Computer Aided Manufacturing

Prof. Janakarajan Ramkumar
Professor
Department of Mechanical & Design Program
IIT Kanpur, India.
Contents

• CIM components
• Modular design
A CIM System consists of the following basic components:

I. Machine tools and related equipment

II. Material Handling System (MHS)

III. Computer Control System

IV. Human factor/labor
Four general categories:

1. **Traditional stand-alone NC machine tool** - is characterized as a **limited-storage**, automatic tool changer and is traditionally operated on a one-to-one machine to operator ratio. In many cases, stand-alone NC machine tools have been grouped together in a conventional part family manufacturing cell arrangement and operating on a one-to-one or two-to-one or three-to-one machine to operator ratio.
2. Single NC machine cell or mini-cell - is characterized by an automatic work changer with permanently assigned work pallets or a conveyor-robot arm system mounted to the front of the machine, plus the availability of bulk tool storage.

• There are many machines with a variety of options, such as automatic probing, broken tool detection, and high-pressure coolant control.

• The single NC machine cell is rapidly gaining in popularity, functionality, and affordability
3. **Integrated multi-machine cell** - is made up of a multiplicity of metal-cutting machine tools, typically all of the same type, which have a queue of parts, either at the entry of the cell or in front of each machine.

Multi-machine cells are either serviced by a material-handling robot or parts are palletized in a two- or three-machine, in-line system for progressive movement from one machining
FMS - sometimes referred to as a flexible manufacturing cell (FMC), is characterized by multiple machines, automated random movement of palletize parts to and from processing stations, and central computer control with sophisticated command-driven software.

The distinguishing characteristics of this cell are the automated flow of raw material to the cell, complete machining of the part, part washing, drying, and inspection with the cell, and removal of the finished part.
Functions of Computer in CIMS

1. Machine Control – CNC
2. Direct Numerical Control (DNC) - manufacturing system in which a number of m/c are controlled by a computer through direct connection & in real time.

Consists of 4 basic elements:
- Central computer
- Bulk memory (NC program storage)
- Telecommunication line
- Machine tools (up to 100)
3. Production Control - This function includes decision on various parts onto the system.

Decision are based on:
• red production rate/day for the various parts
• Number of raw work parts available
• Number of available pallets

4. Traffic & Shuttle Control - Refers to the regulations of the primary & secondary transportation systems which moves parts between workstation.

5. Work Handling System Monitoring - The computer must monitor the status of each cart & /or pallet in the primary & secondary handling system.
6. Tool Control
Keeping track of the tool at each station
Monitoring of tool life

7. System Performance Monitoring & Reporting - The system computer can be programmed to generate various reports by the management on system performance.
• Utilization reports - summarize the utilization of individual workstation as well as overall average utilization of the system.
• Production reports - summarize weekly/daily quantities of parts produced from a CIMS (comparing scheduled production vs. actual production)
• Status reports - instantaneous report "snapshot" of the present conditions of the CIMS.
• Tool reports - may include a listing of missing tool, tool-life status etc.
Production Strategy

The production strategy used by manufacturers is based on several factors; the two most critical are customer lead time and manufacturing lead time.

*Customer lead time identifies the maximum length of time that a typical customer is willing to wait for the delivery of a product after an order is placed.*

*Manufacturing lead time identifies the maximum length of time between the receipt of an order and the delivery of a finished product.*
Production Strategy

Manufacturing lead time and customer lead time must be matched. For example, when a new car with specific options is ordered from a dealer, the customer is willing to wait only a few weeks for delivery of the vehicle.

As a result, automotive manufacturers must adopt a production strategy that permits the manufacturing lead-time to match the customer's needs.

The production strategies used to match the customer and manufacturer lead times are grouped into four categories:
1. Engineer to order (ETO)
2. Make to order (MTO)
3. Assemble to order (ATO)
4. Make to stock (MTS)
Engineer to Order
A manufacturer producing in this category has a product that is either in the first stage of the life-cycle curve or a complex product with a unique design produced in single-digit quantities.

Examples of ETO include construction industry products (bridges, chemical plants, automotive production lines) and large products with special options that are stationary during production (commercial passenger aircraft, ships, high-voltage switchgear, steam turbines).

Due to the nature of the product, the customer is willing to accept a long manufacturing lead time because the engineering design is part of the process.
Make to Order
The MTO technique assumes that all the engineering and design are complete and the production process is proven.

Manufacturers use this strategy when the demand is unpredictable and when the customer lead-time permits the production process to start on receipt of an order. New residential homes are examples of this production strategy.

Some outline computer companies make personal computer to customer specifications, so they followed MTO specifications.
Assemble to Order
The primary reason that manufacturers adopt the ATO strategy is that customer lead time is less than manufacturing lead time. An example from the automotive industry was used in the preceding section to describe this situation for line manufacturing systems.

This strategy is used when the option mix for the products can be forecast statistically: for example, the percentage of four-door versus two-door automobiles assembled per week.

In addition, the subassemblies and parts for the final product are carried in a finished components inventory, so the final assembly schedule is determined by the customer order. John Deere and General Motors are examples of companies using this production strategy.
**Make to Stock**

MTS, is used for two reasons: (1) the customer lead time is less than the manufacturing lead time, (2) the product has a set configuration and few options so that the demand can be forecast accurately.

If positive inventory levels (the store shelf is never empty) for a product is an order-winning criterion, this strategy is used.

When this order-winning criterion is severe, the products are often stocked in distribution warehouses located in major population centers.

This option is often the last phase of a product's life cycle and usually occurs at maximum production volume.
MODULAR PRODUCT DESIGN

“product architecture is the assignment of the individual functional elements (duties/requirements) of a product to the physical building blocks (clusters) of the product.”

• The functional elements of a product refer to the specific subtasks a product would perform (for example, feeding paper in a printer),

• the physical building blocks are the clusters of components that allow implementation of these functions (for example, paper feed being achieved via a collection of rollers and a motor subassembly in a printer).
In a modular product design, clusters implement functions in their entirety and independently, whereas in an integral design, a function may be implemented using more than one (physical) cluster.

Standardization has long been a cost-saving measure, normally implemented at the component level for integral designs.

Modular product design elevates standardization to the level of functional elements, where they can be used in different product models to carry out the same functions, allow easy replacement, and provide expansion (add-on) capability.
MODULAR PRODUCT DESIGN

product (design) modularity is a necessary step in achieving tactical flexibility in a manufacturing environment and providing customers with economically viable variety.
There exist six levels of modularity

- Component sharing: This is the lowest level of standardization: the same components (e.g., motors and clutches) are used across many products (which may be modular or integral in design).

- Component swapping: This is a component sharing modularity approach built around a single core product. Great numbers of variations can be presented to the customers (almost approaching a one-of-a-kind product line). The Swatch family of watches is a typical example.
Component swapping
Cut-to-fit: This is a parametric design variability achieved by customizing a small number of geometric features on the product. In the 1990s, Matsushita in Japan provided customers with personalized bicycles with a two-week delivery schedule once the order was received from the “fitting” store.

Mixing: The product is simply a mixture of components, in which the components lose their identity within the final product. An exemplary application area could be the mixture of chemicals according to a recipe.
Cut-to-fit
Mixing
• Bus configuration: Similar to mixing, a mixture of components is assembled on a “mother” bus/board/platform. Typical examples include computers and automobiles. Naturally, modularity can only be achieved through a flexible design of the bus.

• Sectional: This is the ultimate level of modularity, where the product’s architecture is reconfigurable itself (as opposed to being fixed). Individual modules are configured to yield different products. The most common example is the reconfiguration of software modules to yield different application programs.
Bus configuration

- CPU + RAM + Video card + Modem + Sound card + Motherboard

- Motherboard with RAM, video card and modem.

- OR = Motherboard with RAM, video card, sound card and modem.

- OR = Motherboard with RAM, video card and sound card.
Six Types of Modularity for the Mass Customization of Products and Services

- **Component – Sharing Modularity**
- **Cut-to-Fit Modularity**
- **Bus Modularity**
- **Component-Swapping Modularity**
- **Mix Modularity**
- **Sectional Modularity**
Modular Design Process

A three-step procedure has been commonly proposed for developing a modular product architecture:

1. Create a schematic representation of the product, which normally would comprise a set of functional objectives as opposed to physical building blocks (or their components).
Modular Design Process

2. Group the functional objectives into functional clusters, where possible.

• At this stage the designer can consider issues such as physical relationships (and proximity) between components, the potential for standardization, and even the capability of suppliers to provide clusters.
3. Create a rough geometric layout of the product in order to evaluate operational feasibility through

• analysis of the interactions between the clusters,

• feasibility of production and assembly while maintaining a high degree of quality and economic viability.
Modular Design Process

Discover → Abstract → Implement & Document → Integrate
MASS CUSTOMIZATION VIA PRODUCT MODULARITY

• Mass production adopted in the earlier part of the 20th century was based on the principles of:
  • interchangeable parts,
  • specialized machines, and
  • division of labor.
• The focus was primarily on improving productivity through process innovation.
• The primary objective was to reduce cost and thus cause an increase in demand.

_The objective was set as “variety and customization through flexibility and quick responsiveness.”_
The key features of today’s marketplace are:

1. fragmented demand

2. low cost and high quality (customers are demanding high-quality products, not in direct relation to the cost of the product),

3. short product development cycles, and

4. short product cycles.

The result is less demand for a specific product but increased demand for the overall product family of the company, whose strategy is to develop, produce, market, and deliver affordable goods with enough variety and customization that almost everyone purchases their own desired product.
The primary steps for the design of a mass customizable product are:

1. Identifying customer needs: This stage is similar to any product (concept) design stage with the exception of identifying potential personal differences in requirements for a common overall functional requirement for the product.
2. Develop concepts: Concepts (alternatives) should be developed and compared with a special emphasis for allowing modularity in final engineering design. (QFD and Pugh’s methods should be utilized.)

3. Modularization of chosen concept: The chosen design concept should be evaluated and iteratively modified with the objective of modularization (i.e., mass customization) and fit within the larger family of products, with which the proposed design will share modules.
Product Variety

Mass Production

Continuous Improvement
- Strive constantly to improve processes
- Lean/Agile Manufacturing principles

Mass Customization
- Flexibility and quick responsiveness
- Reconfigurable processes, parts, people
- Efficient Links

1900  1980  Today  Tomorrow
Mass Customization 1.0  
1.0 1990  
- efficient variant production

Mass Customization 2.0  
2.0 2010  
- modular product system with selection aid configurator  
- cars, dell-computers

Mass Customization 3.0  
3.0 2014  
- co-design by the costumer  
- examples: customized designs

Mass Customization 4.0 = SmartCustomization  
4.0 2016  
- Learning configurator  
- Lifelong fit through configuration during operation  
- solution instead of pure product configurator
The New Paradigm of Mass Customization as a Dynamic System Feedback Loop

Product Technology

New Products

Process Technology

Mass Customization Processes

Low-Cost, High Quality, Customized Products

Heterogeneous Markets

Demand Fragmentation

Short Product Life Cycles

Short Product Development Cycles

R

http://www.drawpack.com
your visual business knowledge
• **Manufacturing** is the process of converting raw materials, components or parts into finished goods that meet a customer's expectations or specifications.

• Manufacturing is a value-adding process allowing businesses to sell finished products at a premium over the value of the raw materials used.

• It is a series of interrelated activities and operations involving design, material selection, planning, production, quality assurance, management, and marketing of discrete consumer and durable goods.
Manufacturing

- Raw Materials
- Manufacturing Production
- Disposal Recycling
- Consumer Utilization
- Product Delivery
Overall cycle of development
Summary

• What is Manufacturing?
• What is the Use of Computers and their evaluation?
• Various Computer Applications (CAD, CAM, CAPP etc.)?
• Design Process involved with computers assistance?
• What is Manufacturing Systems and its types?
• What is CIM?
• Sub-systems of CIM
• What is Present Scenario?
• What are Future Prospects?
Thank You