INDUSTRY 4.0 IN MANUFACTURING SECTOR

Introduction

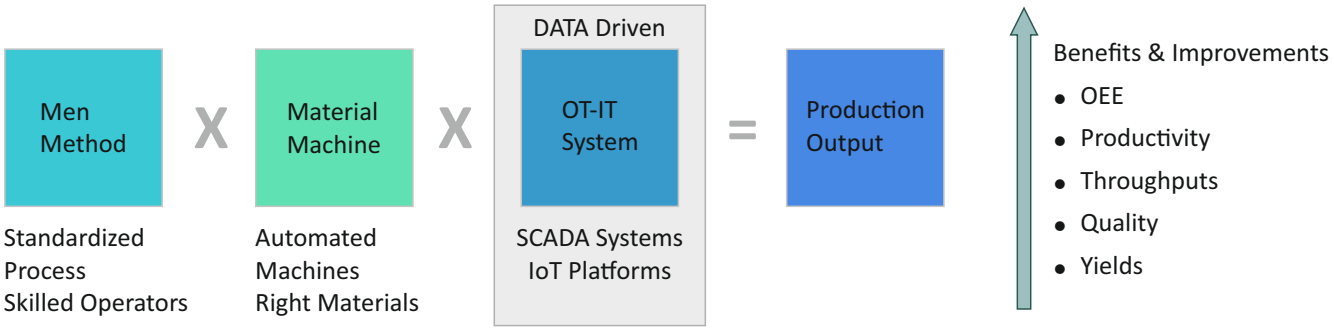
As a practitioner of Industry 4.0, sharing my on-ground views as how Industry 4.0 is being adopted in Manufacturing sector and specially in Food Manufacturing Industries. This paper covers in detail as How Industry 4.0 Journey is managed in below sections **a) importance & opportunity b) elements of Industry 4.0 c) Manufacturing Use cases d) How to approach & implement e) challenges and way forward.**

As per industry experts, Industry 4.0 is going to be the future of Manufacturing; the recent pandemic has also witnessed it. Those Food Manufacturing business with automated lines and digitized processes were able to restart their production operations quickly, because of no human touch & with minimal interventions able to ensure the food safety and hygiene. Since these types of situations are going to repeat in future, it is better to be prepared and more & more companies should move towards Automation & Digitization.

A) Importance & Opportunity for Industry 4.0

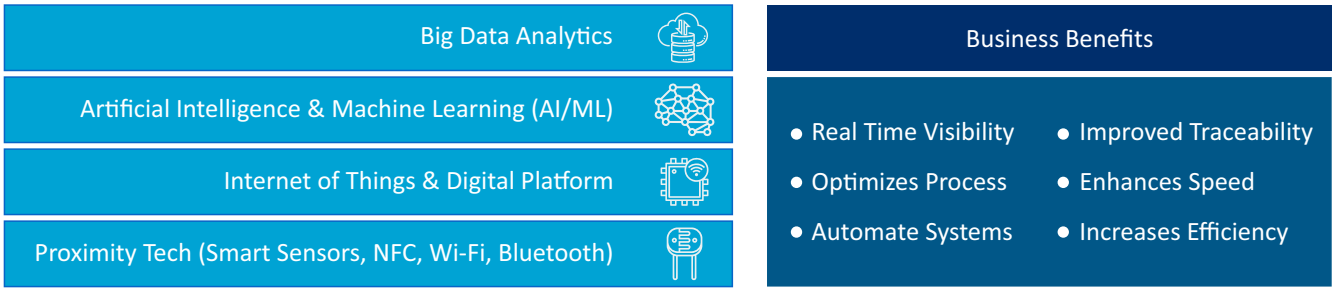
As we all know that industry revolution began with electrification, electronics, computerization era and now its "Industry 4.0" it's a combination of digital technology OT & IT adoption to optimize the processes using data analytics & insights and overall a smart way of managing the operations. Here Industry 4.0 systems cut across many functions be it smart supply chain, smart factories, smart distribution, and logistics etc.

Manufacturing 4.0 is more about smart production operations inside the factories. Where physical OT & IT system are integrated to extract the machine data and process data and together data is analyzed to derive insights and finally decisions are made used for optimizing the production process to achieve better Throughputs, Yields, Quality & Productivity, Minimize Wastages and downtimes etc.



Adopting digital technology - Using AI/ML prediction - Real time decision making - Improve "PQCDS"

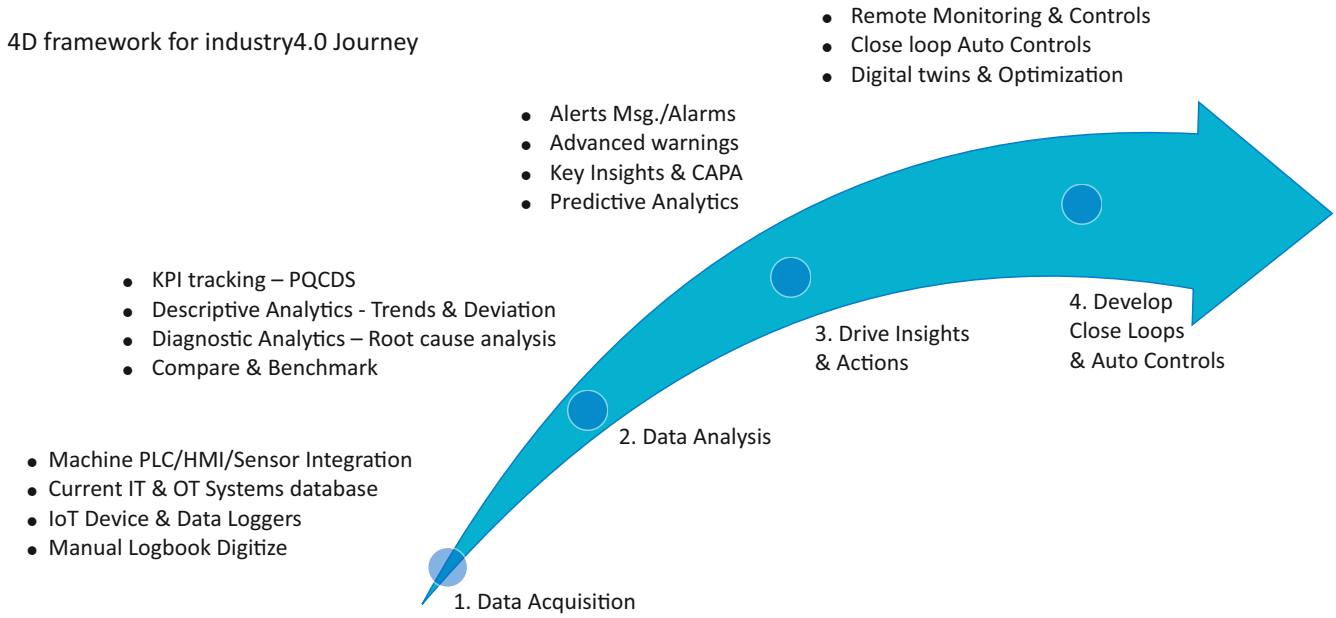
These digital technologies are combinedly used to get maximum benefits.



The Manufacturing 4.0 becomes significantly important as it will add value by impacting the bottom line & top line of companies thru maximizing the asset utilization. Industry 4.0 solves problem beyond post facto analysis by predicting the future output, variance, causes, failures etc. and guides users, when to prevent those losses in upfront. Industry 4.0 is more beneficial for asset heavy Industries like Oil & Gas, Automotive, Steel & Paper and now discreate industries like pharma and food sectors are in pipeline to adopt.

B) Elements of Industry 4.0.

The Industry 4.0 journey consists of L0-L3 building blocks



1.Automation & Instrumentation (L0)

The Food Manufacturing industries is becoming more organized in recent times and whereas still their machinery automation maturity is relatively lower with mix of semi-automated and automated lines. The Automation devices like DCS, PLCs, Drives, HMIs, Sensors are the primary sources to exchange the Machine Data & Information in Real time basis. These systems get connected to a common network thru central SCADA system or Data Historian or IIOT platform.

Still typical challenge is that old legacy machines, works on non-standard or custom-made controllers and no provision for data communication. In other few cases, instrument clusters are still mechanical and with analog devices. So, in order to establish communication with such machines & devices it requires lot of upgrades with investments. So, it is always advised to upgrade only when requirements are clear for loss reduction and clearly justifies for return on investments. Also, while upgrading any machines do check like a) age of machines, very old machines can't meet the speed & versatility, spare availability would be difficult, check is it OEM obsolete parts. B) Downtime, frequent breakdown & with high repair time, skilled resource constraints c). Cost of Maintenance.

2.OT-IT Connectivity (L1)

The Automation (OT) & Information (IT) technology both network acts as backbone for Industry 4.0, Typically IT Network is established at enterprise wide and whereas OT network established at Factory and line level. Normally the LAN connectivity is established either by wired or wireless. The wired systems are connected by Optical fibers or CAT6 cables from Machine PLC to Master PLC or Server Systems. The wireless system includes like IIOT gateways with WI-FI routers or data loggers with mobile SIM connectors to cloud systems etc. But still wireless system is not preferred for closed control loop systems due to Internet stoppages or remote connectivity issues.

The communication protocol is an important element, Ethernet IP is generally recommended either thru OPC UA/DA and generally, basis the existing automation devices in field Modbus TCP IP or Serial RS232 or RS484 communications are established. Though there are multiple protocols it is better to standardize one. Necessary converters can be used for converting data to required protocol. The network standardization will help in minimal OT infrastructure deployment, easy & faster rectification of issues in case of break downs.

3. Data Storage & Security (L2)

Normally, in first step machine data gets collected in machine data logger or PLC systems or SCADA system and then further all the data tags are stored in a relative or time series database as historic records. These machine data are periodically collected at different time intervals, few tags at Second level, Minute level and certain tags on transactional basis. The main databases sources are like Data Historians, SCADA systems SQL databases and My SQL open source. Both these Cloud & On-Premise Servers are deployed to store the information basis company policy & design. Highly critical process and closed loop system data are normally stored at on premises and others remote machines and lesser data frequency are moved to cloud.

The next thing is manual data, those data which are not directly captured from machines. So, it is collected thru digitization of logbooks & check sheets. Many companies are adopting the Industrial grade HMIs, Tabs & Mobiles for manual data collection at plants.

Data security is next important aspects to be considered before implementing Industry 4.0. Data security consists of both software & hardware security. Software security scan be done thru DMZ architecture VLAN Network, Firewalls, Application security, Password Managements, patches updates, etc. The hardware security done thru redundancy raid1 or raid5 servers, industrial grade managed switches, managed ports etc.

4.Data Analytics & Close loop controls (L3)

Data Analytics can be categorized into following stages

Descriptive	Diagnostics	Predictive	Prescriptive
IT & OT connectivity & Visibility Process Data Capture (Near) Real-Time Base Analytics & KPI tracking Vertical Integration	Base Analytics Alerts & Trends Insights & RCA	Advance Analytics Predict Parameters Alarms & Warnings	Auto & Remote Controls Simulation & Digital Twins
What is happening?	Why is it happening?	What will happen?	What should Happen?

Advanced analytics, techniques include anomaly detection or outlier, co-relation analysis, clustering & segmentation, regression & optimization models etc. and commonly used AI/ML algorithms are Random forest, Gradient boosting, Linear regression, decision tree etc. These analytics models are used to find the root causes for a problem with an objective function. Multiple algorithms are tested for correct hypothesis and accurately predict the results.

Visualization is a mode to convey the analytics output to user's basis creating insights, Dashboards, Trends, Pareto, Reports, SMS alerts & alarms etc. to take necessary actions.

Control loops, normally in open loop systems, operator controls the machines parameters in given range basis the feedbacks & insights. In a close loop system, the machine will automatically correct the input parameters to control the output variance.

C) Manufacturing Use Cases

The Use cases can be surrounding these common functions, but latest trends are listed below.

Production Operation	Quality	Engineering	Supply Chain
Manufacturing System Production Planning & Scheduling	Quality Management Lab Info. System	Asset & Maintenance System Spares Mgmt.	Inventory planning Network Planning
Energy & Utility	**Safety & Health**	**Human Resource**	**Logistics**
Utility Management Energy Analytics	Environment Health & Safety Better Workplace	Workforce Mgmt. Smart Training	Warehouse Mgmt. Transportation Mgmt.

1. Smart Manufacturing

Digital Twin - Virtual or Mirror image of production process. Here line data is integrated to real time monitor the efficiency and performance by close monitoring and taking instant decisions.

Yield - The UW % & OW % and Extra Give Away (EGA) % reduction is best use cases to start. It can be a close loop optimization problem to solve material consumption & wastage reduction.

Quality - Using AI/ML model can predict the output quality through vision systems and image analytics techniques to minimize the rejections basis color, size, shape, cracks, chipping etc.

Golden Batch - Using Advanced Analytics and AI/ML models can predict the Golden Batch parameters for the 4Ms - Materials, Machines, Method and Men.

Throughput - Using AI/ML models predict & control the line speed and dwell time settings and by analyzing machine breakdown error codes minimize the downtimes.

Energy - Using AI/ML models predict the consumptions trends, wastages, efficiencies for steam, gases, water, power w.r.t production and achieving the best efficiency.

2. Smart Utility

Utility - The Boiler, Compressor, Chiller HVAC systems are critical assets and biggest contributors for utility cost. So, plan to optimize & control its efficiency in real-time for energy savings.

Similarly tracking the power assets like electric Grid, substation, transformers and water stations like WTP, ETP and STP and automating their operations and reducing the energy consumption.

3. Smart Maintenance

Predictive Maintenance - Smart sensors-based condition monitoring is latest use cases to predict machine health status, asset utilization and failures in upfront.

4.Environment, Health & Safety

Intelligent CCTV system - Using AI/ML models CCTV images are real-time processed to find the SOP violations like Safety Helmet, Hygiene Headgear, Aprons missing, Fire detect, Intrusion etc.

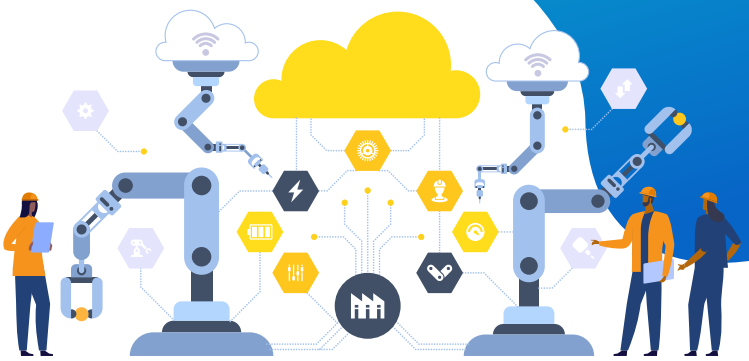
Digital Operators - Using digital apps and platform to track the worker's efficiency, assigns task, alerts, notifications, reports machine status, process parameters & KPI tracking in real time etc.

5.Smart Supply Chain

Intelligent Procurement - Using AI/ML models decide the best RM grades using image analytics techniques and help in deciding the ideal price.

Intelligent Farming - Using the IOT devices and Smart Sensors monitor the crop yields, farming practices, soil chemistry, fertilizers impact, water management, temp monitor for cold items etc.

Inventory Models - Using AI/ML techniques predict and forecast the demand requirements and decide the inventory holdings basis spikes and skews and minimize the stock out situations.



D) Approach & Implementation

The first things we need to remember is that Industry 4.0 is a journey, not a magic wand to improve situations instantly rather it has to be constantly improved & perfectionated. Depending on current infrastructure & OT-IT maturity levels of companies a roadmap has to be created. The first step is to do the gap assessment to identify the potential opportunity for savings and identify use case through idea brainstorming. Parallel it is advised to create a digital strategy plan for detailing OT- IT strategy, digital tool selections, Infrastructure arrangements, vendor eco systems, core operating teams, unit level SPOC, training plan etc.

The best approach is to select the right use case basis business challenges and build the necessary solution and infrastructure, then pilot POC at one location and it gives a real picture of potential savings and challenges to implement. Then Implementation plan to be created with proper timelines, project lead and execution team, clear roles and responsibility, review mechanism.

DEFINE	PLAN	EXECUTE
Maturity Assessment • Current OT-IT landscape • Data Readiness **Plan & Roadmap Creation** • Software & Security Strategy • Automation & Hardware **Identify Potential** • Value scan for opportunity • Capture gaps & pain areas	**Idea Brainstorming** • Problem bank creation • Use case selection **Identify right solutions** • Feasibility Study • Identify best fit Solution **Justify business case** • Compare vendor quotes • ROI payback analysis	**Select Right Partner** • Resource Skills • Core team build **Build Proof of Concept** • Pilot Implementation • Build templates **Rollout Plan** • Training plan • Review Meetings

E) Challenges & Way Forward

- The challenges are many to begin from focus of company's top management to see the clear opportunity in their businesses and invest time & effort to begin the Industry 4.0 journey.
- The Industry wide challenge is to bring standardization from Machine builders, Automation OEMs, System Integrators to adopt the Industry 4.0 capabilities in all machines.
- The skill development is important areas to be focused by all industries at all levels right from Data Acquisition, Data Translation, Data Analytics and Data Insights.
- The way forward is every company should have the digital strategy and Industry 4.0 plan for their Manufacturing setups to sustain in future.
- Finally, selection of right partner to implement digital strategy is suggested, create a vendor eco system for automation system integrator, software service providers & data science experts.

Author Details

Siddaraju G, working as a Senior Principal Consultant at Business Consulting Group, ITC Infotech India Private Limited. Has 19+ years of experience in Manufacturing, Supply Chain & Logistics domain. Current role as Senior Manager - Industry 4.0 for a leading Foods Manufacturing industry in India. Handling digital transformation engagements and executing multiple projects, building digital infrastructure, delivering cost savings.

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www.itcinfotech.com | contact.us@itcinfotech.com

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