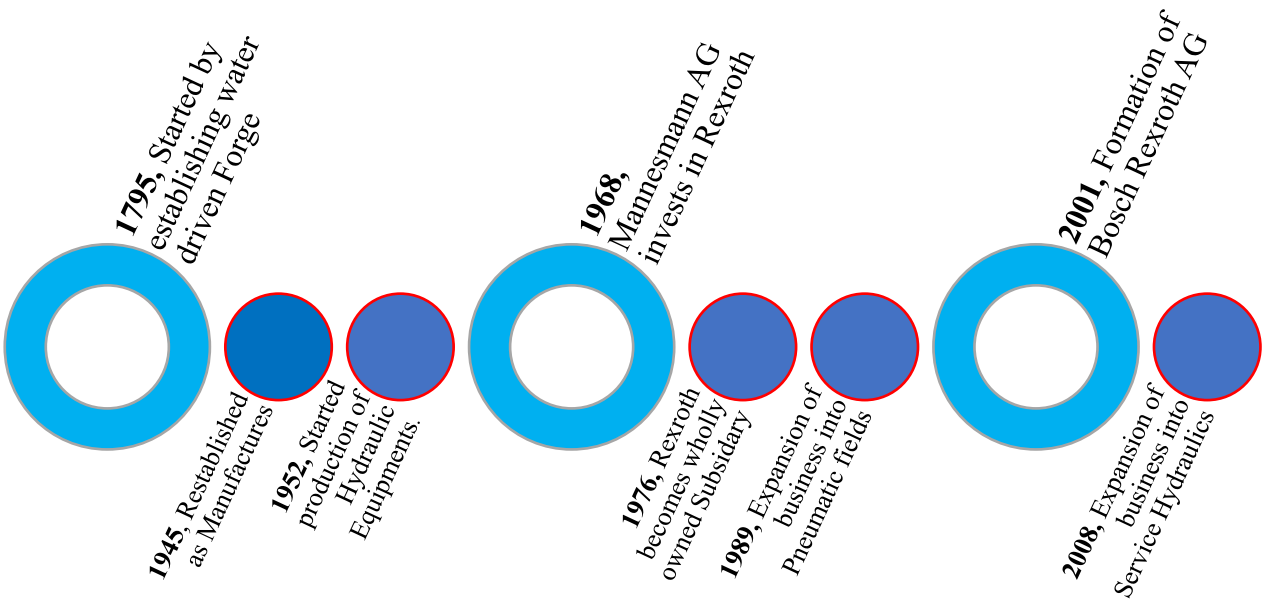
Bosch Rexroth AG, established on 1st July 2001, is a German based Industrial engineering equipment manufacturers and service providers, a subsidiary of Robert Bosch GmBH. Rexroth is a major player in the Drive and Controls market, offers its customers all their driving and control technologies, such as industrial hydraulics, mobile hydraulics, linear motors and mounting technologies, electric drives and controls.

The main objective of this project is to improve the efficiency and effectiveness of manufacturing process using Industry 4.0 tools and techniques and thereby making the organization update with the current technologies in the market and place itself in a better position among the competitors in the market in terms of market volume, customer satisfaction as well as profitability. For the planning of this project, NG6 manufacturing unit was considered, which have various stages of process and execution. For analysis of the process involved and identify the strategy for implementation of Industry 4.0., both qualitative and quantitative methods are applied. After the understanding of these stages and processes, valuable inputs have been provided to the organization in order to carry out a smooth and successful implementation of the project.

Bosch Rexroth

1. About

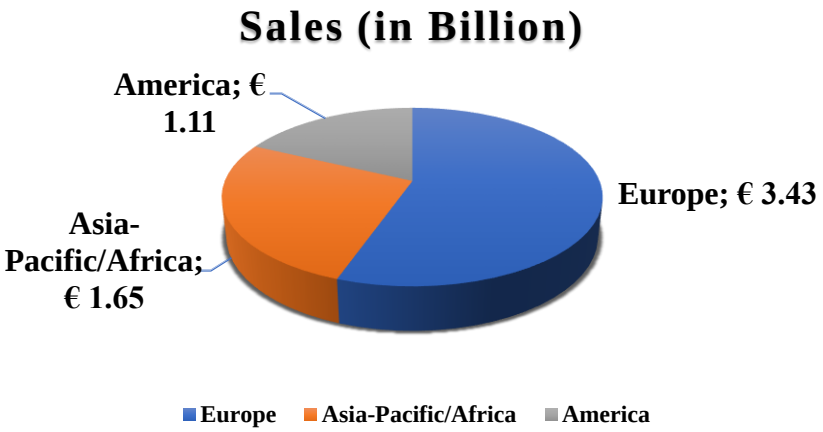
Bosch Rexroth AG is a German based Industrial engineering equipment manufacturers and service providers, a subsidiary of Robert Bosch GmBH. Bosch Rexroth was established on 1st July,2001 as a result of merger between Mannesmann Rexroth AG and Robert Bosch GmBH. Even though established as an Engineering firm in 2001, the organization has its roots in 0395. Founded in 1974, Bosch Rexroth India assists customers over production facility in Ahmedabad and a specialized department in Bangalore with widespread sales and service offices, retailers in India. Rexroth, through Drive and Control, offers its customers all their driving and control technologies, such as industrial hydraulics, mobile hydraulics, linear motors and mounting technologies, electric drives and controls. Rexroth is a reliable partner to its customers and supports the production of their safe and efficient machines, thus contributing to the economic exploitation of normal possessions and resources.



Bosch Rexroth AG is limited company, **AG** *(Aktiengesellschaft)*, a Joint-Stock company whose shares can be traded in the stock market. It is similar to Limited Company in India, in which the shareholders of the company have their liability limited to the investment they have made in the company. In India, Bosch Rexroth AG is registered as Bosch Rexroth India Ltd. The governing board of the organization is divided into two, Supervisory board and Management Board. Supervisory Board consists of the shareholders and few top management employees. They supervise the activities of the management board. The Management

Board is responsible for running the organization, its day to day activities and revenue generation. The members of management board are employed by the supervisory board for taking care of the interests of the stakeholders, vision and mission of the organization. Supervisory board have authority to make any changes in the management board and even to decide the compensation of the management board member i.e., the employees of the organization. In India, the shareholders will select Board of Directors which is similar to supervisory board.

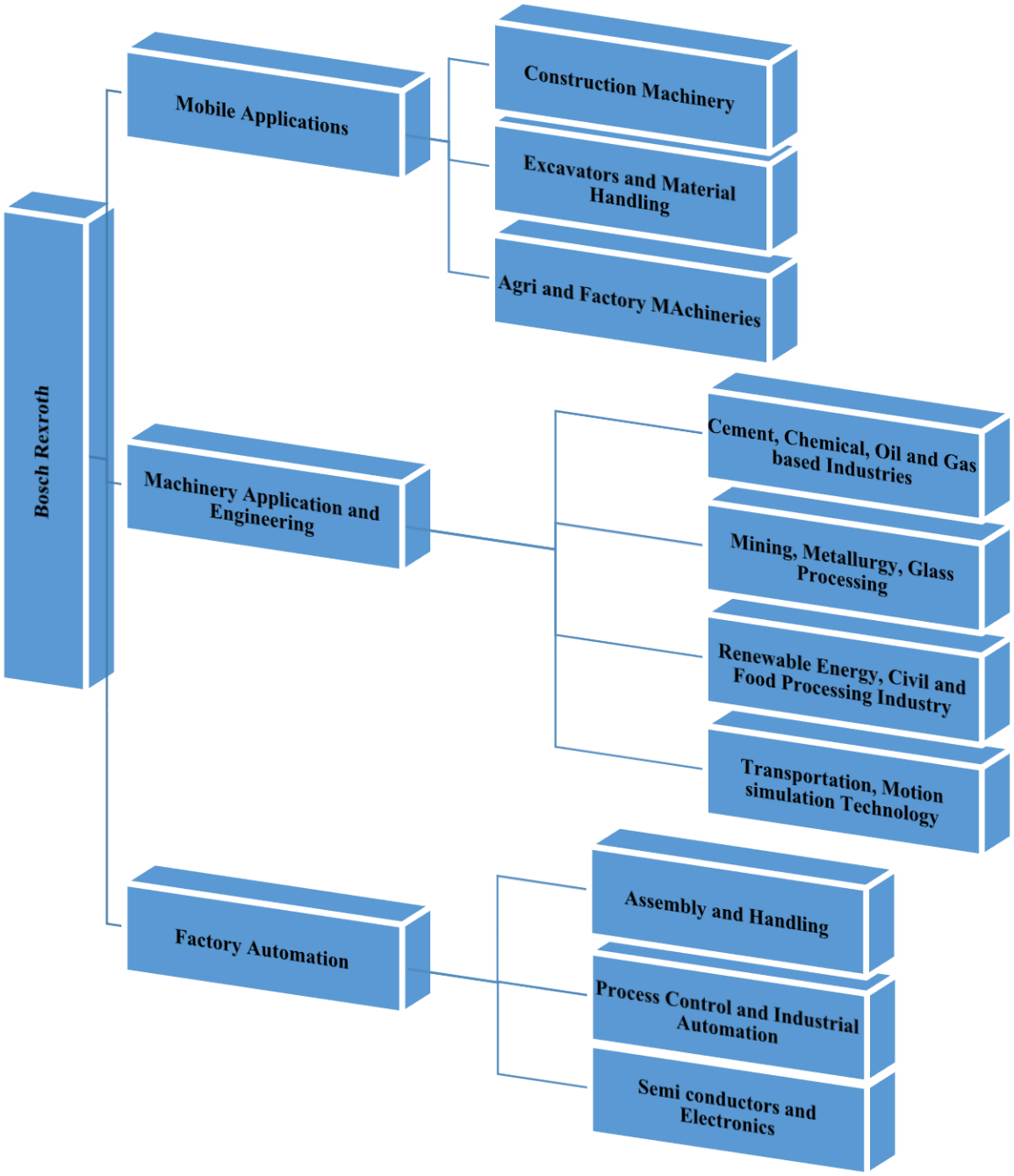
With the slogan - "The Drive and Control system company"- the organization has its presence across 80+ countries in the world, employing more than 31000 people and more than 29000 associates. In 2019-20 FY, it made a sales revenue of 6.2 Billion euros approx.



1.1Products/Services:

Bosch Rexroth offers its customers all their driving and control technologies, such as industrial hydraulics, mobile hydraulics, linear motors and mounting technologies, electric drives and controls, falls under manufacturing sector. Manufacturing sectors manufactures products through various process where the raw material which is the input of the manufacturing process undergoes various process and comes out as valuable product.

Rexroth, industry wise, is mainly classified into mobile application, machinery application and engineering and factory automation. As the slogan of the organization mentions, Rexroth is mainly into Industrial drives and control equipments and mainly focus on Engineering and factory automation. It manufactures the electric, mechanical and hydraulic drive systems and other equipments related to motion and control systems. Apart from this, the organization also manufactures Mobile equipments and applications.



1.2Distribution Structure and Brands Owned:

Bosch Rexroth have excellent procurement and distribution system as well as dedicated customer service system. The organization system is designed in such a way that immediate solution is delivered to the customer be it sales, engineering, service or distribution related. For enhancing this, they have setup strong regional presence. Also, they have enabled greater product access through local inventory suppliers. Excellent distribution enables fast, smooth and efficient movement of the goods. The distribution channels having excellent expertise logistic, supply chain and warehouse management ensures effective and efficient

material flow, inward as well as outward. They have a wide range of services, including on-site services, recovery, reconstruction, system performance, upgrades and productivity, that increase the potential for backward integration. This feature has been adopted by the latest technology from Bosch Rexroth, which provides reliable, high-quality, energy-efficient equipment and the most advanced utility without unnecessary investment.

Bosch Rexroth owns a lot of individual brands under then which they have acquired from the initial time itself. They first acquired Steinschen iron foundry, Lohr am Main, Germany, in 1850. The current list of brands includes:

- Indramat GmbH
- Mannesmann AG
- Rexroth AG
- Hydromatik GmbH
- Brueninghaus GmbH
- Lohmann & Stolterfoht GmbH
- Deutsche Star / Star Linear
- Mecman Pneumatics
- Uchida
- Hägglunds

1.3 Customers and Segmentation:

Bosch Rexroth (India) Private Limited is one of the leading experts in drive systems. The company offers tailor-made solutions for powerful control system and Mobile systems. Bosch Rexroth is a partner for industrial applications (engine construction, factory design and automation), mobile applications and high-quality hydraulic systems, electric drives and controls, linear motion and combination technology of components and systems. This makes almost all industries as their clients.

Some of the clients are organizations from Motion Architectures sector, Chemical Industries, Cement Industries, Construction firms, Material Handling units, Agricultural and Forestry machinaries, Energy sectors, Technology Industries, Marines, Automotive sector, Packaging Industries, Plastic and die casting and many more.

Below are the current large-scale projects taken up by Rexroth:

- the development of an unprecedented topside lifting system for a special vessel

- the company's collaboration on the La Yesca Dam in Mexico
- the renewal of the locks on the Panama Canal

Rexroth innovation can be found all over the place including renewable energy technology where in the transmission equipment manufactured by them guarantees effective vitality move of wind turbines. The Rexroth mobile control technology plays a vital role when building dams or streets, the tallest structures or longest hallways using cranes, excavators and other development vehicles. For a long time, Rexroth has been providing drive and control solutions and support for steel plants, mechanical production systems and semiconductor fabricating, just as turn key solution.

Bosch Rexroth is the ideal accomplice for mechanical and establishment designing and offers both mechanized parts and arrangements, for example, the Rexroth 4EE framework. To put it plainly, Bosch Rexroth is one of the main specialists in control and drive innovation. They are one-stop solution creators for controls, electrical technology, water driven frameworks, power plant and pneumatic pressure medicine manufacturing. Whether it's digging in construction sites, drilling hard tunnels or practicing sustainable forestry, cell phones provide valuable help, reducing the number of dangerous and difficult tasks. When designing such machines or equipments manufacturers must constantly adapt to changing conditions, such as significant emission reductions, in line with TIER's ultimate emission stability. Rexroth shares such problems with its customers. New operating concepts of the hydraulic system guarantee that mobile devices meet these standards and maintain the lowest possible performance. Bosch Rexroth has built up itself as a worldwide expert in the development of plants and individual tasks, from the throwing of substantial metals or plastic to the laying of submarine links and the easing back of journey transport developments in turbulent oceans. Situated in excess of 80 nations, they are specialists in the Bosch Rexroth contacts industry with direct access to the organization's skill in every aspect of impetus innovation and the executives.

The hydraulics industry is divided into two sectors majorly depending upon their application: industrial and mobile. In the industrial sector, all hydraulic systems such as presses or mechanical tools are included and mobile applications for hydraulics started receiving support in this market. All mobile or hydraulic machines, such as tractors or wheel loaders, can be used for mobile applications. These two areas must be distinguished because there are different requirements for the products. Product management business unit gathers all available data on the sale of hydraulic components. On the basis of this data, it is analyzed how the hydraulic market will look like over the next five years. This forecast identifies not only mobile and industrial issues, but also regional issues between Europe, the United States and Asia. Setting up regional markets is important because they offer different sales opportunities and different needs and basic conditions.

1.4 Organization Culture:

Bosch Rexroth calls themselves as “The Drive and Control system company” with a motto of “We move, You win”. As an international partner, Bosch Rexroth supports global technology and technology challenges with its latest technology and unique industry knowledge. Around 31,000 employees worldwide work on safe, effective, smart and powerful solutions. For example, they help produce small batches cost-effectively or save energy and increase productivity. With a huge technical library, digital services and extensive services, Rexroth excels themselves in the field of machines and equipment. They make sure that the employees are provided with safe working environment and the whole manufacturing process happens in secured manner. To avoid the development risks, the complete production process is simulated and safe, fail proof manufacturing process is ensured. They also provide their customers solution for all the process including safe and secure implementation of the equipment to the commissioning of the same, ensuring complete efficiency. WE MOVE, YOU WIN.

1.5 Strategic Framework:

7s strategic frame work was developed by Robert H Watermann and Tom Peters in 1980s. This is a management model which includes Strategy, Structure, System, Skill, Style, Staff and Shared Values.

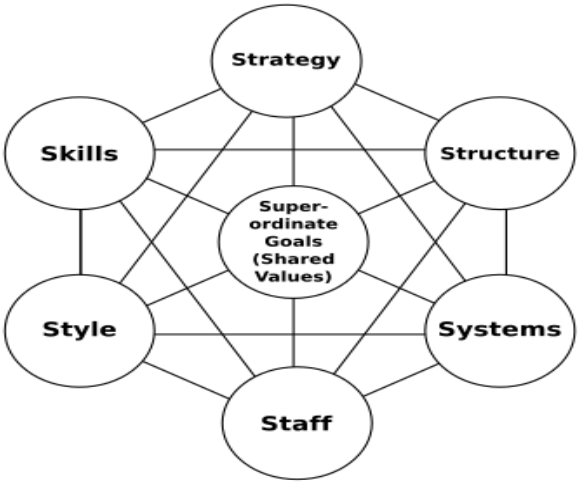


Figure 4.1: McKinsey 7s framework. *Source: en.wikipedia.org*

Strategy: Bosch Rexroth has gone through an extensive transformation process that extends from internal to business planning. As part of its growth strategy, Bosch Rexroth primarily strives for technical integration, taking advantage of the synergistic effect on the market, as well as within the Bosch group and future editions. The latter mainly includes software, automation and related solutions. In addition to its strong traditional position in the field of industrial hydraulics and in particular mobile hydraulic systems, Bosch Rexroth positions itself as a supplier of 4.0 industrial solutions for the factory of the future.

The transformation of the company pays off: Bosch Rexroth has steadily increased its competitive position and gained market share in recent years. For example, a technical company returned to its growth trajectory in 2003 amid significantly improved market conditions. WE MOVE, YOU WIN.

Structure: As any other public limited company, the governing board of the organization is divided into two, Supervisory board and Management Board. Supervisory Board, also known as Executive Board, consists of the shareholders and few top management employees. Currently, Mr. Rolf Najork is the chairman of executive board, who is also responsible for the engineering and driving foreign business forward in the major markets. They supervise the activities of the management board. The Management Board is responsible for running the organization, its day to day activities and revenue generation. The members of management board are employed by the supervisory board for taking care of the interests of the stakeholders, vision and mission of the organization. Supervisory board have authority to make any changes in the management board and even to decide the compensation of the management board member i.e., the employees of the organization.

System: Bosch Rexroth have excellent procurement and distribution system as well as dedicated customer service system. The organization system is designed in such a way that immediate solution is delivered to the customer be it sales, engineering, service or distribution related. For enhancing this, they have setup strong regional presence. Also, they have enabled greater product access through local inventory suppliers. Excellent distribution enables fast, smooth and efficient movement of the goods. The distribution channels having excellent expertise logistic, supply chain and warehouse management ensures effective and efficient material flow, inward as well as outward. They have a wide range of services, including on-site services, recovery, reconstruction, system performance, upgrades and productivity, that increase the potential for backward integration. This feature has been adopted by the latest technology from Bosch Rexroth, which provides reliable, high-quality, energy-efficient equipment and the most advanced utility without unnecessary investment.

Skill: The core strength of Bosch Rexroth is their R&D department. They are constantly in search of innovative ways to find solution for problems as well as to come up with new products and technology. The distributers are experts in logistics and warehouse management, delivering fast, smooth and efficient content from inventory to shipping. In addition to providing world-class Bosch Rexroth products and technologies, our CE distribution partners also provide certified solutions assembly and installation knowledge. Finally, they provide the knowledge to select, apply and maintain Bosch Rexroth products and technologies that guarantee customer satisfaction. In regular intervals, they provide training to their employees in combination

with the latest Bosch Rexroth technology ensure reliable, high-quality and high-quality equipment with maximum added value without unnecessary investments.

Style: The operational style of Bosch Rexroth is defined by their system. They will have inventory suppliers in every region, they will be considered as inventory partners. They will supply the raw materials to warehouse which is then inward to the production unit where these raw materials undergo a various process and procedure before coming out as a useful product or system. Then this end product is packed and send back to warehouse as finished good, and outward to the customers through channel partners and authorized distributors. The whole process is controlled and monitored through SAP.

Staff: Bosch Rexroth was established on 1st July,2001 as a result of merger between Mannesmann Rexroth AG and Robert Bosch GmBH. the organization has its presence across 80+ countries in the world, employing more than 31000 people and more than 29000 associates. In 2019-20 FY, it made a sales revenue of 6.2 Billion euros approx. They provide continuous training to their employees to make them up to date and accustomed with the latest technology. They make sure that each and every employee goes through the skill development process program every stipulated time interval without fail.

Shared Values: Employing more than 31000 people around the world depicts the value they are giving to the cultural diversity.

1.6 Competitive Position:

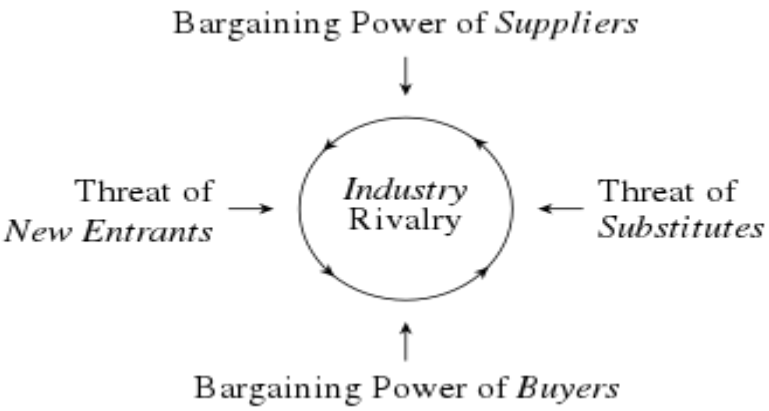


Figure 5.1: Pictorial representation of Porter's Five forces. *Source: en.wikipedia.org*

Porter's five forces define the competitive nature of a business.

- Threats of new entrants
- Bargaining power of suppliers
- Bargaining power of buyers
- Rivalry among competitors

- Threats from substitutes

These factors for Bosch Rexroth are described below:

- Threats of new entrants: Rexroth as well as other big players in this industry such as Siemens, Honeywell, ABB, GE and few more have established as trusted and valued organizations. They have been big players in the industry from past 50 or more years, investing a lot in R&D as well as in the market to gain the value and trust. So, for a new entrant, it would be a tough task to compete with these well-established players at this point. In order to equip themselves to compete with these giants, they need a huge investment in all area mainly R&D, sales and promotion, and will take a large amount of time to create trust and value among the customer. Along with that there are other legalities and procedures to start trading in this market. So, it will be very difficult for new entrants to become a major player in this market and thereby they won't be facing much threat from the new entrants.
- Bargaining power of Suppliers: Even though there is a slight authority with the supplier to take control over the price at which the raw material is supplied to Rexroth due to the nature of the raw material but due to the large number of supplier in the market for these materials and few number of consumers as well as availability of these raw materials in the open market make the supplier to provide the materials at a nominal rate. So, this leave the suppliers with less power to bargain.
- Bargaining Power of Buyers: As the industry and the products are technology based, each organization will have developed their own technology to differentiate themselves from other players and to attract customers based on this differentiation. For example, Rexroth is well known for their fluid technology as well as mechanical and automotive technology which makes the customers in the same field to purchase products from Rexroth and not from any other player in this industry, whereas Siemens is well known for food processing, packaging technology and this makes the customers based on this industry buy from Siemens rather than Rexroth. This is the scenario with other organizations as well. This leave the buyers with less power to bargain. But sometimes, companies will be providing some discount offers to attract customers to buy their product as a part of competition existing in the market.
- Rivalry among the Competitors: Rexroth face a great competition from the giants in the market like Siemens, Honeywell, GE, ABB and others. Even though as these companies differentiate themselves with the technology developed by them and those industries are secured for them like power sector for ABB, process industry for Siemens, oil and gas for Honeywell, to expand their business companies try to enter he domain handled by Rexroth or vice versa which leads to the competition.
- Threats from the Substitutes: As the companies in this industry competes with their own technology, it is very difficult to come up with the substitute. This can happen only if the current technology is improved, for example, a company is coming up with green technology products developed in

existing technology or something similar like this. Other than that it is nearly impossible to bring up a substitute product. But the possibility of new entrant come up with a competitive technology at competitive pricing, and targets the SMEs who always looks for generating revenue is a treat for Bosch Rexroth.

2. Project

The project assigned by Bosch Rexroth is "*The Implementation of Industry 4.0"*

2.1Introduction

Fusion of technology, digital revolution which is blurring the thin line that existed between the physical, digital and biological domains started the new trend in Industry which is termed as Industry 4.0. This brought in a drastic change or break through changes in the fields of AI, Robotics, IoT, Nano-tech, Bio-tech and many other areas. This gave raise in global income and rise in improved quality competition in the market. Different business launched new products and services which were match able or better than those existing in the market. The upgradation of technology also played a big role in increasing the efficiency of the production units by reducing the wastages and optimizing the lead time as well as the process time, drop in transportation and communication cost, also, this gave raise to an improved, efficient and effective logistics and supply chain. This increased the market competition and the existing big players were pushed to adopt to this new phase of technology or Industry 4.0.

So, to adopt and compete with the existing trend in the market and with the aim of improving the manufacturing process by reducing or eliminating the wastages / Non-Value Addition (NVA) and thereby increasing the efficiency and effectiveness and thus the customer requirement and profitability.

2.1.1 Objectives and Benefits

The main objective of this project is to improve the efficiency and effectiveness of manufacturing process using Industry 4.0 tools and techniques and thereby making the organization update with the current technologies in the market and find a better position among the competitors in the market in terms of customer satisfaction as well as profitability. The major steps involved in achieving this objectives are as below:

1. Programming and Planning the Implementation of Node-Red as a part of Digitalization and Connectivity.
2. Understanding VSM and KPIs of NG6 line
3. Identification and tracking of bottlenecks.
4. Designing and Implementation of future state mapping.
5. Implementing complete automation of information flow.

Main aim of the project is to enable Lean Manufacturing. Lean manufacturing which is also known as Lean Production is production method initiated by Toyota Motor Corporation for their production system which is known as Toyota Production System. It is a method designed and executed with aim of reducing or eliminating anything and everything that does not add value to the customer requirement, considered as waste or "Muda" within production process and to attain maximum productivity as well as add maximum value to the customer requirements. Waste is seen as something for which customers see no added value and are unwilling to pay for it. Types of wastes are: i) Defects ii) Over Production iii) Waiting iv) Non -Utilized Talent v) Transportation vi) Inventory vii) Motion viii) Extra Processing.

Lean Manufacturing works on five principles known as Lean Principles, which is described below:

1. Define Value: It is about understanding the customer requirement and the value which the customer is ready to pay for the product with the requirement. Then designing the product according to their requirements. This will be taken care of by Customer Service team.
2. Map Value Stream: Value Stream Mapping is a process involving understanding the customer requirement and designing and mapping the production activity such that it contributes to the value. It also includes identifying and reducing or elimination of unwanted and non-value addition process known as waste.

Figure 1.1: Pictorial Representation of Lean Principles. *Source: https://theleanway.net/The-Five-Principles-of-Lean*

3. Create Flow: After the elimination of the waste, scheduling and strategizing the value-added processes is the basic goal of Flow Creation.
4. Establish Pull: Pull based system helps in managing Inventory. Unused Inventory also adds to waste. So, pull based system enables Just-in-Time delivery of the inventory and Work-In-Process items to ensure a smooth and lean manufacturing process.
5. Pursuit Perfection: This is an important step where each and every employee of the organization is contributing towards reducing the waste and value addition to the process.

Thus, Lean Manufacturing allows the organization to understand its ineffective and inefficiencies in manufacturing process, eliminate the same and thus delivering better value to the customer and their requirements.

Benefits of Lean Manufacturing:

- Increase in Profit.
- Standardization Process with simplified procedures.
- Reduction in errors.
- Increased employee performance and development, thereby increase in efficiency and effectiveness, thus value addition to the customer.

2.2Methodology

Both qualitative and Quantitative methods were used for carrying out the project related tasks. For planning and programming of the Node-Red, which is used for information flow enhancing and optimization, needed an understanding of current information flow process which calls for qualitative methods and then for programming and implementation requires quantitative, mix of both give out efficient and effective planning for digitalization and connectivity which includes IoT system with cloud computing.

For Understanding the VSM, which is also known as current state mapping, qualitative methods are used, where various questionnaires were asked to the employees as well as plant supervisors to understand the Information flow as well as Process flow. In order to understand the Key Performance Indicators (KPIs), quantitative techniques were applied to understand the past process activities stage by stage and machine by machine, the whole duration as well as individual duration of the process and the various stages.

Outcome of these qualitative and quantitative methods are used for the further steps in the project which are Identification of the bottlenecks in the process by continuous monitoring and tracking of KPIs, designing of Future state mapping making use of VSM as well as by eliminating the bottlenecks, and finally Implementation of automated information transfer which is the output of planning and programming of node red which is used for digitalization and connectivity.

2.3Task Solution

Value Stream Design (VSD): Value Stream Mapping is a tool used for visualizing each and every stage involved in a process that takes place in the manufacturing of a product or designing a service, including information flow and material flow in macro level. This is also called current state mapping. This is used to identify the wastes or bottle necks that reduce the efficiency and effectiveness of the process and optimize it. Information flow starts when customer provide purchase order for the product or service to the concerned department of the organization, processing the details, planning the production to giving order for the inventories or raw materials to the suppliers. Material Flow starts from suppliers supplying or delivering the

raw materials required for the production of the material to delivery of the finished good as per the customer requirement to the customer. This also includes the macro level depiction of the production process which includes the various stages of conversion of raw materials to the usable finished good as per the customer requirement. Using value stream mapping, one can identify the bottle necks in the whole processes of manufacturing which points out the area for improvement.

VSM Terms and Terminologies:

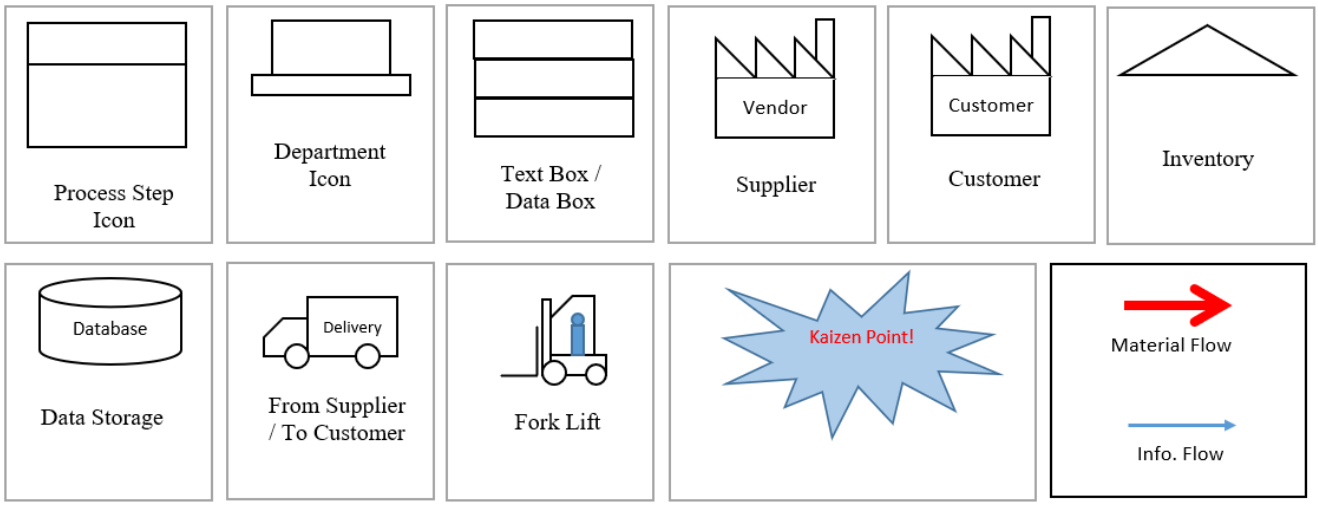


Figure 2.1: Terms and Terminologies used in VSM and their corresponding Icons

i. **Takt Time**: Takt Time gives an idea about the speed at which certain product has to be produced in order to meet the customer demand.

Takt time = Available time for Production / Customer Demand

i. **Process Time**: Time taken to complete a single stage / single process in whole process of production. For example, consider the packaging process of a product. If the packing machine has a capacity to pack 4 products at a time, and for packing a product if the machine takes 10 minutes, the process time of the machine is 40 minutes. Here the process time will be the sum of the time taken for loading the product into the packing machine, time taken by the machine to pack the product and the time taken to unload the product from the packing machine.

ii. **Cycle Time**: Cycle time is the time required for producing a unit of the product in a single stage / single process of whole process. For example, consider the above packaging process of a product. Here the cycle time will be the time taken for one product to successfully complete the packaging process i.e., 10 minutes.

iii. **Throughput Time**: Time required or consumed to complete entire process of manufacturing, i.e., from inward of the raw materials for a single unit of the final product to outward of finished product. It is the sum of the cycle time of different stages of whole process.

iv. **Lead Time**: Lead time is the time consumed or required to complete the whole manufacturing process. It includes the time between initialization of the manufacturing to its completion. It is time taken to deliver the product to the customer after receiving the purchase order from the customer. Lead time has five major parts, Order Lead Time, Order Handling Time, Manufacturing Lead Time, Production Lead Time, Delivery Lead Time.

Steps Involved in VSM:

- Step 1 • **SIPOC** (Supplier, Input, Process, Output, Customer) Analysis
- Step 2 • Construction of Flow
- Step 3 • Customer requirement details
- Step 4 • Production and Shipment Requirements
- Step 5 • Inbound Shipment with Supply frequency details
- Step 6 • Outbound Shipment with Delivery frequency details
- Step 7 • Mapping Process Sequence with Data Box
- Step 8 • Communication mapping with Frequency
- Step 9 • Operator and Inventory details
- Step 10 • Calculation Lead time and Value Index

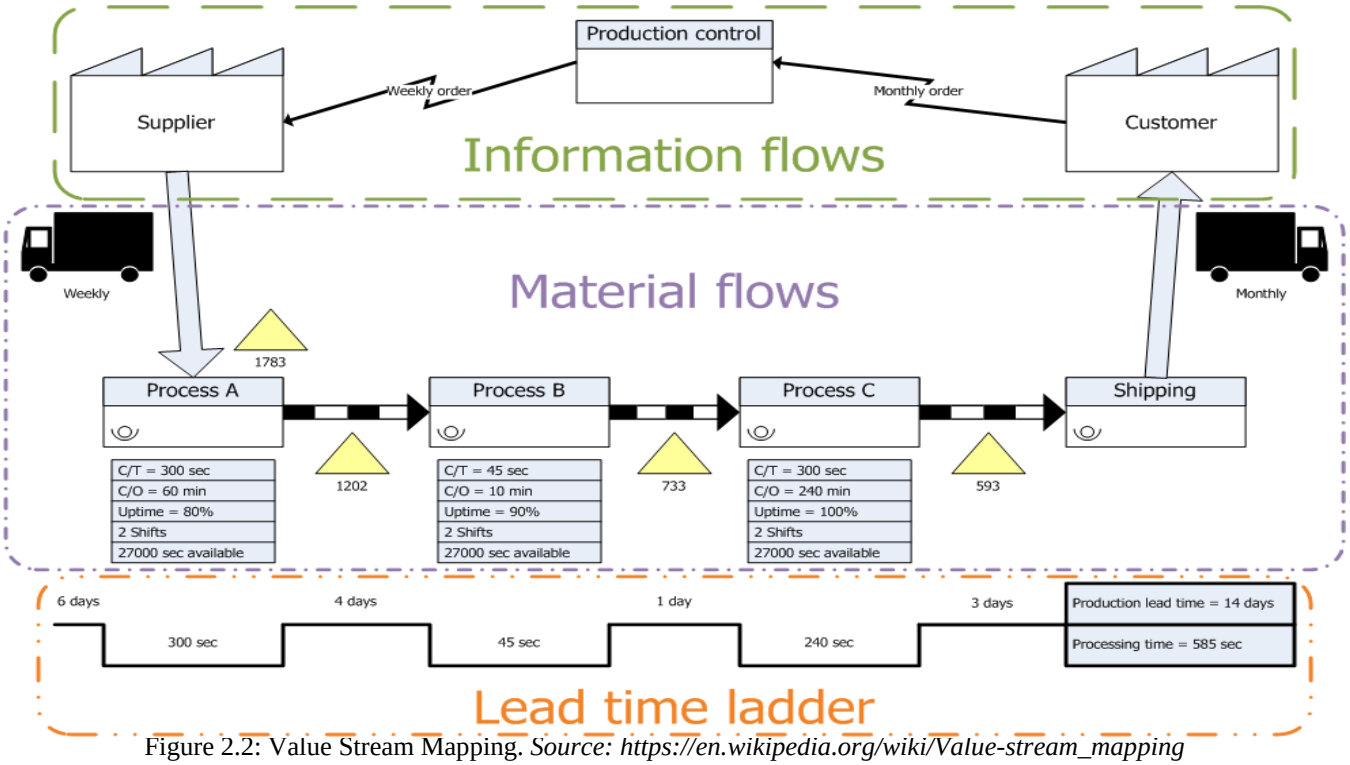


Figure 2.2: Value Stream Mapping. *Source: https://en.wikipedia.org/wiki/Value-stream_mapping*

Value Stream Design (VSD): Value Stream Design is the process of designing improved and optimized version of current state. It involves identification of bottleneck process and other area of improvements, Non-Value Addition (NVA) process from Value Stream Mapping or current state mapping and reducing or eliminating them. It is also called future state mapping.

2.3.1 VSM of NG6 Line

NG6 plant, which manufactures control valve was selected for the initial stage of implementation of the project. For this analysis and understanding the process line was the initial task, I e., understanding the current state mapping or value stream mapping. This included study of both information flow as well as process flow. Information flow starts when customer provide purchase order for the NG6 products, to the sales department of the organization, and they will pass this order to purchase team where the processing of the order and details takes place, planning the production will be taken care of by the production manager, who will prepare the schedules after calculating the takt time, cycle time, process time and the lead time. Then the details of required raw materials are provided to the procurement team who gives the order for the raw materials to the suppliers. At the same time, day to day activity / production schedule is provided to the supervisor of the production floor or the production line in charge, which will be passed to the operators who are in charge of various stages. Here in NG6 plant, the required raw materials are arrived from Rexroth technology lab in Coimbatore and from some foreign vendors. Once the required materials are arrived at the raw material ware house, the production starts. The various process involved in the production process of the NG6 valves are Machining, Deburring, Horning, washing, painting, visual inspection, assembling, testing and packing of “tested ok” instruments. After packing these materials are send to the finished goods warehouse.

Consider yearly demand of NG6 line is 90000 Nos, and number of process days are 300 which gives process planned per day to be 300 pieces per day. If the plant works for 900 mins a day, takt time will be 3 minutes, that means every 3 minutes a product should be produced in order to meet the customer demand. Keeping this 3 minutes takt time as base, inventory time, process time and cycle time of each stages involved in the process are considered to identify the efficiency of the process as well as to identify the bottlenecks and Non-Value addition processes occurring in the whole process.

Here information flow to the production process and back are only at beginning stage, assembly stage and once the finished material enters the warehouse. This leads to a clarity less situations in between stages as well as communication errors happens between supervisors and operators especially when the shift changes. Sometimes this creates a lot of chaos in the manufacturing process which leads to a greater number of defective pieces. Even a break down of a machinery in the intermediate stage, say deburring machine or

washing process, will lead to consumption of greater time which leads to a larger lead time, thus exceeding the takt time, won't be properly reported. In order to avoid these chaos, automation of the information flow is planned through Digitalization and Connectivity using i4.0 tools and techniques where the communication happens directly between the machines in different stages and the centralized server system, which in turn connected with the SAP system.

2.3.2 KPIs of NG6 Line

The Key Performance Indicator (KPIs) are parameters used or closely tracked to identify the loss happening during a process. This can be time loss, material loss or even financial loss. KPIs that affects a process, taking into consideration of Order quantity, production quantity (difference of accepted piece and rejected piece) and cycle time, are majors classified into five namely, Machine Performance Indicators, Plant performance Indicators, Man power performance Indicators, Materials and tools. The major parameters in these elements are in the table below:

Sl.No	Element	Description
1	Machine	Machine Breakdown
2		Start-up Loss / Dry Run
3		Stoppage due to Error
4		Reduced speed to machine
5		Coolant low
6		Coolant change
7		Spare parts change
8		No Power
9	Plant Down	Preventive Maintenance
10		Management Loss
11		AMC
12		Purging and Cleaning
13	Man Power	Operator Shift
14		Operator Absent
15	Material	Rework / Rejection
16		Waiting time delay
03		Quality dept. delay
18		Inspection Loss
19		No load
20	Tools	Tool Change
21		Tool jig fixture non availability / Repair

2.3.3 Automation and Digitalization using Industry 4.0 tools and Techniques

Automation and Digitalization using Industry 4.0 tools basically means that the data containing information to and from various machines involved in a manufacturing process is transferred, controlled and monitored through a centralized system which involves Control Devices, IoT devices, and a Cloud based server which will be connected to ERP system or SAP and even involves cloud computing. This will enable single point of information providing and extraction, eliminating the human intervention in between and will provide accuracy to the communication. Node Red is the software tool used for establishing communication between the machine and the server. It is a visual tool which is used to pull data from the devices and send it to the cloud and vice versa.

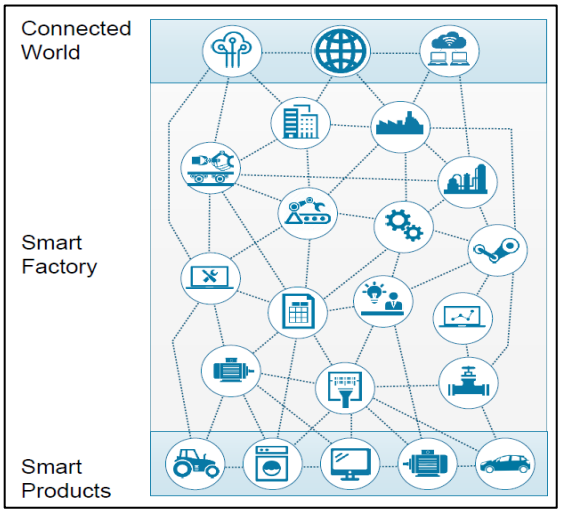


Figure 2.3: Digitalized Data flow chart.
Source: Rexroth Library

Here in the plant, the implementation of Node-red software tool was planned in such a way that it acts as intermediate between the machine and the SAP/ERP system. This will enhance the to and from flow of information that is instructions from the SAP system to the machines and the figures and other critical values related to the process from the machine to system. The IoT platform which is a cloud server installed with the Node-red Software acts as the translator in between, converting the Sap information to machine readable language and Machine language to SAP language. It also does some critical computational process using the cloud computing feature which simplifies as well as clarifies the critical information which includes sum of production, process cycle etc… those are not directly available from the machine but critical data for analysis and auditing.

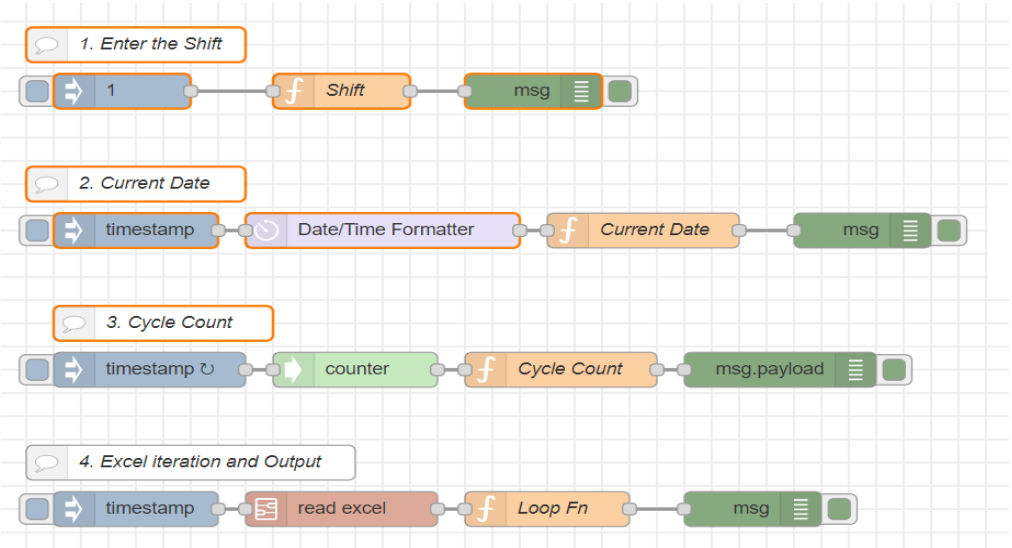


Figure 2.4: Sample Node-Red programming

2.4 Conclusion

Due to Work from Home mode as a result of the pandemic outbreak as well as the time consumed for understanding the various stages in the process, information flow and Material flow, KPIs it was unable to complete the entire project tasks as planned. Below are the plans in order to successful implementation of the Project at NG6:

1. Identification and tracking of bottlenecks.
2. Designing and Implementation of future state mapping.
3. Implementing complete automation of information flow.

Apart from this, some of the recommendation for smooth implementation and running of the projects are:

- Basic knowledge transfer to the operators about the working with a trial run of the process.
- Implementation of redundant system in every stage including the machine PLCs and HMIs, SCADA PCs.
- Centralized monitoring system at the production floor.

3. Learnings

The theory that was learnt in the classroom at Institute of Management was helpful and were applied during entire span of summer internship program. Core operations related topics like Takt time, cycle time, lead time, inventory management, Just in time, were applied and was able to understand these topics in detail.

As my internship was on implementation of Industry 4.0, which was the current trend in the market helping the organization achieve efficiency of production process and increase the profitability. This gave me a deep understanding about the digital transformation process of an organization along with the challenges involved in the process. It also gave an idea of how industry 4.0 can be utilized for lean manufacturing, how it goes hand-in-hand. The planning part was very challenging and informative. The whole planning process made me understand about the hick ups that can happen during the implementation, and how to predict and tackle the same.

This Internship introduced me to a new world of programming and was able to gain a basic idea of JavaScript programming and Node-red software tool which is used for information transfer from one system to another as well as for cloud computing processes. This also showed me a small application of IoT tools and techniques and how they can utilize for a better process planning and optimization of the manufacturing process.

This program gave me more knowledge regarding lean manufacturing and the processes involved in it like value stream mapping and future state mapping, KPIs and bottlenecks in a process along with an understanding of finding Value Additions and Non-Value additions in the process.

I was a part of project planning and strategizing team which included Project Manager, VSM manager, Production Manager and Plant Manager. I was a part of team meetings as well as meeting with the project head. I was able to provide suggestions in the planning of program implementation which was incorporated and presented the plans to the Project department Head.

As a result of virtual internship due to the pandemic, my experience at Bosch Rexroth was limited to the planning and understanding part of the process and was unable to take part in the implementation process which was started in the early weeks of June. Even though, it was rich in learning and provided an idea of how corporates work, how the meeting are schedules and carried out within the scheduled time.

I thank all my mentors at organization for guiding me through this process and giving me this wonderful opportunity.

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