Future of Smart manufacturing Industries

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Abstract

The manufacturing industry today is new a hub for exciting new technology and innovation and never has there been more scatting technology transforming the manufacturing than there is 2019. Manufacturing has evolved and become more automated, computerised and: complex. Smart manufacturing is an emerging form of production integrating manufacturing assets of today and tomorrow with sensors, computing platforms, communication technology, data intensive modeling and predictive engineering. It utilises the concepts of cyber-physical systems spearheaded by the internet of things, cloud computing, service-oriented computing, artificial intelligence and data science. Once implemented, these concepts and technologies would make smart manufacturing the hallmark of the next industrial revolution. The essence of smart manufacturing is captured in six pillars, manufacturing technology and processes, materials, data, predictive engineering, sustainability and resource sfaring and networking. Material handling and supply chains have been an 'integral part of manufacturing. The anticipated developments in material handling and transportation and their integration with manufacturing driven by sustainability, shared services and service quality and are outlined. The future trends in smart manufacturing are captured in ten facts ranging from manufacturing disitisation and material-product-process phenomenon to enterprise dichotomy and standardisation.

Index Terms

smart manufacturing ; data mining; automated manufacturing systems; sustainable manufacturing ,inteligent manufacturing systems; transportation; cyber - physical systems, convergence.

1. Introduction

Now a day, the videly used terms describing the production of tomorrow smart manufacturing industries. Smart manufacturing has attracted attention of numerous researchers who reported their findings in the literature. Thoben, Wiesner, and Wuest (2017 discussed the main characteristics of cyber-physical systems and provided an over- view of Germany's Industry 4.0 initiative and manufacturing efforts undertaken in other counties. An attempt was made to identify relevant research issues. Kang et al. (2016) reviewed the literature related to smart manufacturing and identified technologies of importance to its progress. In addition, some future trends in smart manufacturing were discussed. Helu et al. (2016) defined requirements for data-driven decision-making in manufacturing. Based on these requirements, main technologies and barriers facing implementation of data-driven decision-making in industry were identified. Lu, Morris, and Frechette (2016) reported on the standards that may impact products, systems and business aspects of smart manufacturing. O' Donovan, Bruton, and O'Sullivan (2016) focused on problems facing applications of data analytics in industry. The authors advocated the use of formal methodologies to develop analytics capability rather than focusing on prescriptive approaches. The methodology discussed in their paper was demonstrated with a case study. Standards are important in integration of smart manufacturing technologies facing transformation challenges, some of which were out- lined in Macke, Rulhoff, and Stjepandic (2016). A tool deployed on mobile devices for initiating queries in support of | incoming changes was discussed. Zhang et al. (2014) overviewed technologies such as cloud computing, internet of things, service-oriented solutions and high performance computing. It was suggested that they make a cloud manufactur ing platform outlined in their paper. Shafiq et al. (2015) proposed a framework for knowledge representation of engineering objects incorporating relevant knowledge and experience. It was demonstrated that the framework was a ~ specialisation of a cyber-physical system. Zhong et al. (2017) discussed the concept of smart manufacturing objects handled with the internet of things and wireless technologies. Data analytics was applied to any behaviour of smart manufacturing objects.

Besides architectures and concepts of interests to smart manufacturing, research offering specific models and algorithms has been initiated. Ivanov et al. (2016) addressed the short-term supply chain scheduling in a smart factory. A scheduling approach involving non-stationary jobs flow and temporal decomposition was developed. Moon and Park (2014) offered a scheduling solution for management of energy consumption in manufacturing. Chun and Bidanda (2013) reviewed the literature on sustainable manufacturing. They raised the issue of sustainability in global manufactur- ing, design for sustainability, product life-cycle management and green supply chain management.

2. Pillars of smart manufacturing

Smart manufacturing has been inspired by the concepts largely developed in the realm of computing. Though manufacturing will continue benefit from these concepts and other ideas that will emerge it has its own identity captured in six pillars that are discussed below:

(i) Manufacturing technology and processes

The emergence of manufacturing technologies and processes are expected in future years. New materials, components and products will emerge. Additive manufacturing can serve as an example of a new technology that has prompted the development of new materials, impacted the design and manufacture of products and opened doors to new applications such as biomanufacturing. Manufacturing tools have been designed to integrate various opera- tions, e.g. machines that are capable of horizontal and vertical milling as well as drilling. New hybrid processes will emerge, e.g. hybrids of traditional and additive processes, laser and net-shape manufacturing.

Greater integration of processes will occur, e.g. integration of new materials, product design, manufacturing processes, such as discovery of a chemical compound leading to design of a new medication and a delivery device, as well as the manufacture of medication and the device. Big and small area additive manufacturing will expand its prominence in the factories. New generation of low cost robots will enhance factory automation. Sensors and software capabilities will make the new manufacturing equipment smarter and amenable to factory and beyond communication.

(ii) Materials

Smart manufacturing does not make a special call for the development of smart materials, e.g. shape memory alloys or functionally graded materials. It may well be that smart materials and smart products will follow their own development paths. Smart manufacturing is open to all types of materials, including organic-based materials and biomaterials, needed to produce future products. The significance of recovering materials from products at the end of their lifecycle will increase. It is conceivable that landfills will become new mines of various materials. Some new materials will require novel processes that must be developed and incorporated in smart manufacturing. Additive manufacturing alone will be a great contributor to the search for new materials and their mixes.

(iii) Data

We are witnessing the renaissance of data in manufacturing. Some of it has been triggered by deployment of sensors, wireless technology and the progress in data analytics. Greater collection of data from diverse sources, ranging from material properties and process parameters to customers and suppliers has begun. The data will be used to power any application to be envisioned, including building predictive models. Moreover, it will be the best source for preserving and extraction of past and new knowledge related to manufacturing.

(iv) Predictive engineering:

Predictive engineering is one of the latest additions to the space of manufacturing solutions that will lead to an anticipatory rather than reactive enterprise. Traditionally, the manufacturing industry has focused on using data for analysis, monitoring and control, e.g. productivity analysis, process monitoring and quality control. Six sigma and other data-analysis concepts have had tremendous impact on advances in the quality of manufactured products and services. However, for the most part, traditional efforts have emphasised the past over the future states of manufacturing processes and systems. Predictive engineering offers a new paradigm of constructing high-fidelity models (digital representations) of the phenomena of interest. Such models will allow exploring future spaces, some within the realm of the existing technology and others that have not been seen previously. In the future, today's models will be enriched with both limited-scope models (e.g. behaviour of a supply chain) and those that involve multiple systems (e.g. models that integrate productivity, product quality, energy and transport) to support decisions concerning future production and market conditions. Such wide-scope models may contribute to restructuring the manufacturing industry. It is conceivable that some manufacturing will become highly distributed and some may be centralised. For example, products that are sensitive to the transportation cost, time-to-market and customisation could be produced at locations in the proximity to the customers.

(v) Sustainability

Sustainability will be of paramount importance in manufacturing. The goals of sustainability efforts will be materials, manufacturing processes, energy and pollutants attributed to manufacturing. The entry points of any major sustainability effort are the product and the market. There is no doubt that the greatest sustainability gains are accomplished when the development of products and processes is guided by the sustainability criteria. Examples of possible scenarios include: (i) sustainable product design will drive manufacturing, (ii) sustainable manufacturing processes will impact the design of products and (iii) simultaneous development of sustainable materials, products and processes will take place. Additive manufacturing represents the second scenario in which a process has resulted in new designs of components and products. Sustainability is not about what is manufactured but how it is performed. It is the main force behind providing equal footing for remanufacturing, reconditioning and reuse with manufacturing. Because of sustainability, the line between manufacturing and service will remain blurry. For example, reconditioning a used product is not a traditional manufacturing activity, however, it may enter the new manufacturing dictionary.

(VI) Resource sharing and networking

As manufacturing is becoming digital and virtual, much of the creative and decision-making activities will take place in the digital space. While at some level the digital space may be highly transparent, the physical manufacturing assets with their know-how will be protected. This digital-physical separation will allow for shared use of resources across businesses, including the ones that compete.

The manufacturing industry has been exposed to service and contract models with production taking place at facilities operated by a third party. The rapid manufacturing (a predecessor of 3D printing) service model was established decades ago as a result of the high cost of technology, low utilisation, learning curve and uncertainly about utility of the technology. Shared resource models have seen success and are expanding from sharing rides aimed at reducing highway traffic to Uber in transportation and Airbnb in accommodation services. Smart manufacturing is likely to benefit from these concepts to share manufacturing equipment, software, expertise and most importantly, the collaborative modeling and creativity space .

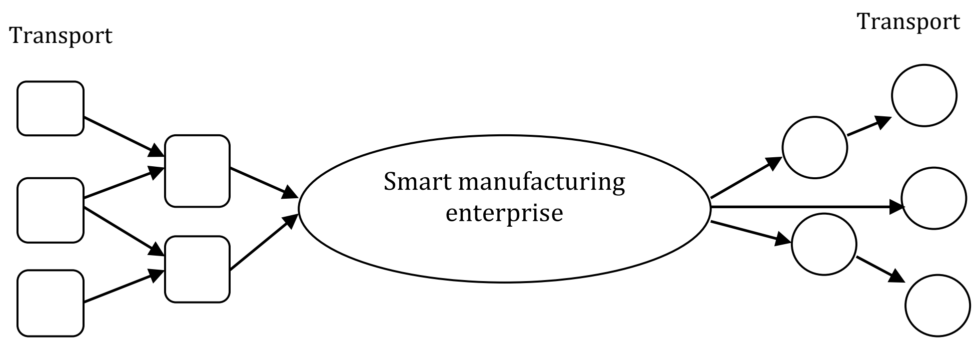
While the logistics of leasing manufacturing equipment and sharing commercial software could follow the existing models, sharing the creativity space is a challenge. Application of the principles similar to those of Facebook and Wikipedia to various areas of manufacturing is not easy and will likely take decades to realise. All sharing transactions will be accomplished in the space populated with digital models rather than physical assets.

Besides the manufacturing equipment, transport is a meaningful resource that deserves attention. There are two broad categories of transport in manufacturing: internal, involving specialised material handling equipment or various tracks and external, which serves the supply and distribution chain. From the manufacturing accounting point of view, transport is generally considered as a non-value-adding activity. This triggers a thought that minimising the distances travelled would not only reduce the cost, but also have a positive environmental impact. Developments in robotics and autonomous vehicles (from surface to air) will impact the internal and external manufacturing transport by increasing its degree of autonomy and sharing. Transport will be an important factor in evolving the spatial configuration of manufacturing on a regional and global scale.

3. Material handling transport of materials , components and products

Material handling and transport are inherent functional areas of manufacturing involving distances measured in nanometer to kilometre scale. Both support manufacturing processes and shipment across different plants and around the globe. While material handing is usually used to describe the movement of material in a factory, transport is associated the movement of materials, components and products through supply chains covering regions, counties and continents (see Figure1 Material handling and transportation can be significant contributors to the product cost, e.g. 8% of the cost of a wind turbine tower is attributed to the transport (Cotrell et al. 2014) and higher percentage (e.g 20%) to other components.

It is likely that due to the distributed nature of manufacturing, transport of materials, components, products and people will become a significant cost item in production. This will naturally lead to optimisation of the transportation and utilisation cost of personnel supporting the physical and digital infrastructure at multiple manufacturing facilities. Job description that do not exist today, will be created to meet the smart manufacturing tasks. Similar to components,e.g. differentiating the products, manufacturing specialists could be travelling in large numbers using different modes of transportation from cars to trains and plains. The efficiency of transporting materials, components, products and people will impact the manufacturing cost. Transportation and communication are the cornerstone of global connectivity in manufacturing. Irrespective of the ownership, transportation is likely to become an integral part of smart manufacturing due to: (i) greater reliance on the movement of materials, components, products and service personnel driven by personalised needs, (ii) sustainability; (iii) quality of service. Transportation networks involving the supply side and distribution (including customer delivery) similar to the one shown in Figure1 are likely to play a meaningful role. Limiting the sustainability consideration to the manufacturing envelope, would provide a suboptimal solution due to interconnectivity of manufacturing with the supply and distribution network trade-offs. The quality of customer service is tightly connected to the inventory level, manufacturing response time and transportation.



Supply network Distribution network

Figure 1. Integration of manufacturing with supply and distribution chain

4. future of smart manufacturing

Smart manufacturing offers opportunities and challenges. The greatest challenge could be in the acceptance of the emerging manufacturing reality and change. A new wave of factory automation will be supported by the next generation of low-cost robotics. This alone will create new 'cyber' jobs rather than traditional jobs. The conversion of blue-collar jobs into white-collar jobs is not new, yet it is a challenge every time it happens. The 'cyber' part of the smart factory, in itself, is an enterprise within the enterprise, with jobs descriptions to be defined and a workforce to be trained by the educational establishments. The better we understand the future needs, the better smart enterprise will function.

The transformation of the manufacture of today to the manufacture of the future is an enormous task. No single corporation can be effective in accomplishing all tasks on its own due to the market and a uncertainty.

Smart manufacturing is evolving and its specifies will emerge in years to come . Some of the characteristics of the future manfufacturing are captured by the following facts. They may enhance understanding of the core manufacturing issues as well as capture trends and chages affecting samart manufacturing and is given below

- **Manufacturing digitalization**
- **Increased reliance on modeling optimization and simulation**
- **Material - product - process phenomenon**

- **Vertical separability of the physical assets and the cyberspace**
- **Enterprise dichotomy**
- **Greater horizontal connectivity and interoperability**
- **Resource sharing**
- **Equipment monitoring diagnosis and repair autonomy**
- **Standardisation and collaboration**
- **Cyber security and safety**

5. Conclusion

Automated factories were envisioned and demonstrated decades ago. In general, the industry has retreated from pursuing the vision of total automation for valid business reasons. There is no doubt that some smart factories will be highly automated. However, smart manufacturing is not about the degree of automation of the manufacturing floor; it is about autonomy, evolution, simulation and optimisation of the manufacturing enterprise. The scope and time horizon of the simulation and optimisation will depend on the availability of data and tools. The level of 'smartness' of a manufacturing enterprise will be determined by the degree to which the physical enterprise has been reflected in the cyber space. This paper offers a vision of smart manufacturing. Its essence was encapsulated in six pillars differentiating it from the manufacturing as we know it. The pillars were supported with abovefacts chanateristng smart manufacturing. A special anniversary note was included.

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