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Factory automation: A tool to create competitive advantage

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Abstract
Manufacturing industry has witnessed an explosive growth over the past decade. As globalization expands the market, it attracts a lot of new players. To survive and to thrive in a highly-fragmented environment, companies need to create sustainable competitive advantage. Broadly speaking, competitive advantage can be created through Product Differentiation, Cost Leadership, Target Marketing and excellent After Sales service. A company needs to achieve some of them if not all to maintain or to grow market share. When translated in the context of the Manufacturing industry, manufacturers need to come up with innovative products with low defect rates and aggressive marketing plan to be successful. Defining a consistent process, installing smart equipment, automating process steps and designing and implementing robust system architecture are key pillars to produce world class products. This paper outlines high level approach to System Architecture and Automation process to improve productivity and reduce costs in factories.

Keywords: automation, advantage, manufacturing industry

Introduction

Manufacturing has been at the forefront of job creation and growth across the world. It's one area which creates employment for individuals of virtually all academic and professional backgrounds. Hence, Governments all over are creating a very favorable environment for Manufacturing. They offer multiple incentives to setup manufacturing facilities. With the adoption of automation, factories have regained their charm even in geographies like EU and North America. However, in a globalized world, Manufacturing faces multiple challenges.

First is to keep pace with consistently falling prices through aggressive cost reduction roadmap. There are multiple approaches to tackle this; reducing the input cost by sourcing raw materials where they cost the least, creating and maintaining an optimized supply chain, reducing overheads during manufacturing and bringing down sales and distribution costs. A straight forward way to reduce manufacturing overhead is to set up plants in low cost locations such as Asia and Latin America. However, such is the competition in Manufacturing, setting up plants in a low-cost location isn't enough, as it's easily replicable. Innovative systems and processes need to be in place along with geographic advantage to facilitate increased productivity leading to significant cost reduction.

Second is to ensure top product quality to meet performance guarantee of products produced. This requires putting in place system checks to ensure quality standards are adhered to and strong traceability is maintained to link individual product Serial Number to Raw Material lots used.

Third to introduce new products with enhanced functionality at a fast pace to cater to different customer segments as well as different geographies. Hence, systems should have the agility to launch new products seamlessly without compromising on quality, traceability and time to market.

The following sections describes a high-level approach to design a system to address all the three challenges outlined above.

1. Key considerations for system design

Business Objectives: First and foremost, the overall objective of automation needs to be defined. Sometimes, organizations embark on automation journey without clearly defining quantified goals. Numerical targets for Through Put, Capacity per Line, Reduction in DL (Direct Labor) and cost/unit should be set. Traceability requirements and ability to launch new products within a specified time frame should also be included in objectives.

ROI

There should be a broad agreement on ROI (in terms of months) between teams. (Operations, IT & Finance) Normal guideline is 12-18 Months.

Level of automation

Team needs to decide the level of automation, how many process step(s) they want to automate and to what level.

Identifying/Prioritizing the Processes to be automated- prioritize the process steps to be automated depending on the level of automation desired and ROI. Factors impacting the selection of process step(s) for automation are number of DL (Direct Labor) involved, Number of defects reported and if it involves decision making.

Equipment's compatibility

Next step is to assess if, equipment(s) associated with process step(s) identified for automation adhere to industry standards in terms of communication protocol (SECS/GEM). Need to check if required hardware such as Barcode readers are installed and integrated with MES.

Solution architecture

Need to decide on the solution architecture, typically organizations resort to a four-tier architecture for automation, PLC-OPC-MES-Oracle. PLC provides location details of a given Serial Number to MES and MES in turn relays start and end of a process step through tag addresses in the OPC layer. ERP system consolidates all the manufacturing data for costing, reporting etc

Scalability

The solution should be scalable. New lines should be added with minimal additional investment. In case there is a need to add manual lines in the same facility that should be doable without engineering a new solution. Solution architecture should accommodate both automated and manual lines with ease.

User Training

User training is more important than ever. They should know the process steps they need to perform, Data entry they need to do and execution of Out of Control Action Plan (OCAP), if needed. They should also be aware of initial troubleshooting and teams they need to escalate in case of issues. They should also be trained to operate the line in a manual mode if required.

Support model

Supporting an automated line is not straight forward. Support team has to include members from Industrial Engineering, Applications and Infrastructure teams. An issue can be caused by a PLC issue or an application error or an issue with Server or network. Hence the support team needs to have cross functional representation unlike traditional team which consists primarily of application consultants.

2. Proposed architecture

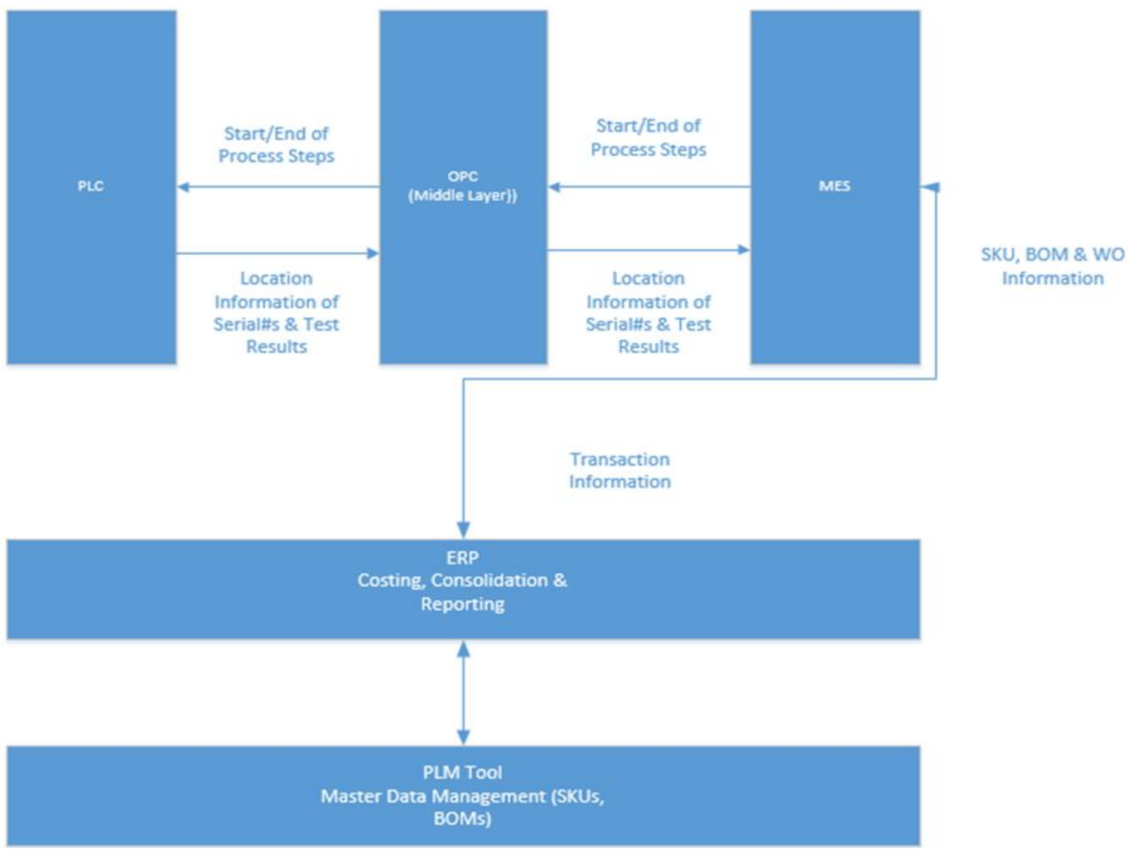

Fig 1

- Master Data like SKUs (Stock keeping Units) & Bill of Materials (BOM) are maintained in the PLM tool. PLM tool publishes SKU and BOM related information to ERP system daily through a custom interface program. ERP system, in turn relays SKU and BOM related data to MES (Manufacturing Execution System) through a custom outbound interface.
- Work Orders (WO) are created and managed in the ERP system. They are published to MES where they get executed. Team needs to decide the strategy for WOs, whether to publish one WO for the entire assembly or Separate WOs for Finished Goods and Work in Process. Either way the WO strategy should support better lot traceability and genealogy.
- As the product 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 Work in Process (WIP) arrives at the station. As the process step is completed at the station, transactions and test results are recorded in MES.

- Once the Finished Good (FG) reaches the end of the line, it's palletized and the pallets are sent to the Carrier. As the pallets are completed, information is sent back to the ERP system from MES for Inventory reconciliation, Costing and generation of Financial statements. Pallets are shipped out of Warehouse management system using the hand held mobile device.
- Additional checks can be put in place to minimize Operators working around "Quality Checks/Quality Standards".

3. Challenges faced during Implementation

Aggressive timelines

Considering the industry dynamics, new products need to be frequently launched and new plants must be up and running in a couple of quarters. Hence, right from conceptualization till deployment must be done in a short time. This adds to existing complexities. This can be mitigated by having multiple releases instead of one big bang release.

Selecting the right MES

An MES needs to be selected which fits into the overall design, can communicate with different PLCs, can support quick fire implementation, is within budget and easy to learn. What makes the selection even more challenging is a fragmented market of MES packages, Challenging timelines, accommodating the priorities of multiple cross functional teams and compliance with procurement and legal policies.

Selection of Middle Layer (between MES & PLC)

Next challenge is to select the middle layer between MES & PLC, one example of OPC product is Kepware.

Tying together PLCs from different manufacturer

Equipments and associated PLCs can be different in different process steps, e.g. one of the PLCs may have Omron and another one may have Siemens. OPC layer is leveraged to connect both the PLCs.

Multiple Iterations to stabilize PLC-OPC-MES Integration

PLC and MES are normally integrated through a middle layer (e.g. OPC, Kepware). PLC & MES talk to each other through tags. It's a challenge to setup tags with "delay" just enough for PLC to pass Serial# & position information to MES and for MES to respond back confirming a given step is over. It requires multiple iterations till the communication is smooth.

Deciding implementation team structure

Normally system project includes IT and the business group which will use the solution. In case of Automation project, it can be a bit tricky as multiple teams needed to take care of the three layers; Industrial Engineering (IE) team being responsible for PLC, Applications team being responsible for OPC, MES and ERP and Infrastructure team being responsible for Sensors, Barcode Readers etc.

Timing of UAT (User Acceptance Test)

One of the dilemmas that any team will face is to decide when to conduct UAT? UAT must be conducted in an environment as close to production as possible. That means all the equipments and PLCs should be installed an operational when UAT is conducted. However, once the equipments and PLCs are ready, there will be a push from management to start production ASAP. Engineering Runs and Test Builds can be leveraged for UAT.

Building the support team

Building the support team is not easy. In case of issues, the first challenge is to identify where the issue is, e.g. which layer has the issue. Support team needs to have knowledge base to fix issues in Hardware as well as in application layers (OPC, Oracle & MES). It requires multiple SMEs (Subject Matter Experts) to support the entire solution. Considering budget constraints and lack of availability of SMEs in remote locations where plants are located innovative models need to be designed, for example, infrastructure can be supported onsite, applications can be supported partly onsite and remining remotely. (remote team can be much larger than the onsite one)

Training super users

Training the super users a brand-new solution is a challenge. This can be mitigated that by a two-prong strategy, breaking down the training into two parts and starting the training early. The first part of training can cover basic principles from existing plants and the second part cover automation. Training super users should start well before the go live date.

Managing "Fear" factor

Automation is synonymous with fear associated with complexities and job loss. Robust training plan can mitigate the complexity aspect. Robust expansion plan can allay fears regarding job loss.

4. Results achieved

This architecture allows to achieve the thee key objectives mentioned in the beginning;

1. Automation of assembly lines along with process optimization and smart equipments normally leads to significant reduction in through put time, there by increasing the productivity. Direct labor required to run a line sees a significant decrease vis a vis a manual line which reduces overheads.
2. With PLC tracking the position of Work in Process (WIP) as well as Finished Good (FG), traceability improves. A Product Serial number can easily be associated with lots of raw materials used to manufacture it. Automation helps reduce the number of defects by practically eliminating operator error.
3. PLM Tool in the architecture acts as the central repository for SKUs and Bills of Material. SKUs and BOMs along with their attributes are created and maintained in the PLM tool. They are published to all downstream applications

through custom interface. This ensures SKUs and BOMs need not be created separately in all applications and in all plants. Single source if truth ensures accuracy of items & BOMs. Centralized PLM tool along with Phantom BOMs enables Organizations to create SKUs and their multiple variants within a short time. This makes SKU updates much quicker as well. This is really helpful to reduce system set up time during new product launch.

Conclusion

Solving a complex business problem requires cross functional collaboration with each team doing their part. Increasingly system based solutions are playing a key role solving business problems. This article demonstrates how a carefully designed system can go a long way to help a company succeed in this tough market place. This is, however is not the end, rather a continuous journey which keeps pushing the limits.

Glossary

ROI- Return on Investment
MES- Manufacturing Execution System (Shop Floor Transactional system where the operators log the process steps, material consumption etc)
ERP- Enterprise Resource Planning (OLTP-Online Transaction Processing system; Oracle, SAP etc)
PLC- Programmed Logic Control (Industrial control system which controls the actions/movements of equipments through Ladder Programming)
OPC- Open Platform Communications (Middle Layer between MES & PLC)
PLM- Product Life Cycle Management (Item Hub)
IoT- Internet of Things
FG- Finished Goods
WIP- Work in Process
SKU- Stock Keeping Units
BOM- Bill of Materials
UAT- User Acceptance Test
MW- Mega Watt (Measure of Energy generated)
WO- Work Order

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