COURSE MATERIAL

III Year B. Tech II - Semester

MECHANICAL ENGINEERING

Smart Manufacturing Technologies

R18A0321

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

(Autonomous Institution-UGC, Govt. of India)
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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
DEPARTMENT OF MECHANICAL ENGINEERING

CONTENTS

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

VISION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

MISSION

- To become a model institution in the fields of Engineering, Technology and Management.
- To impart holistic education to the students to render them as industry ready engineers.
- To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

QUALITY POLICY

- To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- To provide state of art infrastructure and expertise to impart quality education.
- To groom the students to become intellectually creative and professionally competitive.
- To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never - ending ladder of **SUCCESS** year after year.

For more information: www.mrcet.ac.in

VISION

To become an innovative knowledge center in mechanical engineering through state-of-the-art teaching-learning and research practices, promoting creative thinking professionals.

MISSION

The Department of Mechanical Engineering is dedicated for transforming the students into highly competent Mechanical engineers to meet the needs of the industry, in a changing and challenging technical environment, by strongly focusing in the fundamentals of engineering sciences for achieving excellent results in their professional pursuits.

Quality Policy

- ✓ To pursuit global Standards of excellence in all our endeavors namely teaching, research and continuing education and to remain accountable in our core and support functions, through processes of self-evaluation and continuous improvement.
- ✓ To create a midst of excellence for imparting state of art education, industry-oriented training research in the field of technical education.

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12.Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Ability to analyze, design and develop Mechanical systems to solve the Engineering problems by integrating thermal, design and manufacturing Domains.

PSO2 Ability to succeed in competitive examinations or to pursue higher studies or research.

PSO3 Ability to apply the learned Mechanical Engineering knowledge for the Development of society and self.

Program Educational Objectives (PEOs)

The Program Educational Objectives of the program offered by the department are broadly listed below:

PEO1: PREPARATION

To provide sound foundation in mathematical, scientific and engineering fundamentals necessary to analyze, formulate and solve engineering problems.

PEO2: CORE COMPETANCE

To provide thorough knowledge in Mechanical Engineering subjects including theoretical knowledge and practical training for preparing physical models pertaining to Thermodynamics, Hydraulics, Heat and Mass Transfer, Dynamics of Machinery, Jet Propulsion, Automobile Engineering, Element Analysis, Production Technology, Mechatronics etc.

PEO3: INVENTION, INNOVATION AND CREATIVITY

To make the students to design, experiment, analyze, interpret in the core field with the help of other inter disciplinary concepts wherever applicable.

PEO4: CAREER DEVELOPMENT

To inculcate the habit of lifelong learning for career development through successful completion of advanced degrees, professional development courses, industrial training etc.

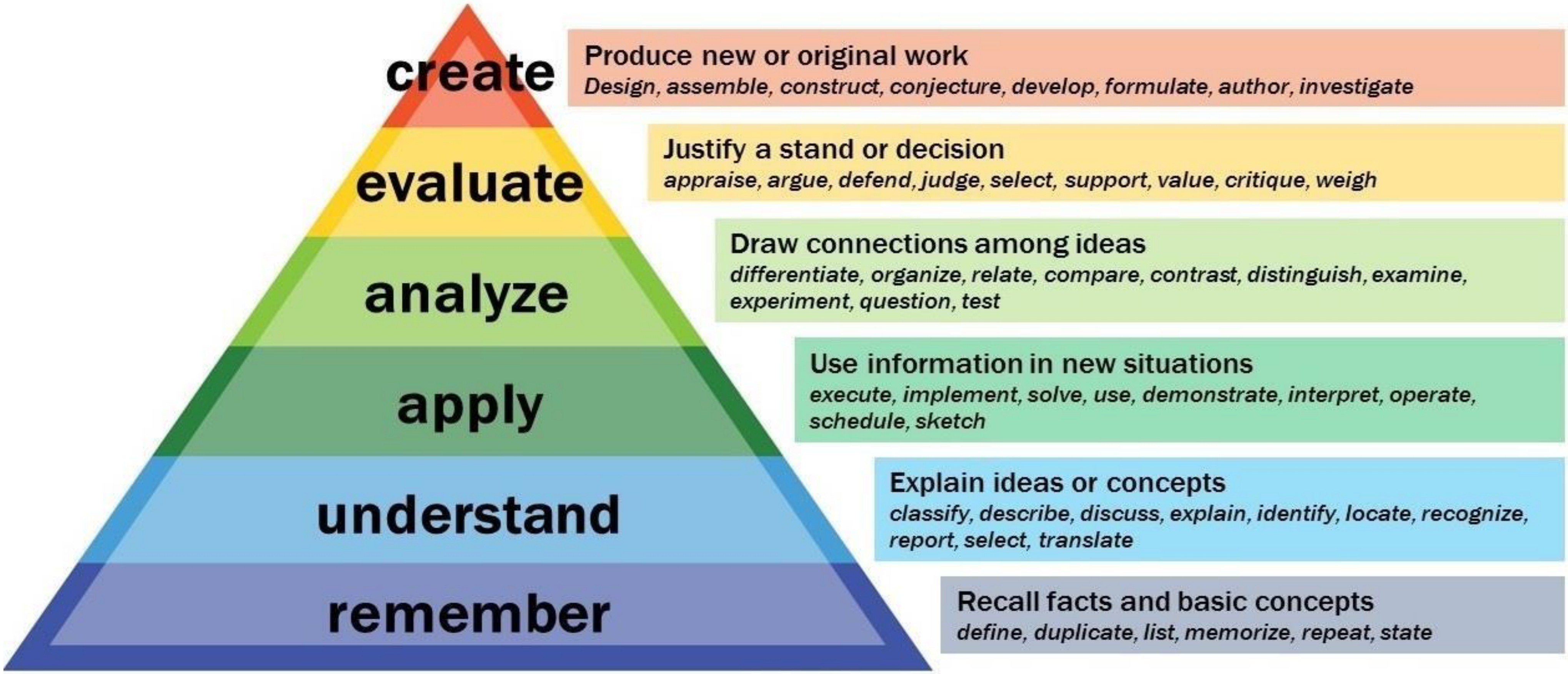
PEO5: PROFESSIONALISM

To impart technical knowledge, ethical values for professional development of the student to solve complex problems and to work in multi-disciplinary ambience, whose solutions lead to significant societal benefits.

Blooms Taxonomy

Bloom's Taxonomy is a classification of the different objectives and skills that educators set for their students (learning objectives). The terminology has been updated to include the following six levels of learning. These 6 levels can be used to structure the learning objectives, lessons, and assessments of a course.

1. **Remembering**: Retrieving, recognizing, and recalling relevant knowledge from long- term memory.
2. **Understanding**: Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Applying**: Carrying out or using a procedure for executing or implementing.
4. **Analyzing**: Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
5. **Evaluating**: Making judgments based on criteria and standard through checking and critiquing.
6. **Creating**: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.



create
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate
evaluate
Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique, weigh
analyze
Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test
apply
Use information in new situations
execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch
understand
Explain ideas or concepts
classify, describe, discuss, explain, identify, locate, recognize, report, select, translate
remember
Recall facts and basic concepts
define, duplicate, list, memorize, repeat, state

Course Syllabus

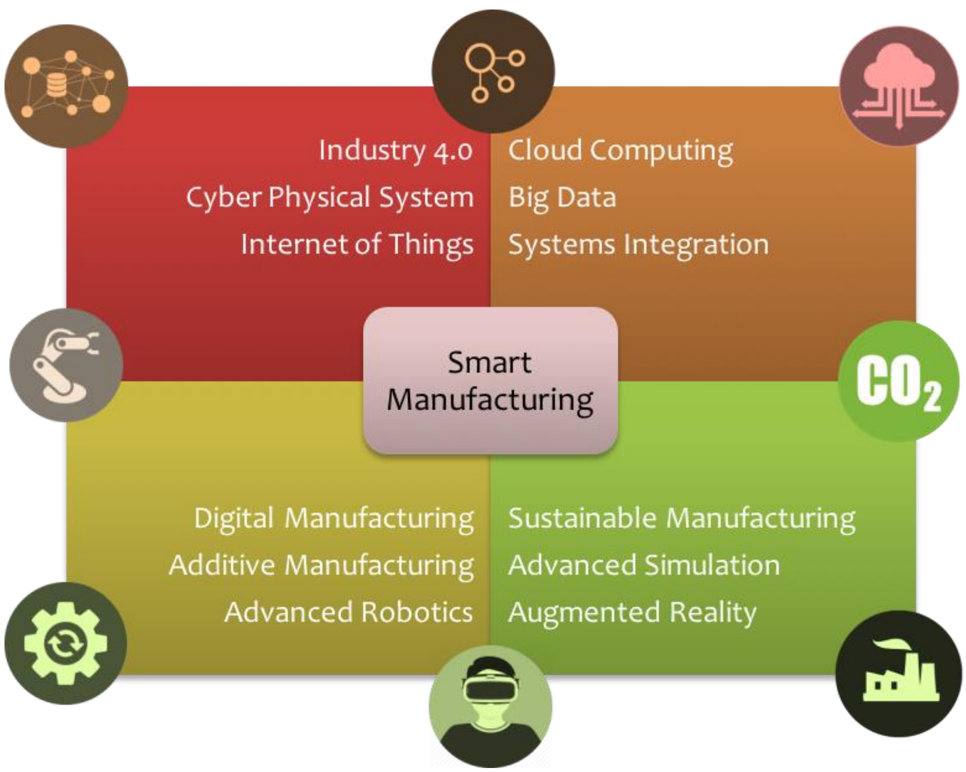
UNIT - I

SMART MANUFACTURING TECHNOLOGIES

UNIT I: INTRODUCTION TO SMART MANUFACTURING

What is "smart manufacturing" really and how does it differ from conventional/legacy manufacturing, Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages & Disadvantages of CIM.

Smart manufacturing is a broad category of manufacturing with the goal of optimizing concept generation, production, and product transaction. While manufacturing can be defined as the multi-phase process of creating a product out of raw materials, smart manufacturing is a subset that employs computer control and high levels of adaptability. Smart manufacturing aims to take advantage of advanced information and manufacturing technologies to enable flexibility in physical processes to address a dynamic and global market. There is increased workforce training for such flexibility and use of the technology rather than specific tasks as is customary in traditional manufacturing



The 21st century manufacturing facilities have ushered a new wave of manufacturing with an amalgamation of technologies from advanced robotics to fully integrated production systems. With smart manufacturing or Industry 4.0, manufacturers are moving towards a new level of interconnected and intelligent manufacturing system which incorporates the latest advances in sensors, robotics, big data, and controllers.

To keep pace with the evolution of these “smart factories’ requires highly skilled and nimble engineers to manage the increasing complexity and shorter mind-to market product cycles. The goal of this program is to train future manufacturing engineers with basic knowledge on IT in addition to the strong problem-solving skills that are imparted in today’s programs. Students will be trained in manufacturing processes, manufacturing systems, systems engineering, IT, Networks and basic shop floor communications. Experiential learning approach will be followed and students will be gaining hands-on experience in many spheres of technology related to smart manufacturing.

Smart Manufacturing is a specific application of the Industrial Internet of Things (IIoT). Deployments involve embedding sensors in manufacturing machines to collect data on their operational status and performance. In the past, that information typically was kept in local databases on individual devices and used only to assess the cause of equipment failures after they occurred.

Now, by analyzing the data streaming off an entire factory's worth of machines, or even across multiple facilities, manufacturing engineers and data analysts can look for signs that particular parts may fail, enabling preventive maintenance to avoid unplanned downtime on devices.

Manufacturers can also analyze trends in the data to try to spot steps in their processes where production slows down or is inefficient in their use of materials. In addition, data scientists and other analysts can use the data to run simulations of different processes in an effort to identify the most efficient ways of doing things.

As smart manufacturing becomes more common and more machines become networked through the Internet of Things, they will be better able to communicate with each other, potentially supporting greater levels of automation.

For example, SM systems might be able to automatically order more raw materials as the supplies, allocate other equipment to production jobs as needed to complete orders and prepare distribution networks once orders are completed.

A lack of standards and interoperability are the biggest challenges holding back greater adoption of smart manufacturing. Technical standards for sensor data have yet to be broadly adopted, which inhibits different kinds of machines from sharing data and communicating with each other effectively.

In the United States, the National Institute of Standards and Technology (NIST) is investigating opportunities to develop and promote standards with various industry stakeholders, including technology companies and manufacturers. The process is ongoing. Other challenges include the cost of implementing sensors broadly and the complexity of developing predictive models.

History/background

It's been nearly 260 years since the beginning of the original Industrial Revolution, thought to have started around 1760. In the United States, the latest iteration of this process, the fourth industrial revolution, has been called "smart manufacturing," while in Europe it's known as "Industry 4.0."

The first industrial revolution was characterized by steam power and the power loom; the assembly line was introduced during the second industrial revolution; and automation and data-enhanced automation came along in the 1970s during the third industrial revolution.

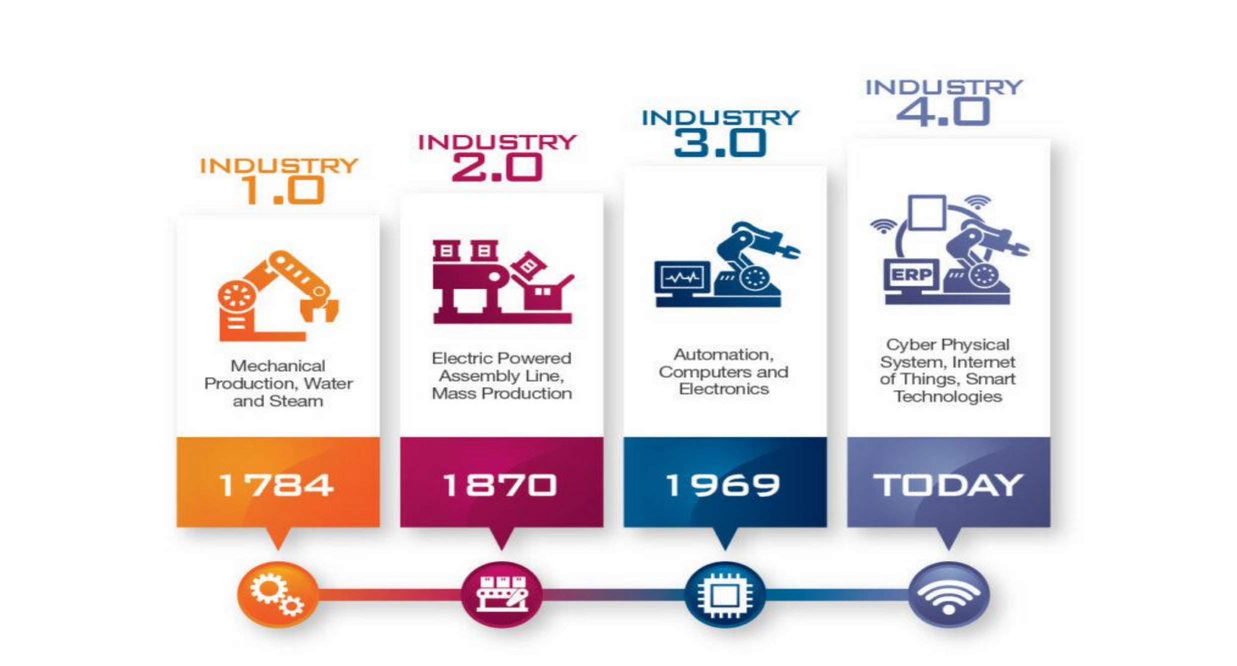
This fourth industrial revolution is characterized by a range of interconnected automated systems that are fusing the physical, digital and biological worlds.

Related technologies

In addition to the Internet of Things, there are a number of technologies that will help enable smart manufacturing, including:

- Artificial intelligence (AI)/machine learning – enables automatic decision-making based on the reams of data that manufacturing companies collect. AI/machine learning can analyze all this data and make intelligent decisions based on the inputted information.
- Drones and driverless vehicles – can increase productivity by reducing the number of workers needed to do rote tasks, such as moving vehicles across a facility.
- Blockchain – blockchain's benefits, including immutability, traceability and disintermediation, can provide a fast and efficient way to record and store data.
- Edge computing – edge computing helps manufacturers turn massive amounts of machine-generated data into actionable data to gain insights to improve decision-making. To accomplish this, it uses resources connected to a network, such as alarms or temperature sensors, enabling data analytics to happen at the data source.
- Predictive analytics – companies can analyze the use huge amounts of data they collect from all their data sources to anticipate problems and improve forecasting.
- Digital twins – companies can use digital twins to model their processes, networks and machines in a virtual environment, then use them to predict problems before they happen as well as boost efficiency and productivity.

Manufacturing is an ever-evolving industry and data shows that the industry contributes to the significant amount of revenue to any country. With said that, the industry leaders have started to shift their focus from traditional to smart manufacturing using industry 4.0 solutions as they offer a plethora of benefits to operators, managers, and executives of companies under this sector. To add to that, partnering with a right IoT app development company can't be ruled out as well.



Industry 4.0 solutions have taken manufacturing by storm. According to a Forbes report, the new machines, devices, and robots will help companies produce better with little human inputs.

And according to the Deloitte University Press, Industry 4.0 brings in the physical-digital-physical link. That means the advanced technologies will pave way for connected enterprises that operate smart and deliver unparalleled customer satisfaction.

Before getting started with here are a few challenges the industry faces with the manual-only approach.

- Drawing information fast,
- Improving services and products,
- Marketing and selling products and services smartly,
- Improving market experience,
- Optimizing the performance and distribution,
- Communicating and analyzing process performance of humans, machines,
- Lack of real-time data extraction for faster decision making.

How Smart Manufacturing differs from traditional manufacturing approaches

Traditional manufacturing methods, developed during the age of mass production, focus on economy of scale and machine utilization. The thinking was that if a machine was idle, it was losing money, so companies kept them running continuously.

To achieve customer satisfaction, traditional manufacturing companies keep large inventories on hand so they can fulfill potential orders. Consequently, these companies have to keep their machines running with specific setups for as long as they can to reduce the costs of making the parts.

This is known as batch-and-queue processing – a mass production approach to operations where the parts are processed and moved to the next process, whether they're needed or not, and wait in a line (queue).

However, this approach isn't very efficient for several reasons, including:

- A longer machine set-up time means more lost production time, because nothing is produced while a machine is down.
- The quality of the product suffers because if parts in a batch aren't made correctly, no one will likely notice the problem until the next operation. This means the work has to be done again, which is expensive and ties up valuable resources.

Smart manufacturing, on the other hand, is a collaborative, fully-integrated manufacturing system that responds in real-time to meet changing the conditions and demands in the factory, in the supply network, and in the needs of the customers.

The goal of smart manufacturing is to optimize the manufacturing process using a technology-driven approach that utilizes Internet-connected machinery to monitor the production process. Smart manufacturing enables organizations to identify opportunities for automating operations and use data analytics to improve manufacturing performance.

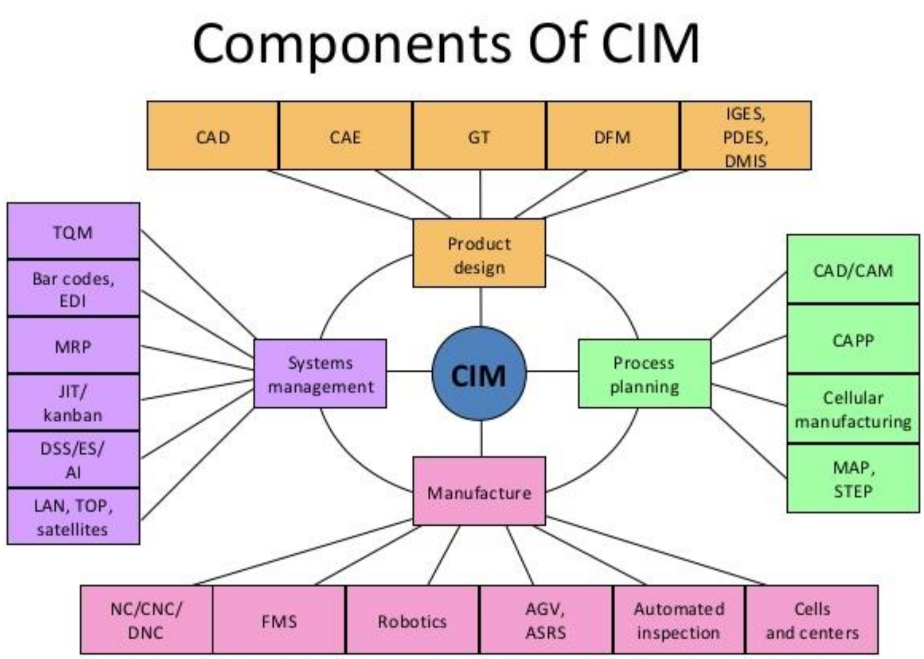
The Smart Factory Opportunity

In the next five years, smart factories may contribute as much as $500 billion in added value to the global economy, according to Capgemini's Digital Transformation Institute. The reason: Smart factories can produce more with lower costs, according to a recent report. In fact, manufacturers expect smart technologies to drive a sevenfold increase in annual efficiency gains by 2022. *Some industries can expect to nearly double their operating profit and margin with smart technologies.* Smart factories increase output, quality, and consistency. Additional benefits include:

- **Streamlined and automated data:** Smart technologies automate data collection and provide advanced production analytics, so managers can make more informed decisions. In a smart operating environment, manufacturers can tie their operations technology with business systems to measure their key performance indicators against business goals.

- **Predictive maintenance:** With better visibility, manufacturers can predict and resolve maintenance issues before they lead to downtime or product-quality issues. For example, sensors affixed to machines or devices may send condition-monitoring or repair data in real time, so manufacturers can identify problems more efficiently.
- **Significant cost reductions:** Manufacturers can identify waste and increase forecast accuracy when their operations and enterprise systems are connected. They have better insight into supply chain issues, such as inventory levels and delivery status, as well as demand cycles. With this information, they can reduce costs related to excessive inventory or unexpected production volume.
- **Reduce workforce challenges:** Automation helps manufacturers launch and complete projects with fewer workers. Having real-time access to data across multiple platforms frees workers to focus on their core responsibilities. This allows manufacturers to innovate faster without investing in additional resources.
- **Enhanced productivity:** Smart, connected systems help factories improve throughput. In a connected enterprise, manufacturers have seamless visibility into bottlenecks, machine performance, and other operational inefficiencies. With this data, manufacturers can make adjustments to increase yields, improve quality, and reduce waste

CIM WHEEL



CIMS STRUCTURE AND FUNCTIONS

CIMS Structure

The components of CIMS include both hardware and software. The hardware includes computer hardware, network, manufacturing devices, and peripherals. The software includes operating systems, communication software, database management systems, manufacturing planning and control soft- ware, management information software, design software, office automation software, and decision support software. These different hardware and software systems have different functions and work together to fulfill the company's business goals. To make it easier to understand, CIMS is normally decomposed into a number of subsystems interacting with each other. Unfortunately, no unique and standard decomposition method exists. Every company can define a method according to its specific situation and requirements. One decomposition method is shown in Figure 5.

From Figure 5, it can be seen that CIMS consists of four functional subsystems and two support subsystems. The four functional subsystems are management information, CAD / CAPP / CAM, man- ufacturing automation, and computer-aided quality management. These functional subsystems cover the business processes of a company. The two support subsystems are computer network and database management. They are the basis that allows the functional subsystems to fulfill their tasks. The arcs denote the interfaces between different subsystems. Through these interfaces, shared data are ex- changed between different subsystems.

CAD / CAPP / CAM System

CAD / CAPP / CAM stands for computer-aided design / computer-aided process planning / computer- aided manufacturing. The system is sometimes called the design automation system, meaning that CAD / CAPP / CAM is used to promote the design automation standard and provide the means to design high-quality products faster.

CAD (Computer-Aided Design)

Computer-Aided Design **CAD** is a process that uses computers to assist in the creation, modification, analysis, or optimization of a product design. It involves the integration of computers into design activities by providing a close coupling between the designer and the computer. Typical design activities involving a CAD system are preliminary design, drafting, modeling, and simulation. Such activities may be viewed as CAD application modules interfaced into a controlled network operation under the supervision of a computer.

A CAD system consists of three basic components: hardware, which includes computer and input– output devices, application software, and the operating system software (Figure 7). The operating system software acts as the interface between the hardware and the application software system.

The CAD system function can be grouped into three categories: geometric modeling, engineering analysis, and automated drafting.

Geometric modeling constructs the graphic images of a part using basic geometric elements such as points, lines, and circles under the support of CAD software. Wire frame is one of the first geometric modeling methods. It uses points, curves, and other basic elements to define objects.

Then the surface modeling, solid modeling, and parametric modeling methods are presented in the area of geometric modeling area. Saxena and Irani (1994) present a detailed discussion of the development of geometric modeling methods.

Engineering design completes the analysis and evaluation of product design. A number of computer-based techniques are used to calculate the product's operational, functional, and manufacturing parameters, including finite-element analysis, heat-transfer analysis, static and dynamic analysis, mo- tion analysis, and tolerance analysis. Finite-element analysis is the most important method. It divides an object into a number of small building blocks, called finite elements. Finite-element analysis will fulfill the task of carrying out the functional performance analysis of an object. Various methods and packages have been developed to analyze static and dynamic performance of the product design. The objectives and methods can be found in any comprehensive book discussion of CAD techniques. After the analysis, the product design will be optimized according to the analysis results.

The last function of the CAD system is automated drafting. The automated drafting function includes 2D and 3D product design drafting, converting a 3D entity model into a 2D representation.

CAPP(*Computer-Aided Process Planning*)

Computer-Aided Process Planning **CAPP** is responsible for detailed plans for the pro- duction of a part or an assembly. It acts as a bridge between design and manufacturing by translating design specifications into manufacturing process details. This operation includes a sequence of steps to be executed according to the instructions in each step and is consistent with the controls indicated in the instructions. Closely related to the process-planning function are the functions that determine the cutting conditions and set the time standards. The foundation of CAPP is group technology (GT),

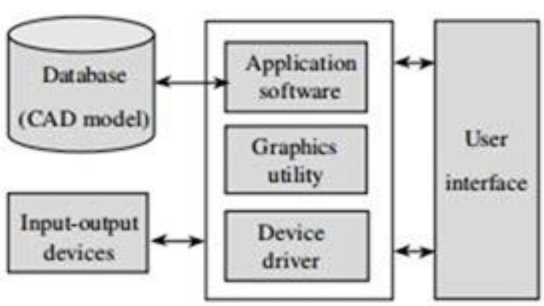


Figure 7 Basic Components of CAD.

which is the means of coding parts on the basis of similarities in their design and manufacturing attributes. A well-developed CAPP system can reduce clerical work in manufacturing engineering and provide assistance in production.

One of the first tasks of the CAPP system is to complete the selection of the raw workpiece. According to the functional requirements of the designed part, it determines the attributes of the raw workpiece, such as shape, size (dimension and weight), and materials. Other jobs for the CAPP system are determining manufacturing operations and their sequences, selecting machine tools, and selecting tools, fixtures, and inspection equipment. Determination of manufacturing conditions and manufacturing times are also part of the work of CAPP. These conditions will be used in optimizing manufacturing cost.

The CAPP system consists of computer programs that allow planning personnel interactively to create, store, edit, and print fabrication and assembly planning instructions. Such a system offers the potential for reducing the routine clerical work of manufacturing engineers. Figure 8 presents the classification of various CAPP systems.

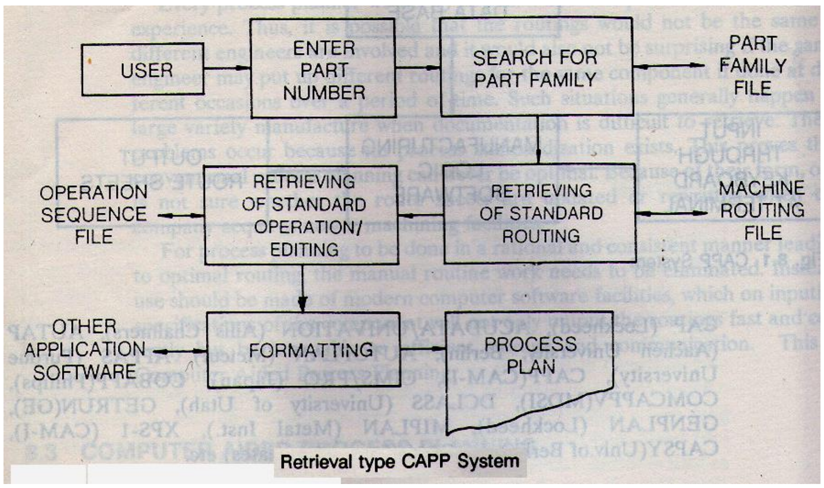
It is difficult to name all the packages available so far for process planning.

A few have been listed alone with their sources.

- CAP (Lockheed
- ACUDATA/UNIVATION (Allis Chalmers),
- AUTAP (Aachen University, Berlin),
- AUTOPLAN (Metcut),
- APPAS (Purdue University),
- CAPP(CAM-I),
- CIMS/PRO (Japan),
- COBAPP(Philips),
- COMCAPPV(MDSI),
- DCLASS (University of Utah),
- GETRUN(GE),
- GENPLAN (Lockheed),
- MIPLAN (Metal Inst.),
- XPS-1 (CAM-I),
- CAPSY(Univ.of Berlin),
- LOCAM (Logan Associates)

Retrieval Type CAPP System

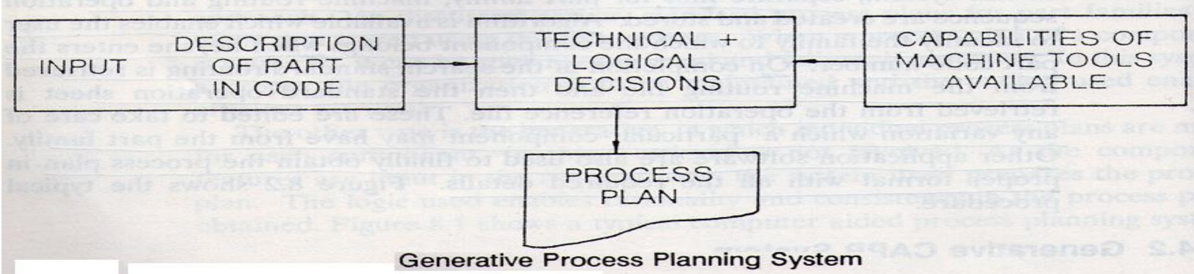
In this system, separate files for part family, machine routing and operation sequence are created and stored. Algorithm is available which enables the user to identlfy the family to which the component belogs whenhe/she enters the part code number. On completion of the search, Standard routing is retrieved from the machine routing file and then the standard operation sheet is retrieved from the operation reference file. These are edited to take care of any variation which a particular component may have from the art family. Other application software are also used to finajlly obtain the process plan in proper format with all the required details



Retrieval type CAPP System

Generative CAPP System

As mentioned earlier, this differs from the varient type in that in this case the process plan is made from scratch. No standard plans exist and as such no retrieval is involved in this case. The software inthe system is capable of taking technical and logical decisions (based on stored information pertaining to capabilities of machine tool available) when the user inputs description of the part in proper coded form and thus outputs the process plan. It builds up optimal processe sequence based on part description provided on the machine capabilities.



Generative Process Planning System

<u>CAM(Computer Aided Manufacturing)</u>

Computer-Aided Manufacturing In this section, *computer-aided manufacturing* (CAM) refers to a very restricted area that does not include general production control functions. The production control functions will be introduced in the manufacturing automation subsystem (MAS) section. Here, CAM includes preparing data for MAS, including producing NC code for NC machines, generating tool position, planning tool motion route, and simulating tool movement. Auto- matic NC code generation is very important for increasing work efficiency. Before the NC code for NC machine centers can be generated, a number of parameters regarding machine tool specification, performance, computer numerical control system behavior, and coding format should be determined first. The manufacturing method and operations will be selected according to these parameters, ge- ometric dimensions, solid forms, and designed part specifications. The CAM system will calculate the tool position data. Then the data regarding the part dimension, the tool motion track, cutting parameters, and numerical control instructions are generated in a program file. This file, called the NC program, is used by the machine tool to process part automatically.

The benefits of CAM

Using CAM has a number of benefits when it comes to creating components used in building construction. Compared to manually operated machines, CAM generally offers:

- Greater speed in producing components
- Greater accuracy and consistency, with each component or finished product exactly the same
- Greater efficiency as computer-controlled machines do not need to take breaks
- High sophistication in terms of following complex patterns like tracks on circuit boards

CAD / CAPP / CAM Integration Besides the utilization of CAD, CAPP, and CAM tech- nology alone, the integration of CAD, CAPP, and CAM is an important way to enhance the company's product design standards. Three methods can be used in the integration of CAD / CAPP / CAM: exchange product data through specific defined data format; exchange product data through standard data format, such as STEP, IGES, and DXF; and define a unified product data model to exchange product information.

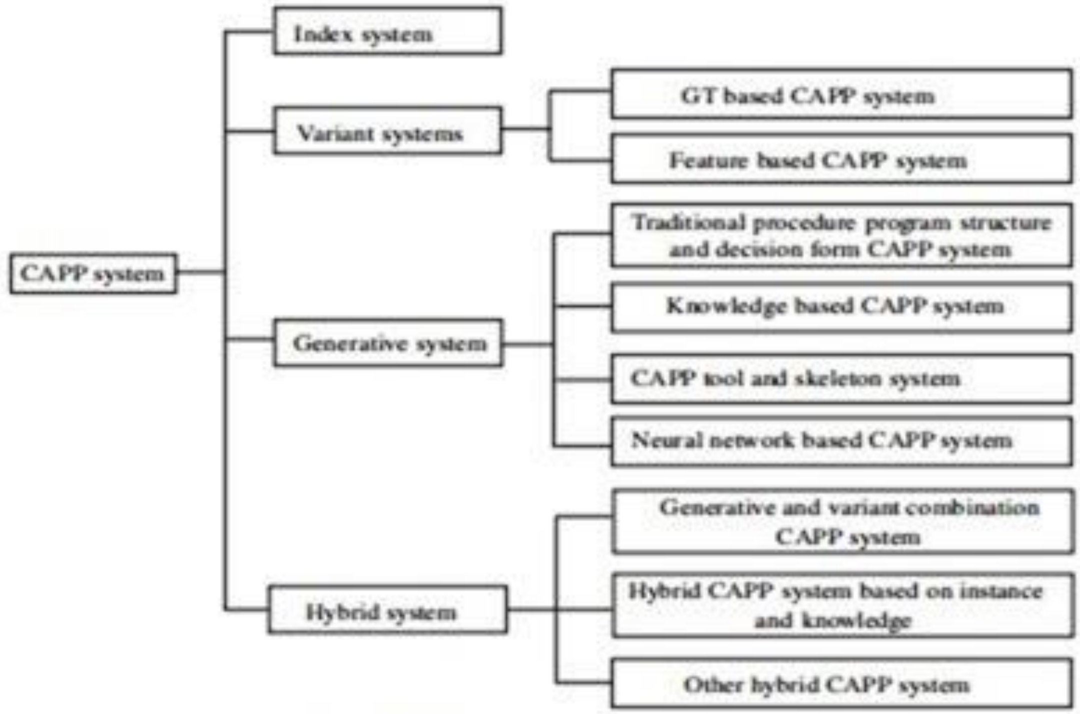


Figure 8 Classification of CAPP System.

Figure 9 is a STEP-based CAD / CAPP / CAM integration system developed at the State CIMS Engineering Research Center of China (located at Tsinghua University, Beijing). It was developed as a part of the CIMS application integration platform (Fan and Wu 1997) for manufacturing enterprises. This system focuses on part-level CAD / CAPP / CAM integration. XPRESS language and the STEP development tool ST-developer are used to define and develop the integration interfaces. Different kinds of CAD, CAPP, and CAM systems can be integrated using the interfaces provided.

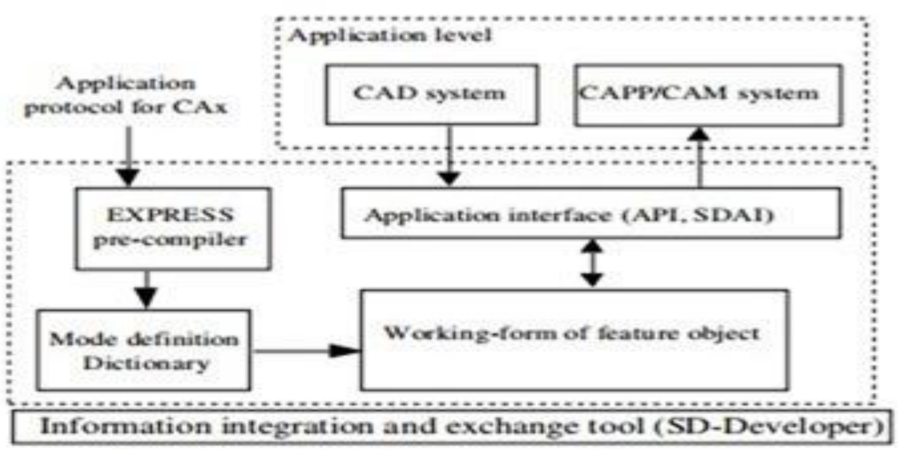


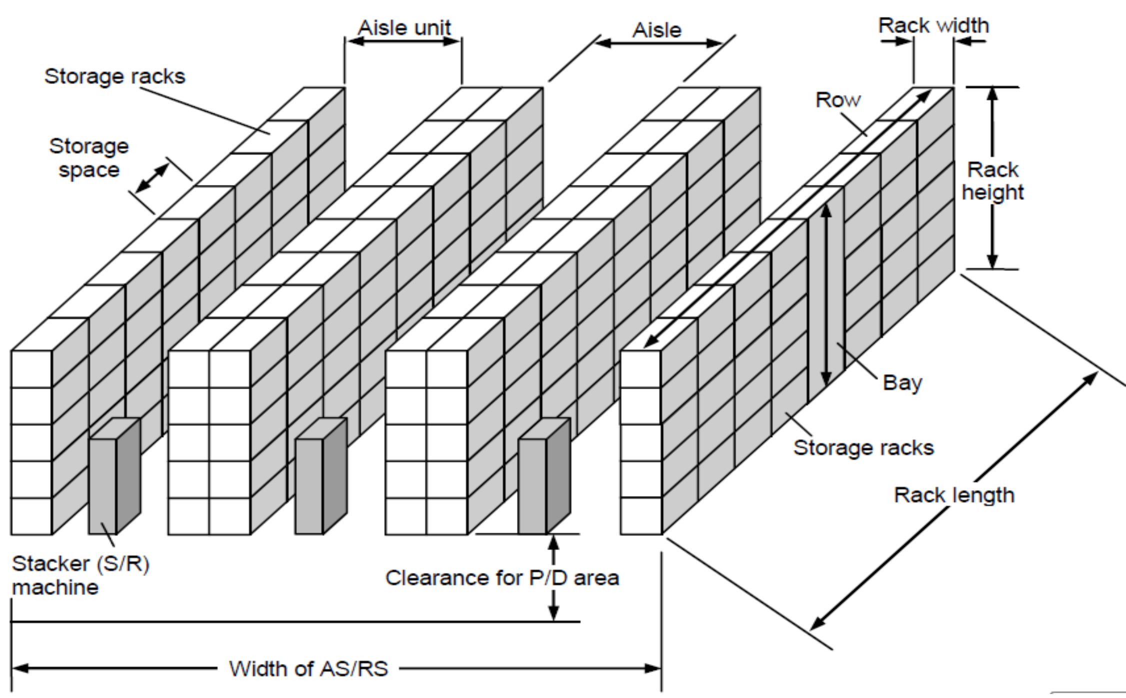
Figure 9 CAD/CAPP/CAM Integration System Structure.

ASRS (Automated Storage and Retrieval System:

- The conventional storage system requires a human worker to access the items in storage in which the storage system itself is static.

- Automated storage systems are available to reduce or eliminate the amount of human intervention

- An AS/RS is a combination of equipment and controls which handles, stores, and retrieves materials with precision, accuracy, and speed under a defined degree of automation
- Focuses on finding a specific desired item and delivering it to the operator.



- An AS/RS consists of one or more storage aisles that are serviced by a storage/retrieval (S/R) machine.
- The stored materials are held by storage racks of aisles.
- The S/R (storage/retrieval) machines are used to deliver and retrieve materials in and out of the inventory.
- P/D(Pickup/deposit) stations are where inventory are transferred into and out of the AS/RS

OBJECTIVES OF ASRS

- Increasing the storage capacity
- Increasing the stock rotation
- Maximum utilization of floor space
- Customer service is improved
- Control over inventories is improved
- Ensuring safety in storage function
- Reducing labour cost in storage operation

TYPES OF ASRS:

1.UNIT LOAD AS/RS:

(i) The unit load AS/RS is used to store and retrieve loads that are palletized or stored in standard-sized containers

(ii) The loads are generally over 500 lb. per unit

Stacking heights are up to 130 feet Hight

2.MINI LOAD AS/RS

(i) This system is designed to handle small loads such as individual parts, tools, and supplies that are contained in bins in the storage system.

(ii) Such a system is applicable where the availability of space is limited.

(iii) A mini load AS/RS is generally smaller than a unit load AS/RS and Stacking heights range from 12 to 20 feet

3.DEEP-LANE AS/RS

Similar to unit load ASRS, except loads can be stored to greater depths in the storage rack for storing large quantities of stock.
A rack-entry vehicle is used to carry loads into the racks from the storage retrieval machine and is controlled by the machine

ASRS APPLICATIONS:

1. ***UNIT LOAD STORAGE AND RETRIEVAL***

   (i) Warehousing and distribution operations

   Used AS/RS types: unit load, deep lane (food industry)

2. ***ORDER PICKING***

   Used AS/RS types: mini load, man-on-board

3. ***WORK-IN-PROCESS STORAGE***

(i) Helps to manage WIP in factory operations

(ii) Buffer storage between operations with different production rates

(iii) Kitting of parts for assembly

CAQC(Computer Aided Quality Control)

QUALITY

- Quality in a manufacturing context can be defined as the degree to which a product or its components conform to certain standards that have been specified by the designer.

INSPECTION

- Inspection is normally used to examine whether a product conforms to the design standards specified for it. For a mechanical component, this would be probably concerned with the dimensions, surface texture and tolerances specified for the part. Non-conforming goods result in scrap, rework, and the loss of customer goodwill.

TESTING

- Testing is a process of the checking the quality by the third party tools , either the developed component as the customer requirement or not
- Various categories of tests used for final product evaluation:
- Functional tests under normal or simulated operating conditions
- Fatigue or wear tests to determine the product's life function until failure
- Overload tests to determine the level of safety factor built into the product
- Environmental testing to determine how well the product will perform under different environments (e.g. humidity, temperature, vibration).

CONTACT INSPECTION METHODS

- In contact inspection, physical contact is made between the object and the measuring and gauging the instrument.

- Typically contact is achieved using a mechanical probe or other deice that touches the item, and allows the inspection procedure to occur.
- By this nature, contact inspection is concerned with some physical dimension of the part, and so contact methods are widely used in manufacturing and production industries to assess the metal parts.

TYPES OF CONTACT INSPECTION METHODS

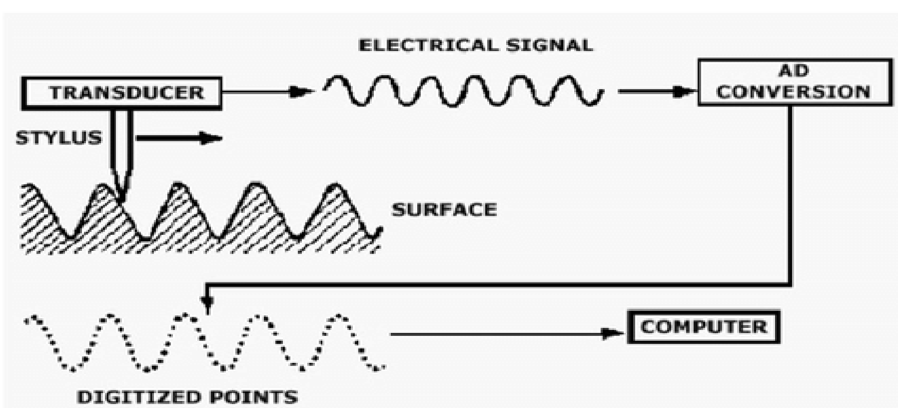
1. Conventional instruments
2. Stylus measuring system
3. Coordinate measuring machine

1. Conventional instruments

- Scale
- Gauge bars
- Slip gauges
- Vernier calipers
- Screw gauge

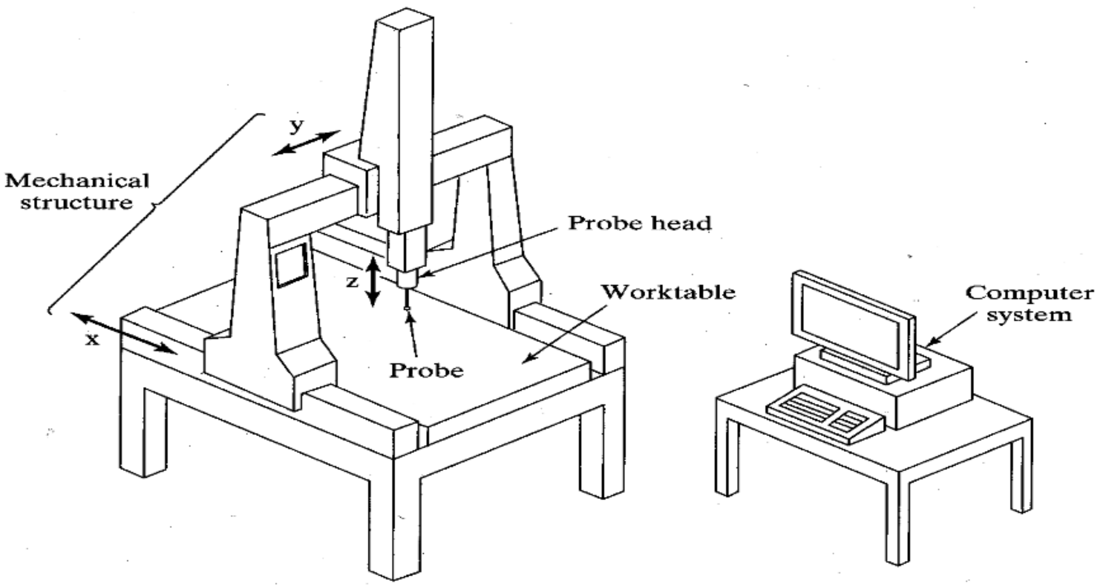
2. Stylus measuring system

Stylus – type instruments are commercially available to measure surface roughness. These electronic devices have a cone shaped diamond stylus with point radius of about 0.005mm and a 90° tip angle that is traversed across the test surface at a constant slow speed. As the stylus head moves horizontally, it also moves vertically to follow the surface deviations. The vertical movements are converted in to an electronic signal that represents the topography of the surface along the path taken by the stylus. This can be displayed as either 1. a profile of the surface or 2. an average roughness value.

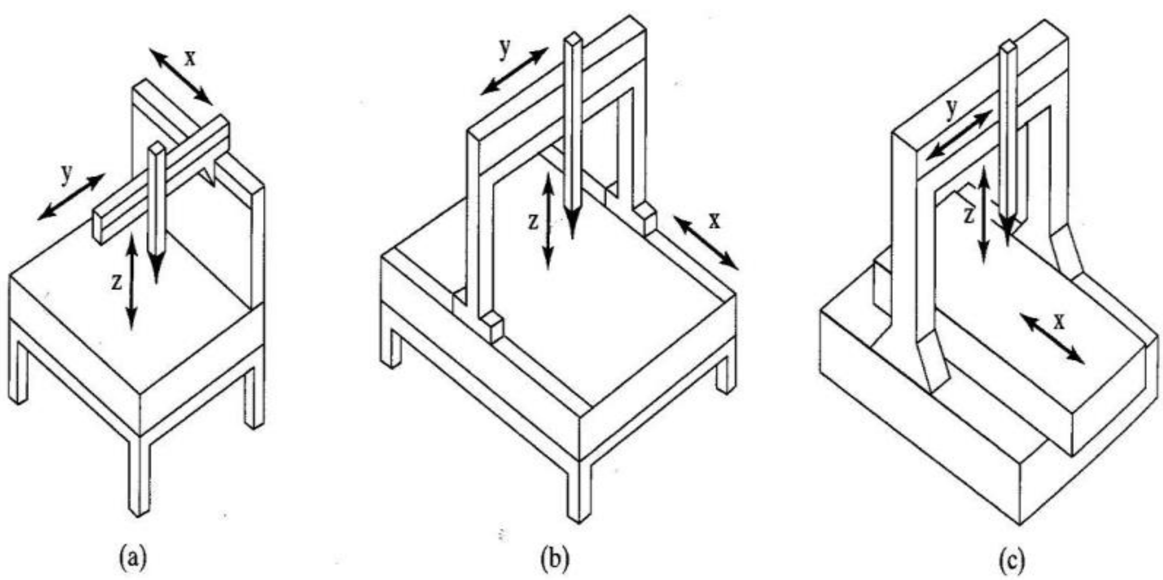


3.COORDINATE MEASURING MACHINE

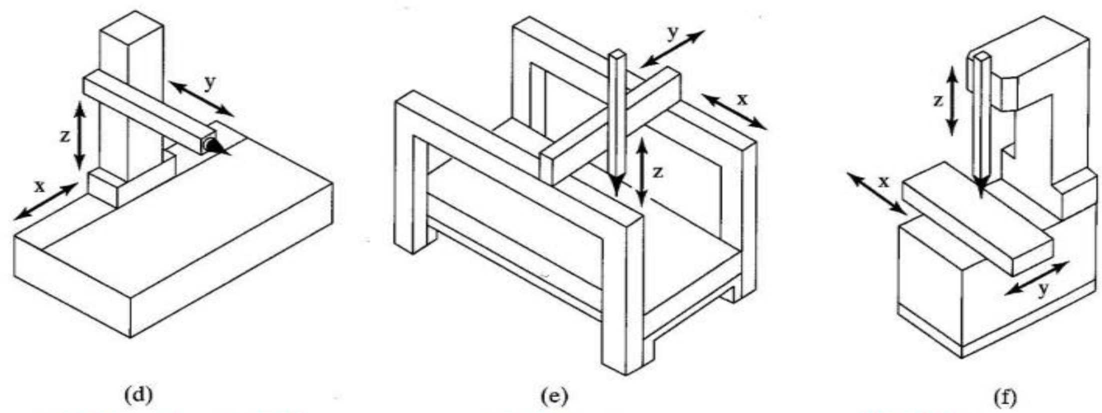
A CMM consists of a constant probe that can be positioned in 3D space relative to the surface of a work part, and the x, y, and z coordinates of the probe can be accurately and precisely recorded to obtain dimensional data concerning the part geometry



TYPES OF CMM



(a) Cantilever (b) Moving bridge (c) Fixed bridge



(d) Horizontal Arm **(e) Gantry** **(f) Column**

NON-CONTACT INSPECTION METHODS

The noncontact methods are divided into two categories for our purposes:

1. Optical

Machine vision, Scanning laser beam devices, Photogrammetry

2. Non-Optical

Electric Field techniques, Radiation techniques, Ultrasonic.

CIM Advantages:

- Responsiveness to shorter product life cycles
- Better process control emphasizes product quality and uniformity.
- Supports and co-ordinates exchange of information
- Designs components for
  - machines.
- Decreases the cost of production and maintenance

CIM Disadvantages:

- Unfamiliar technologies used.
- Requires major change incorporate culture.
- Reduction in short term profit.
- Perceived risk is high.
- High maintenance cost and expensive implementation

UNIT – II

Industry 4.0, IIoT, and digitisation are currently some of the most-discussed and yet least understood topics within manufacturing today. With still a lot of confusion surrounding Industry 4.0, today we'll be exploring the key technologies behind Industry 4.0, as well as real-world applications.

Industry 4.0 in a nutshell

Industry 4.0 is signalling a change in the traditional manufacturing landscape. Also known as the Fourth Industrial Revolution, Industry 4.0 encompasses three technological trends driving this transformation: connectivity, intelligence and flexible automation.

Industry 4.0 converges IT (Information Technology) and OT (Operational Technology), to create a cyber-physical environment.

This convergence has been made possible thanks to the emergence of digital solutions and advanced technologies, which are often associated with Industry 4.0. These include:

- Industrial Internet of Things
- Big Data
- Cloud computing
- Additive manufacturing (AM)
- Advanced robotics
- Augmented and virtual reality (AR/VR)

These technologies are helping to drive manufacturing's digital transformation through the integration of previously disparate systems and processes through interconnected computer systems across the value and supply chain.

Embracing Industry 4.0, digital manufacturing and the interconnectivity that comes with it opens a myriad of benefits for companies, including greater agility, flexibility and operational performance.

Industrial Internet of Things

At the heart of Industry 4.0 is the Internet of Things (IoT).

Put simply, IoT refers to a network of physical devices that are digitally interconnected, facilitating the communication and exchange of data through the Internet. These smart devices could be anything from smartphones and household appliances to cars and even buildings.

Industrial IoT is a subset of the Internet of Things, where various sensors, Radio Frequency Identification (RFID) tags, software and electronics are integrated with industrial machines and systems to collect real-time data about their condition and performance.

IIoT has many use cases, with asset management and tracking being one of the major applications of the technology today.

For example, IIoT can be used is to prevent the overstocking or understocking of inventory.

One way to achieve this is to use shelf-fitted sensors and weighing devices to broadcast inventory information to your warehouse management system. Putting such a system in place allows warehouse managers to monitor inventory levels, thereby gaining real-time visibility and control over the inventory.

Let’s take a look at how BJC HealthCare uses an integrated inventory management solution to achieve cost-savings in its supply chain.

BJC HealthCare adopts IoT for inventory and supply chain management

BJC HealthCare is a healthcare service provider that operates 15 hospitals in Missouri and Illinois.

The company deploys radio frequency identification (RFID) technology to track and manage thousands of medical supplies. RFID technology uses radio waves to read and capture information stored on a tag attached to an object, such as healthcare supplies. Previously, the process of tracking inventory involved a lot of manual labour. However, monitoring inventory manually can be a challenge, since hospitals purchase a variety of products from suppliers and store a lot of items on site for specific procedures.

In some cases, products’ expiration dates will need to be closely monitored, while the loss of stock can lead to a lot of time spent on conducting inventory checks.

For these reasons, BJC decided to implement RFID tagging technology in 2015.

Since implementing the technology, BJC has been able to reduce the amount of stock kept onsite at each facility by 23 per cent. The company predicts that it will see ongoing savings of roughly $5 million annually, once RFID tagging is fully implemented this year. As this example demonstrates, IIoT can significantly improve operations, increase efficiency, reduce costs and provide valuable real-time visibility across the supply chain.

Big Data and Analytics

Big Data refers to the large and complex data sets generated by IoT devices. This data comes from a wide range of cloud and enterprise applications, websites, computers, sensors, cameras and much more — all coming in different formats and protocols.

In the manufacturing industry, there are many different types of data to take into consideration, including the data coming from production equipment fitted with sensors and databases from ERP, CRM and MES systems. But how can manufacturers convert the data collected into actionable business insights and tangible benefits? With data analysis.

When it comes to data, the use of data analytics is essential to convert data to information that can deliver actionable insights. Machine learning models and data visualisation can aid data analytics processes. Broadly speaking, machine learning techniques apply powerful computational algorithms to process massive data sets, while data visualisation tools enable manufacturers to more easily comprehend the story the data tells. Ultimately, by taking previously isolated data sets, collecting and analysing them, companies are now able to find new ways to optimise the processes that have the greatest effect on yield.

Big Data decision-making at Bosch Automotive factory in China

Combining IIoT and Big Data is a recipe Bosch is using to drive the digital transformation of its Bosch Automotive Diesel System factory in Wuxi, China.

The company connects its machinery to monitor the overall production process at the core of its plant. This is achieved by embedding sensors into the factory's machines which are then used to collect data about the machines' conditions and cycle time. Once collected, advanced data analytics tools process the data in real time and alert workers when any bottlenecks in the production operations have been identified. Taking this approach helps to predict equipment failures, enabling the factory to schedule maintenance operations well before any failures occur.

As a result, the factory is able to keep its machinery running and operating for longer stretches of time. The company states that using data analysis in this way has contributed to more than 10% output increase in certain areas, whilst improving delivery and customer satisfaction. Ultimately, a greater insight into the plant's operations supports better and faster decision-making throughout the entire organisation, enabling it to reduce equipment downtime and optimise production processes.

Cloud computing

For decades, manufacturers have been collecting and storing data with the goal of improving operations.

However, with the advent of IoT and Industry 4.0, the reality is that data is being generated at a staggering speed and at high volumes, making it impossible to handle manually. This creates a need for an infrastructure that can store and manage this data more efficiently.

This is where cloud computing comes in. Cloud computing offers a platform for users to store and process vast amounts of data on remote servers. It enables organisations to use computer resources without having to develop a computing infrastructure on premise. The term cloud computing refers to information being stored in the “cloud”, accessed remotely via the Internet. In itself, cloud computing is not a solution on its own, but enables the implementation of other solutions that once required heavy computing power.

The capability of cloud computing to provide scalable computing resources and storage space enables companies to capture and apply business intelligence through the use of big data analytics, helping them to consolidate and streamline manufacturing and business operations.

Manufacturers’ global spending on cloud computing platforms is predicted to reach $9.2 billion in 2021, according to IDC. A key factor behind this adoption is the benefit of being able to centralise operations, eliminating so that information can be shared across an entire organisation. According to one IDC survey, Quality Control, Computer-Aided Engineering and Manufacturing Execution Systems (MES) are the three most widely adopted systems in the cloud.

Clearly, cloud computing is transforming virtually every facet of manufacturing, from workflow management to production operations – and even product qualification.

Volkswagen creates Automotive Cloud

Connected cars are a big new trend in the automotive industry, having emerged as an opportunity to offer digital added-value services for customers. One of the first automakers to jump on this trend is Volkswagen, which joined forces with Microsoft to develop a cloud network, the “Volkswagen Automotive Cloud”.

The technology, planned for 2020, will offer a range of features, including smart home connectivity, a personal digital assistant, predictive maintenance service, media streaming and updates.

Volkswagen aims to add over 5 million Volkswagen brand offerings per year to its Internet of Things (IoT) with the help of this cloud service.

As the automotive industry makes impressive strides in developing advanced autonomous and electric vehicles, carmakers need to come up with an effective approach of managing and transmitting large amounts of data to their vehicles. Incorporating cloud-based storage and communication platform emerges as an effective way to overcoming the challenges faced by these automakers.

Advanced Robotics

While robotics have been used in manufacturing for decades, Industry 4.0 has given new life to this technology.

With recent advancements in technology, a new generation of advanced robotics is emerging, capable of performing difficult and delicate tasks. Powered by cutting-edge software and sensors, they can recognise, analyse and act upon information they receive from the environment, and even collaborate and learn from humans.

One area of robotics gaining significant traction is collaborative robots (“cobots”), designed to work safely around people, freeing workers from repetitive and dangerous tasks.

Fetch Robotics help DHL improve warehouse operations

California-based Fetch Robotics has developed collaborative Autonomous Mobile Robots (AMRs) for locating, tracking, and moving inventory in warehouse and logistics facilities.

A DHL distribution centre in the Netherlands is using Fetch AMRs to perform pick and place operations. At DHL, AMRs autonomously move across the facility alongside the workers, automatically learning and sharing the most efficient travel routes. Using self-driving robots in this way can help reduce order cycle time by up to 50% and provide up to twice the picking productivity gain, according to the company.

As robots become more autonomous, flexible and cooperative, they will be able to tackle even more complex assignments, relieving the workers from monotonous tasks and increasing productivity on the factory floor.

Additive Manufacturing

Alongside robotics and intelligent systems, additive manufacturing, or 3D printing, is a key technology driving Industry 4.0. Additive manufacturing works by using digital 3D models to create parts with a 3D printer layer by layer.

Within the context of Industry 4.0, 3D printing is emerging as a valuable digital manufacturing technology. Once solely a rapid prototyping technology, today AM offers a huge scope of possibilities for manufacturing from tooling to mass customisation across virtually all industries.

It enables parts to be stored as design files in virtual inventories, so that they can be produced on-demand and closer to the point of need — a model known as distributed manufacturing. Such a decentralised approach to manufacturing can reduce transportation distances, and hence costs, as well as simplify inventory management by storing digital files instead of physical parts.

Digital Twins

The concept of a digital twin holds great promise for optimising the performance and maintenance of industrial systems. Global research firm, Gartner, predicts that by 2021, 50% of large industrial companies will be using digital twins to monitor and control their assets and processes.

A digital twin is a digital representation of a real-world product, machine, process, or system, that allows companies to better understand, analyse and optimise their processes through real-time simulation.

While digital twins can be confused with simulation used in engineering, there is much more to this concept. Unlike engineering simulations, a digital twin runs an online simulation, based on data received from sensors connected to a machine or other device. As an IIoT device sends data almost in real time, a digital twin is able to collect this data continuously, maintaining its fidelity with the original throughout the lifespan of the product or system.

This enables the digital twin to predict potential issues so that preemptive measures can be taken. For example, an operator can use a digital twin to identify why a part is malfunctioning or to predict the lifetime of a product. This continuous simulation helps to improve designs of products as well as to ensure equipment uptime.

This use of digital twins has long been an important tool in demanding aerospace, heavy machinery and automotive applications. Now, advances in computing technology, machine learning and sensors are expanding the concept of digital twinning across other industries.

Augmented reality

Despite its uptake in consumer applications, the manufacturing industry is just beginning to explore the benefits of Augmented Reality (AR) technology. And yet, there is a huge untapped potential for the technology, from helping with assembly processes to helping to maintain manufacturing equipment.

Augmented reality bridges the gap between the digital and physical worlds by superimposing virtual images or data onto a physical object. For this, the technology uses AR-capable devices, such as smartphones, tablets and smart glasses.

Let's take a medical instance as an example — a surgeon using AR glasses during a surgical operation. The glasses could overlay data from patient's MRI and CT scans, such as nerves, major blood vessels and ducts, onto the patient, and highlight them in colour. This helps the surgeon to find the safest path into the region that needs invasion, minimising the risk of complications and improving surgeon's precision.

In the context of manufacturing, AR could enable workers to speed up the assembly process and improve decision-making. For example, AR glasses could be used to project data, such as layouts, assembly guidelines, sites of possible malfunction, or a serial number of components, on the real part, facilitating faster and easier work procedures.

AR increases productivity at GE

General Electric offers a glimpse at how AR technology can empower manufacturing. The company is currently piloting the use of AR glasses at its jet engine manufacturing facility in Cincinnati. Before using these smart glasses, jet engine makers often had to stop what they were doing in order to check their manuals and ensure tasks were being performed correctly.

However, with AR glasses, they can now receive digitised instructions in their field of view. The mechanics can also access training videos or use voice commands to contact experts for immediate assistance.

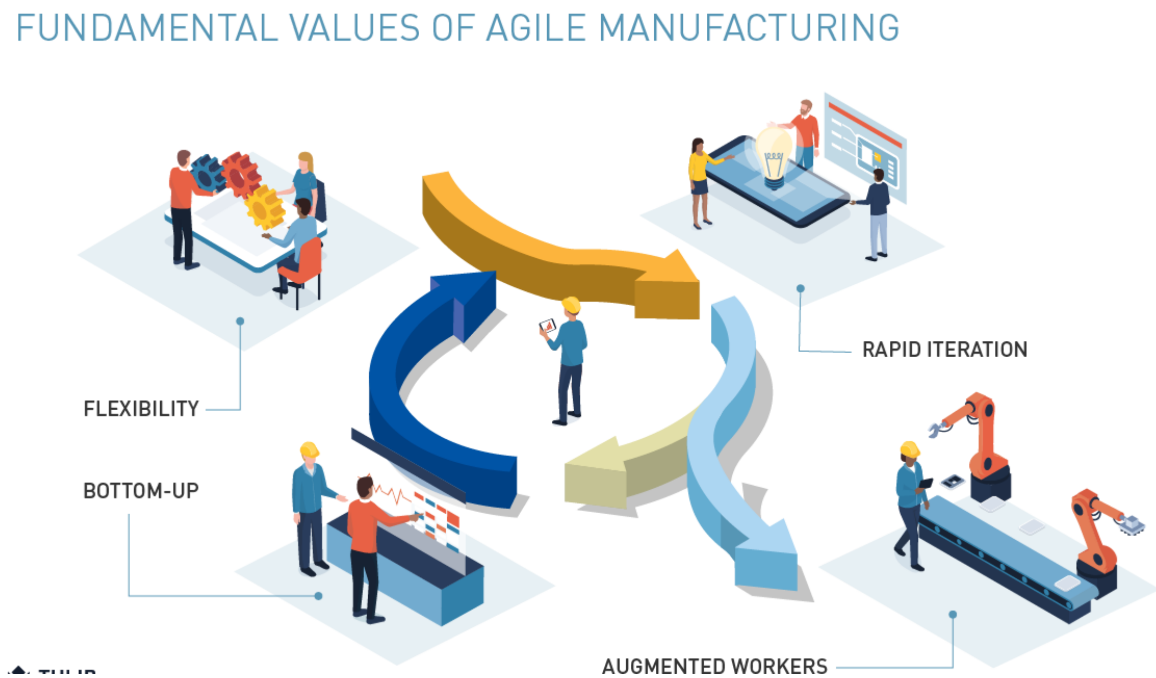
During the pilot, GE reports that the productivity of workers using smart wearables increased by up to 11%, compared to previously. Ultimately, this approach could offer a tremendous potential to minimise errors, cut down on costs and improve product quality.

Even with this example from GE, we're still scratching the surface when it comes to implementing AR within the manufacturing context.

Manufacturing is changing. Quickly. Call it Industry 4.0, the Fourth Industrial Revolution, or the new status quo, but the fact remains the same: manufacturing is experiencing an era of acceleration. To keep up, manufacturers need to adopt an approach that welcomes change.

Increasingly, that approach has been Agile. Across industries and verticals, manufacturers apply Agile methods to access faster time to value and increase resilience in a time of disruption. Initially designed for software development, Agile allows manufacturers to harness a fast rate of change for competitive advantage. By emphasizing rapid iteration, operator augmentation, operational flexibility, and bottom-up innovation, Agile Manufacturing enables a fast response to customer demands while empowering workers to innovate.

This guide will introduce you to Agile Manufacturing. We'll review history, dive deep into each of the principles, and give concrete tips on how to adopt this method of working on your shop floor.



The 4 core values of Agile Manufacturing: flexibility, rapid iteration, augmentation and bottom-up innovation

What is Agile Manufacturing?

Agile Manufacturing is an approach to manufacturing that leverages flexibility, bottom-up innovation, and augmentation in order to adapt, through an iterative process, to changing conditions.

Four major shifts in the manufacturing landscape have made Agile methods necessary.

1. Rapidly evolving environment – Technology is driving significant changes in manufacturing. But technology is not the only moving part. Customers are also evolving quickly. They now have higher standards. They expect product customization, fast delivery, and cheaper production. Regulations are changing as well, increasing in number and severity. Add to this increasingly complex supply chains and questionable trade stability and you have an environment that demands flexibility.

2. Constant technological development – New technologies appear every day, and manufacturing is getting its bearings in the digital age. Moving forward, manufacturers will feel the effects of new technologies in unexpected ways. According to a report published by McKinsey in 2018, manufacturing will experience more disruptions in the next five years than in the past twenty years combined.

3. More access to information – Connected factories product data on an unprecedented scale. Data will enable leaps forward like predictive maintenance and supply chain optimization. Companies will be able to act on real-time data at every level. Upper management will be able to evaluate plant-level performance in real-time. Production managers will diagnose quality issues before they reach downstream. And executives interested in contract manufacturer performance will gain new visibility.

4. Workforce transformation – Low unemployment rates and an enduring skills gap make it difficult for manufacturers to recruit skilled workers. Research by Deloitte shows that this skills gap may leave over two million manufacturing positions unfilled between 2018 and 2028.

By incorporating Agile, manufacturers can survive these shifts and remain competitive. But too often, “agile” is a buzzword, dissociated from its real meaning and principles. Let’s go back in time and recall the development of the now-famous approach.

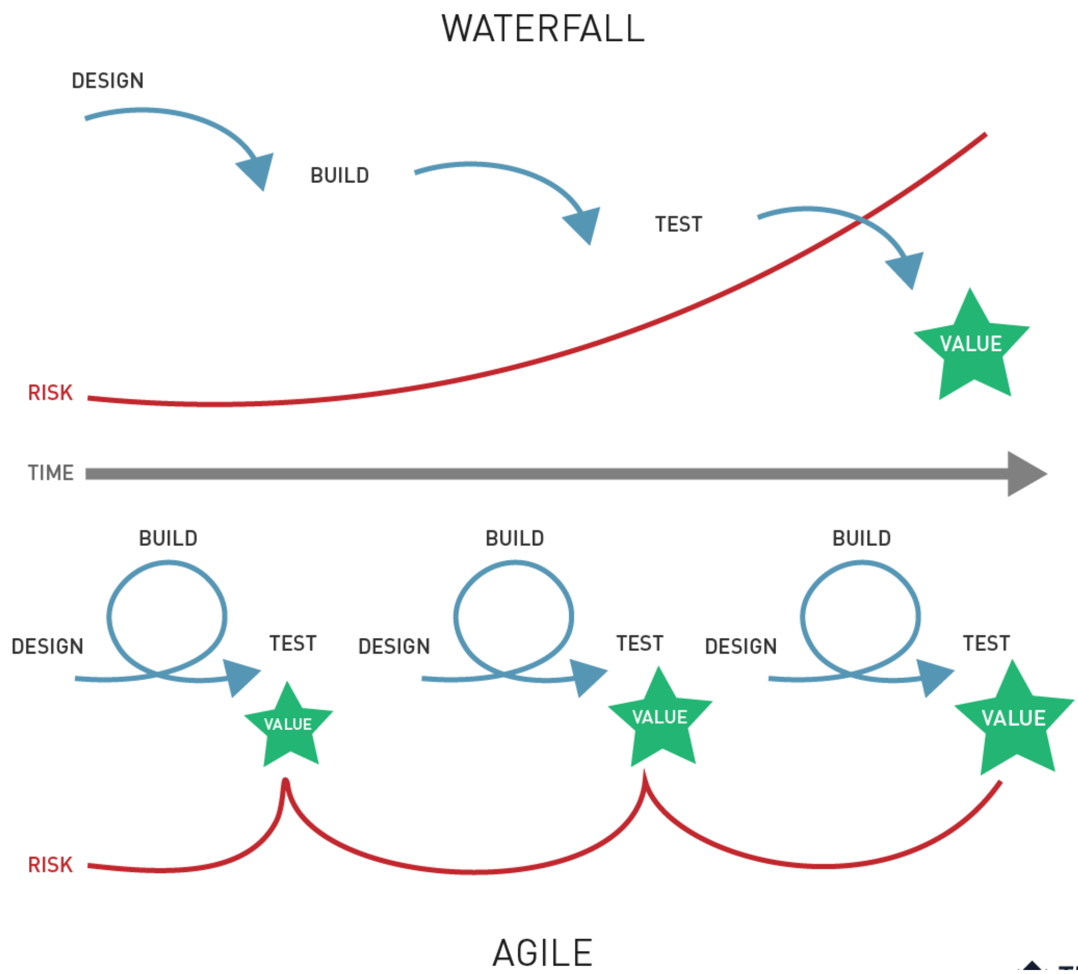
The 4 major shifts in manufacturing: rapidly evolving environment, constant technological development, workforce transformation and more access to information.

History of Agile

The Agile movement was born in 2001, when seventeen software developers gathered in a ski lodge in Utah. They all had at least one thing in common: a deep dissatisfaction with the Waterfall model.

The Waterfall model is a development method that is linear and sequential. Practitioners must complete each step of production before they start the next. Though structured and easy to follow, the Waterfall model has many pitfalls.

Primarily, the Waterfall model discourages changing course until the end of the development cycle. Because it privileges forward progress, the waterfall model delays incorporating feedback, makes it challenging to adapt to changing requirements, and slows production as engineers go to great lengths to avoid mistakes.

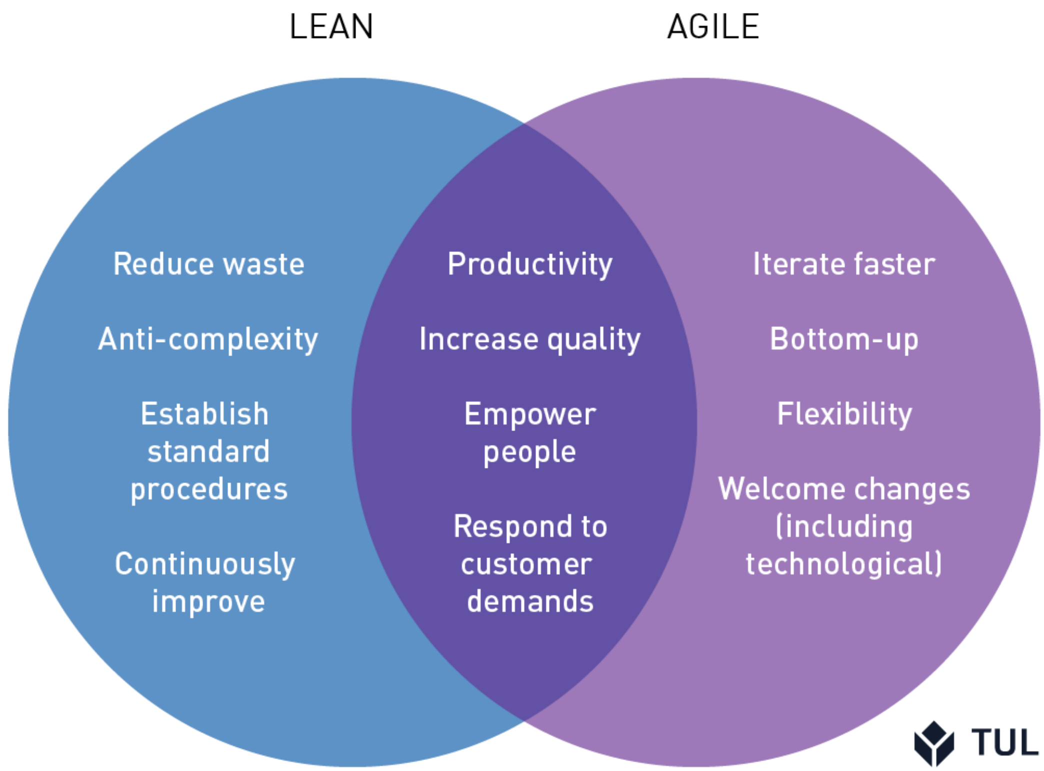


In the Waterfall model, production steps are followed one after the other, with no back-and-forth, until the final product is obtained. In the Agile model, multiple cycles of production take place.

Agile Manufacturing Principles

The Lean and Agile approaches are both wildly popular. However, they should not be confused. On the one hand, Lean Manufacturing is focused on increasing efficiency by reducing waste. On the other hand, Agile Manufacturing aims to increase efficiency via flexible, parallel problem solving.

While some of the ideas of Lean Manufacturing and Agile Manufacturing overlap, the fundamental principles are different.



The intersection and difference between Agile Manufacturing and Lean Manufacturing.

Key principles of Agile Manufacturing:

1. Iterate Faster

The idea of delivering smaller pieces of value more frequently is central to Agile Manufacturing. Rather than attempting to design a single, perfect product in one go, the objective is to rapidly produce multiple versions. Each iteration, with its flaws and strengths, reveals new insights that make it possible to improve the process. As the process improves, each new version of the product surpasses the previous.

Why does this incremental, iterative method result in a superior result? Because process engineers deal with many variables. Iterations allow them to test different solutions, and gather data on individual variables. Without this data, it is difficult to determine which changes are necessary at a given stage to optimize production.

2. Flexibility

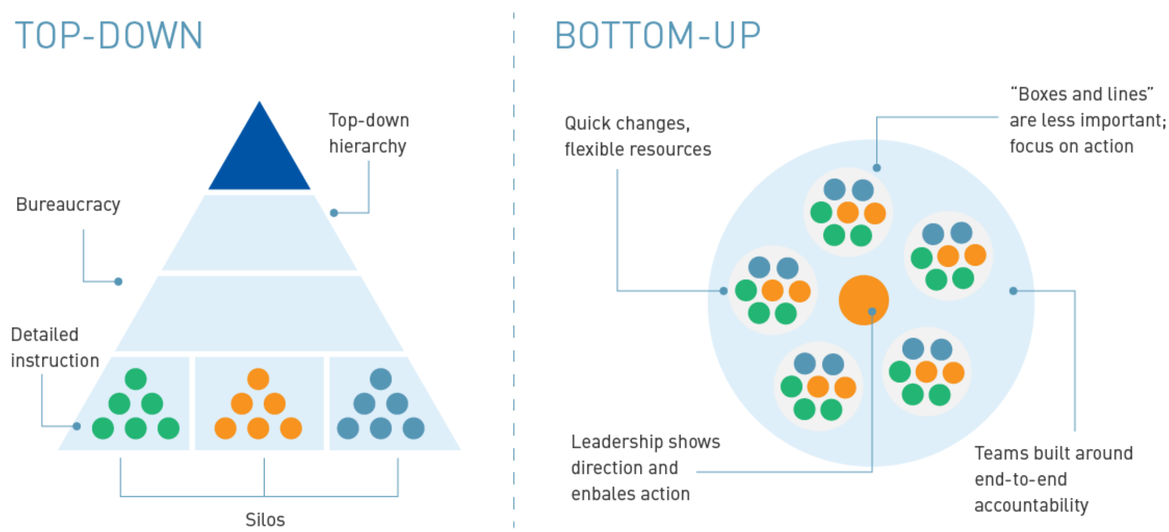
According to McKinsey, “Volatility is rising and taking its toll. Whether from increasing fluctuations in demand, labor rates and input prices, or from disruptive events like natural disasters and financial crises, volatility has damaged supply chains, increased costs and eroded profits. […] Companies are increasingly recognizing that they must alter their manufacturing strategies in the face of rising volatility.”

In order not to bend under external forces, manufacturing companies need to have flexible systems. Their internal structure needs to be dynamic enough to rebound quickly from external disruptions. Agile manufacturers are aware that environmental factors – economic, political, environmental, social, technological – require them to constantly stay on their toes. They make sure that every component of their system can grow organically and adapt to changes.

3. Bottom-Up

For decades, goals and directives have passed from the top of the organization, to the bottom. The top-down approach has its advantages, such as the quick implementation of decisions taken by upper levels of a company. However, this comes at a cost. Employees at the bottom can feel disconnected and disengaged. Low engagement can discourage accountability and innovation.

Agile manufacturers favor a bottom-up approach, in which ideas and directives flow seamlessly between all layers of the company. With this approach, directors and managers give operators and shop floor workers a voice. Agile Manufacturing supports the idea that those closest to manufacturing challenges understand them best. The more operators, engineers, managers, and business executives collaborate, the more effective operations will be as a whole. Collaboration across functions and seniority levels yields higher value products and processes.



Agile organizations abandon the hierarchical, top-down approach to adopt a flexible, bottom-up approach.

4. Augmentation

Augmentation is best understood in contrast to automation. Automation consists of automating workers' tasks – in other words, of replacing workers by machines. Augmentation, on the other hand, enhances workers' capabilities through technology. For years, automation was considered the solution to high labor costs and human error in the factory. Yet automation is also expensive, difficult to maintain, and inflexible.

Agile manufacturing argues that humans will perform best if they have tools that enable them to evolve their work. From computer-vision assisted quality checks to error-proofing work instructions, Agile manufacturers use technology to help their people do more work, better.

How to Implement Agile Manufacturing

In order to successfully implement Agile Manufacturing, manufacturers need to apply its principles and encourage some changes to their organization. These changes will vary depending on the organization's size and structure, but some underlying features are common to most successful Agile organizations.

Implementing Agile Manufacturing Through Organizational Changes

1. Culture and purpose

Agile culture puts people at the center. Agile organizations are structured in a way that team members have ownership over their work. Leaders in an Agile organization do not rule over their employees, but rather provide them with tools to achieve results on their own.

These autonomous Agile teams are goal-oriented. After setting their goals and deciding how to achieve them, teams are held accountable for their progress. Even if different teams work on different goals, there is an organization-wide cohesion: all goals fit into a greater purpose. Agile organizations understand that purpose is essential to give meaning to the short-term goals that teams work hard to meet.

Purpose also increases productivity: when employees work with a sense of purpose, they are more engaged and motivated. Agile organizations share their purpose with everyone so that every employee knows why they're doing what they're doing. A purpose-driven mindset fuels people and boosts motivation and engagement.

2. Network of teams

Teams hold great importance in Agile organizations. Accountability, transparency and collaboration are crucial within teams. Team members have clear roles, but they do not necessarily have a single role and roles can be shared among multiple people. The work environment should be open and safe. Finally, teams should be in touch with each other, so that members can source knowledge and insights from other teams.

3. Rapid cycles

The "Iterate Faster" principle of Agile Manufacturing encourages teams to quickly go through multiple versions of a process or product. The ability to implement this principle is a core feature of successful Agile organizations. In order to iterate faster, Agile teams work on concrete goals over short, predetermined periods of time. Both the goals and the timeframe are critical to agility. Goals should be realistic and measurable. Team members are held accountable for them. The timeframe should be fairly short – on the order of weeks – to keep teams iterating quickly.

4. Technology

Technology is essential to all of the cornerstones of Agile Manufacturing. Without the right technologies, it is impossible for companies to deliver value at a fast enough pace to keep up with customer demands and market fluctuations.

Examples of enabling technologies include real-time communication and work management tools, to improve flow and organization; hackathons, to swiftly push out new solutions and products; and interactive digital work instructions, to easily keep employees' skill sets up to date. But Agile isn't about adopting solve-it-all technologies. Rather, it is about finding the right technologies to improve their unique processes, workers, and products.

Applications of Agile Manufacturing:

Manufacturers can bring agility to their organizations by adopting the right technologies.

To iterate faster, Agile manufacturers turn to technologies that help them collect data. To become flexible, tools and software that enable quick turnovers are essential. To follow a bottom-up approach, Agile manufacturers award their workers more trust and power. To augment their workers, they equip them with the proper tools and training.

Let's look at some examples of enabling technologies in action.

Using Real-Time Data to Guide Iteration

Contract manufacturer Jabil supports a wide variety of customers and is subject to fast-changing requirements. Moreover, Jabil's customers need to receive their products as fast as possible. This means Jabil also had to increase its speed.

Thus, non-value-add steps had to be identified and eliminated quickly. The only way to achieve this is to run processes again and again, and collect data on each iteration. Jabil started using IoT connected tools and sensors to collect real-time data on every iteration. This data, collected through the use of a manufacturing app platform, allowed process engineers to incorporate feedback after each process completion. This cycle of iterative improvements stripped processes of non-value-add steps. With such visibility into their processes, process engineers were able to take control over their operations, following a bottom-up approach. The result: cycle times were reduced, and production yield and throughput were significantly increased.

Using 3D Printing to Prototype Faster

3D printers have the potential to greatly accelerate designing and prototyping. Iterative cycles become shorter as new versions of products are tested in a fraction of the time. Indeed, new prototypes no longer need to be designed and manufactured in a process that can take months. Rather, they are simply printed and tried immediately. Products are thus tested early and often, and improvements are made with each version. The result: optimal end products that satisfy customer demands.

3D printing also makes mass customization realistic for manufacturers. For example, 3D printing is transforming the jewelry industry by allowing the rapid production of highly detailed, custom parts. 3D printing allows manufacturers to be much more flexible to changing customer demands.

Using Computer Vision to Augment Operators

Computer vision systems can assist operators through a production process. These systems track the operator's movements and inspect the product as it is being made. Based on ongoing context analysis of the manufacturing environment, the computer provides assistance and performs the relevant quality checks.

With computer vision, manufacturers can deliver a much greater array of products without sacrificing productivity or quality. When used to assist operators in line, computer vision systems can help fatigued workers detect defects, and provide error proofing in complex assemblies where workers or prone to miss or mis-execute steps. With computer vision assisting with cognitively taxing tasks, operators have more attention and focus for problem-solving and innovation.

Using Manufacturing Apps to Amplify Training Programs

At Merck, a multinational pharmaceutical and life sciences company, the complex lab equipment requires highly skilled operators. Training used to be excruciating and expensive. The firm's paper-based training instructions were difficult to follow, and training programs required taking experienced operators to supervise new hires through each step of the training process.

Interactive training apps with step-by-step work instructions were a game changer. The photos, videos and live stream sensor data transformed the training experience, making it more interactive and constructive. For Merck, the outcome was remarkable: training costs were reduced by 57%, and training times by 92%. The new training program augmented workers' capabilities: rather than using technology to automate workers' tasks, Merck leveraged it to simplify re-skilling and close the skills gap.

Using Digital Work Instructions to Error-Proof High-Mix Assemblies

Dentsply is the world's largest provider of dental solutions. Their implants division receives thousands of custom orders every day, and each requires a very specific kitting combination.

A senior process engineer at Dentsply created an app to simplify the kitting process. The app was connected to IoT devices like pick-to-lights and break beams that would guide workers to the bin with the right part from for each kit. Process engineers were able to improve the process by building the apps themselves. They no longer needed to go through IT or get the change reapproved as part of their Quality Management System. Moreover, production became as flexible as Dentsply's customized products required it to be.

The Agile Methodology has been in the spotlight for almost two decades. 41% of the organizations surveyed by McKinsey say their companies have fully implemented or are in the progress of implementing a company-wide Agile transformation. However, it is only in recent years that technologies enabling agility in the manufacturing sector have emerged. Now, there is promising potential for manufacturing companies to join the digital revolution and leave the past behind.

Mass Customization

Mass customization is the process of delivering market goods and services that are modified to satisfy a specific customer's needs. Mass customization is a marketing and manufacturing technique that combines the flexibility and personalization of custom-made products with the low unit costs associated with mass production. Other names for mass customization include made-to-order or built-to-order.

- Mass customization is a process that allows a customer to personalize certain features of a product while still keeping costs at or near mass production prices.

- Innovative manufacturing techniques help companies produce interchangeable parts that can be combined in a variety of ways to build a cost-effective product that satisfies a specific customer's needs.
- The four primary types of mass customization are collaborative customization, adaptive customization, transparent customization, and cosmetic customization.
- Various companies employ mass customization techniques, including retail companies, software creators, financial services companies, and modular home builders.
- Companies that offer mass customization can give themselves a competitive advantage over other companies that only offer generic products.

Understanding Mass Customization

Mass customization allows a customer to design certain made-to-order features of a product while still keeping costs closer to that of mass-produced products. In some cases, the components of the product are modular. This flexibility allows the client to mix-and-match options to create a semi-custom final product. Mass customization may apply to many fields, but many connect it to the retail industry. Software creators may use this method to include software-based product configurations that enable end-users to add or change specific functions of a core product. Even the financial services industry embraces mass customization through the growth of independent, fee-only advisory firms.

The Growth of Mass Customization

B. Joseph Pine II looked at the growth of the American economy due to mass production. In his book, Mass Customization: The New Frontier in Business Competition (Harvard Business Review Press, 1992), he describes four primary types of mass customization which took the concept of mass production to a new level:

Collaborative customization: companies work in partnership with clients to offer products or services uniquely suited to each client

Adaptive customization: companies produce standardized products which the end-user may customize

Transparent customization: companies provide unique products to individual clients without overtly stating the products are customized

Cosmetic customization: companies produce standardized products but market them in different ways to various customers

Pine focused on the concept of creating a small number of interchangeable pieces. The individual parts may be combined in a variety of ways producing a cost-efficient production model and still allows consumers to choose how the pieces go together.

Robotics & Automation

Robotics is a field of engineering that deal with design and application of robots and the use of computer for their manipulation and processing. Robots are used in industries for speeding up the manufacturing process. They are also used in the field of nuclear science, sea-exploration, servicing of transmission electric signals, designing of bio-medical equipments etc. Robotics requires the application of computer integrated manufacturing, mechanical engineering, electrical engineering, biological mechanics, software engineering.

Automation and Robotics Engineering is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization.

A specialization in robotics engineering may lead to potential career opportunities in manufacturing, research and engineering, agriculture, mining, nuclear, power-plantmaintenances and a variety of other areas. Besides, thereis great scope for qualified experts and researchers to associate themselves with different segments of R & D in robotics. As the recent global career trend in robotics suggests, fields as diverse as surgery, modern warfare and nanotechnology have registered a remarkable increase recently in their demand for technical expertsand researches in robotics.

Benefits

A course in Robotics trains and educates an individual in the following fields,

- Artificial Intelligence
- Computer Aided Manufacturing
- Computer Integrated Manufacturing System
- Computational Geometry
- Robot Motion Planning
- Robot Manipulators

One of the great ways to learn about robotics is to take part in robotics competitions organized by GGI every year. Students from various engineering colleges and high schools cantake part in this technical festival. Surveys conducted by the government and private agencies reveal that the robots enhance the job quality, productivity, productquality, profitability for those who work in hazardous environment. The use of robots creates jobs and people who are working manually can be rehabilitated in different areas through training. Even,robots require maintenance, programming and design change.

Robotics consists of a branch of technology that predominantly deals with the design, construction and operation of robots. An industrial robot is typically a standard machine controlled by an internal or external computer that is able to carry out a complex series of movements automatically. There are a wide range of robots available; from basic robot arms through to completely autonomous vehicle mounted robots. Robots are often equipped with audio, visual and tactile sensors. Whilst a standard robot usually follows a pre-determined program, collaborative robots have force sensing built in and as a result are able to follow a person’s movements and work collaboratively with them.

Robots today perform a variety of jobs within factories such as:

- Palletising
- Parts assembly
- Painting
- Welding
- Machine tool tending
- Material handling
- Pick and place
- CNC milling

Robots are also often used to substitute humans in dangerous environments including hazardous areas environments, high temperature environments, radioactive environments and areas where there are harmful vapours and gasses.

The main advantage of robots is their adaptability and flexibility. They are also a known component when designing an automated system with mixed products/requirements. They can also be a very cheap way to automate multiple tasks with a lot of variables that would otherwise need a very specialist bespoke automated system.

Automation

There are two main types of automation; software automation and industrial automation. Software automation performs computer based tasks that would otherwise be performed by a human, whereas industrial automation performs physical activities that would otherwise be done by a human.

Bespoke automation is the term typically used where there is a stable and predictable production processes that needs specialist automation designed specifically to perform that process.

Processes where bespoke automation is often used includes;

- Quality control inspection
- Liquid filling
- Parts sorting
- Box erection and sealing
- Box filling
- Repetitive tasks with few variables
- Production monitoring
- Product and carton labelling
- Safety improvements

The main advantage of bespoke automation is that it can be tailored exactly to a process in the most efficient way. This can often result in faster production speeds, and more effective solutions for repeat tasks with little variation in products or requirements.

Robotics or Bespoke Automation – Which do I need?

Now you understand more about robotics and automation, but you may still be wondering which you need! Maybe you need both? This depends entirely on the process you are wishing to automate. Robotics or bespoke automation may be used, but as they are both developed in different ways, it may often be necessary to use both to enable the optimum automation solution to be created.

To summarise, the main difference between robotics and automation is that robots are a piece of equipment that can perform a variety of tasks with programming, whilst bespoke automation is a term that is used for special purpose machines or systems that are designed to perform a specific task.

But in short Robotics are just one of many methods of Automation!