KnowGenix
sustainable strategies

KnowGenix *Insights*

No.10.October 2019

Digital technologies
To shape the future of manufacturing: A

Digital technologies: To shape the future of manufacturing - A

New technologies on the horizon are fast changing the present manufacturing structure in efforts towards meeting challenges arising from global mega trends. Many of these technological advances are likely to rewrite the fundamental understanding of many businesses. The emergence of digital technologies is shaping the present business models in diverse and unexpected ways. 2015-2020 period will be a very crucial one for global manufacturing sector which will need sophisticated equipment, complex data and software expertise backed by high-end technology systems to make manufacturing more elegant, smart and sustainable. The present focus on sustainability in manufacturing is being driven by the way "The Internet of Things (IoT)" technologies and devices are leveraged in manufacturing plants. IoT holds immense promise to rationalise and optimise manufacturing systems, enhance quality, reduce waste through wide spread use of data analytics and other digital technologies. This two part discussion takes a macro and micro level view of many emergent technologies that are poised to write new pages in the history of manufacturing.

Emerging directions in manufacturing technologies

In a new initiative the World Economic Forum's Meta-Council on Emerging Technologies explored many new technologies that are most likely to radically change and transform manufacturing models in an attempt to address the emerging challenges driven by global mega trends (1).

They promise to usher in novel and sustainable products and solutions to address diverse concerns: food and energy security, transportation and infrastructure; healthcare and wellness; information, communication technologies and energy and fuels. Driven by powerful engines of innovation, regulations and markets such breakthrough technologies are already bringing about radical transformations in industry and society. A brief look at these technologies follows.

Fuel cell based zero emission vehicles: These will bring about a major shift in mobility. "Fuel cell" vehicles are hybrids that will deploy regenerative braking – a key capability for maximizing efficiency and range. Mass-market fuel cell vehicles are likely to dominate future transportation needs if reliable and economic production of hydrogen from low carbon sources becomes a viable reality.

Next-generation robotics: The use of robotics in manufacturing has shifted beyond just automotives to pharmaceuticals, hazardous chemicals, advanced materials, high performance electronics assembly systems, life sciences, and aviation where high levels of precision, product integrity and safety is called for. New advances in robotics technology have now made human-machine collaboration more viable; we have new applications in sensors, biological structures, patient handling, surgical operations and also in cloud computing technologies. They have brought in precision, reliability and work place safety in manufacturing plants.

Recyclable thermoset plastics: Unheard of a few years back researchers have now developed new pathways to make thermosets totally recyclable, a move that will usher in a closed loop sustainable manufacturing for plastics. Known as poly(hexahydrotriazine)s, or PHTs, these can be dissolved in strong acid followed by breaking the polymer chain which are then reassembled to newer recyclable product.

Precise genetic-engineering techniques: New advances in genetic engineering area have led to new generation crops which are more safer and acceptable at the market place. This breakthrough offers better crops with less controversy. These are based on processes that allow researchers to directly "edit" the genetic code of plants to enable better nutritive values and capable of managing the impact of climate change. Some of these are ZFNs, TALENS and, more recently, the CRISPR-Cas9 system which is used to insert new DNA sequences, or even whole genes, into the genome in a precise way. Another aspect of genetic engineering that appears poised for a major advance is the use of RNA interference (RNAi) in crops which is expected to protect staple-food crops: wheat from *stem rust*, rice from *blast*, and potato from *blight* and banana from *fusarium wilt*. These developments have immense potential for agriculture in developing nations by rationalising inputs, water and land resources. However long term impacts still need to be evaluated.

Additive manufacturing: This is a radically new concept of immense significance to the chemical industry. Unlike subtractive manufacturing which is based on converting a larger materials to smaller sized products of desired shape, additive manufacturing is based on starting with smaller separate materials and then turn it to a 3 D shape using digital platforms. 3D products are all custom made for example new 3D based near invisible braces tailored to each mouth are being explored just as 3D printing for developing

living tissues. This application will have far reaching impact on drug safety protocols, tissue repair and regeneration. Bio printing is in use to generate skin and bone, as well as heart and vascular tissue. These promise to usher in personalised medicine.

There are of course limitations while developing IC components due to low compatibility between materials. There are report of products based on 4D printing which can track ambient environmental changes, all of which have major implications in diagnostic devices. Though nascent today this technology can be disruptive when it is finally pushed to the market place.

Emergent artificial intelligence (AI): AI has advanced significantly in many segments of manufacturing. It HAS found wide use in security systems in the form of image-recognition technology; Self-driving cars and automated flying drones etc. Emergent AI systems are enabling machines TO learn automatically by assimilating large volumes of information. The big promise of safer cars, precision surgeries, improved diagnostics and new therapy options in oncology can be realised with AI. It can bring about higher work and community place safety, faster delivery of emergency medicines and supplies to remote locations.

Distributed manufacturing: Among the range of new manufacturing models distributed manufacturing is poised to revolutionise future manufacturing practices. It will radicalise the way the industry practices in supply chain management. In this model the raw materials and methods of fabrication or manufacturing will be more decentralized with final product manufacturing close to the customer. It is expected to lead to sustainable manufacturing and supply chains using digital platforms while leading to efficient resource management. It will be a disruptive practice and highly impact labour and economics and can have major socio economic implications. It will be more amenable for simpler products while conventional models will play a dominant role in complex products.

Digital genome technologies: These technologies will bring about major changes in the way future healthcare deliveries will take place. New developments in this area have made it possible to have a good understanding of the risk of many genetic diseases.

‘Sense and avoid’ drones: New developments in design of drones have high promise in defence and sustainable agriculture, more so for imaging,

digitalising and monitoring migration of pests and disease manifestation through aerial surveillance; rationalise water, pesticide and other inputs.

Neuromorphic technology: While miniaturisation technologies led to high level of computing power they also led to high demand for energy. The new developments in Neuromorphic technology contribute to immense energy optimisation allowing for faster data processing and machine learning capacity. It can use vast amount of data needed for analysing and making projections about climate and weather forecasting essential for agriculture.

Next Generation Chemical Manufacturing

The challenges of a globally polarised markets, climate change pressures, sustainability mandates and increasing carbon-constrained future have led to chemical industry seeking a vast array of new technologies which will address future manufacturing challenges. This will be based on the rate at which new research and technology pursuits can be dovetailed into manufacturing platforms capable of putting competitive, functional and sustainable products in the market place.

Newly emerging technology areas have significant impact on productivity, resource utilization, emissions, and profitability. Slow shift from a linear model to a circular chemical economic model seems to be happening. Changes in technology, public policy, world security, financial and energy markets are accelerating drastic change in manufacturing systems in the chemical industry. In some of the technologies being discussed here several developments from the past - microelectronics, computers, automatic controls, genetic and biological engineering, computational science, analytical methods and nano-science - have contributed.

An analysis by American Chemical Society (ACS) has marked six technology directions poised to alter manufacturing of chemicals in the future.(www.acs.org/smrt)

Process Intensification: New advances in intensified processes for fine and speciality chemicals manufacturing will vastly rationalise material, energy and capital requirements while incorporating enhanced safety parameters in the plant. Process intensification praxis need highly reliable process and equipment design capabilities besides thermochemical and mass transfer phenomena. Flow reactors are now leading to wider use of PI approaches and will have profound positive impact in the future. However, research is needed to resolve clogging and rapid gas evolution issues.

Active Analytical Devices: These devices assure reliability of inputs, conditions, and outputs to match engineering and operating specifications which do pose major challenges. These allow for precise knowledge of manufacturing parameters in real time and lead to better productivity, profitability, safety and product quality. New investment in R&D in microelectronics, competitive and durable sensor materials, optimal wireless communications, and on-line and computational resources are needed.

Advanced Separation Processes: There have been several advancements in materials (e.g., membranes) and processes (e.g., membrane-reactors). Advanced chromatography (a mainstay in analytical work) to lowering costs and improving product purity; ionic liquids for cleaner, more energy-efficient and precise separations; carbon dioxide capture and sequestration technologies are some of the areas which will influence chemical manufacturing in myriad ways.

New Energy Activations: New advances in activations like photochemical (lowering dissociation time), microwave (improving energy efficiency), ultrasonic (precise measurement of energy transfer/usage) and electron beam energy (developing semiconductors) are emerging as key areas in chemical industry and afford large scale efficiencies, product reliability and manufacturing flexibility.

Computational Modeling: New frontiers have opened up in computational sciences - increasing computing power to analyze massive data sets, provide visualization and integrate finite-element analysis with biological, chemical, thermal and mechanical modeling. These are likely to improve economics, avoiding costly downtime, retrofits or failures.

Automation, Robotics, Computing, and Intelligent Systems: Integration of computational and mechanical systems are expected to lead to new automation and intelligent systems and provide continuous monitoring and feedback of the manufacturing processes. This will lead to more sustainable manufacturing in diverse fine and speciality chemical manufacturing plants.

Digital technology revolution in chemical manufacturing

In the last decade chemical industry invested billions in automation and information technology to rationalise energy efficiency, reduce overhead, and increase reliability. According to a PwC report, “Global Innovation Survey: Innovation, growth and business strategy” ninety-five percent of chemicals industry respondents said they foresaw digital technology innovation at their

company over the next three years, and 50 percent expected breakthrough or radical advances. In this and coming years major investments will be made in digitally assisted machines, tools, and parts to enable real time performance indicators and analytics. New digitally enabled technologies will change business functions across the company.

In this context 3D Printing has made a major foray in the chemical manufacturing field with the possibility of a 3D printer being able to systematically synthesize thousands of different molecules and raw materials. It promises flexibility in manufacturing and is a low cost option to build custom built reactors.

Real-Time Data Analysis in chemical processing tools are leading to new knowledge mobility in manufacturing sites to access analytics and data to keep track of production, spot quality issues, and minimize delays and downtime.

Managing sustainability in chemical manufacturing

An irreversible movement driven by sustainability mandates is bringing in major changes and is now driving rapid transition to environmentally sustainable and socially responsible manufacturing. Besides, innovation in plant engineering, material efficiency, resource optimisation, supply chain and facility management will be critical. With innovations happening more in the interphases of various disciplines the industry will also need to develop newer operating models.

Firms pioneering innovative feedstocks generation, process optimization tools and product redesign approaches around sustainability protocols will develop leadership position. This will have to be complemented by improved design and development of sustainability tools, metrics and methodologies.

Regulatory compliance and customer preferences will remain the primary influencers for sustainable innovations and it is imperative for the industry to analyze the long and short term impact of new regulations. Global chemical companies will also have to learn to compete in the backdrop of new regulatory requirements emanating from multiple political jurisdictions.

In the future sustainability will be decided by several technologies discussed here. To ensure sustainable value creation the industry will need to grow revenue through differentiated products/services; reduce costs through

resource efficiency; manage risks emanating from regulatory, market and operational fronts; and adopt innovative feed stocks, technology and operational models.

Reference:

1. http://www3.weforum.org/docs/WEF_Top10_Emerging_Technologies_2015.pdfAccessed 12 February 2016)

Author: R.Rajagopal