



Industry 4.0 Overview & Related Terms

WHAT IS INDUSTRY 4.0?

Imagine a world in which engineers can interact with 3D models in an immersive environment, where machines and products communicate with each other, and where products wend their way independently through the production process. This is Industry 4.0, the Fourth Industrial Revolution, defined as the convergence of digital and physical technologies disrupting the manufacturing industry and being realized today in smart factories across the globe.

TECHNOLOGY SECTORS

Automation Alley, Michigan's Industry 4.0 knowledge center, identifies Industry 4.0 as a collection of eight emerging technology sectors, all of which require new ways of thinking and working:

- 1. Additive Manufacturing & Advanced Materials** - Additive Manufacturing is the construction of complex three-dimensional parts from 3D digital model data by depositing successive layers of material. Advanced Materials focuses on new materials and modifications to existing materials to obtain superior performance in one or more characteristics that are critical for the application under consideration. They can also exhibit completely novel properties.
- 2. Artificial Intelligence** - The simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions) and self-correction.
- 3. Big Data** - Extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations.

4. **Cloud Computing** - Shared pools of configurable computer system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet. Cloud computing relies on sharing of resources to achieve coherence and economies of scale, similar to a public utility.
5. **Cybersecurity** - The protection of computer systems from theft or damage to their hardware, software or electronic data, as well as from disruption or misdirection of the services they provide.
6. **Modeling, Simulation, Visualization and Immersion** – A set of technologies used in the design, analysis, verification and validation on a product to improve quality, processes, training techniques and situational preparedness.
7. **Robotics** - Mechanical or electrical engineering coupled with computer science used to design, construct, operate and apply robots, including the computer systems for their control, sensory feedback and information processing.
8. **The Industrial Internet of Things** - The use of Internet of things technologies to enhance manufacturing and industrial processes, incorporating machine learning and big data technologies to harness the sensor data, machine-to-machine communication and automation technologies that have existed in industrial settings for years.

WHY INDUSTRY 4.0 MATTERS FOR YOUR BUSINESS

Right now, in factories around the globe, manufacturers are attempting to wrap their heads around the magnitude of change involved with Industry 4.0. The Fourth Industrial Revolution of connected, smart factories, is creating new ways to design and produce products, changing the way companies operate and revolutionizing the role humans will play in the labor economy.

According to the World Economic Forum, 65% of children entering primary school today will ultimately end up working in completely new job types that currently do not exist.

Humans are programmed to invent and create, and to always progress. Industry 4.0 has opened the flood gates of innovation, creating both immense opportunities and great challenges for an industry that now must rethink, retool and rebuild the way they do business.

Automation Alley's role is to help manufacturers increase revenue, reduce costs and make strategic decisions during this time of rapid technological change.

INDUSTRY 4.0 TERMS

5G: Fifth generation of cellular technology—designed to increase speed, reduce latency and improve flexibility of wireless services.

3D Printing: A specific additive manufacturing technology; however, this term has gained common usage to describe all manner of additive manufacturing. See Additive Manufacturing.

Advanced Composites: Composite materials made by imbedding high-strength, high-modulus fibers.

Advanced Manufacturing: Use of innovative technologies to create existing products and new products. Advanced manufacturing can include production activities that depend on information, automation, computation, software, sensing and networking.

Agile Manufacturing: Tools, techniques, and initiatives (such as lean and flexible manufacturing) to help a plant and/or organization rapidly respond to their customers, the market and innovations. It can also incorporate “mass customization” concepts to meet unique customer needs as well as “quick response manufacturing” to reduce lead times across an enterprise.

Applied Technology: Technological skills or expertise utilized for practical applications. Such skills are often gained in vocational schools.

Autoclave Molding: A method of curing reinforced plastics that uses an autoclave with 50-100 pounds per square inch (345-690 kilopascals) steam pressure to set the resin.

Automated Guided Vehicle: A mobile robot guided by markers or wires in a floor, or uses vision, magnets or lasers for navigation. Typically used to move materials around a manufacturing facility or a warehouse.

Automated Storage and Retrieval System (ASRS or AS/RS): Computer-controlled systems used for placing and retrieving loads from defined storage locations.

Automation: Using control systems to operate an apparatus, process or system with minimal or reduced direct human intervention.

Benchmarking: Formal programs that compare a plant’s practices and performance results against “best-in-class” competitors or against similar operations.

Blockchain: A digital ledger that enables multiple parties to reach an agreement on the authenticity of a transaction in a decentralized manner. As businesses today become more complex, data and transactions are increasingly managed across untrusted parties. Blockchain technology can help increase trust and simplify operations for enterprises through a more transparent and secure approach to transactional relationships.

Bottleneck: A point of congestion in a manufacturing system that arises when parts arrive at a given machine/operation faster than that machine/operation can process them.

Cellular Manufacturing: When dissimilar equipment and workstations to produce a family of similar components or subassemblies are arranged close together to save space and time and to simplify process routing and supervision. Workers are typically cross trained to perform multiple tasks within a manufacturing cell.

Composites: Materials comprised of two or more components with significantly different physical or chemical properties, that when combined, produce a material that behaves differently from the individual components. The individual components remain separate and distinct within the finished structure. Examples of engineered composite materials include carbon fiber-reinforced polymers, metal matrix composites, ceramic matrix composites, cement and concrete. Wood is an example of a naturally occurring composite material.

Computer Numerical Control (CNC): The digital control of a physical machine that consists of a series of integrated actuators, power electronics, sensors and a dedicated computer running under a real-time operating system. CNC can control multiple machines, usually when they are grouped in a manufacturing cell. This is a form of digital automation.

Computer-Aided Design (CAD): CAD is the use of a wide range of computer-based tools that assist engineers, architects and other design professionals in their design activities. It is the main geometry authoring tool within the Product Lifecycle Management process and involves both software and sometimes special-purpose hardware.

Computer-Aided Manufacturing (CAM): In general, CAM refers to the use of computer systems to plan, manage and control the operations of a manufacturing plant through either direct or indirect computer interface with the plant's production resources. CAM often refers to software that takes the geometric design authored with CAD software as input and outputs manufacturing instructions that are downloaded to automated equipment such as a computer numerically controlled (CNC) machine tool. CAM is also referred to as computer-assisted manufacturing.

Computer-Integrated Manufacturing: An approach to integrate production-related information and control entire production processes, automated lines, plants and networks by using computers and a common database.

Continuous-Flow Manufacturing: A manufacturing method in which the materials (dry bulk or fluids) that are being processed are continuously in motion, undergoing mechanical, thermal and/or chemical treatment. This is the opposite of batch production. Synonyms include continuous manufacturing, continuous processing, continuous production and continuous flow process.

Cross-Training: Training employees in several skill sets so they can fill in for one another as needed.

Digital Manufacturing: Aims to improve product design and manufacturing processes across the board with seamless integration of information technology systems across the supply chain. Digital manufacturing focuses on reducing the time and cost of manufacturing by integrating and using data from design, production and product use; digitizing manufacturing operations to improve product, process and enterprise performance; and tools for modeling and advanced analytics—throughout the product life cycle.

Digital Twins: Virtual representations of physical objects or systems that are used to understand, predict and optimize performance in order to achieve improved business outcomes. Digital twins consist of three components: a data model, a set of analytics or algorithms and knowledge.

Discrete Manufacturing: Producing finished products that can be recognized as distinct physical units via serial numbers or other labeling methods.

Electrical Computer-Aided Design Software (ECAD): Software used in the design and development of electronic systems.

Factory Local Area Network: A computer network that links devices within a factory.

Flexible Manufacturing System: Integrated group of manufacturing equipment and/or cross-trained work teams that can produce a variety of parts in the mid-volume production range. Flexible refers to the systems capability to manufacture different part variants, and production quantity can be adjusted in response to changing demand.

Frascati Manual: An internationally recognized methodology for collecting and reporting data on research and experimental development.

Just-in-Time (JIT): JIT techniques reduce setup times, inventory and waste; and improve products and reduce manufacturing cycle time. Synonym includes continuous-flow production. JIT is a total manufacturing system that was first introduced by Toyota Motor Corporation.

Kaizen: Practice of focusing on continuous process improvement.

Lean Manufacturing: A manufacturing practice that aims to reduce wasted time, effort or other resources in the production process.

Manufacturing Cost: Includes quality-related costs, direct and indirect labor, equipment repair and maintenance, other manufacturing support and overhead and other costs directly associated with manufacturing operations.

Manufacturing Cycle Time: The time of actual production from the moment a customer order arrives on the plant floor to the completion of all product manufacturing, assembly and testing.

Manufacturing Innovation Institute: A public-private partnership of companies, academia, state and local governments and federal agencies that co-invest in developing world-leading technologies and capabilities. Each Institute creates the necessary focus and provides the state-of-the-art facilities needed to allow collaborative, mostly pre-competitive development of promising technologies. An Institute provides workforce education and training in advanced manufacturing and promotes the creation of a stable and sustainable innovation ecosystem for advanced manufacturing.

Matched Metal Molding: A reinforced plastics manufacturing process in which matching male and female metal molds are used to form the part with time, pressure and heat.

Mechanical Computer-Aided Design Software (MCAD): Software used in the design and development of mechanical systems.

Manufacturing Work Instructions (MWI): Information and directions on how to perform a manufacturing task.

North American Industry Classification System (NAICS): A coding system of the U.S., Mexican and Canadian governments that identifies specific economic sectors.

Planning and Scheduling Technologies: A variety of software-based advanced planning, scheduling and optimization systems.

Process Manufacturing: Manufacturing products such as chemicals, gasoline, beverages and food products in “batch” quantities.

Process Technology: The manufacturing method used to make silicon chips, which is measured by how small the transistor is and driven by the goal to create more computing power per inch.

Product Data Management System (PDM System): Also known as “Work in Progress (WIP) vault.” Holds MCAD files, including parts and assembly models as well as drawings.

Product Development Cycle: Often called “time to market,” this is the period from when design/development work begins to the time that the final product is available for purchase.

Prototype: An original model constructed to include all the technical characteristics and performances of the new product.

Rapid Prototyping: Techniques to quickly fabricate a scale model of a physical part or assembly. Historically, this term has referred to the use of additive manufacturing to create the part. The term is falling out of favor to describe all additive manufacturing technologies because they are able to do more now than just prototyping (i.e., they are now being used for production of final parts and assemblies).

Six Sigma: One method of preparing and controlling the compliance of processes and products with predetermined quality standards. Six Sigma at many organizations simply means a measure of quality that strives for near perfection. Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities.

Smart Manufacturing: Aims to reduce manufacturing costs from the perspective of real-time energy management, energy productivity and process energy efficiency. Initiatives will create a networked data driven process platform that combines innovative modeling and simulation and advanced sensing and control. Integrates efficiency intelligence in real-time across an entire production operation with primary emphasis on minimizing energy and material use—particularly relevant for energy-intensive manufacturing sectors.

Supply-Chain/Logistics Systems: Manufacturing software to optimize scheduling and other activities throughout the supply chain.

Total Quality Management (TQM): A company-wide approach to improving quality and customer satisfaction—including fast response and service, as well as product.

Traditional Manufacturing: Manufacturing with a focus on quantity, constant production (disregarding waste) and reactive problem solving.

Vacuum Bag Molding: A process in which a sheet of flexible transparent material plus bleeder cloth and release film are placed under the lay-up on the mold and sealed at the edges.

Vacuum Hot Pressing: Experimental forming method of putting prepreg is placed in a vacuum bag and heated, and then placed in a mold that is closed in a hot press and formed under pressure.

Zero Bleed: Laminate fabrication procedure that does not allow loss resin during cure.

REFERENCES AND RESOURCES:

National Institute of Standards and Technology

Platform Industrie 4.0 (German Ministry of Economic Affairs and Energy)

Industry Week

U.S. Department of Commerce

Simio LLC

Arena Solutions

Oden Technologies

Cisco

ge.com

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INDUSTRY 4.0

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Manufacturing On-Demand