DIGITAL TRANSFORMATION OF MANUFACTURING OPERATIONS - ROLE OF IIoTs AND IoRTs FOR SMART FACTORIES

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Introduction

Aeronautical engineers of the next destination airport getting information, even before landing, about which parts of a flying aircraft's engine are to be examined and repaired before clearance for the next flight is no longer a farfetched imagination. Industrial internet of things (IIoT) embedded with sensors and signal emitting capability can provide online real time information about the engine's health to those ground engineers and manufacturer of the aircraft. Similarly, it is no longer a matter of imagination that a refrigerator can send information to the owner's smart phone about depletion of stored food materials, average consumptions, and new orders to be placed. If permitted, it can directly place orders to the vendor, like Siri and Alexa of smart phones can play music as you wish to listen and order them to play.

Aircraft and refrigerator buyers in these examples as prosumers[1] can help manufacturers to customise product design and pre-feed the IoTs with the required metadata and other relevant information as they would prefer when such IoTs are made artificially intelligent. These examples of end-products are smarter than their previous versions. Many more such smart products will soon be available in markets. If a product can be made smarter why not its manufacturing processes.

In a lay man's perception smart manufacturing means application of robots. Use of robots is just one of many more that are required for digital transformation of manufacturing operations in a smart factory. In the emerging business ecosystem end to end effectiveness of entire plant operations will be the critical most factor for sustaining with competitive advantages beyond labour productivity and efficiency in capital asset utilisations.

Objective

Gartner[2] pre-alerted IT leaders in 2011 to achieve a state of readiness for evolution of their organizations by converging, aligning, and integrating IT and operational technology (OT) environments. In Indian manufacturing ecosystem successful integration of IT with OT is yet to be a widely accepted and soon to be implemented phenomenon, particularly in medium and small-scale manufacturing units. This paper aims at promoting this concept of converging IT to OT with innovative applications of smart devices called IIoTs.

Digital transformation of manufacturing processes is a large subject and can hardly be covered in such a monthly column. Accordingly, the author has taken up IIoTs and IoRTs, which can be fitted to machines and robots with relative ease for deriving many benefits, as the main subject for discussion.

Mechanisation of Manufacturing

Mankind had witnessed the first industrial revolution in 1780s when human and animal power was replaced by the power of water and steam engine for moving wheels and other devices. It took another hundred years for electricity to be invented. In 1870s electrical power helped large scale mechanisation of production process. During this second industrial revolution the concept of mass scale component manufacturing was introduced. Separate assembly lines facilitated voluminous production of goods. However, monitoring and controlling of such mechanised technologies continued to remain dependent on human interventions. Obviously, the axiom of 'To err is human' did have its impacts through value destructions in many ways.

The first level of automations of manufacturing process started in 1970s with the advent of electronics and computerised methods for controlling and monitoring of operations to a greater degree. In this third industrial revolution only information technology, i. e., IT started collaborating with OT. However, two-way communication between machine and IT remained elusive. Therefore, the huge mass of data generated by machines at various stages of production operations could not be leveraged for data analytics results of which could have helped in studying behaviour of man and machines, innovation, and strategic decision making for initiating corrective actions in time.

Digital Transformation of Manufacturing

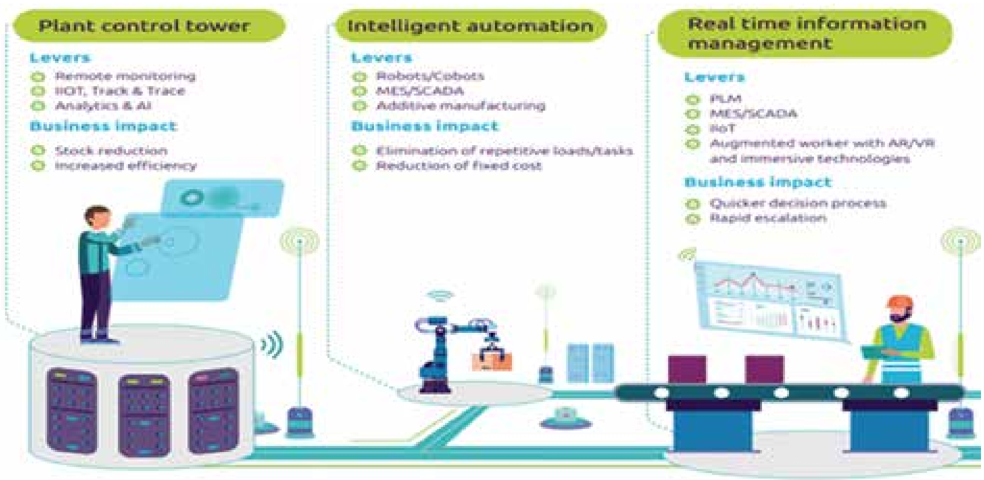
The present era of Industry 4.0 is more about communication and networking to ensure complete collaboration between information and communication technology and operational technologies for manufacturing of products and generation of utilities and services. Manufacturing processes are made smarter by enabling M2M, i.e., machine to machine communication for end to end automated actuation, sequencing, integration, collaboration, and cooperation.

Robotic devices can also communicate with each other and machines. This enables higher degree of interactions and collaboration between robot, machines, and men in a hybrid factory. Such robots are also called as Cobots or Collaborative Robots. Hybrid factories provide shared space where human beings, robots and other machines are in close proximity for working in tandem.

All these are possible due to extensive applications of IIoTs which help networking for M2M communication. In factories where physical robots are used Internet of Robotic Things (IoRTs) are used for robot to robot and machine (R2R and R2M) communication. Such online real time two-way M2M, R2R and R2M communication help gathering and leveraging of useful data for quicker analyses and initiating actions with minimum loss of time and resources. Simultaneous applications IIoTs and robotic process automations (RPA) help deriving maximum benefits from modern OTs and scaling up operations with a quantum leap.

According to Capgemini Research Institute[3] "*A Smart Factory leverages digital platforms and technologies to gain significant improvements in productivity, quality, flexibility and services…. The main characteristic of a smart factory is "closed loop, data-driven optimization of end-to-end operations. Advanced analytics are first used for decision support, but the ultimate goal is to reach "self-optimizing operations" where the factory constantly adapts to demand, variations in supply and process deviations."*

It is axiomatically said that a picture explains more than what thousand words can describe. The author is, therefore, tempted to present the following graphics from the report of Capgemini Research Institute. Readers will observe that the nerve centre for a smart factory is the plant's control tower which relates to machines and equipment through IIoTs for gathering information.



Source: Capgemini Research Institute's Report on Smart Factory[3]

Industrial Internet of Things

IoTs make all things at our home, cars, cities, and industries smart. These are physical devices fitted with tiny wires and sensors and have wireless transmission capacity in varying degrees of mega-bits. According to published survey results, by 2030 an average human being will use five IoTs and be under indirect influence of ~ twenty more IoTs. The given example of the aircraft could be one of those indirect influences.

The above definition of a smart factory from Capgemini lays down emphasis on real time information management. For this every information related to operation of each equipment is critically important because orchestration of every single equipment in production line is essential. For this, enabling machines with IIoTs is critically important.

Coming to the specific of definition of an IIoT it would be appropriate to quote Margaret Rouse[4], : *" …… IIoT is the use of smart sensors and actuators to enhance manufacturing and industrial processes…… IIoT leverages the power of smart machines and real-time analytics to take advantage of the data that ‹dumb machines› have produced in industrial settings for years. .... Connected sensors and actuators enable companies to pick up on inefficiencies and problems sooner and save time and money in addition to supporting business intelligence (BI) efforts ……. In an industrial setting, IIoT is key to processes such as predictive maintenance (PdM), enhanced field service, energy management and asset tracking."*

IIoTs function in a network of intelligent devices. Those are kept connected to a computing system that functions as the supervisor to monitor and control their functioning, collect, exchange, and analyse data. IIoTs can also participate in M2M communication beyond a factory environment. The author is of the view that IIoTs are constrained resources and by themselves are not secured and safe. Therefore, for safety, security, and effective usage of IIoTs, a Blockchain Platform would be useful in a larger Network of such IIoTs within and beyond the factory. Each IIoT would be an individual participant as a node, for which records are to be kept in the memory segment of the IIoT with or without the help of edge computing. Even if the concerned entity's ERP system is hacked, the Blockchain Platform cannot be hacked.

Impacts from Application of IIoTs and RPA

The above narratives identify IIoTs and IoRTs only as participants in a network for communications and help in ensuring smart usage of a machine and transmitting data to the control centre. However, impacts of using such IIoTs and RPAs are far reaching. According to Phill Catwright[5], Executive Chairman of Raconteur's Centre for Modelling and Simulation, *"Industry 4.0 is the bringing together of robots, interconnected devices and fast networks of data within a factory environment, basically to make the factory more productive and to execute the routine tasks that are best done by robots and not best done by humans."* These impacts can be briefly narrated in the following points:

Source of picture: Supertek GMBH[6]

1. Communicate and collaborate to be more efficient and effective as an orchestrated system of manufacturing including synchronization of individual machine's and robot's functions in a pre-programmed manner.
2. Minimise variations and lapses in production processes due to reduced scope for human interventions and inadvertent errors.
3. Sustain what has been achieved and innovate for more through data analytics and remain in search of excellence despite handling voluminous productions.
4. Strike the optimum balance between physical and cyber systems for deriving best of benefits from both operating and information technologies, and optimization of operating processes.
5. Achieve a state of readiness for prosumers by predicting his / her needs and meeting those. For giant products like an aircraft or household equipment like a refrigerator IIoTs can be used for interactive product designing and monitoring health and performance of the product while in use by the customer / end user.
6. Function with 'stragility' by attaining capabilities to plan and work with agile strategies. These are possible in matters of management of individual machines and the entire plant, including generation of utilities like electricity, steam etc., and auxiliary support functions like maintenance.
7. Enable factory operations being autopiloted and self-disciplined for functioning in a pre-planned manner, and thus turning the plant to be a smart factory.

Form the above narrative it is evident that "*The driving philosophy behind IIoT is that smart machines are not only better than humans at capturing and analysing data in real time, they are better at communicating important information that can be used to drive business decisions faster and more accurately.*"[7]. According to the result of a survey conducted Capgemini in 2019 covering 1,348 manufacturers, as published by i-Scoop[7], USD 2.2 Bln. will be the estimated value addition by manufacturing industry due to productivity gains achieved through smarter factory initiatives. Readers will agree that IIoTs will have a significant role in achieving this feat.

More Actions for Smart Factories

Only digital transformation of operations with monitoring systems and converging to digitally operated control tower is not enough for establishing a smart factor. The first and foremost need is to change the mindset of people and make them to unlearn before relearning and reskilling. The author's study reveals that experience of implementors so far is that more of change in mindset of people and their training / reskilling are needed across hierarchical levels of officials than investment in capital assets. Gestation period for implementation of such a digital transformation project is also not that long and RoI is also quite high. Experience of those entities which have implemented smart factories reveals the following action steps:

- Revisit the vision and mission statement of the entity and redefine those to the extent required.
- Introduce policy statements and guidelines for governance of digitally transformed manufacturing operations in compliance with related legal and regulatory provisions.
- Develop a time-bound plan for deploying and integrating digital platforms for end to end orchestration of manufacturing operations and convergence of OT with ICT.
- Introduce SOPs for operating a smart factory with definite statements of people's roles, responsibilities, and authorities.
- Introduce metrics and methodologies for periodical assessment of progress and financial impacts, without forgetting that allowing innovators to make mistakes will accentuate the process of innovation.
- Articulate a plan for change management to migrate from and work towards developing a culture of data-driven operations in a manufacturing space shared by man, machine, and robots.
- Retrain and reskill people who have sufficient insight of the legacy systems and complement their contributions by recruiting people to fill the perceived gaps of human resources.
- Implement all these with unwavering commitment and needful allocation of financial and human resources, including incentivization for innovative contributions.
- Share benefits from digital transformation with all internal and external stakeholders

For successful implementation of all the above one of the most important requirements is alignment of thoughts and objectives of board of directors with those of leadership team and ground level officials. The Board must perform oversight functions with the needful insights.

Industry 5.0

While Industry 4.0 era is very much on, flying the kite of imagination never stops for foreseeing the shape of things that may come in the next era of industrial revolution. Ascension research papers on Industry 5.0 predict that next industrial revolution would be based on the concept of personalisation of designs with the unique assumption that each end user's requirement is unique and should not be met with a one size fit all kind of a solution. Readers are familiar with various Apps they use on smartphones. A user will have to do what the App directs him / her to do without any variation that may be required to meet his / her unique purpose. This is even true regarding Apps for mobile banking operations.

The present author is of the view that the idea for such personalised design will be drawn from a kitchen. Everyday a homemaker uniquely decides what he / she wants to cook in what style of recipe and what variations she / he wants from the similar food that was cooked last time. On entering the kitchen, she / he finds all cereals, lentils, raw food items, spices, utensils, burners, ovens, etc. All these will enable her / him to cook exactly what is desired. Thus, in industry 5.0 era products will be uniquely designed in a similar manner to meet specific requirements of individual end users. They can also have their say in prescribing specifications, design, and process of manufacturing the product as per their sweet will. Manufacturing system will have to be flexible enough to meet such requirements. In that upcoming era the manufacturing space will be shared by men and robots, in which men will take up cerebral jobs of innovators and 'innoventors while robots will do the rest. Such pairing of human and machine workers would open vistas for innumerable opportunities in manufacturing with due flexibilities.

Conclusion

This much is in no way even a summary of the features of a smart factory with digital transformation of manufacturing processes using IIoTs and IoRTs. The author must hard stop here as this paper is being written by way of a monthly contribution. Interested readers may continue reading other literature on the subject and imagine about the shape things to emerge more in a smart factory. Rest can be left for collaboration to bring imaginations to reality for benefits of mankind.

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