“Smart Garments Factory and What is required to setup a Smart Garments Factory”

Submitted By

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DEPARTMENT OF TEXTILE ENGINEERING

SONARGAON UNIVERSITY (SU), DHAKA.

This report presented in partial fulfillment of the requirements for the degree of BACHELOR OF SCIENCE IN TEXTILE ENGINEERING.

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February, 2022

DECLARATION

Authors attest that this report is totally our own work, except where Authors have given fully documented references to the work of others and that the materials contained in this report have not previously been submitted for assessment in any formal course of study. If Authors do anything, which is going to breach the first declaration, the examiner/supervisor has the right to cancel our report at any point of time.

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LETTER OF TRANSMITTAL

Date:

To

Md. Juel Sarker

Asst. Coordinator & Lecturer

Department of Textile Engineering

Sonargaon University (SU), Dhaka.

Subject: Letter regarding the submission the "Smart Garments Factory and What is required to setup a Smart Garments Factory".

Dear Sir,

Authors are pleased to submit the Thesis the "Smart Garments Factory and What is required to setup a Smart Garments Factory". It was a great pleasure to work on such an important topic. This project was assigned to us in partial fulfillment of the requirement for the award of the degree of bachelor of Textile Engineering (4 years) from Sonargaon University (SU) Dhaka.

Authors believe that this project will certainly help you in evaluating our work. Authors would be very happy to provide any assistance in interpreting any part of the paper wherever necessary.

Sincerely Authors,

Md. Uzzal Mia	TEX-1801013034	Group-A (AM)
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APPROVAL SHEET

This research entitled the "**Smart Garments Factory and What is required to setup a Smart Garments Factory"** at Sonargaon University (SU), Dhaka. Fall-2021, prepared and submitted by **Md. Uzzal Mia (TEX-1801013034), Md. Shazib (TEX-1801013143), Nihar Roy (TEX-1801013044) & Md. Habibur Rahman Sifat (TEX-1801013017)** in partial fulfillment of the requirement for the degree of Bachelor of Science in Textile Engineering has been examined and hereby recommended for approval and acceptance.

____

Md. Juel Sarker

Asst. Coordinator & Lecturer

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Then Specially Authors would like to show a huge thanks go to **Md. Juel Sarker, Asst. Coordinator & Lecturer,** Department of Textile Engineering, Sonargaon University (SU), Dhaka for her encouragement and valuable suggestions.

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Table of Content

ABSTRACT

Since Industry there is a growing interest in smart manufacturing across all industries. However, there are few studies on this topic in the garment industry despite the growing interest in implementing smart manufacturing. This paper presents the feasibility and essential considerations for implementing smart manufacturing in the garment industry. A systematic review analysis was conducted. Studies on garment manufacturing and smart manufacturing were searched separately in the Scopus database. Key technologies for each manufacturing were derived by keyword analysis. Studies on key technologies in each manufacturing were selected; in addition, bibliographic analysis and cluster analysis were conducted to understand the progress of technological development in the garment industry. In garment manufacturing, technology studies are rare as well as locally biased. In addition, there are technological gaps compared to other manufacturing. However, smart manufacturing studies are still in their infancy and the direction of garment manufacturing studies is toward smart manufacturing. More studies are needed to apply the key technologies of smart manufacturing to garment manufacturing. In this case, the progress of technology development, the difference in the industrial environment, and the level of implementation should be considered. Human components should be integrated into smart manufacturing systems in a labor-intensive garment manufacturing process.

Keywords

- systematic review analysis;
- smart manufacturing;
- smart factory;
- garment manufacturing;
- key technology

Chapter-1

Introduction

1.1: Introduction

As consumer markets continue to grow across the global marketplace, the ever-present need of industrial manufacturers to provide higher quality, and lower cost consumer products at higher outputs are growing as well.

Alongside this change is the constant innovation and introduction of business technologies that deliver new business processes, functionality and capability to serve growing markets.

At the intersection of these two are value-added ROI-based solutions for businesses that deliver the next level of evolutionary production processes—the Smart Factory.

1.2: What is a Smart Factory?

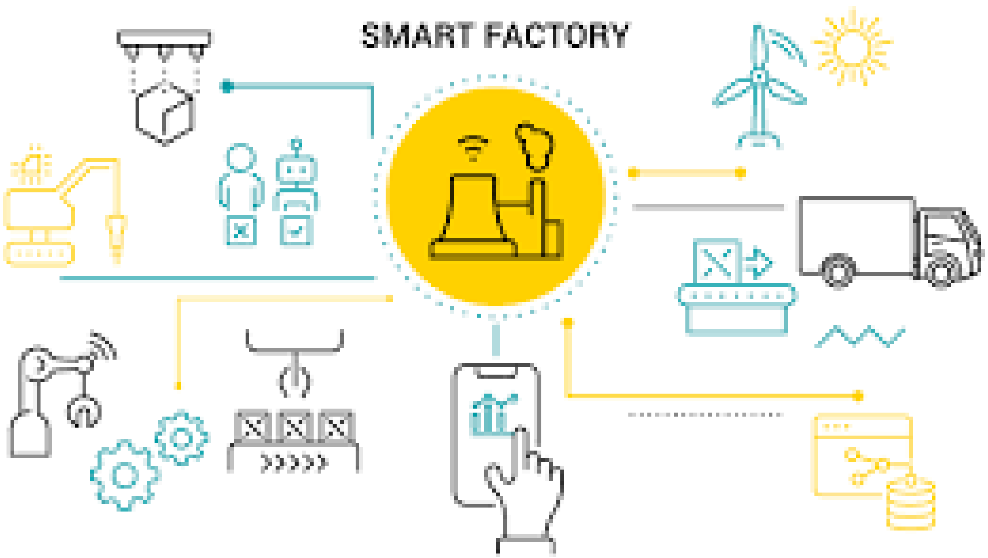


Figure-01: Smart Factory

The smart factory is defined as a factory where physical production processes and operations are combined with digital technology, smart computing, and big data to create a more opportunistic system for companies that focus on manufacturing and supply chain management (abaserp.com). The smart factory is an aspect of Industry 4.0, a new phase in the Industrial Revolution that focuses heavily on real-time data, embedded sensors, connectivity, automation, and machine learning. A factory that used industry 4.0 technologies - such as Robotics, Artificial Intelligence (AI), Internet of Things (IoT), Analytics, and AR/VR (blacksmithint.com).

Though the name sounds like it is something new and a hi-tech factory setup and the factory will take over all the human activities - that is not the case. A smart factory works with a lot of automation with the existing operator sewing machines. Through the case study and example of a smart factory, we will try to understand what a smart factory means. This article is written based on information gathered on a webinar presentation organized by NIFT Fashion Technology Department.

Chapter-2

Literature

2.1: Company Profile

Figure-2: Smart Garments Factory

This is a 100% export oriented garments industry in Bangladesh. The factory was established in 2021 with all the advanced technology, latest computerized machinery, and specialist technicians.

Experts setup the factory with a space 40,000 square feet with high quality machinery from Japan, Germany, Korea and Singapore. The factory is managed and run by a professional group of dedicated specialists and executives with proven track record for custom made services to ensure premium quality. The Management of the factory has got highly experienced entrepreneurs and has a long track record of running successful business in the relevant fields. The factory has grown by offering consumers high quality products and high value branded apparel & every year it exports a large quantity of ready-made garments to our European, American & Canadian customers.

The factory has a Quality Control team whose responsibility is to ensure proper quality standard by conducting inspections at different stages of production.

Our policy is not employing child labor.

The garments factory in Marketing, material procurement, accounting, inventory and shipping documents are connected to a central computer network for efficient management.

We have the following facilities in our factory, which can be referred to as examples of Best Practices:

- Time Attendance & Pay Roll: We have setup computerized software based Time Attendance & Pay Roll system for all workers and employees. This can generate Barcode ID Card, Salary Sheet, Pay Slip etc.
- House Keeping Team: The factory has a House keeping Team for maintaining neat and tidy environment and atmosphere in accordance with the Health and Safety Act of our country.
- Medical Facilities: The workers enjoy free health care benefits and Medicare. We have a qualified Doctor who visits our factory every working day of week.

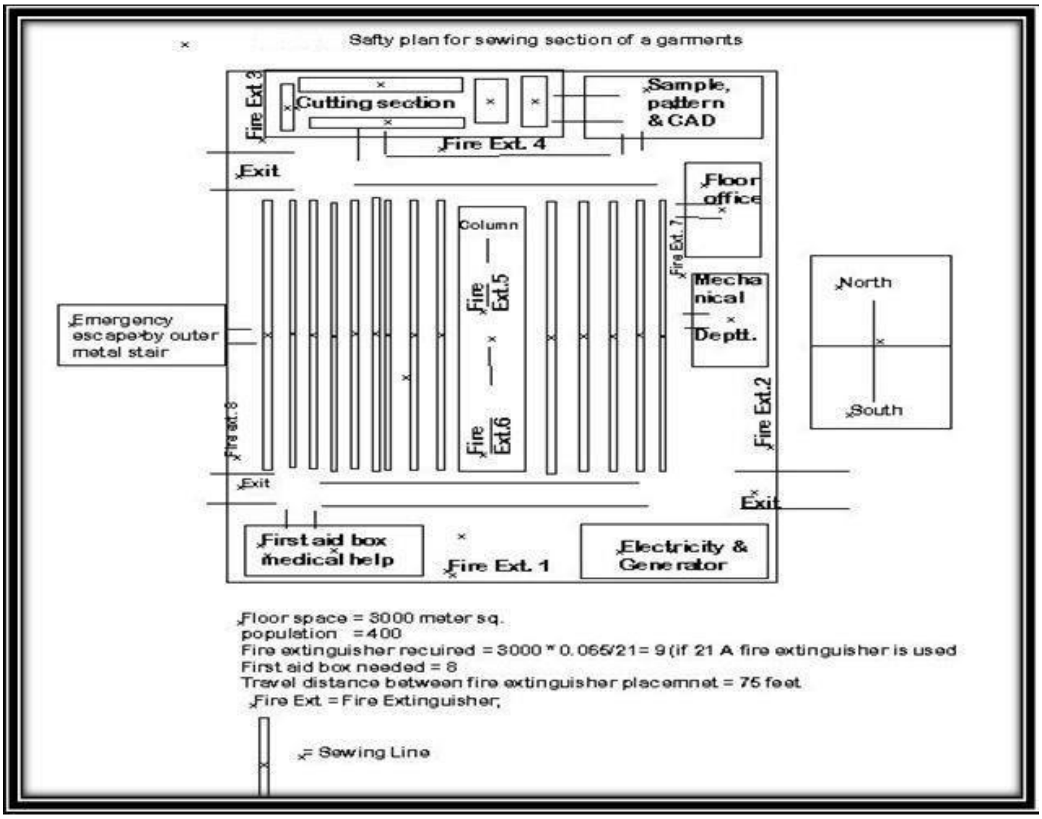


Figure-3: Fire Evacuation Plan

- Evacuation Plan: There are some diagrams kept in the floors of the factory showing direction for all employees to run out in case of any emergency situation.
- Emergency Exits: We have one extra exit in all the floors for use by the workers in case of any emergency in the factory.
- Fire Drills: We have Fire Fighting Equipment in the factory as per Factory Act and in order to use them effectively as and when required we have a Fire Fighting Team who are specially trained to deal with any fire emergency. We have arrangement for Fire Drills on regular basis i.e., once every month so that the team can perform their duty effectively when required.

- First Aid Boxes: For every 150 workers we have a person trained in First Aid and Medicare. We keep certain quantity of medicine of different types in a First Aid Box in each floor for employees to use as First Aid.

2.2: Company Data

Name of the Factory	:	Smart Garments Factory
BGMEA Reg No.	:	1234
Chairman of the company	:	XYZ
Managing Director	:	XYZ
Contact Person	:	Owner, GM, Merchandising & Production Coordinator
Year of establishment	:	2021
Mailing Address	:	Narayanganj
Factory Address	:	Shiddhirganj, Narayanganj
Telephone	:	Head Office: +88-02-******** Factory: +88-02-********* E-mail: smartfactory@gmail.com
Number of employees	:	Male: 435; Female: 463; Total: 898
Number of machine	:	497
Total Unit	:	01 (One)
Floor	:	04 (Four) Floors

2.3: Smart Factory Solution

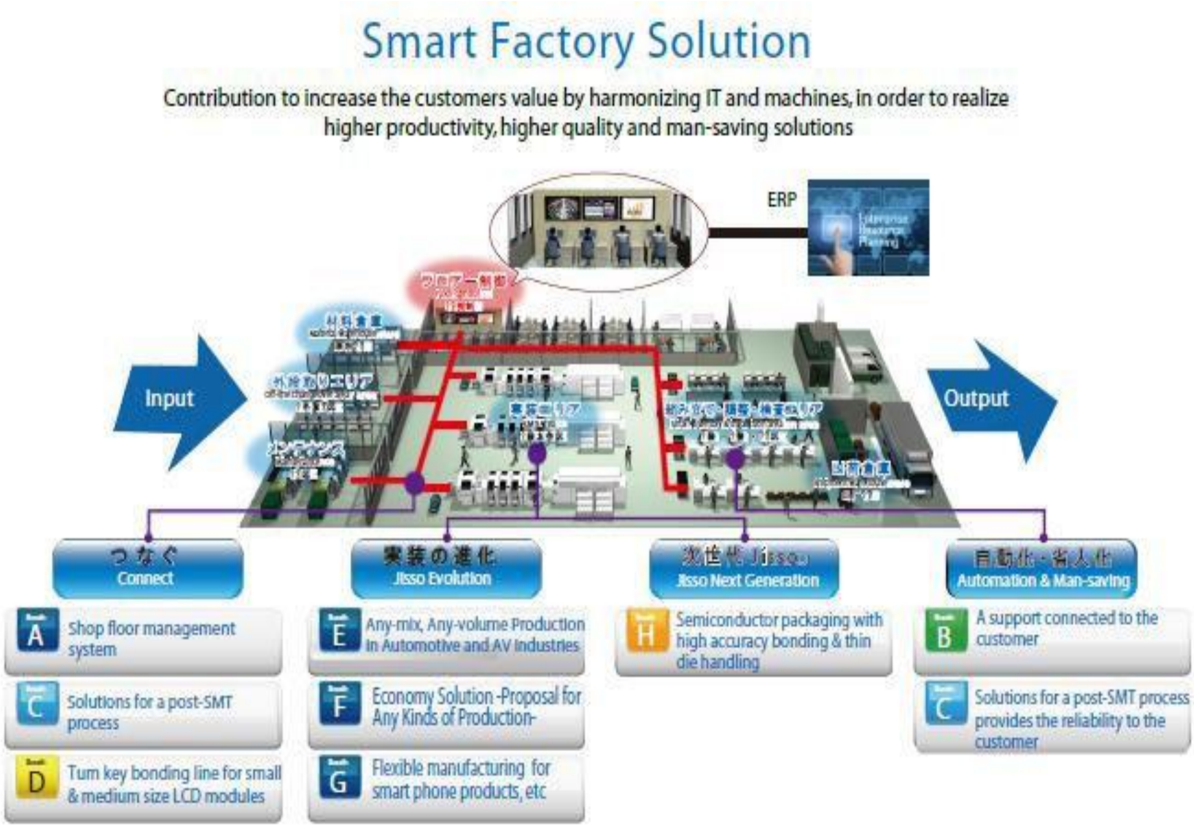
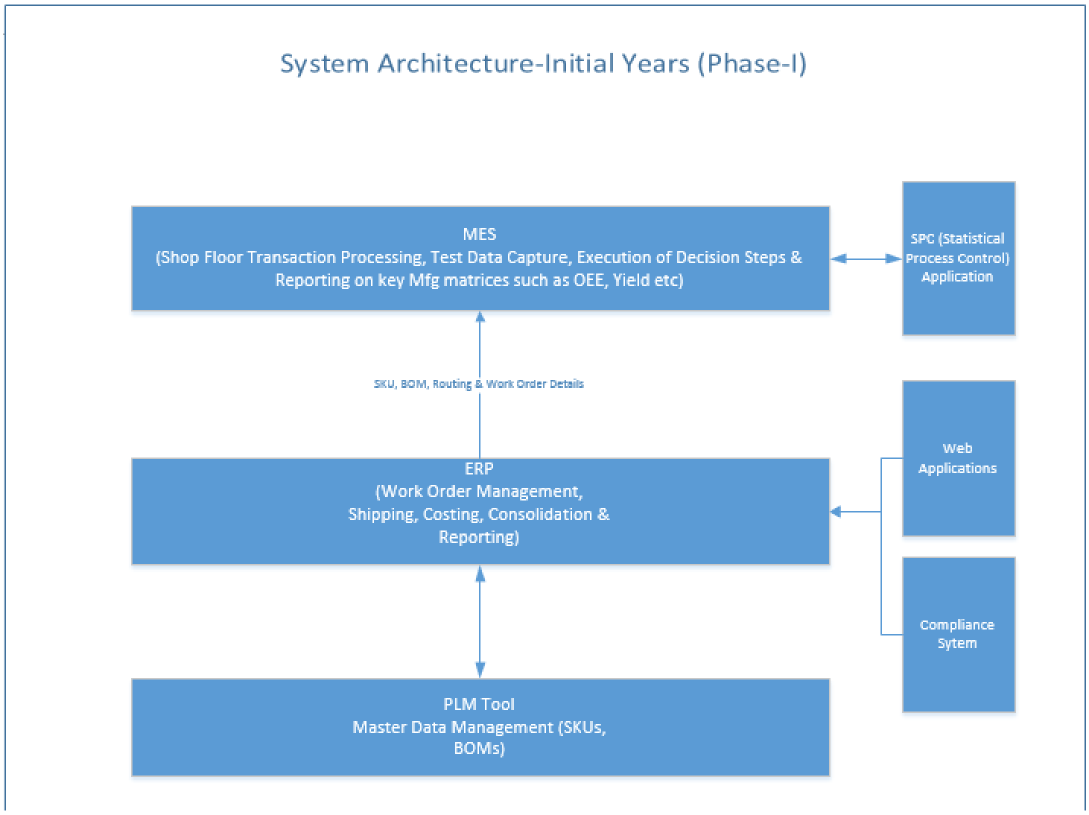


Figure-4: Smart Factory Solution

2.4: System Architecture Initial Year

1. Phase-I (Isolated Systems)

This factory was setup in 2011 in one of the Latin American countries. Most of the equipment was not equipped with sensors. Lines were setup in a way that a new SKU can be produced with limited "Change Over" time. We adopted the following system architecture which had quite a few advantages.



Key Considerations:

- Establishing a Central repository of SKUs and BOMs
- No paper trail for shop floor transactions
- Implementing a Shop Floor Execution system
- Improving Lot Traceability and Lot Genealogy
- Making sure we comply with regulatory requirements

Key Product/Platform Decisions:

- Select a Shop Floor Execution system
- Select an ERP system such as Oracle EBS, SAP, NetSuite etc
- Select a PLM tool such as Arena

Solution Details:

- SKU & BOMs were created and maintained in the PLM (Product Life Cycle Management) tool. They were published to the OLTP (ERP) system. ERP system in turn sends SKU and BOM information to the Shop Floor execution system.
- Work Orders were created in the ERP system and were published to Shop Floor Execution system. Work Orders were executed in MES; but all transaction details didn't flow into the ERP system.
- Material Issue, Back Flush and creation of LPNs were done manually in in the ERP system
- Test results were manually uploaded to the test data repository to address customer complaint
- SPC (Statistical Process System) supports generation of charts, Control Limits etc. It facilitates OCAP (Out of Control Action Plan)
- Selected Web Apps were there to take care of specific manufacturing steps, such as storing Module images, performing specific tests on modules, HR related apps (Attendance System, Break Time Monitoring System, etc.)
- Compliance system stored manufacturing related data to comply with local statutory requirements

Implementation Approach:

Implementation was done in three waves

- ERP was implemented in the first wave. "Waterfall Model" was adopted to implement ERP system. "Agile Methodology" can also be adopted to implement an ERP system, each sprint representing one functional area. Sprint#1 for Financials (Payables, Receivables, General Ledger etc), Sprint#2 for basic Supply Chain modules (Inventory, Procurement, Sales Order etc), Sprint#3 can be for Planning modules, etc.
- MES was implemented in the second wave. Interface was built between ERP and MES. That was predominantly two-way integration from ERP to MES. This interface was used to publish SKU and Work Order related information to MES.
- Product Hub (PLM Tool) was implemented in the third wave. An integration was also built between the PLM application and ERP.

Infrastructure Details:

Line Peripherals: Desktops with manual Barcode Readers and Printers were installed in the line. Servers & Storage: we implemented a Single Node Server-Storage architecture. It lacked HA-DR capability

Network: We implemented network architecture using Core and Edge Switches. However, it lacked structured IP allocation and network optimization.

Security: Firewall was the only security layer

Results Achieved:

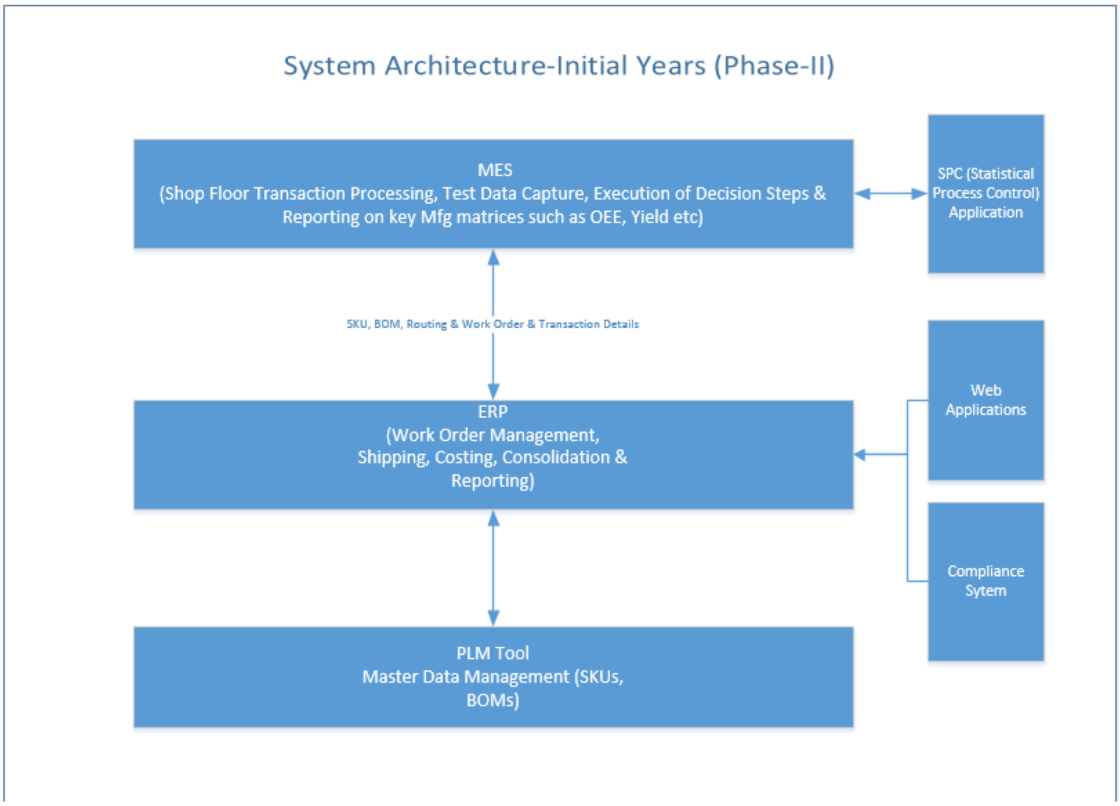
- Packaged OLTP system (ERP system) was in place. Key business processes such as Manufacturing, Source to Pay, Order to Cash, Planning, Accounting & Costing were executed using packaged application
- Shop Floor Execution system (MES) was implemented, which provided the platform to manage all shop floor transactions including multiple testing steps
- PLM Tool was setup as a central item repository which made sure there is single source of truth for SKUs and BOMs

Challenges in this Architecture:

- High level of manual work, leading to reduced productivity and higher cost of production
- Relatively lower accuracy in traceability
- Limited Analytics capability
- Supporting this system was more complex and expensive

2. Phase-II: Seamlessly Integrated Systems

Primary objective of this phase was to seamlessly integrate two core systems, i.e. ERP & MES. We achieved this by overhauling the existing integration and coming up with a new architecture for automated integration between ERP & MES.



Key Considerations:

- Bi-Directional seamless integration between ERP & MES
- Further improvements in Lot Traceability and Lot Genealogy
- Reduction in Manual Transactions and improvement in Productivity
- Making sure we comply with regulatory requirements

Solution Details:

- SKU & BOMs were created and maintained in the PLM (Product Life Cycle Management) tool. They were published to the OLTP (ERP) system. ERP system in turn sends SKU and BOM information to Shop Floor execution system (MES).
- Work Orders were created in the ERP system and were published to Shop Floor Execution system (MES). They were executed in MES;
- End to End Manufacturing process steps are executed in MES and transactional details are sent to ERP at periodic intervals through an automated interface.
- Test results are captured automatically in MES
- Pallets are created in MES and related information are sent to ERP system through the interface automatically
- Corresponding Transactions in ERP (Material Issue, Back Flush, On Hand management etc) are done automatically. ERP acts the system of record to generate financial statements, prepare statutory reports and pay taxes.
- Physical pallets are shipped out of Warehouse Management system in ERP using the hand held mobile device.
- SPC (Statistical Process Control) supports generation of charts, Control Limits etc. It facilitates OCAP (Out of Control Action plan)
- Efforts to decrease the number of Web Apps continued.
- Compliance system continued to be a part of the architecture

Implementation Approach:

Implementation was done in one wave

- Focus of this phase was primarily to automate Transaction processing in ERP system, which reduced manual effort required and increased productivity
- Test results (such as Flash Test Data) were automatically captured by the MES and published to ERP and Compliance systems eliminating manual intervention.
- Functionality of some internally developed Web Applications were migrated to MES and ERP system further reducing the overall number of apps and associated Total Cost of Ownership (TCO).

Infrastructure Details:

Line Peripherals: Retained existing peripherals.

Servers & Storage: As the MES application became increasingly Mission Critical, the infrastructure was extended for redundancy and load balancing.

Network: Retained existing architecture.

Security: Firewall continued to be the security cover

Results Achieved:

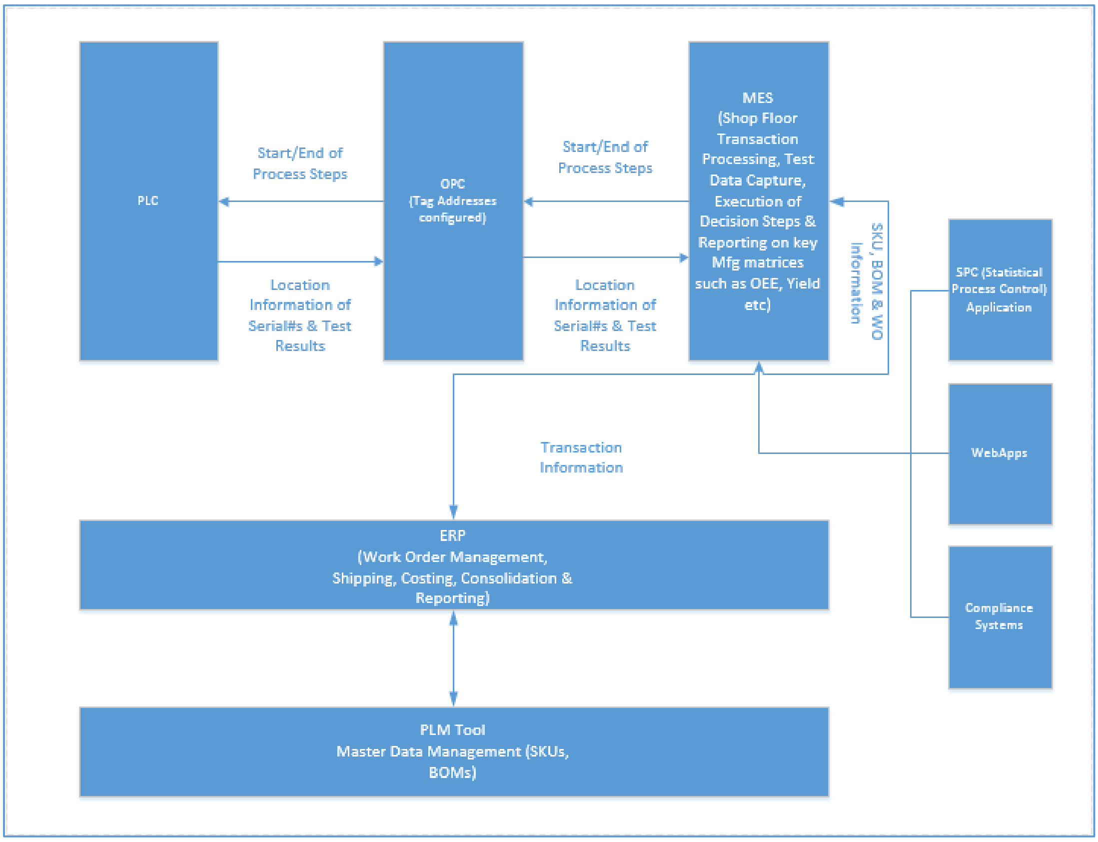
- As a result of automated processing of Shop Floor Transactions in the ERP system, manual effort was reduced, resulting in significant cost savings.
- With automated Transaction processing in the ERP system, Lot Traceability/ Lot Genealogy improved
- With automated upload of test data, addressing customer complaints became streamlined
- Root Cause Analysis of Customer Complaints resulted in improvements being made to the MES so that operator errors were trapped and prevented at source. Customer complaints dropped significantly as a result.
- Usage of Hand Held devices in the Warehouse for Palletizing and Shipping leading to productivity improvements in warehouse

Challenges in this Architecture:

- Absence of Automation through PLC Integration and Robotics resulting in higher Direct Labor/Line
- Challenges in maintaining automated ERP-MES integrations
- Limited Analytics capability

3. Phase-III: Smart Equipment, Improved Processes and high Levels of Automation through PLC integration

During this phase, we introduced "smart" machines. "Smart" machines are not necessarily equipped with equipped with Machine Algorithm, but they have sensors which can capture various data and have industry standard PLC attached to them. We introduced conveyer system for most part of the factory lay out. We built integration between PLC and MES through OPC layer so that most of the transactions were logged automatically. Additional Barcode readers were integrated with the conveyor systems and PLC's to completely eliminate manual transactions wherever possible.



Key Considerations:

- Focus of this phase was "Industrial Automation" which drives productivity. New Solution was developed to integrate PLC with MES. MES was already seamlessly integrated with the ERP system. Essentially PLC, ERP and MES were integrated to drive automating multiple process steps.
- Usage & Adoption of Mobile (Hand Held Devices) in the warehouse for shipping
- Smart Equipment, Process improvements & Optimization
- Automated Barcode reading in selected stations to augment automation

Key Product/Platform Decisions:

- Selection of Vendors to supply "Smart" equipment, primarily driven by Industrial Engineering team
- Selection of Middle Layer between PLC and MES

Solution Details:

- Master Data like SKUs & Bill of Materials (BOM) are maintained in the PLM tool. We publish this information to ERP system daily through a custom interface program. ERP system in turn relays SKU and BOM data to MES (Manufacturing Execution System) through a custom outbound interface.
- Work Orders are created and managed in the ERP system. They are published to MES where they get executed. Separate WOs are released for Finished Goods (Modules) and Work in Process (String & Laminates) to have better control over material consumption and traceability.
- As the Module progresses through the assembly line, PLC tracks its coordinates. When a given Serial# arrives at a station through the conveyer belt, PLC communicates the Serial# to MES through pre-defined tags in the OPC layer. Sensor mounted on the equipment scans the Serial# into MES as the module arrives at the station. As the process step is completed at the station, transactions are recorded in MES. Some transactions, especially test steps are automatically recorded in MES. There are some steps which still has operators, primarily to load the inventory into MES and to consume them. However overall there is a significant reduction in number of operators required to run a line, thereby leading to big reduction in overheads.

Implementation Approach:

Implementation was done in one wave

Focus of this phase was “Industrial Automation” which drives productivity. New Solution was developed to integrate PLC with MES. MES was already seamlessly integrated with the ERP system. Essentially PLC, ERP system and MES were integrated to drive automating multiple process steps.

Lot of focus on User Training and Change Management to make sure users are ready to interact with a highly-automated ecosystem

Infrastructure Details:

Line Peripherals: There was a departure from earlier type of Line Peripherals. During this phase emphasis on installing mounted automatic Barcode Reader on multiple stations to reduce Manual scans

Servers & Storage: Dual Node system was augmented with automated backup of Transactional data in AWS to improve redundancy. Existing Server architecture was altered to improve HA-DR capability.

Network: Re-architected the Network Architecture to allocate IP addresses to devices, terminals on the line, scanners etc in a methodical manner. To improve trouble shooting, Edge Switches were re-configured to accommodate specified lines, we upgraded the Core Switch as well to manage increased network traffic on account of smart machines

Security: Along with Firewall, we installed PAN to further strengthen security.

Results Achieved:

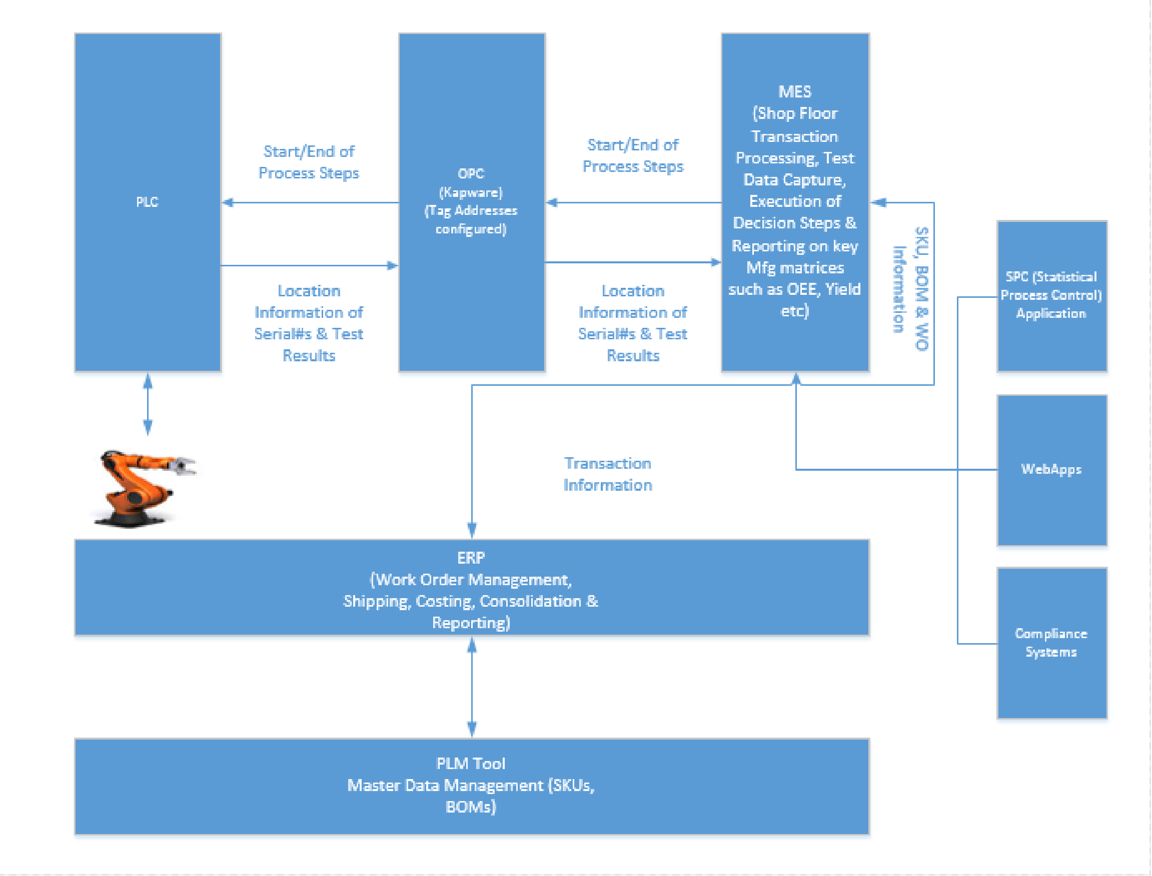
- Productivity improved and there was a significant reduction in Cost/Watt
- Direct Labor required per line was reduced by about 40%
- Lot Traceability/Lot Genealogy further improved
- Launching new products were more swift

Challenges in this Architecture:

- There were still scope for Direct Labor reduction in Lines
- There was scope to reduce manual effort in delivering RMs (Raw Materials) to the Lines from the Warehouse
- Limited Real time Analytics of data from sensors & devices in machines

4. Phase-IV: Next Level of Automation-Introduction of Robots

- During our reviews, we identified multiple process steps which can be performed by Robots. Once Robots can perform these tasks, we can deploy the Operators for those process steps to new lines or to other areas on the shop floor, such as Warehouse. In such a case, Direct Labor/Line will come down which will help us improve Cost/Watt. This will also help reduce defects. Focus of this phase was to introduce Robots in a gradual (phased approach-phases within this phase)



Key Considerations:

- When we reviewed, the Operating Expenses incurred per Line post Phase-III roll out, we felt there are still scope to reduce manual activities and drive up productivity.
- Hence, we evaluated if Robots can help us further drive down the OpEx
- Process Steps to be automated through Robots should have an ROI of no more than one year
- They should fit into the factory lay out (Form Factor)
- Down Time required to Retrofit existing Lines

- Process steps shouldn't be too complex, else lot of money must be spent to get a customized Robot. That may not justify the ROI
- Process steps should be relatively stable. If the way a specific process steps is performed on the shop floor changes then Robots may not be an effective solution.
- We need to carefully consider if Robots should be introduced for existing lines or in new lines to be introduced. There are additional challenges when introducing Robots in existing lines. They will be invasive in nature, meaning they need to work alongside operators who might be working in other process steps or prep steps. Achieving the alignment and rhythm will be challenging. Normally there will be Down Time (DT) required to install and commission the Robot and it will then take a few weeks (e.g. 4-8 wks) to get the Robot up to speed. Productivity loss arising out of this should be considered while making the final decision.

Key Product/Platform Decisions:

- Selection of Robot
- Selection of SI partner to commission the Robot

Solution Details:

- Planning began to introduce Robot (**Planning in process at the time of writing this paper**)
- Master Data Management (SKU, BOM etc) continues to happen through PLM Tool and Interfaces between the PLM Tool & the ERP system and ERP & MES.
- Work Order creation and management happens in the ERP system and gets executed in MES, as earlier.
- PLC-OPC-MES integration continues to work the same way as in Phase-III with PLC controlling the movement of Strings, Laminates and Modules and MES logging most of the transactions automatically
- Selected Process being considered to be automated in multiple phases.
- Once introduced, Robots to perform selected process step(s) and interact with PLC to make sure they are aligned with the overall manufacturing process and transactions for them are logged in MES automatically.
- Evaluations are underway to automate Material Handling through TUGs/AGVs as well

- SPC (Statistical Process System) supports generation of charts, Control Limits etc. It facilitates OCAP (Out of Control Action plan)
- Compliance system continued to be a part of the architecture

Implementation Approach:

- During initial weeks, we conducted an internal workshop with key stake holders from Operations, Facility, Engineering and IT to perform a detailed due diligence of each process step in terms of activities performed, complexity of the activities and number of Operators involved
- We shortlisted process steps which could be potential candidates for Robotic automation
- We looked at Manual Material movements to and from the warehouse and checked if they can be automated through TUGs/Mobile Robots
- This was followed by detailed due diligence of Robot Suppliers and short listing of a few of them
- We looked for SI partners who can help commission the robots. We came up with a few of them, pairing them with each Robot Vendor.
- We conducted onsite workshop with key stakeholders, Robot Suppliers and SI Partners. We validated the findings of internal workshop and invited fresh ideas from external parties (prospective Robot & SI partners)
- We had follow up discussions to crystalize the process step(s) which can be and should be automated
- We came up with ROI for short listed processes. ROI were calculated separately to automate a process step in existing lines and to automate them in new lines. While calculating the ROI, we considered cost elements and as well the benefits arising out of implementing the robots.
- While calculating the cost elements, we need to consider key cost elements. (a) Material Cost (b)Engineering Cost (c) Assembly and Commissioning Cost which includes the integration cost with PLC and other Shop Floor systems (d) Project Management Cost € Training Cost. We need to add the productivity lost due to DT associated with commissioning of Robots and ramp time to reach the desired throughput.

- Benefits were calculated based on Man Power reduction, Defect reduction. We also factored in in tangible benefits such as improvement in safety, compliance improvements etc.
- We came up with the Payback Period/ROI based on the costs and benefits listed above.
- Based on the ROI, a few process steps look promising
- If they make the cut, execution will be planned

Infrastructure Details:

Line Peripherals: Similar to the previous phase

Servers & Storage: Same architecture as previous phase. Added a core and storage to manage additional data processing

Network: Same architecture as previous phase. Added capacity to Core switches to manage additional network traffic because robots

Security: Same as the previous phase.

Results expected to be Achieved:

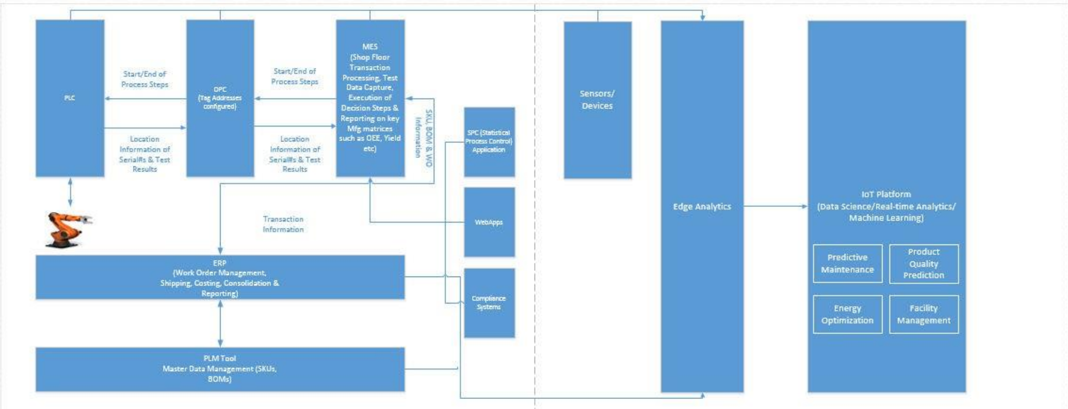
- Productivity improvement resulting in further reduction in Cost/Watt
- Reduction in Direct Labor required per line.

Challenges envisaged in this Architecture:

- In case of higher user churn, training new users becomes a challenge
- Supporting this system requires teams with expertise in multiple area(s); ERP system, MES, PLC, OPC, Robots, Integration and Infrastructure (Network, Servers, etc.)
- In case of process step changes for the automated ones, Robots need to be re-programmed
- At times ROI for Robots in Asia, Latin America & Africa is challenging to justify

5. Phase-V: Real Time Analytics

This phase envisaged leveraging real-time analysis of voluminous data (big data) generated by machines and use them to perform predictive maintenance, improve energy management, reduce defect etc. We adopted a phased approach where we started off with one Use Case and gradually going to address remaining. This also has phases within this phase, with each phase broadly mapping to a Use Case.



Key Considerations:

- Collecting data from multiple systems and devices.
- Real-time analysis, identification of patterns and translate them to Machine Learning
- Using Machine Learning for key Use Cases such as Defect Prevention, Product Quality Predictions etc

Key Product/Platform Decisions:

- Selection of IoT Platform
- Selection of SI partner to help implement Machine Learning for first couple of Use Cases

Solution Details:

- Solution Architecture from Phase-IV is retained
- An IoT need to be added to overall solution architecture
- Initial phase of assessing IoT Vendor and SI partner
- “Edge Analytics” looks promising to massage the extracted data so that we optimize the volume of data and make sure we are bringing in “relevant” data.
- Once data is available in IoT platform “real-time” analysis happens, which includes “Predictive Analysis”, “Machine Learning” etc. This is expected to help bring down Unplanned Downtime of Machines, improve quality etc

Implementation Approach:

- We had discussions with multiple IoT platform providers and with companies which help with Data Engineering
- Cross-functional discussions and Detailed due diligence (which included Fitment, TCO analysis etc.) in process to choose an IoT platform
- During the sessions, we found some Use Cases promising for our plants, they were around Preventive Maintenance, Energy Management, Defect Analysis & Prevention & Cost Management
- We decided to start off with Defect Prevention. Even this started with a limited scale, where we focused on one type of machine in one plant. Based on results, we will be extending to other machines and then to other plants

Infrastructure Details:

Line Peripherals: Similar to the previous phase

Servers & Storage: Same architecture as previous phase. Added a core and storage to manage additional data processing

Network: Same architecture as previous phase. Added capacity to Core switches to manage additional network traffic because robots

Security: Same as the previous phase.

Results Expected to be Achieved:

- Reduction in Machine breakdown which would lead to improved OEE and Uptime.
- Reduction in Defects.

Challenges in this Architecture:

- Realizing the ROI for real-time analytics can be a longer process at time, hence at times getting executive sponsorship is challenging
- Supporting the entire architecture and finding all the required skill sets becomes difficult
- Budgeting for and managing upgrades/patch application
- With so many devices inter connected keeping the entire system secured is a big challenge. Hence security team need to be engaged through the implementation to avoid any security breach.

2.5: Summary of Phases

Phases	**Description**	**Key Platform/ Product/ Technology Decisions**	**Architecture Highlights**
Phase-I	Isolated Systems	MES ERP PLM	MES+ ERP+ PLM+ SPC+ Web Apps+ Compliance System
Phase-II	Seamlessly Integrated Systems	None	MES +ERP+ PLM+ Automated MES-ERP Integration+ SPC+ Web Apps+ Compliance System
Phase-III	Smart Equipment Improved Processes and high Level of Automation through PLC integration	Middle Layer-OPC	MES + ERP+ PLM + Automated MES-ERP Integration + PLC-OPC- MES integration+ SPC+ Web Apps+ Compliance System
Phase-IV	Next Level of Automation-Introduction of Robots	Robots (some top Robot providers are Kuka, ABB, FANUC)	MES+ ERP+ PLM+ Automated MES-ERP Integration+ PLC-OPC-MES integration+ Robots+ SPC+ Web Apps+ Compliance System
Phase-V	Real Time Analytics	IoT platform (some top vendors are C3IoT, Thing Worx, Jasper	MES+ ERP+ Arena PLM+ Automated MES-ERP Integration+ PLC-OPC-MES integration+ Robots+ IoT Platform+ SPC+ Web Apps+ Compliance System

2.6: Different Sector of Smart Factor

1. Components of a smart factory

In the garment manufacturing sector where you can add a technology that helps existing companies to become a smart factory. Components of a smart factory include - Automation in production, maximum use of Robotics, Artificial Intelligence (AI), Internet of Things (IoT), Machine learning, Analytics, and AR/VR, application of rea-time production and quality data capturing and processing of data toward controlling the processes.

Here are a few examples of technology solutions and innovations available for moving towards a smart factory (Dr. Jana). Smart procedures can be introduced in apparel manufacturing such as

- pre-sewing areas in automatic pattern making, on-screen digitizer, an accessory dispensing system which reduces time wastage,
- IoT enabled CNC cutter which is familiar in the last decade. Tukatech has already initiated the automatic pattern making system.
- Virtual digitizer which is generally done by taking photos also helps in pattern making.
- application of robots in the pickup section of the sewing area also uplifted the motion of smart manufacturing,
- an operator-less sewing machine is in the near future with the addition of sew-bot.
- Digital sampling.

2. Achievements through smart factories

To date, the kinds of achievements smart factories have are listed here.

- Manufacturing of full instrument operated t-shirt production of Adidas in 22 seconds as well as operator less sewing machine.
- In post-sewing areas, automation is there in the garment measurement system using a digital measuring tape.robotic ironing system and garment folding system. The automated measurement system laser-based measurement system is also there in the commercial sector.
- IoT based technology enables tracking the skill set of operators as well as the average quality score of the operation along with the strength and weakness of

the operator. Sewing machine operation and production evaluation systems work with a material handling system that is how much time an operator needs for that operation.

- RFID tags help to track the time taken between two consecutive operations. CGS's Bluecherry shop floor control system is an example of an RFID based real-time production tracking system.
- Juki, Brother are some of the sewing machine manufacturers that come up with IoT technology for tracking operations in sewing machines by an operator.

3. Advantages of being a smart garment factory

As per experts, benefits that a smart factory enjoys include -

- A smart factory is fully equipped with a WIFI system,
- Smart factories can track the operation done in a sewing machine through a real-time system and using a cloud-based system.
- the prediction of defects in the material where he addresses that the more the data is pre-input in the system, the more it will be flexible for the tracker.
- Better prepared for the production
- Reduced manpower and dependency of staffs

4. Technology level found in a smart garment factory - Case-I (Hugo Boss)

On the webinar, Mr. Erkut Ekinci from Hugo Boss, Turkey, shared the strategies they have taken for the implementation of their foot toward their journey of installation of a smart garment factory.

- They have opted for artificial intelligence, robotics, and digital twins in which machines, people, products, and processes are considered part of the smart factory.
- A system enabling faster data entry systems, easy IT access, modular flexible systems, and people mentality impacted towards better smart manufacturing is necessary.
- They have completed certain projects in this arena such as Smart data management, group & line board
- They are using augmented reality (AR) and virtual reality (VR) applications.

In smart data management, they have shown how easily they are tracking every data through tablet devices situated on the shop floor workstations. A large screen line board graphical representation in the midway of their factories helps their employees to know about the quality, repairs, inventories, shipments, delivery dates, and time left.

AR/VR helps them in employee training, machine maintenance to understand the critical operation of manufacturing particular apparel. Active digital assistants (chatbots) help them in data retrieval and stocking of information.

Speech recognition is one of their completed projects. Completion of Robotic process automation enables them to eliminate non-value-added items and reduces unnecessary human interventions. They have introduced AI to detect quality defects, with fabric consumption estimation and improvement in the cutting section of garment manufacturing as well as an advisory warning signal generator in each segment.

From the above example, you can see that there are many things a garment factory can do to convert their factory into a smart factory. Each event, process, and activity of the apparel supply chain can become part of the industry 4.0.

5. Technology level found in a smart garment factory - Case-II (Raymond)

Mr. Kaushalendra Narayan of Silver Spark Apparels of Raymond Ltd has shared their journey of how they have implemented a smart manufacturing system in one of their factories.

The IoT has enhanced their Made-to-Measure (MTM) production of blazers and jackets for exports in fabric quality, cutting, cut components inspection system sewing and inventory departments too.

A bar-code system is quite easy for tracking its huge manufacturing system in a more synchronized manner. The Bar-code system also tracks the fabric inventory, raw material, order status, pressing of blazers.

Production planning software and line balancing solutions are two software's which have been taken by Raymond in their journey.

They have also built up their quality tracking management system with the help of an RFID. An SMS based sewing machine maintenance system was incorporated by them along with an internal environment maintenance system, energy monitoring system as well as fuel consumption monitoring system.

In that factory, they have implemented a digital Kan-ban system and live production system to track the ongoing production system. Bar-code for every piece and digital material in-house communication system. For the ergonomic betterment of the labor, they have introduced pneumatic chute for trims issues and automated fabric inspections too.

Raymond has also introduced the digitization of everyday reports to reduce the paper consumption in reports, Virtual sampling auditory activity as well as virtual shipment procedure and tracking of inventory through virtual systems.

Raymond is quite innovative and also can act as a pathway to many other Indian apparel manufacturers. With technology adoption, they have also improvised the processes internally to make the factory as a smart factory.

2.7: Elements of Smart Factory

Three Foundational Elements of Smart Factory

A. Accurate and Trusted Information

Consistent and accurate information is a key component of every business and the first foundational element of the Smart Factory. Without accurate information, the Smart Factory isn't smart.

Data accuracy comes from an implementation process known as Critical Data Analysis. This process seeks to untangle the constraints often associated with the management of critical data elements that drive analytics, business execution activities and link key automated business practices. This Smart Factory component focuses on:

- Untangling the web of constrained data elements
- Applying critical data analysis to unlock qualitative information required to efficiently run the operations
- And place those data sets in a single-tenant system where the information can be properly and more efficiently managed and secured

B. Comprehensive Communication

Communication is the second foundational element of the Smart Factory. While loading critical data elements into a single system allows for easier and more accurate management of the information, it does little to help aid operations if business systems cannot access the data.

Critical to the Smart Factory is mapping operational systems and linking operational paths to the information needed to smooth operations, increase productivity and drive additional profitability. Smart Factory-based businesses configure and manage the communication between machines, people, production planning, production operations, financials and reporting for a comprehensive and end-to-end view of the business. The outcome of Smart Factory communication is the evolution to a dynamic production environment where processes can now interact across lines of business and business solutions.

C. Smart or Intelligent Automation

The third and final foundational element of the Smart Factory is comprehensive automation. Building on the first two foundational elements a business can easily adopt a true systematic automation environment leading to a digital shop floor transformation of the business. Real-time Analytics and KPI measures become readily available for management and operations to make immediate and accurate decisions. Production and equipment operations can benefit from Artificial Intelligence (AI) to notify service of issues, drastically reducing unplanned downtime, and provide enhanced processes for retooling and equipment calibration to make shop floors both more efficient and flexible.

Chapter-3

Research & Methodology

3.1: Floor Layout

Ground Floor	:	Store, Child Care, Doctor's Room, Workers canteen, Generator Room, Security Room
2nd Floor		Cutting section, Fabric Inspection, IE Room
3rd Floor	:	Finishing Section, Inspection room
5th Floor	:	Sewing floor (Woven)
6th Floor	:	Sewing floor (Knit)
Number of Line	:	6 (Six) Lines
Factory setup	:	i. Quality Control Section ii. Pattern & Sample Section iii. Fabric Inspection Section iv. Cutting Section v. Sewing Section vi. Finishing Section vii. Packing & cartooning Section
Banker's Name & Address	:	Dutch Bangla Bank Ltd. Narayanganj Branch Shiddhirganj, Narayanganj Phone : *************
Product Range	:	Men's & Boys Dress and Casual Shirts, Ladies Blouses
Production capacity	:	1,50,000 pcs per month
Major Buyers	:	Sears, Wal-Mart, Costco, H&M, Primark, Jalando, Aldi
Special Features	:	Vacuum ironing table, Feed of the Arm, Placket Fusing machine, Collar forming machine, Cuff Forming machine, Kansai Special, Fabric Inspection machine, Collar notcher, Button pull test Machine, Shaddle Stitch machine, Pintect machine, Bottom cutting, maximum sewing machines are Auto-trimming and vertical trimmer

3.2: Garment Production Systems

In simple a ‘garment production system’ is a way how the fabric is being converted into a garment in a manufacturing system. Production systems are named according to the various factors, like- number of machines is used to make a garment, machines layout, total number of operators or tailors involved to sew a complete garment and number of pieces moving in a line during making a garment. As the fashion industry evolved and demand for readymade garments are increased, the need for mass production systems become the essential way to meet the market demand. Simply because tailoring shops are not able to produce the volume and supply across the world.

3.3: Different Types of Garment Production Systems

1. Make Through System

When a tailor alone makes a complete garment, then it is called as make though systems. The tailor even makes a pattern (use ready-made pattern), cuts fabric and does the finishing of the garment. For example, tailors in the tailor shops do all jobs from cut to pack. In this system, tailors are not depended to others.

2. Progressive Bundle System

In Progressive bundle system, each operator does different operations of a garment. All sewing machines needed to make the garment are laid in a line. Cut parts are fed in a bundle form. When an operator receives a bundle of cut components, she opens the bundle and does her operation (job) for all pieces of the bundle. After completing her job she moves the bundle to the next operator who is doing the next operation. A number of people involved in sewing a single garment. Major benefits of this system are – as operators work on single or limited operations, their performances increases. Secondly, product consistency can be maintained garment to garment. Most of the export-oriented garment manufacturers adopted progressive bundle system as the main production system.

3. Section Production System

This system is similar to the progressive bundle system. But the difference is that, instead of one line, work is divided into sections. Machines of similar operations are clubbed together instead of spreading over in all lines. For example, when a man’s formal shirt is being made in a section layout – collars, cuffs and sleeves are in the preparatory sections and then send to the assembly section. This system is popular to improve line balancing and utilization of human resources.

4. Modular Production System

In ‘Modular production system sewing operators work as a team. Neither they sew complete garment nor do they sew only single operation. Multi-skilled operators form a group and each of the team members do multiple operations. In a modular system, operators help each other to finish the garment quickly and the team is fully responsible for quality and production. In modular, always team performance is measured instead of individual operator performance. This system is very successful where quick response is needed.

5. One Piece Flow System

Instead of making a bundle of multiple pieces, a bundle is made with all components of a single piece. Sewing machines in One-piece-flow system can be laid in a straight line or modular line. The main difference is that the operator will receive one piece from the back and move one piece to his next operator after completing his work. Benefits of One-piece-Flow system are less throughput time, Less WIP in the line.

6. Overhead Production System (UPS -Unit Production system)

In the overhead production system, garment components are clamped in a hanger and the hanger moves on an overhead rail. In the hanger components of a single piece is clapped. So this is also one kind of single-piece-flow system. See the example of overhead production systems.

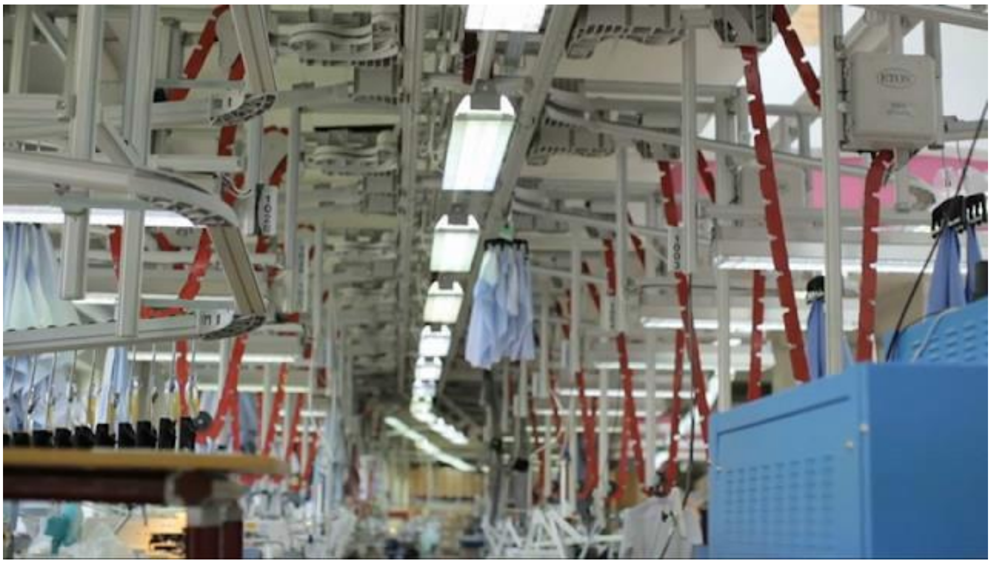


Figure-6: Overhead Production System (UPS -Unit Production system)

7. Piece Rate Production System

Piece rate system also one of the most popular production system in small and unorganized factories. Though people called it a piece-rate system, actually it is not a production system. Whatever Production system is used as mentioned above, when operators are paid according to their works (how many pieces produced), is named as a piece-rate system.

3.4: What is the line layout?

The sewing line layout can be defined as the way sewing workstations are placed in the sewing floor to form a line (or batch) that works on single style. The purpose of choosing one line layout over other is to achieve best production with existing resources.

The line layout in a factory is not changed frequently. Line layout is designed at the time of plant set up and after that if factory wants to change production system they might need to redesign the line layout. You may reallocate sewing machines while setting line for new styles but you don't change the form of line.

3.5: Different Types of Line Layout

Though there are multiple options of sewing line layout to choose from, most garment manufacturers are comfortable with straight lines having center table in between two rows of machines.

In this article I will be showing you different types of line layout found in garment industry. This article would not tell you which line layout is good and which one is not so good when compared with others.

3.6: The other common sewing line layouts are as following

1. Line with center table and operators facing same direction

In the line a center table is placed in between two rows of sewing machines. All operators sit on workstation facing same direction. Operators pick bundles from center table and after stitching dispose bundles on the center tables.

Figure-6: Straight line.

2. Line with center table and operators facing opposite direction

Machine layout is same as above one. Difference is on operators' sitting position. Operators sit on the machine keeping center table left side. This layout is more convenient to all operators for picking up work from left side.

Figure-7: Straight line operator facing opposite direction

3. Straight line without center table and one raw of machines

In this layout no center table is used for material handling. Instead cutting and finished garments are kept of hangers, on baskets or on trolleys. See the different form of layout where machines are placed in a straight line but no center table is used.

(a) Overhead material movement: Garment components are placed clipped on hanger. and transported on a rail.

Figure-8: Straight line layout with overhead material transportation

(b) Trolley for material transportation: In this layout instead of center table trolleys are used for material transportation.

Figure-9: Straight line layout with trolleys

(c)) Line having individual disposal basket (Fig-5):

Instead of center table individual disposal baskets are provided to operators.

Figure-10: Straight line layout with individual disposal basket

4. Side by side machine layout:

In this layout sewing machines are placed side by side. Two rows of machines are faced each other. This type of layout is used for single piece production system.

Figure-11: Side by Side machine layout

5. U-shaped line layout:

This kind of line layout is used in lean manufacturing. Machines are placed side by side and U-shape is formed to make a line. Operators sit inside. No center table is used. This line layout is also known as modular line.

Figure-12: U-shaped line layout.

6. Modular line layout:

In lean manufacturing, to reduce material transportation and increase the machine utilization sewing machines are placed in such a way that neither it forms a U-shape nor a straight line. Instead machines placed that suits better to work into multiple sewing machines sitting in single chair. I don’t know what the exact name of this kind of layout is. This layout is named as modular layout to differentiate from the above one.

7. Machine layout in UPS system

This is bonus for you. I found this while searching on the web. Machines are placed in straight line but in an angle. In the other UPS workstation machines can be placed side by side.

Figure-13: Line layout in UPS system

Chapter-4

Result & Discussion

4.0: Result & Discussion

Move and stay ahead of your competition. Reach your full potential and see results immediately with Smart Factory Logistics.

1. Leaner Process

- **Maximum** savings on order management cost
- **Significant** reduction in material handling cost
- **Lowest** inventory holding cost
- **Highest** availability

2. Maximum flexibility

Smart Factory Logistics Systems are engineered to suit different manufacturing environments and production setups. This ensures maximum operation flexibility.

3. Increased agility

Using advance embedded sensors technology, Smart Factory Logistics Systems automatically recognize manufacturing demand fluctuation. This will allow supply chain to respond with better agility.

4. Improved predictability

ARIMS application software analyzes big data to uncover meaningful patterns, which increases supply chain predictability and efficiency.

5. Proven Productivity

Based on the value-stream-mapping methodology, Smart Factory Logistics Advisory provides expertise for continuous and sustainable productivity improvement. Execution focused, result oriented.

The smart manufacturing systems have been playing a vital role in the implementation of better manufacturing technology in the current industrial age. The smart manufacturing technology improves the operational efficiency, productivity and has great impact in the global economy. It has been found that emergence of IoT and IoT has been playing a vital role in uplifting the manufacturing system equipped with smart manufacturing systems. Various researches in manufacturing system have investigated that there are many industries which are intending to upgrade their industries with smart manufacturing systems. The challenging factor for a smart manufacturing system is being the issues with compatibility of their existing machines and systems with the new technology.

Smart devices like IoT and CPS has now emerged as a universal paradigm that can drastically transform any industries equipped with sensing, identification, remote control and automated control capabilities. The industry 4.0, Society 5.0, Made in China 2025 and Industrial Internet all has the technological base of Internet and the interconnected devices, which basically has the theme of process control through less human interventions and smart decisions which has a very huge impact on the global market. This paper explained about the smart manufacturing system and its associated technologies, newly introduced paradigms, associated technologies and their impact in smart manufacturing technology, related standardizations and the challenges and opportunities of smart manufacturing system has been discussed.

As seen through various Internet integrated systems, the inter-link between the physical objects through the internet or the IoT has explicitly played a vital role in the upgrade or upliftment of the existing systems and procedures. Internet technology has seen to be enhancing the SCADA systems in the automation sector by introducing the remote sensing and control facilities. Due to the interlinkage of physical objects like public transportation, power grid operations and monitoring, better health care by tracking the body vitals and frequently reporting, coordination of live traffic, tracking of assets, interconnected fleet management, self-driving vehicles like AGVs through internet has improved the lifestyle as well as the socio-economic status of the people around the world. The use of IoT in different sectors has helped to reduce the people to work in hazardous environment by using the automated systems and increased productivity too.

For the successful implementation of smart manufacturing technology, the associated technologies like artificial intelligence, cyber physical systems, big data processing, augmented and virtual reality, IoT, robotics technology etc. needs to be developed properly in the industrial area. The defined functions of these technology have not been found to be in common in the current manufacturing scenario and lacks a big gap from the conceptual smart manufacturing system and the existing manufacturing system. Also, for the proper communications between the machines in the industries, there should be implemented the latest IPv6 technology which supports more devices in interconnection.

Chapter-5

Conclusion

Conclusion

Journey to a Smart Factory is a fairly long journey fraught with challenges. It requires executive sponsorship, building of a strong cross-functional team who constantly collaborate with each other, selecting the right products and platforms, selecting SI partners with required capabilities, paying close attention to learning from every phase and last but not the least, “patience.” As the world becomes increasingly competitive only the fittest will survive, we need to constantly improve in order to remain competitive.

In the future, some garment factories will evolve themself and become smart factories. They will be in a better position to control the business processes - from production planning to order execution to employee training, real-time automated data capturing, automated data analysis. But the traditional garment production factories will co-exist. Garment businesses are investing in Saas based software solutions for the digital revolution. All these are possible through the changes of mindset. Reasonable investment and better solutions are coming to bring the changes.

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