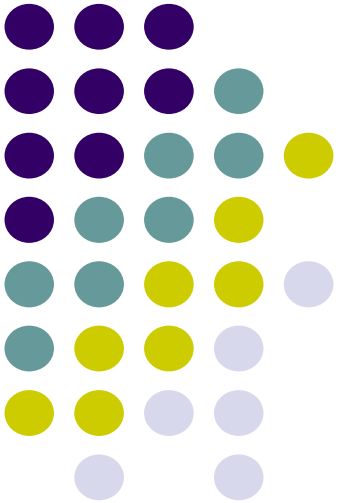
ME 333 – Manufacturing Processes II

Chapter 1

Introduction to Manufacturing and Production



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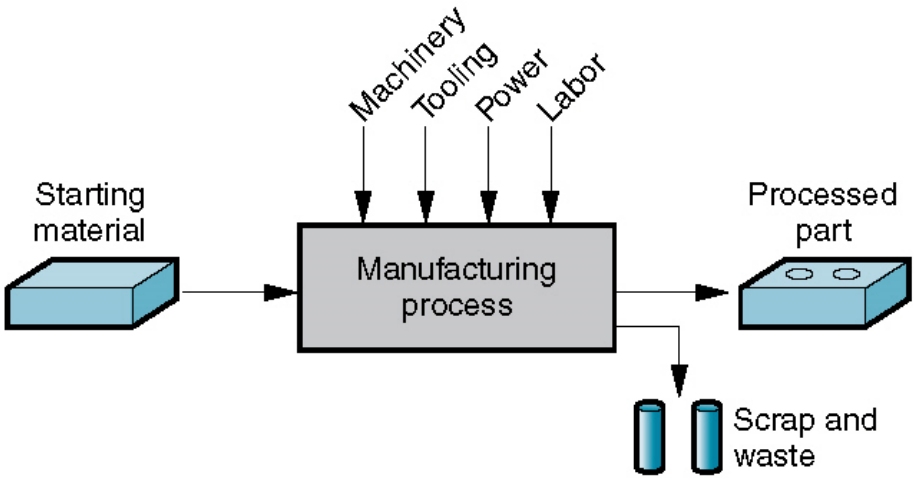
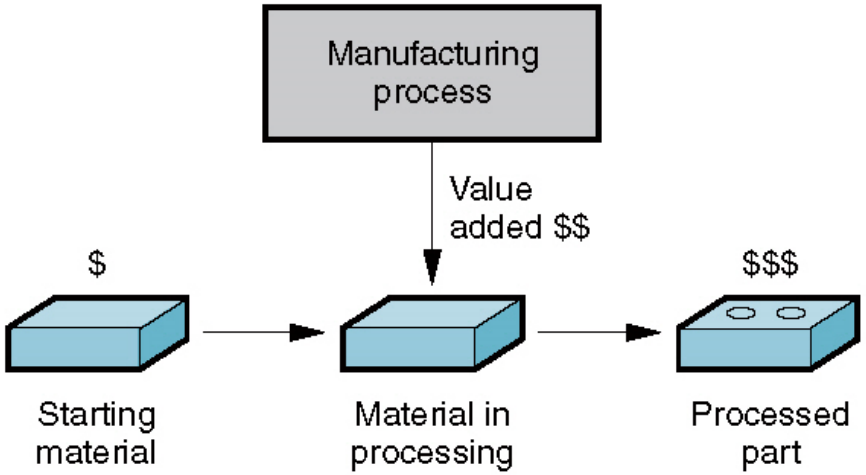
What is Manufacturing?

Manus (hand)	+	**Factus** (make)	=	**Manufacture**

- **Technologically:** It is the application of physical and chemical processes to alter geometry, properties and/or appearance of a starting material to make parts/products including assembly of multiple parts.



- **Economically:** It is the transformation of materials into items of greater value by means of one or more processing and/or assembly operations.



Manufactured Products and Production Quantity

Final products made by the industries can be divided into two major classes:

- **Consumer goods:** products purchased directly by consumers (e.g. TV, car, tires, etc.)
- **Capital goods:** purchased by other companies to produce goods and supply services (e.g. aircrafts, machine tools, construction equipment, etc.)

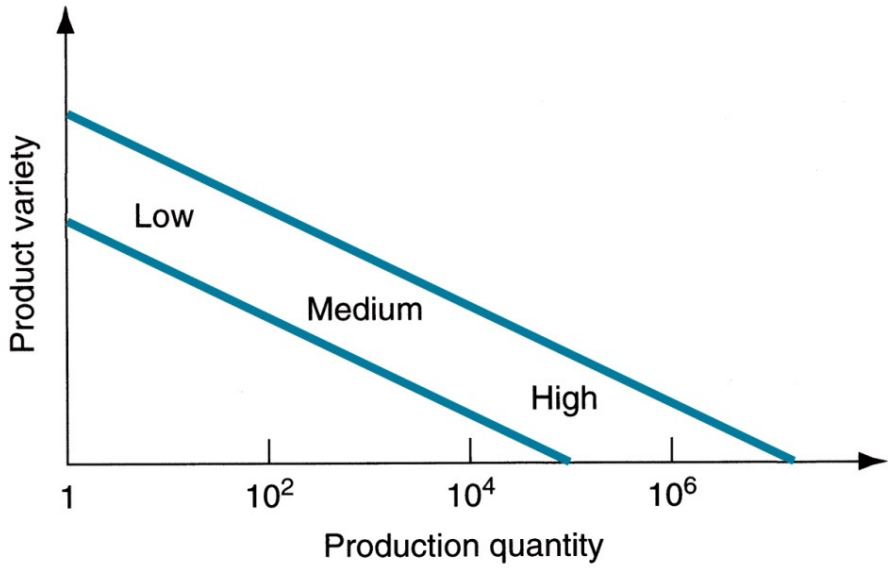
- **Production quantity:** refers to **the number of units produced annually** of a particular product type. The quantity of products made annually by a factory **(Q)** can be classified into three ranges:

low production: **Q** < 100

medium production: 100 < **Q** < 10 000

high production: 10 000 < **Q**

- **Production variety:** refers to different product designs/types that are produced in the plant.



Manufacturing is Important

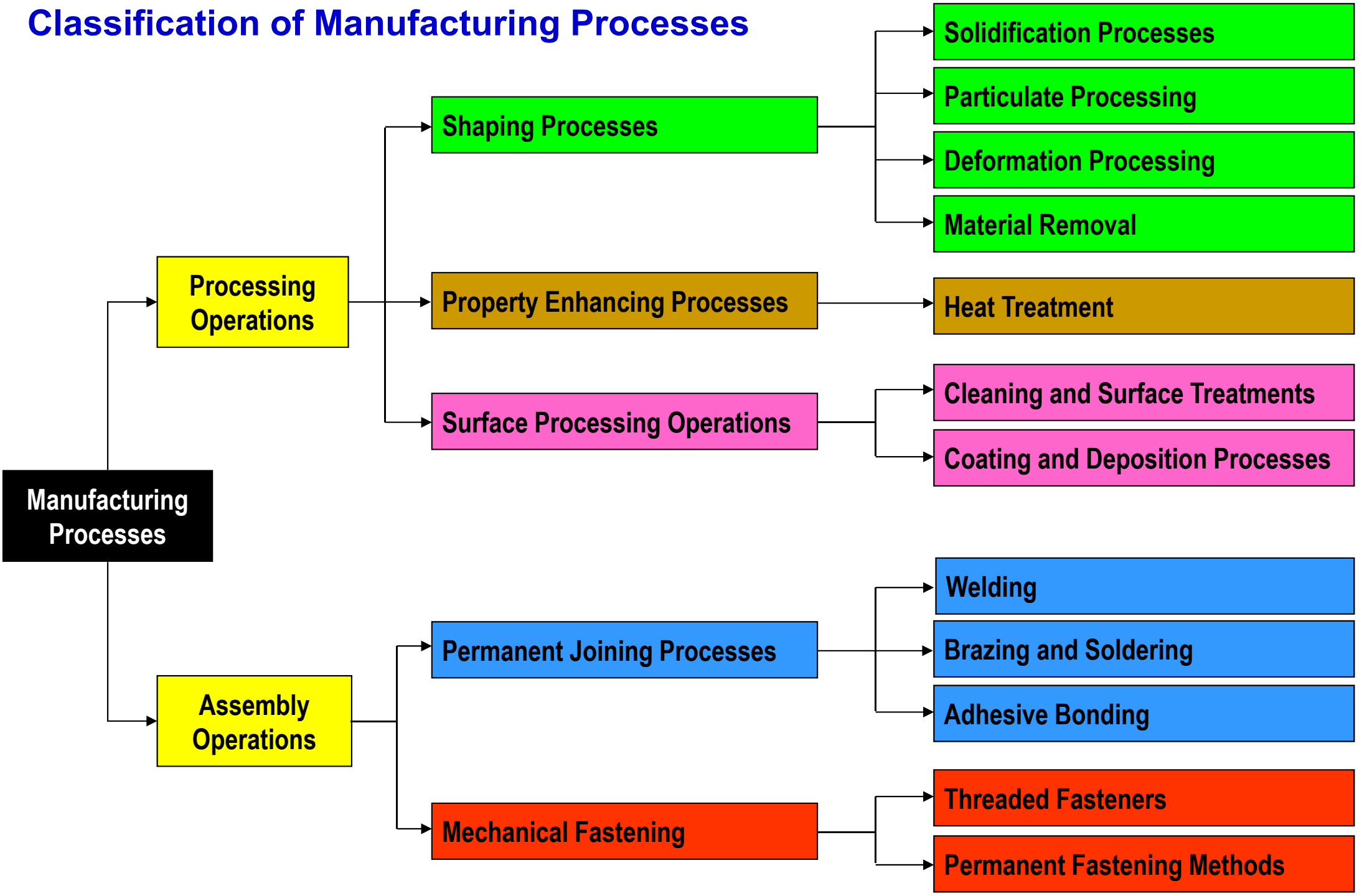
Manufacturing is important: **technologically**, **economically**, and **historically**

- **Technology** can be defined as the application of science to provide society and its members with those things that are needed or desired. Thus, manufacturing is the essential factor that makes technology possible.
- **Economically**, manufacturing is important means by which a nation creates material wealth.
- **Historically**, the importance of manufacturing in the development of civilization is usually underestimated. However, throughout history, human cultures that were better at making things were more successful.

Production vs Manufacturing

- The words **PRODUCTION** and **MANUFACTURING** are often used interchangeably.
- The difference is **the raw material**: In production, raw material is not procured from outside. In manufacturing, company procures raw material from outside and makes the final product.
- Production has **broader meaning** than manufacturing: Every manufacturing is production, but every production is not manufacturing.
- For example, “oil production” seems better than “oil manufacturing”.
  On the other hand, we can usually use both terms for metal parts and automobiles.

Classification of Manufacturing Processes



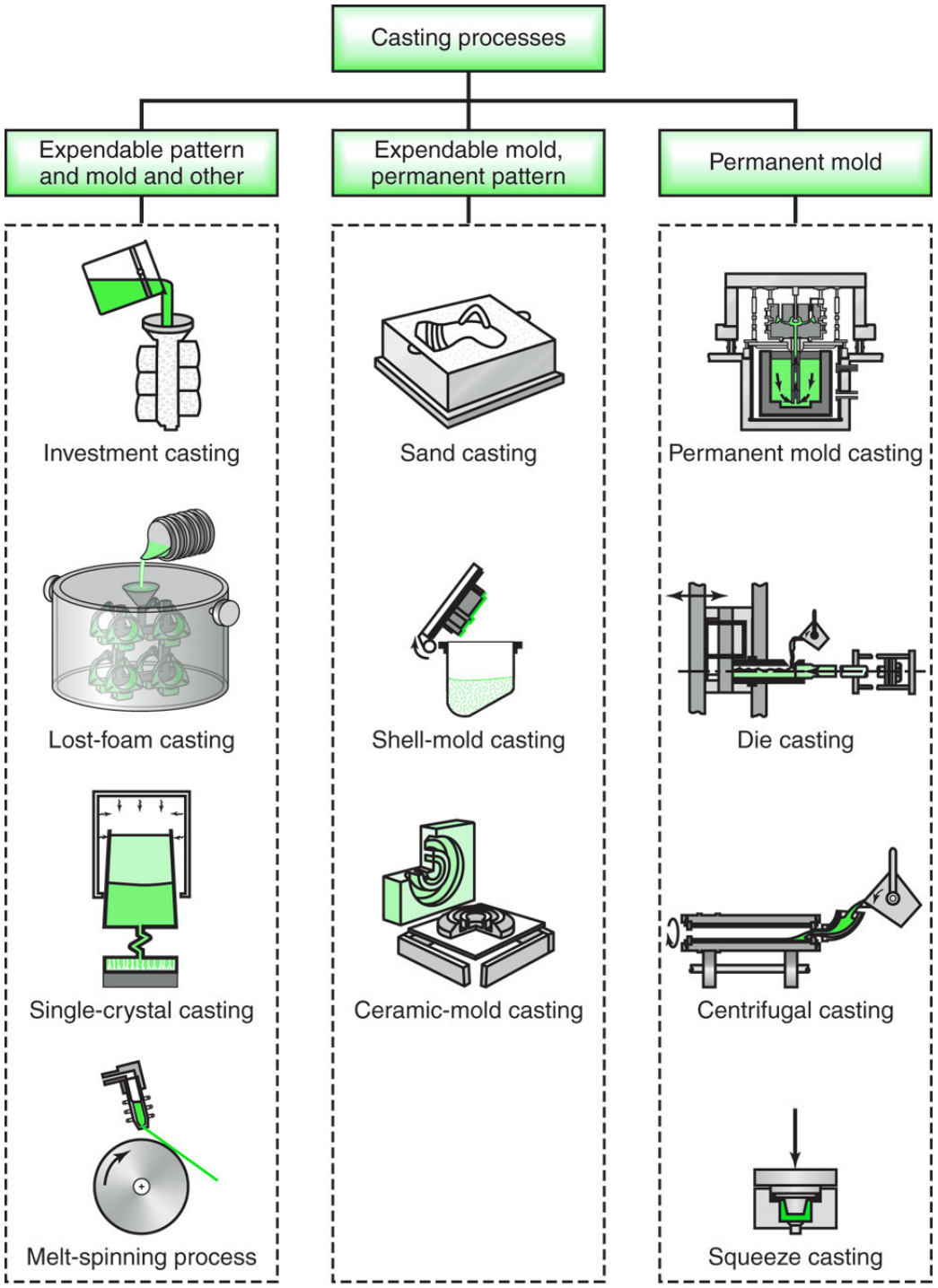
Manufacturing Process Selection

Manufacturing process selection depends upon several criteria:

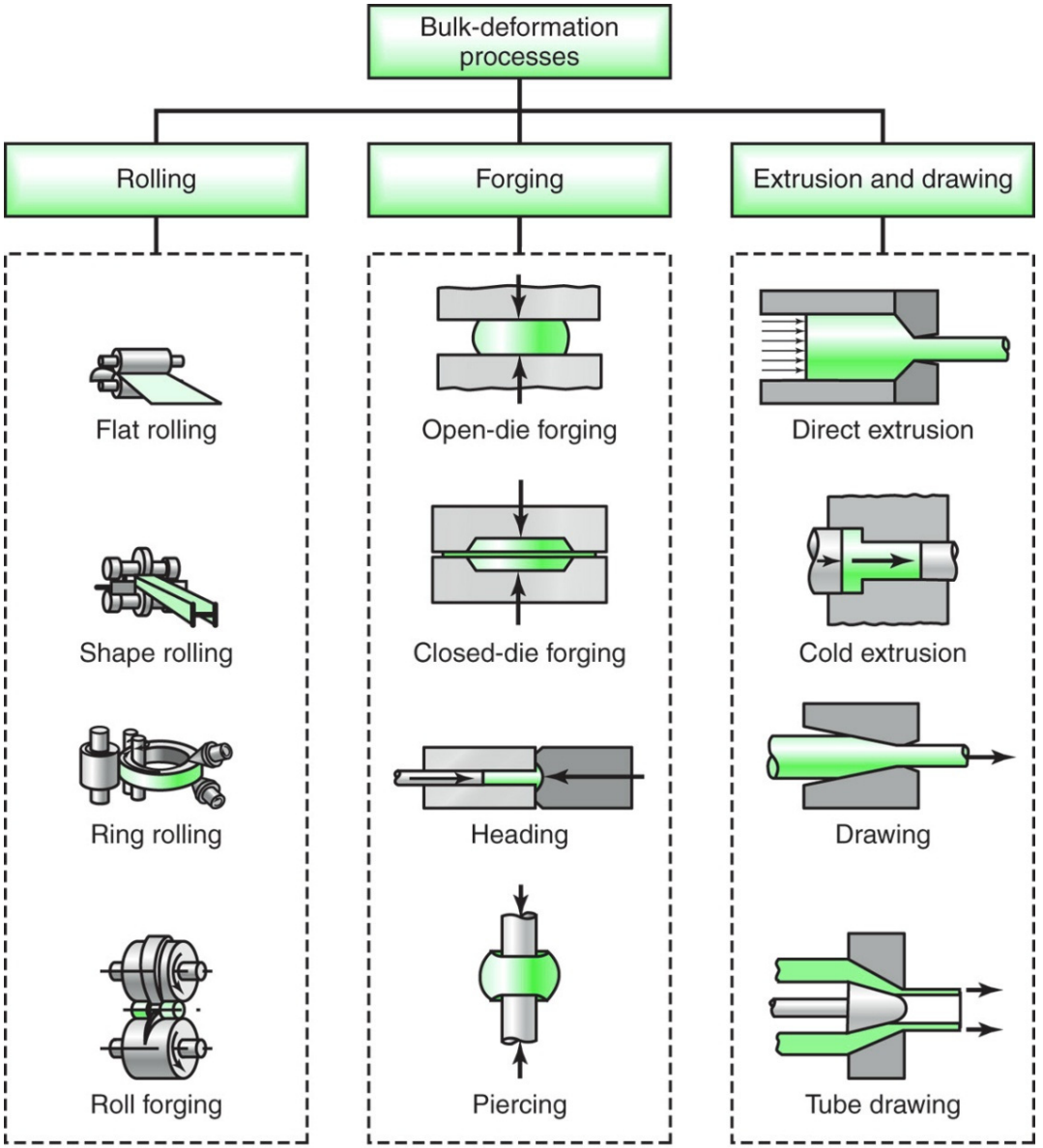
- Geometric features of the parts to be produced
- Dimensional tolerances
- Surface texture
- Workpiece material
- and so on…

Examples:

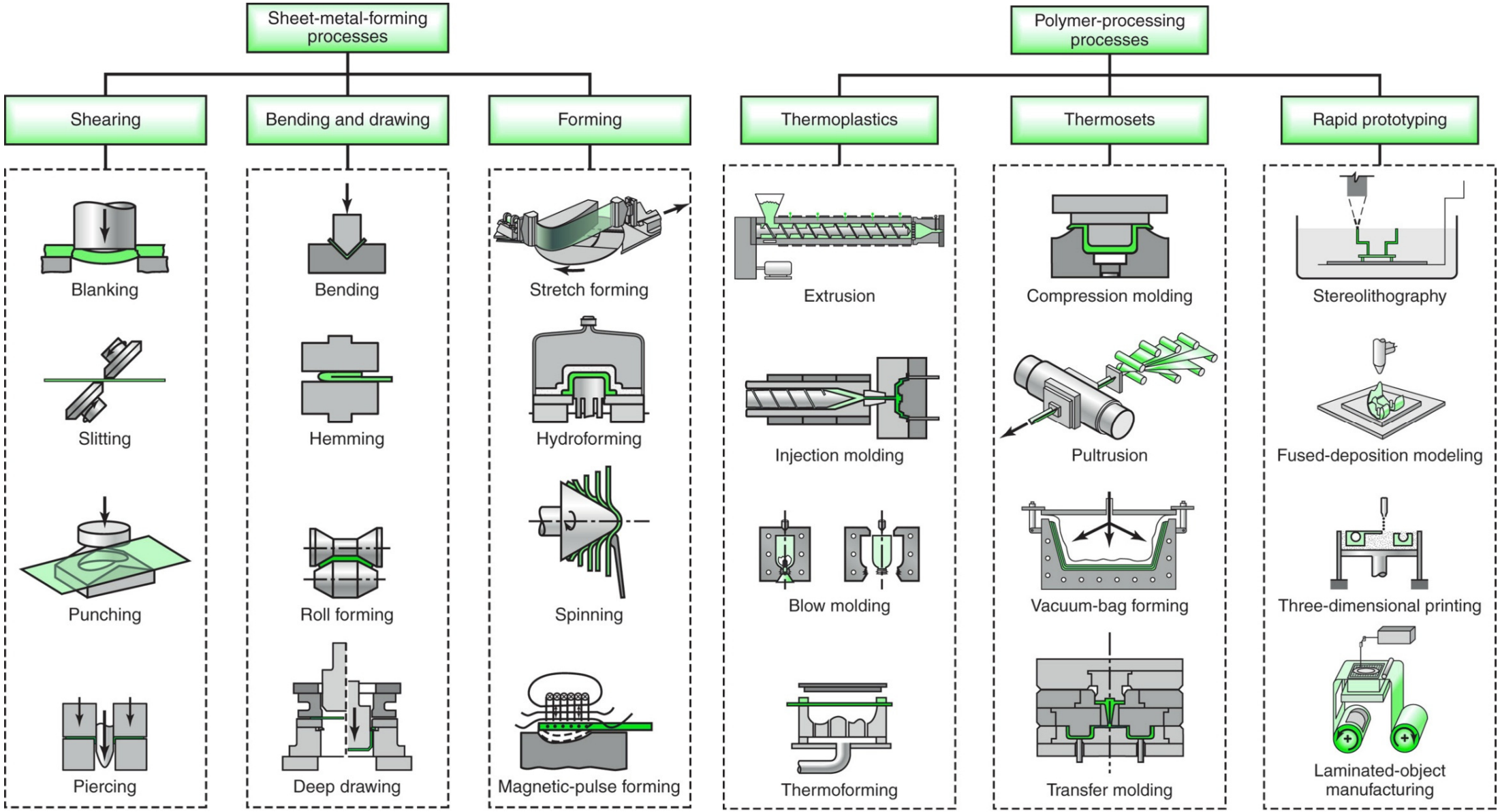
- Flat parts and thin cross sections can be difficult to cast.
- Complex parts generally cannot be shaped easily and economically by such metal working techniques.
- Dimensional tolerances and surface finish in hot-working operations are not a fine as compared to cold working.

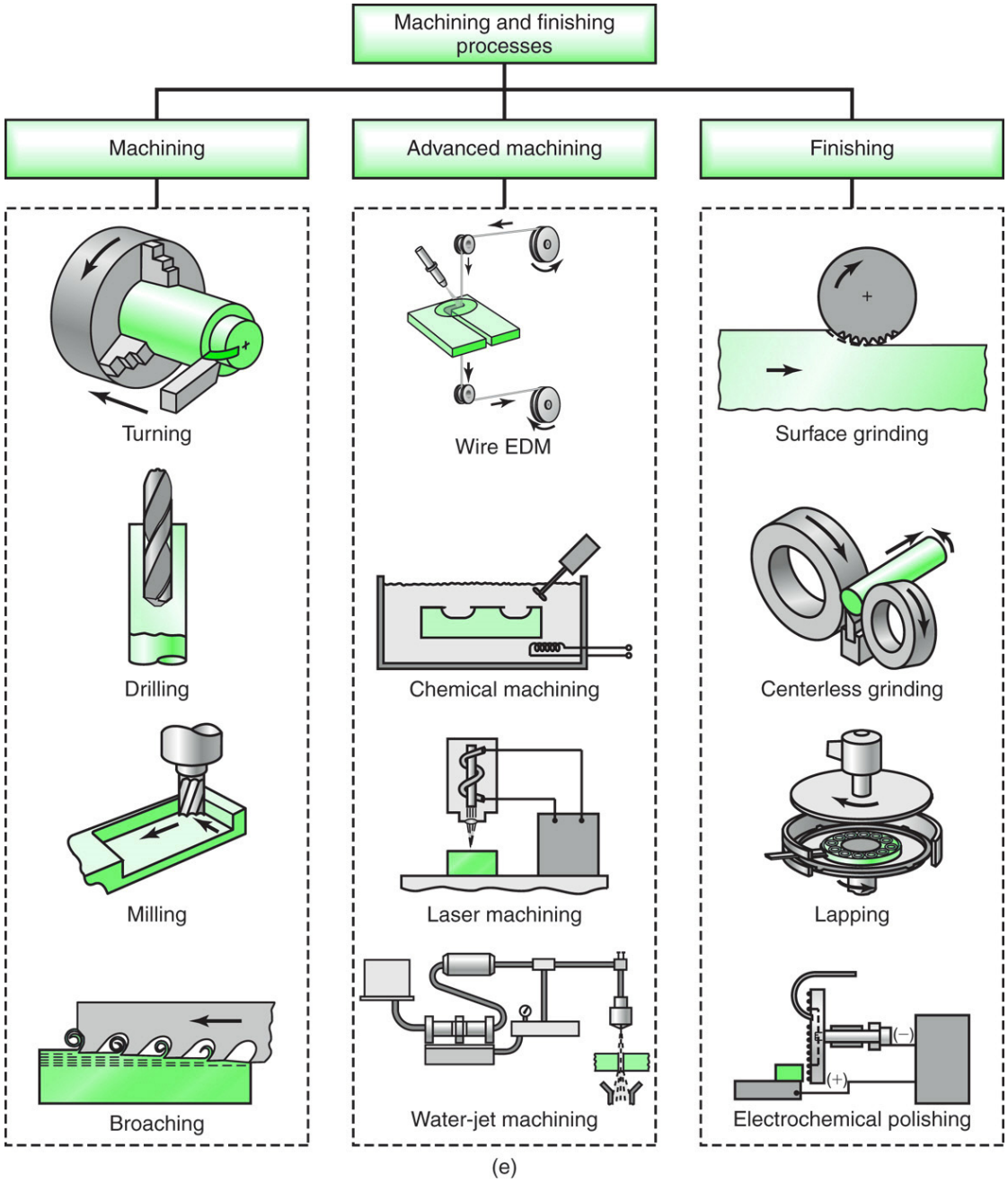

Casting processes
Expendable pattern and mold and other
Expendable mold, permanent pattern
Permanent mold
Investment casting
Sand casting
Permanent mold casting
Lost-foam casting
Shell-mold casting
Die casting
Single-crystal casting
Ceramic-mold casting
Centrifugal casting
Melt-spinning process
Squeeze casting

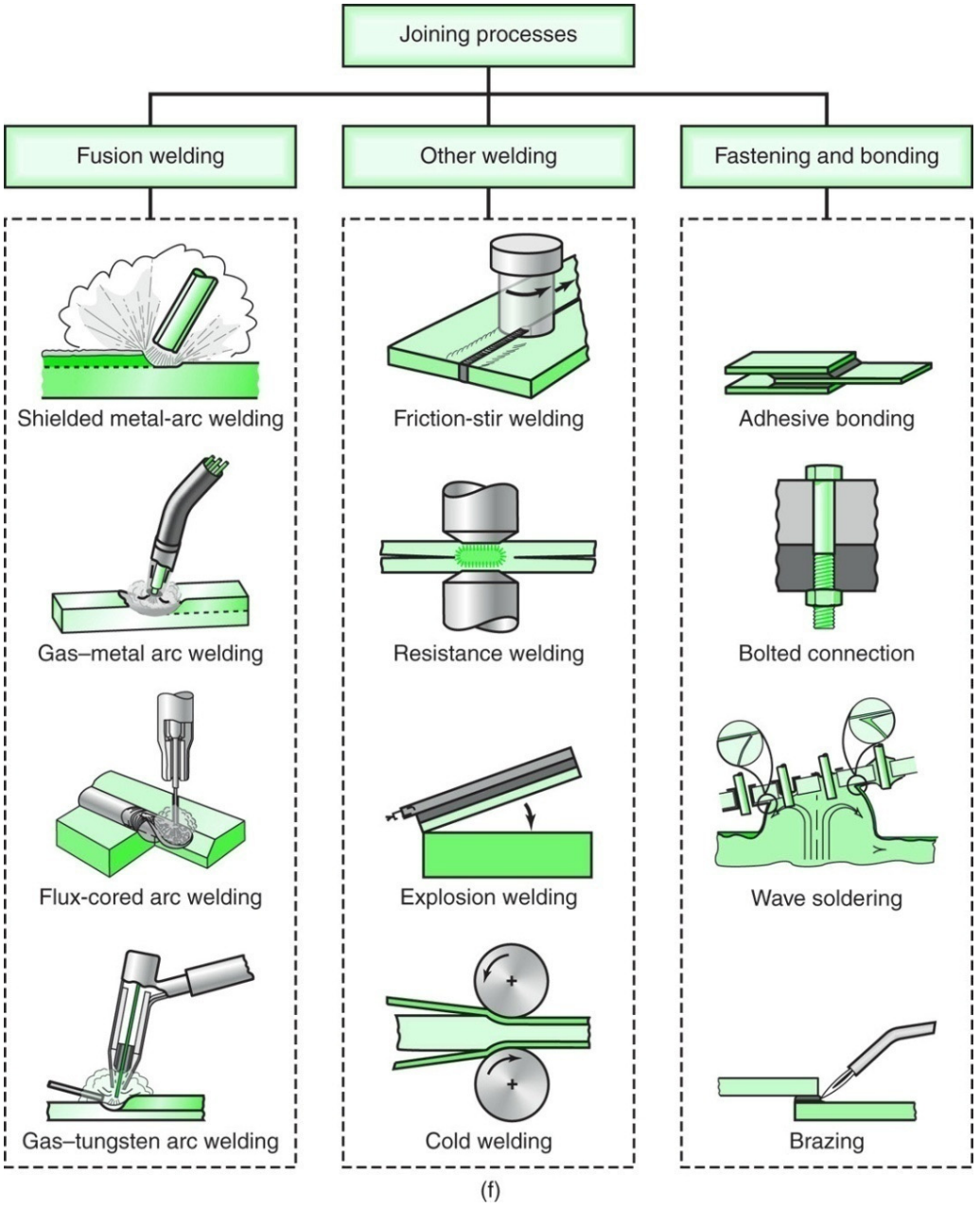
(a)


Bulk-deformation processes
Rolling
Forging
Extrusion and drawing
Flat rolling
Open-die forging
Direct extrusion
Shape rolling
Closed-die forging
Cold extrusion
Ring rolling
Heading
Drawing
Roll forging
Piercing
Tube drawing

(b)


Sheet-metal-forming processes
Shearing
Bending and drawing
Forming
Blanking
Slitting
Punching
Piercing
Bending
Hemming
Roll forming
Deep drawing
Stretch forming
Hydroforming
Spinning
Magnetic-pulse forming
(c)
Polymer-processing processes
Thermoplastics
Thermosets
Rapid prototyping
Extrusion
Injection molding
Blow molding
Thermoforming
Compression molding
Pultrusion
Vacuum-bag forming
Transfer molding
Stereolithography
Fused-deposition modeling
Three-dimensional printing
Laminated-object manufacturing
(d)


Machining and finishing processes
Machining
Advanced machining
Finishing
Turning
Drilling
Milling
Broaching
Wire EDM
Chemical machining
Laser machining
Water-jet machining
Surface grinding
Centerless grinding
Lapping
Electrochemical polishing
(e)


Joining processes
Fusion welding
Other welding
Fastening and bonding
Shielded metal-arc welding
Gas–metal arc welding
Flux-cored arc welding
Gas–tungsten arc welding
Friction-stir welding
Resistance welding
Explosion welding
Cold welding
Adhesive bonding
Bolted connection
Wave soldering
Brazing
(f)

Near-shape and Near-net shape Manufacturing

- Net-shape and near net-shape manufacturing together constitute an important methodology by which a part is made in only one operation at or close to the FINAL desired dimensions, tolerances, and surface finish.
- The difference between them is a matter of degree (i.e. how close the product is to its final dimensional characteristics).

cast or forged gear

crankshaft forging die

connecting rod

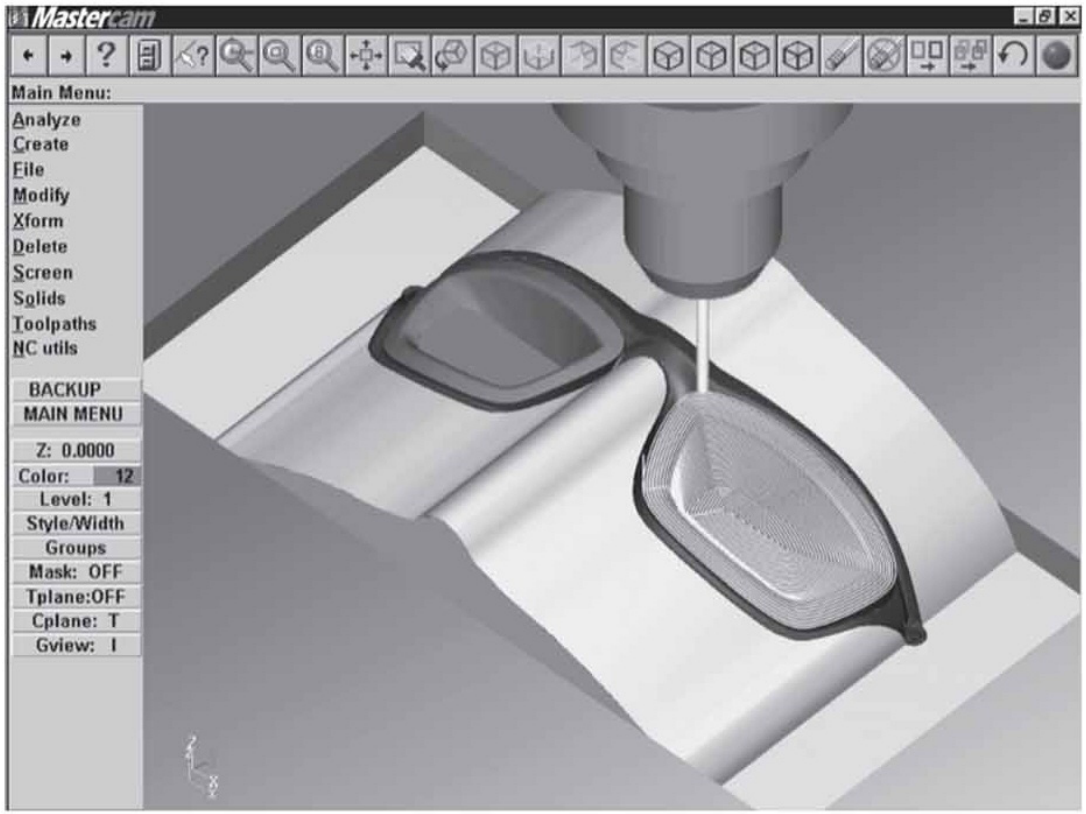
a part produced by additive manufacturing

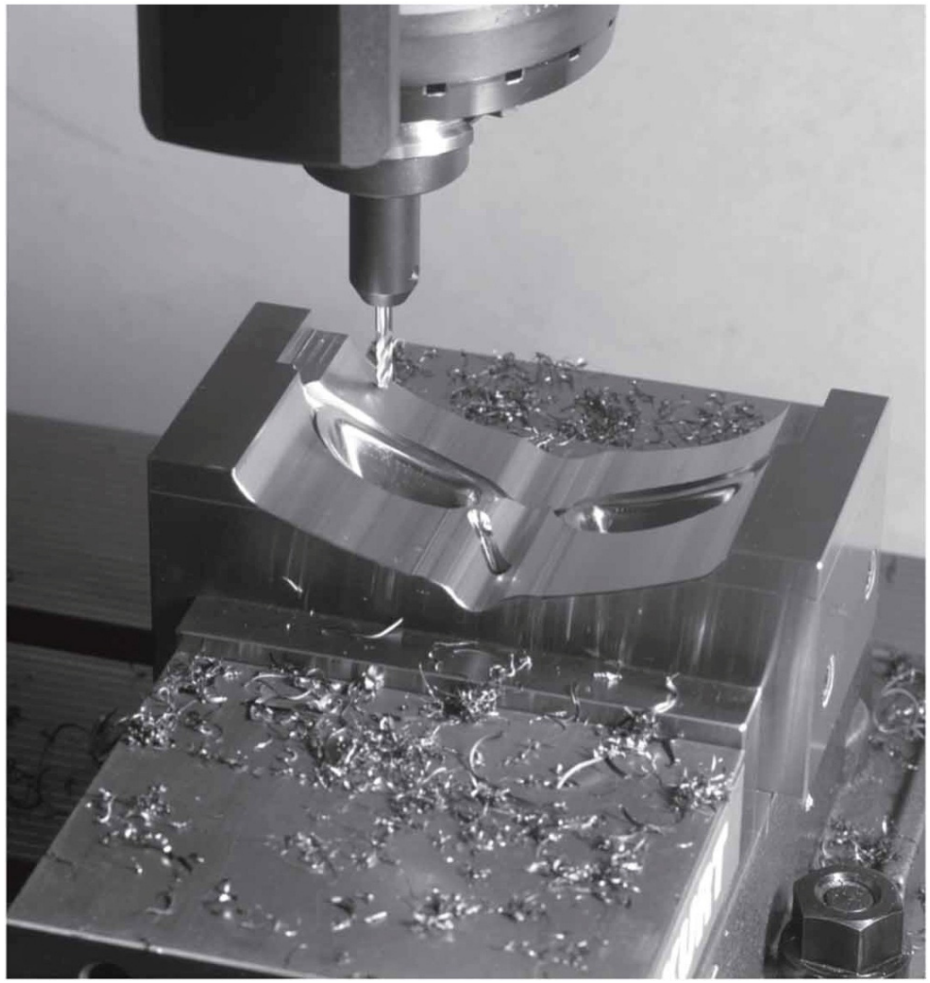
Precision and Ultra-Precision Manufacturing

- Micromechanical (MM) and microelectromechanical (MEM) device fabrication needs highly sophisticated technologies and highly accurate equipments.
- Micromachining uses cutting tool nose of 250 μm.
- The equipments (or machines) used in precision or ultra-precision manufacturing should be highly specialized, with very high stiffness (to minimise deflection as well as vibration and chatter during machining) and should be operated in a temperature-controlled environment in order to avoid thermal distortions.

Computer Integrated Manufacturing (CIM)

- CIM integrates software and hardware needed for computer graphics, computer-aided modelling/design (CAD) and computer-aided manufacturing (CAM) activities, from initial product concept through its production and distribution in the market place.



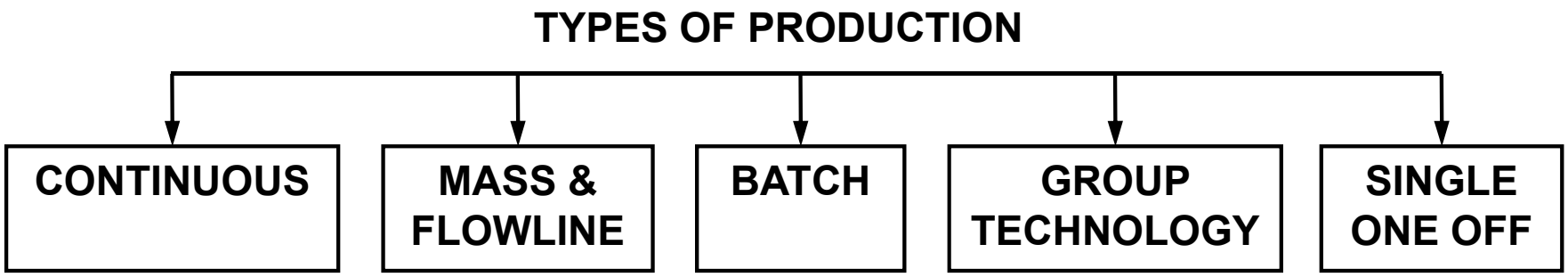


Machining a mold cavity for making sunglasses
(left) Computer model of sunglasses as designed and viewed on the monitor.
(right) Machining of the die cavity, using a computer numerical-control milling machine.
Source: Courtesy of Mastercam/CNC Software, Inc.

Computer Integrated Manufacturing (CIM)

Elements of CIM:

1. **Computer Numerical Control (CNC):** Multiple-axes computer-controlled machines
2. **Adaptive Control (AC):** adjustment of process parameters using sensors
3. **Industrial robots**
4. **Automated materials handling**
5. **Automated assembly systems**
6. **Computer-Aided Process Planning (CAPP):** improving productivity and product quality
7. **Group Technology (GT):** grouping and manufacturing similar parts together
8. **Just-in-Time Production (JIT):** delivering everything in time
9. **Cellular Manufacturing (CM):** different operations made in different cells
10. **Flexible Manufacturing Systems (FMS):** re-arranging factory layout for different parts
11. **Artificial Intelligence (AI):** imitating/simulating human brain for learning/optimising features



Continuous Production

- Material/product to the same specification is produced **continuously for 24 hrs throughout the year** except for maintenance or seasonal variation of raw material supply.
- **Highly automated and specialised process** that uses special machinery and equipment (if the process is stopped even for a short time, damage of materials/equipment will occur)
- Typical examples are: oil refineries, iron and steel production, etc.

Mass and Flowline Production

- It covers mechanical items to be manufactured one after the other to the same specifications **throughout the year in 1, 2, or 3 shifts** until the model changes.
- The demand must be **in large quantities**.
- **Highly automated transfer facilities** and **special purpose machines** are used (involving heavy capital expenditure on plant).
- Manufacture of motor cars is an example.

Batch Production (Job Lot or Intermittent)

- It processes **items when and as ordered**. **Small lot of items** is ordered, and once the lot is completed it is likely that it will **never be manufactured again**.
- **Flexibility of operations** is very important.
- **General purpose automatic machines** are used.
- Degree of automation depends on production volume (generally small volume items).
- Same product may be produced **several times a year at different dates**.

Group Technology (GT) or Cellular Production

- It is the definition of **identifying and bringing related or similar parts together** in a production process in order to utilize the inherent economy of flow production methods.
- GT in manufacturing is the replacing of traditional job lot manufacture by analysis and grouping of work into families (size, shape, material, tolerance, surface finish and required production operations) and formation of groups of machines to manufacture these families on a flowline principle with the object of minimizing setting times and throughput times.

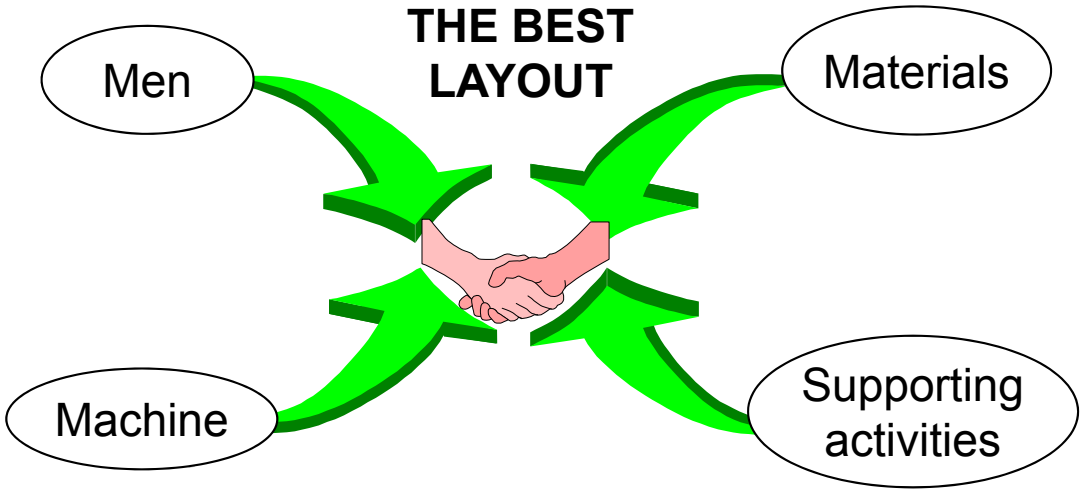
One Off (Single) Production

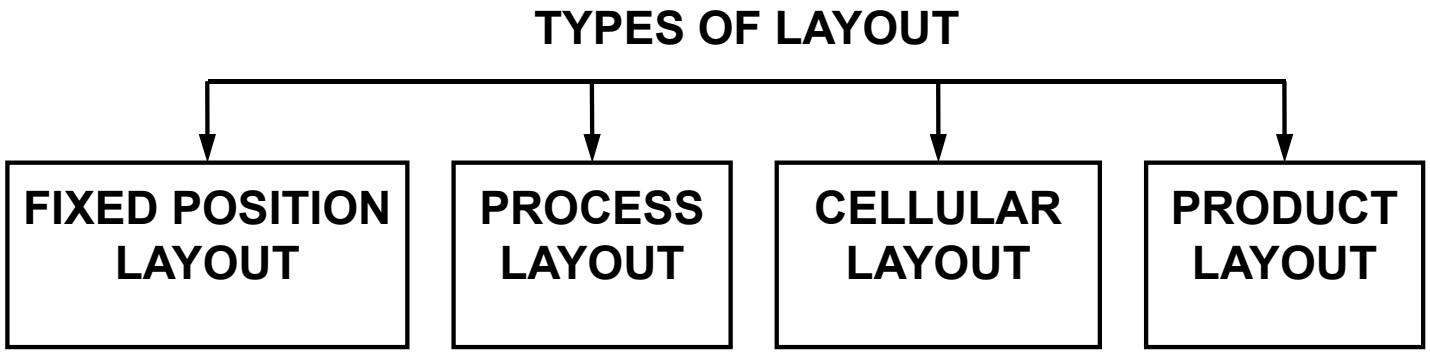
- **Single or few machinery, equipment or vessels are manufactured** to a specified design.
- **General purpose machine tools** for specific sizes are used.
- **Automation is generally not considered** (except welding).
- Production of marine gearboxes, ship building are typical examples.

Production for Repair and Maintenance

- No new end product except that the present one is repaired.

- **Plant Layout** is the act of planning to obtain the optimum arrangement of industrial facilities (including personal, operating equipment, storage space, material handling equipment) and all other supporting services with the design of the best structure to contain these facilities.
- In practice, most factories are laid out using a combination of different layouts.

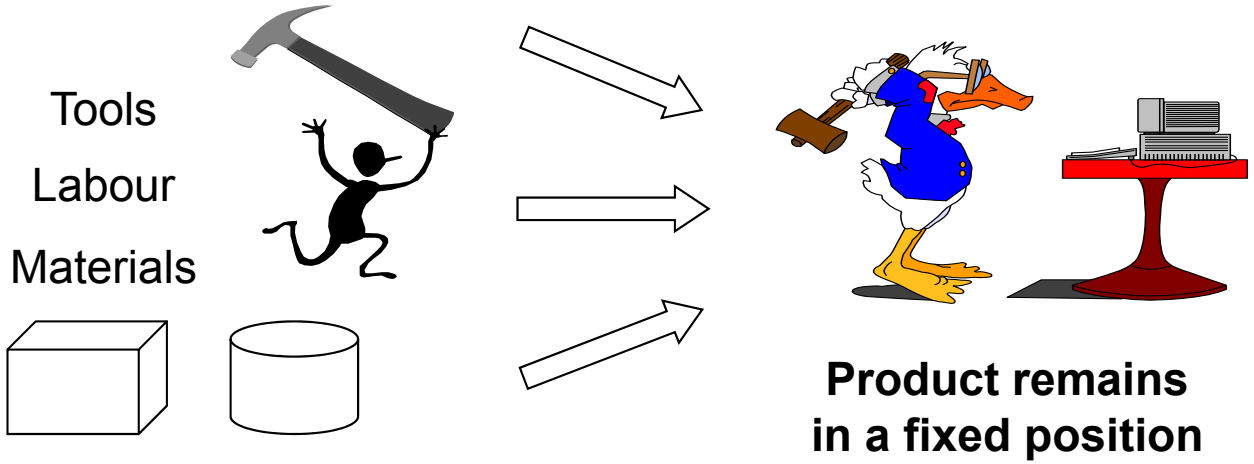




Fixed Position Layout

Characteristics

- The least important today
- e. g. shipbuilding, house building, large assembly works



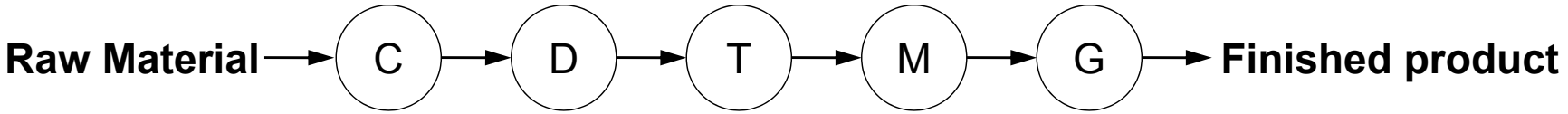
Advantages

- Allows worker to identify with a particular product resulting in high job satisfaction and high quality standards
- Flexible (allows frequent product or design changes)
- May reduce investment in mechanical handling equipment
- Adaptable to changes in demand

Disadvantages

- High degree of skill required. This can limit flexibility and put up cost of labour.
- May cause scheduling problems where more than one group of workers is involved.

Product Layout



Characteristics

- Only one type of product is produced. Machines are arranged in the order of operation.
- The product must be standardized and manufactured in large quantities.

Advantages

- high through-put
- usually less skilled labour required
- lower total material handling cost
- lower total production time
- less work-in-progress
- high level of performance due to greater incentive for group of workers
- less floor area required per unit of production
- simple production control, fewer records and lower accounting cost

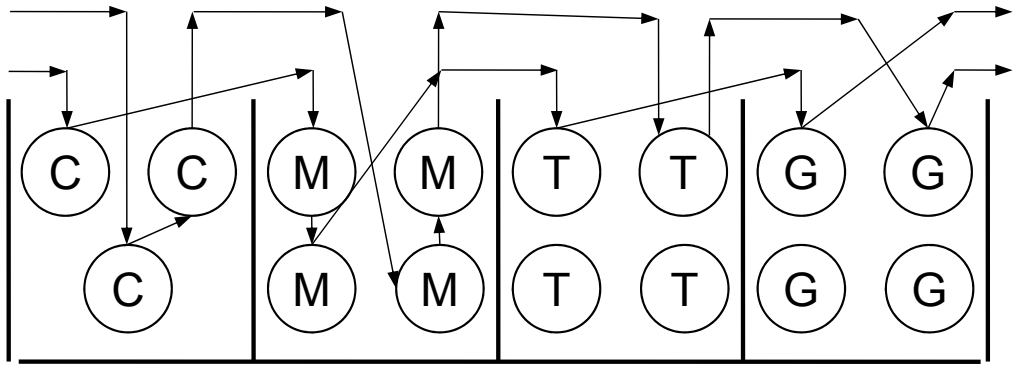
Disadvantages

- Inflexible to design, processing and volume changes
- High initial capital investment required
- Susceptible to absenteeism, breakdown and dispute
- Difficult to balance lines

Process (Functional) Layout

Characteristics

- groups all identical operations together
- workpiece passes from dept. to dept. according to sequence of operations



Advantages

- flexible (a wide variety of products, frequent design changes and varying demand)
- easy to maintain continuity in case of breakdown by transferring work to another machine
- less duplication of equipment, hence lower total investment in equipment
- better and more efficient supervision possible through specialization
- high level of performance
- better control of process

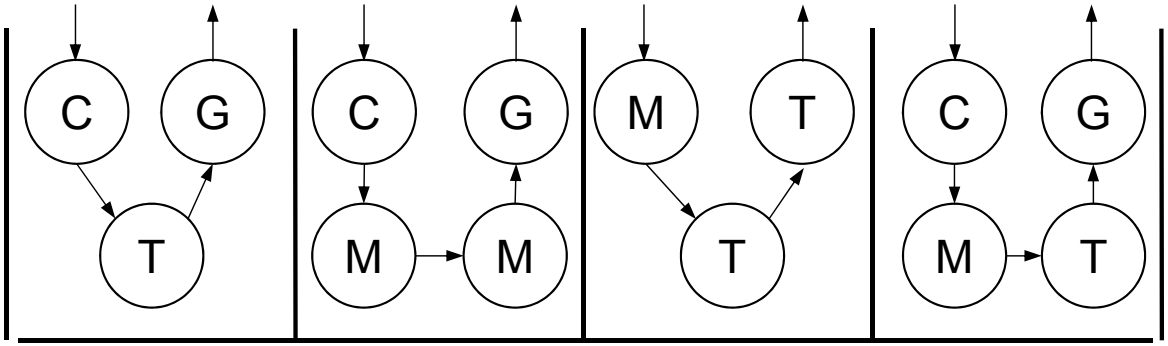
Disadvantages

- high cost of material handling
- lower through-put
- high work-in-progress
- skilled labour is required
- extensive scheduling and control required

Product Layout vs Process Layout

WHEN TO USE PRODUCT LAYOUT	WHEN TO USE PROCESS LAYOUT
One or few standard product	Many types or styles of products
Large volume of production of each item	Relatively low volume of individual product
Possibility of motion and time studies to determine rate of work	Adequate motion and time studies difficult or impossible to make
Possibility of good labour and equipment balance	Difficult to achieve labour and equipment balance
Minimum of inspection required during sequence of operations	Many inspection required during sequence of operations
Minimum of very heavy equipment requiring special facilities	High portion of very heavy equipment requiring special facilities
Materials and products permit bulk or continuous handling by mechanical means	Materials and products are too large or too heavy to permit bulk or continuous handling by mechanical means
Little or no need to use the same machine or workstation for more than one operation	Frequent need to use same machine work station for more than one operation

Group Technology (Cellular Layout)



Characteristics

- groups together similar parts
- mass and flowline principle is applied to each cell

Which Layout to Use?	
Production System	**Layout Type**
Single (one-off)	Fixed position
Batch	Process
Mass/flowline/continuous	Product
GT	Cellular

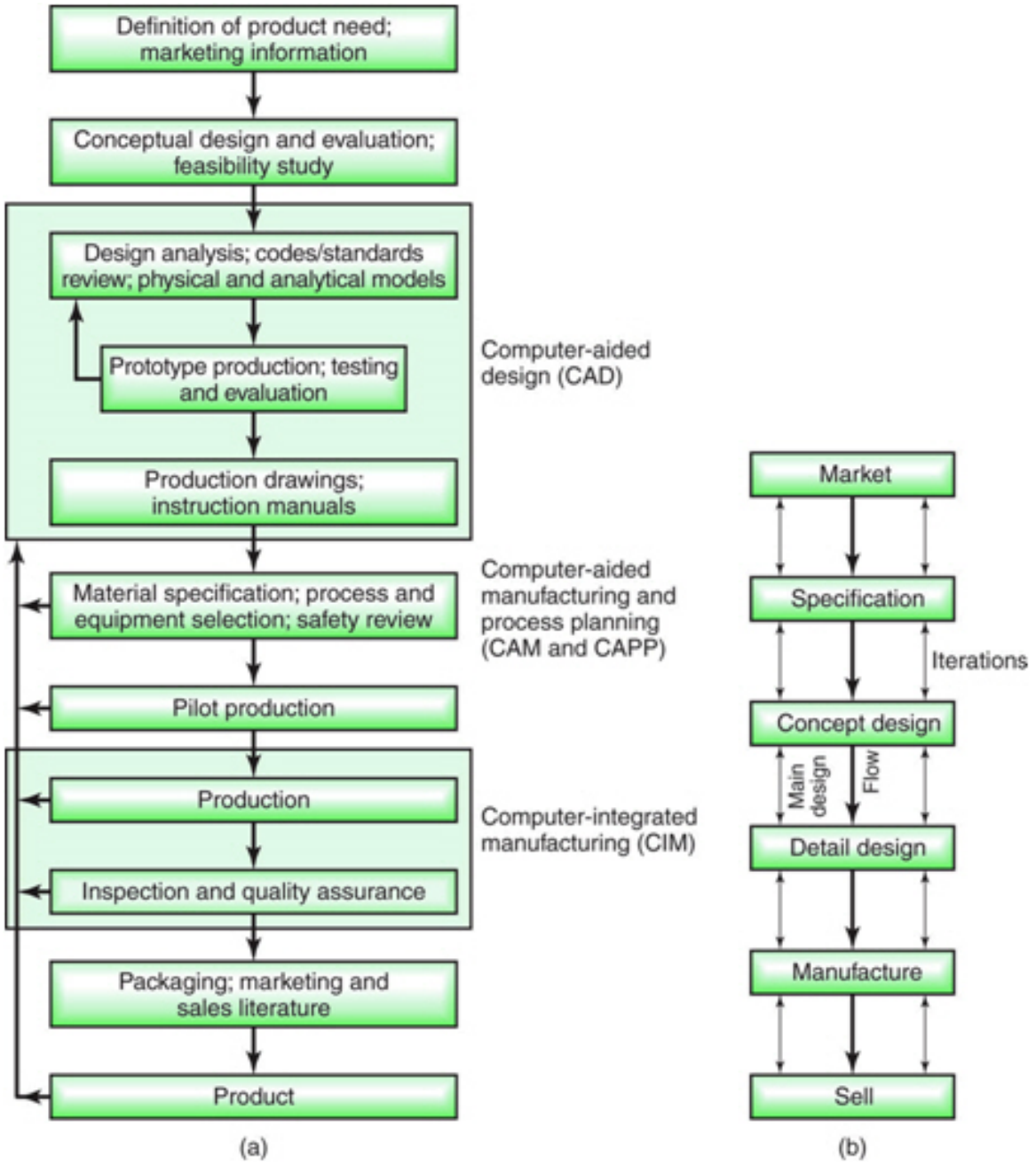
Manufacturing Costs

- The economics of manufacturing has become even more important with:
  - ever-increasing global competition
  - the demand for the high quality products

- Typically, the manufacturing cost of a product represents about 40% of its selling price, which is often the overriding consideration in a product marketability and general customer satisfaction.

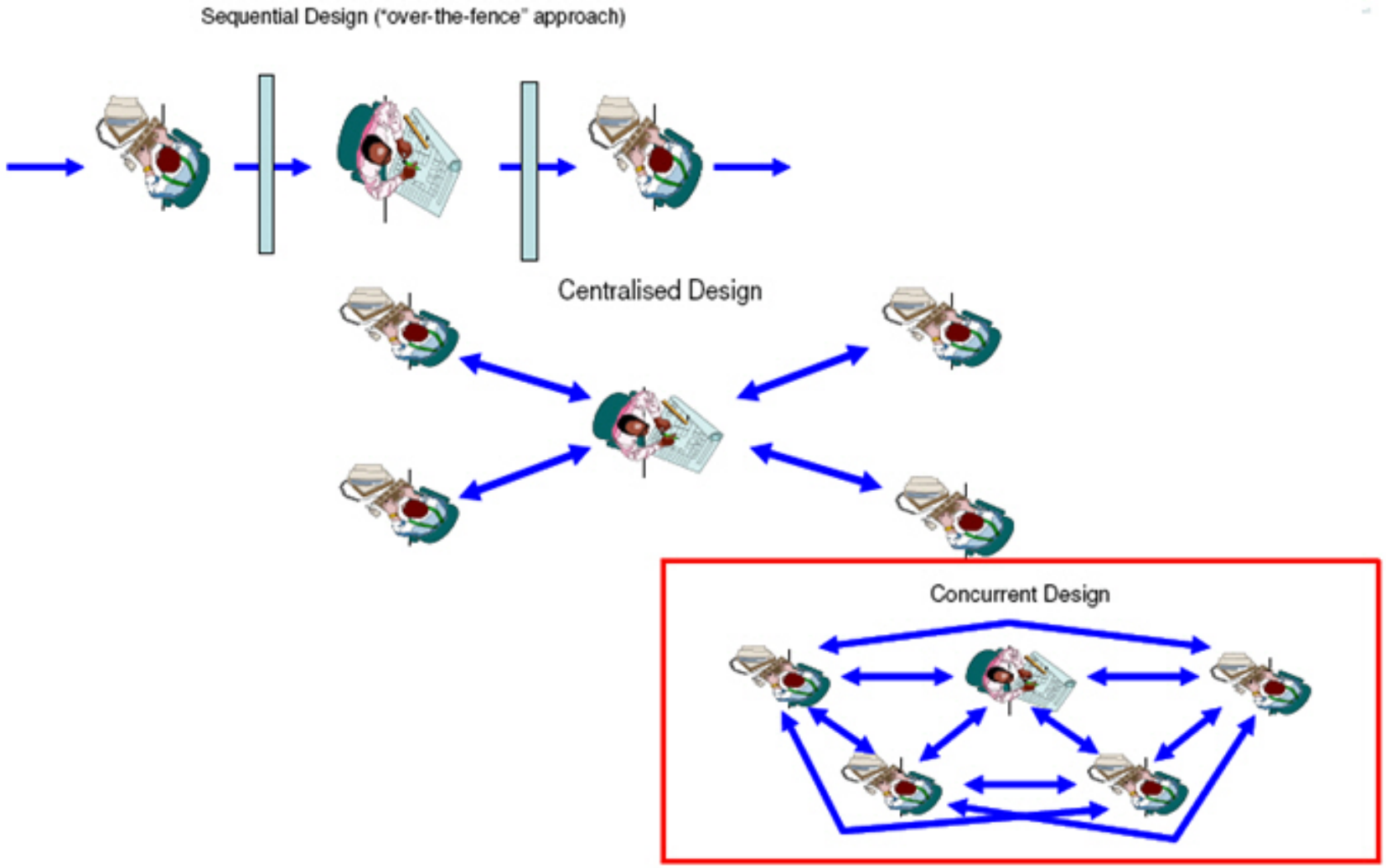
- **Total cost of manufacturing of a product** generally consists of following components:
  - **Materials:** raw material costs
  - **Tooling:** cutting tools, dies, molds, work-holding devices, and fixtures
  - **Fixed:** Cost of energy, rent for facilities, insurance and real-estate taxes
  - **Capital:** production machinery, equipment, buildings, and land
  - **Labor:** Direct and indirect costs. Direct labor is productive labor which directly related to the production. Indirect laboring is for servicing of the total manufacturing operations.

- **Product design** involves creative and systematic definition of shape and characteristics of an artifact to achieve specified objectives while simultaneously satisfying several constraints.



(a) Chart showing various steps involved in traditional design and manufacture of a product. Depending on the complexity of the product and the type of materials used, the time span between the original concept and the marketing of the product may range from a few months to several years.
(b) Chart showing general product flow in concurrent engineering, from market analysis to marketing the product.
Source: After S. Pugh.

- **Concurrent (Simultaneous) Engineering** refers to the applications of tools, techniques, methodologies, and behavioral initiatives that are used to minimize the product development timescales by maximizing the degree of overlap of design activities.



Green Design and Manufacturing

- Millions of cars, tires, lamps, plastic products, etc. are discarded every year.
- From manufacturing viewpoint; manufacturing operations generally produce waste such as:
  - chips
  - slag
  - additives (sand casting operations)
  - hazardous waste
  - lubricants and coolants
  - processed liquids
  - solvents
  - smoke and pollutants

- **Green design** concerns with selection of environmentally-friendly materials and processes.
- **Green manufacturing** is now concerning to reuse the waste products and recycle them in an effective way.