InnoVision Business Review

Innovations in Manufacturing

This article is a review of the journey of the human race in developing the discipline of manufacturing goods and the introduction of a string of the most amazing innovations. It covers innovations starting with the Industrial Revolution, Frederick Taylor's Scientific Management, Mass Production techniques perfected at the Ford Motor Company. Lean Production techniques developed by the Toyota Motor Corporation and New Age Manufacturing Systems in use today.

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We take for granted the vast array of goods we use in our daily lives. If we were to look back on the journey of how the human race developed the discipline of manufacturing goods we would discover a string of the most amazing innovations. Many of these continue to be relevant in today's environment.

If you are interested only in the recent developments, you may skip the sections titled Industrial Revolution, Frederick Winslow Taylor and Scientific Management, Henry Ford and Mass Production, Taiichi Ohno and Toyota Production System (Pages 1 &2).

Industrial Revolution

The genesis of the Industrial Revolution can be traced back to the time steam was harnessed for industrial use by Thomas Savery in 1698. James Watt in collaboration with Matthew Boulton built a steam engine that could be commercially produced and used, ushering in the industrial age in 1778.

The Industrial Revolution brought about profound changes in manufacturing processes, technology, and society as a whole. The key changes were the shift from hand craftsmanship to mechanisation, the emergence of the factory system, where large numbers of workers were employed in centralised locations to operate machinery, the expansion of railway networks that improved transportation of raw materials and finished goods, the invention of the Spinning Jenny for textile production, metal presses for mass printing, technological advancements in iron and steel production, development of process plants that transformed industries such as industrial chemicals, agriculture and medicine, to name a few.

Another significant change it brought about is the advent of the capitalist economy with far-reaching effects around the globe.

Frederick Winslow Taylor & Scientific Management

As modern manufacturing facilities matured, it was time to organise it to achieve higher productivity. The man who can be credited with this transformation is Frederick Winslow Taylor (1856–1915), an American engineer and management theorist who is referred to as the father of scientific management. Taylor's concepts had a significant impact on the field of production and industrial engineering, influencing the way work was organized and tasks were performed. Some of his key concepts include the scientific management system to study work and finding the best way to improve productivity, meticulous time and motion studies breaking down each task and constituent motions to arrive at the most efficient way, standardisation of tools and equipment in addition to processes, piece rate system to determine wages linking productivity with earnings, introduction of managerial roles by function such as quality, maintenance, engineering etc., task specialisation of workmen creating expertise in designated areas and introduction of formal training for workmen to improve productivity and quality.

Henry Ford & Mass Production

In the early years of the 20th century the process of industrial manufacturing was transformed by a few industrial organisations of which the Ford Motor Company probably made the most significant contribution.

Henry Ford, the founder of the Ford Motor Company gave the world the concept of **standardisation** as a key to success in mass production. The other pathbreaking innovation was the **moving assembly line**, introduced by Ford at its Highland Park, Detriot, Michigan plant in 1913.

Ford implemented the idea of interchangeable parts and standardised components. By using standardised, mass-produced parts, Ford could streamline the manufacturing process and reduce costs. This standardisation not only made production more efficient but also simplified repairs and maintenance.

The other major innovation was the development and implementation of the moving assembly line in automobile manufacturing. Prior to this innovation, cars were typically built by skilled craftsmen who assembled entire vehicles from start to finish. Ford's assembly line divided the manufacturing process into smaller, more specialised tasks. Workers remained stationary, and the vehicles moved along a conveyor belt, with each worker responsible for a specific part of the assembly. This significantly increased production efficiency and reduced the time required to build a car.

Other Ford innovations were vertical integration by owning upstream processes in manufacturing and a significant wage increase for workmen aimed at improving productivity and reducing turnover.

Taiichi Ohno & Toyota Production System

Post World War II as the resource-constrained Japanese industry struggled to compete with American competitors with their massive resources, The Toyota Motor Corporation under the leadership of Taiichi Ohno created the Toyota Production System (TPS) labelled Lean Production by western observers.

The primary concepts of the Toyota Production System are 1.**Just in Time inventory** where parts are delivered when needed, reducing parts inventory, 2. **Jidhoka**, also called autonomation or "intelligent automation," where the worker has the authority to stop the process when an abnormality occurs or building quality into the process of manufacturing, rectifying defects as and when they occur through worker-generated quality control and worker empowerment, 3.**Kaizen**, or continuous improvement where a large number of small improvements suggested by ordinary line workers and implemented meticulously add up to major improvements with minimal costs, 4. **Kanban**, or a pull system of production managed by Kanbans or cards used to order parts from the previous process as and when required as opposed to producing parts merely to feed the machines, reducing inventories and defects, 5. **Heijunka**, or maintaining a steady production pace by better planning, 6. **Andon** system where a worker can pull a cord to highlight a problem and resolve it before it spreads, 7. **Poka Yoke** error proofing systems that prevent an error from happening like detecting a hand movement that should or should not have happened and raising an alarm accordingly, 8.**Seven Wastes**, the process of identifying and minimising the seven wastes, waiting, transporting, processing, inventory, motion, defects/rework, and overproduction, 9. **Five S and 3M System** of Sort (Seiri), Set in Order (Seiton), Shine (Seiso), Standardize (Seiketsu), and Sustain (Shitsuke), provide a methodology for organizing, cleaning, developing, and sustaining a productive work environment and elimination of Muda (waste), Mura (unevenness), and Muri (overburden).

Most importantly, TPS is about making the manufacturing facility central to running the company where the leadership is completely committed to serving and supporting the manufacturing process. Many traditional manufacturing companies see production units as sweatshops set up to serve the supposedly more important functions of management.

On the people front, TPS emphasized respect for people. This involved recognizing the skills, knowledge, and contributions of every employee, fostering a culture of teamwork, and providing opportunities for professional development.

Manufacturing in the New Age

Digital Technologies, Artificial Intelligence and Data Analytics

The integration of digital technologies, AI (Artificial Intelligence), and advanced analytics has transformed operations management. This includes the use of sensors, connecting physical devices and objects to the internet, Internet of Things (IoT) based systems that enable collection and exchange of data and data analytics to optimize processes, monitor equipment health, and improve overall efficiency.

Big Data and Analytics

The massive amount of data generated by connected devices is analysed using advanced analytics tools. This data-driven approach helps in making informed decisions, optimizing processes, and identifying patterns or trends. The use of data analytics for predictive maintenance is becoming widespread. By analysing data from sensors and other sources, companies can predict when equipment is likely to fail and schedule maintenance proactively, reducing downtime and maintenance costs.

Artificial Intelligence (AI) and Machine Learning

AI and machine learning technologies are used to analyse data, make predictions, and improve decision-making processes. In manufacturing, AI can optimize production schedules, predict maintenance needs, and enhance overall efficiency.

Advanced Robotics

Advanced robotics, including collaborative robots (cobots) that can work alongside human operators, are in use. Cobots are designed to enhance productivity and safety in manufacturing and other operational environments. Robotics automation improves precision, efficiency, and flexibility in manufacturing processes.

Cyber-Physical Systems (CPS)

CPS involves the integration of computational algorithms and physical processes. This integration allows for real-time monitoring and control of physical systems, contributing to increased efficiency and responsiveness.

Cloud Computing

Cloud-based systems facilitate the storage and access of vast amounts of data. It can be used for sharing data across different locations and enabling collaborative efforts in a multi-location/ globalized manufacturing environment.

Blockchain Technology: Blockchain is being explored for its potential to enhance transparency and traceability in supply chains. It can help reduce fraud, errors, and inefficiencies in operations, especially in industries where a secure and transparent record of transactions is crucial.

Augmented Reality (AR) and Virtual Reality (VR)

AR and VR technologies are applied for training, maintenance, and design purposes. They provide immersive experiences that can enhance worker skills, support troubleshooting, and aid in the design and visualization of products and processes.

Sustainability

Organizations are placing a greater emphasis on sustainable and environmentally friendly practices in their operations. This includes optimizing supply chain processes to reduce carbon footprints, adopting green manufacturing practices, and implementing circular economy principles.

(Written by Dr. Amit Bhadra, Founder, InnoVision Enterprise Solutions, Management Practitioner and Professor of Marketing, Operations & Strategy)