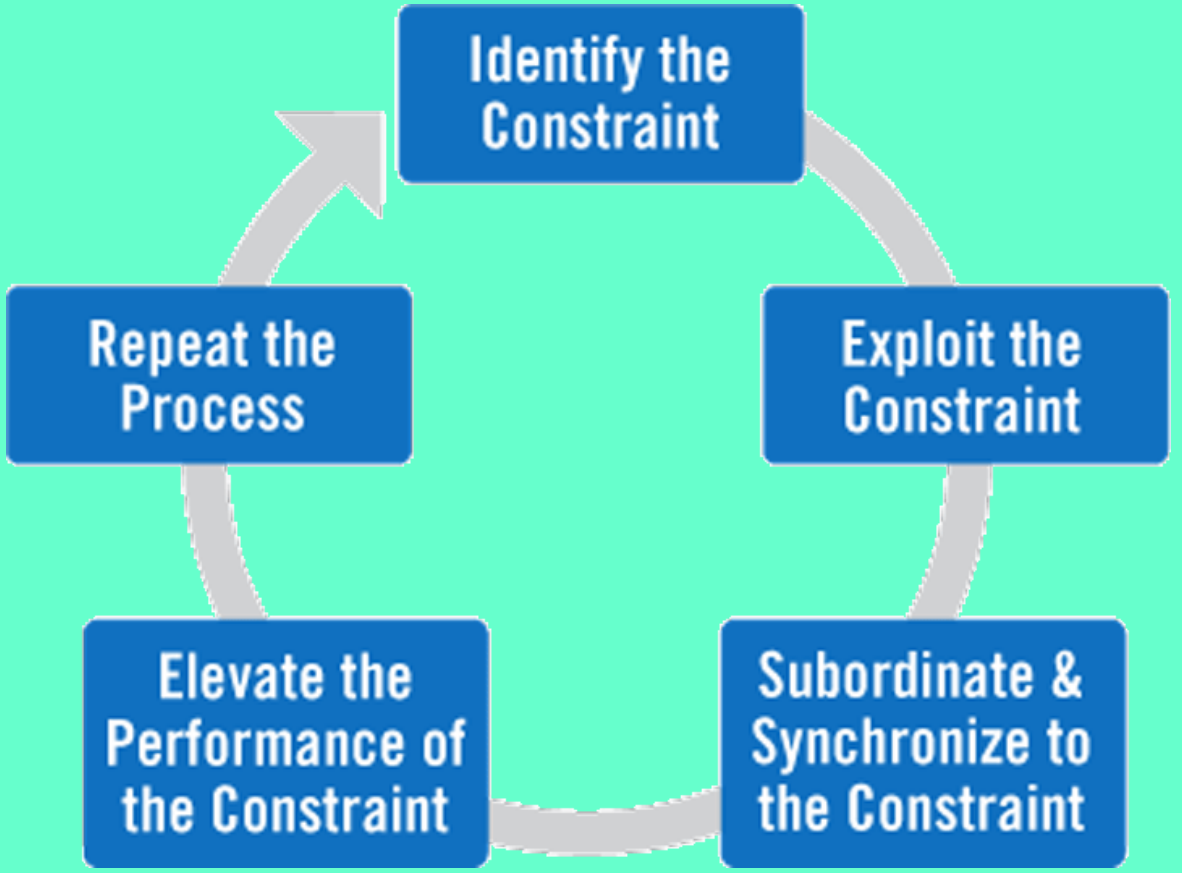
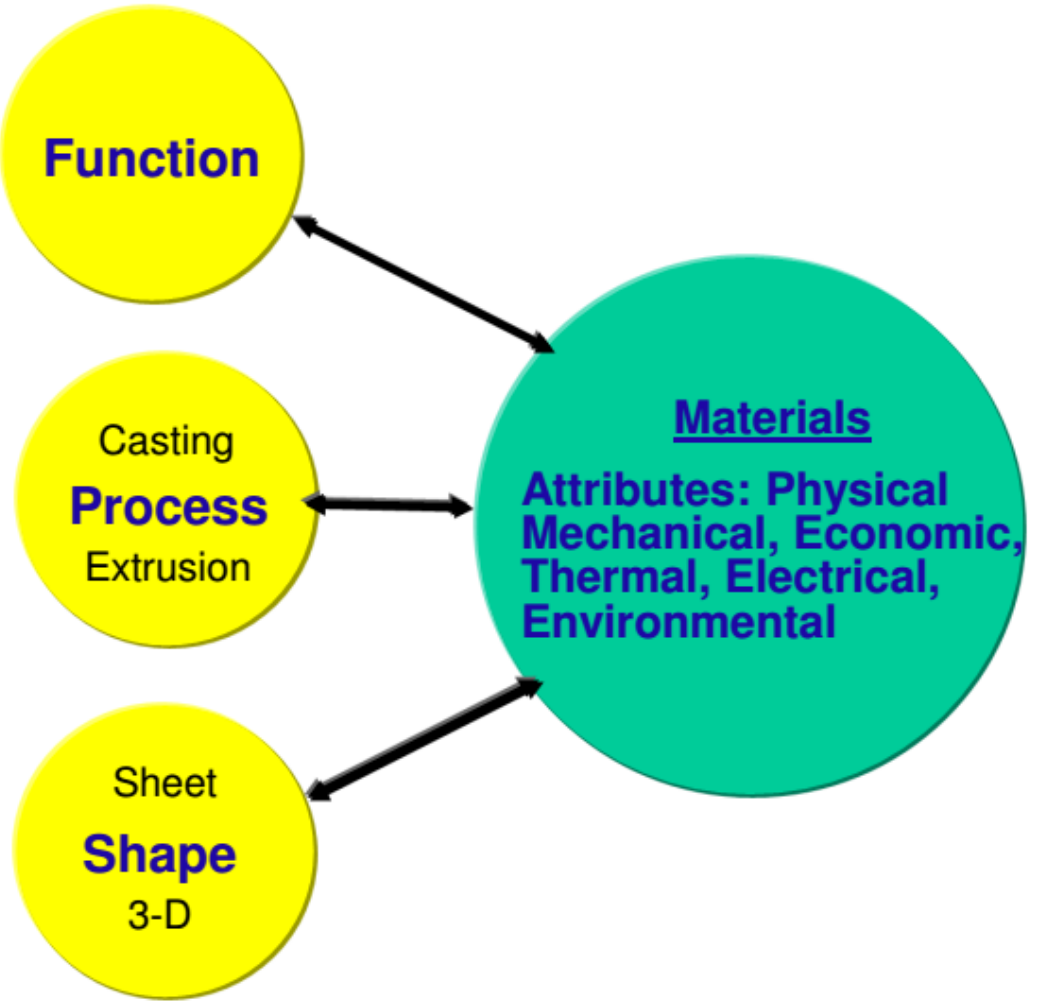
LECTURE-05: SELECTION OF MANUFACTURING PROCESSES



DR. NIKHIL R. DHAR
Professor, IPE Department
BUET

Interaction between Material, Shape and Process

- There is an interaction between material, shape and process
- Materials properties and shape limit the choice of process.
  - Ductile materials can be forged, rolled and drawn
  - Brittle material must be shaped by other methods
  - Materials which melt at moderate temperature and have excellent castability can be cast.
- Selection of a manufacturing process is made difficult by the large variety of processes.

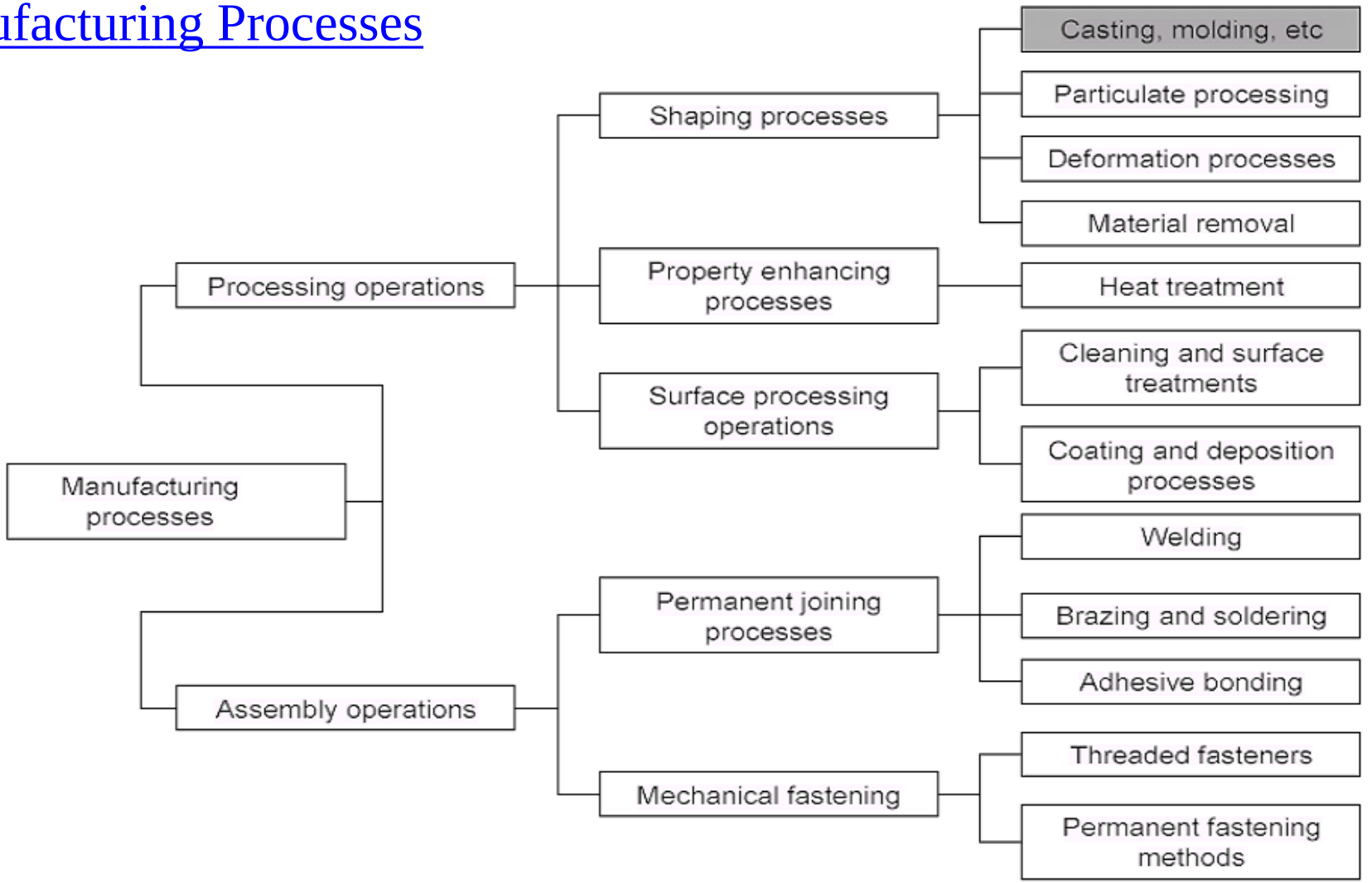


- Selecting a manufacturing process is finding the best match between a set of attributes (of the process) and the design requirements
- The selection procedure identifies promising processes by using Process Selection Charts.
- Each process, casting for example, occupies a characteristic area of the chart.
- Like other aspects of design, process selection is an iterative procedure. The final choice requires a comparison of end cost.
- What is a manufacturing process?
  - Is a process which coverts materials from one form to another.
    - Raw material →new product (iron ore into iron and steel)
    - Raw material →component (fabrication)
    - Components →finished product (assembly)
  - Two types of manufacturing processes:
    - Technical process
    - Economic process (add value)

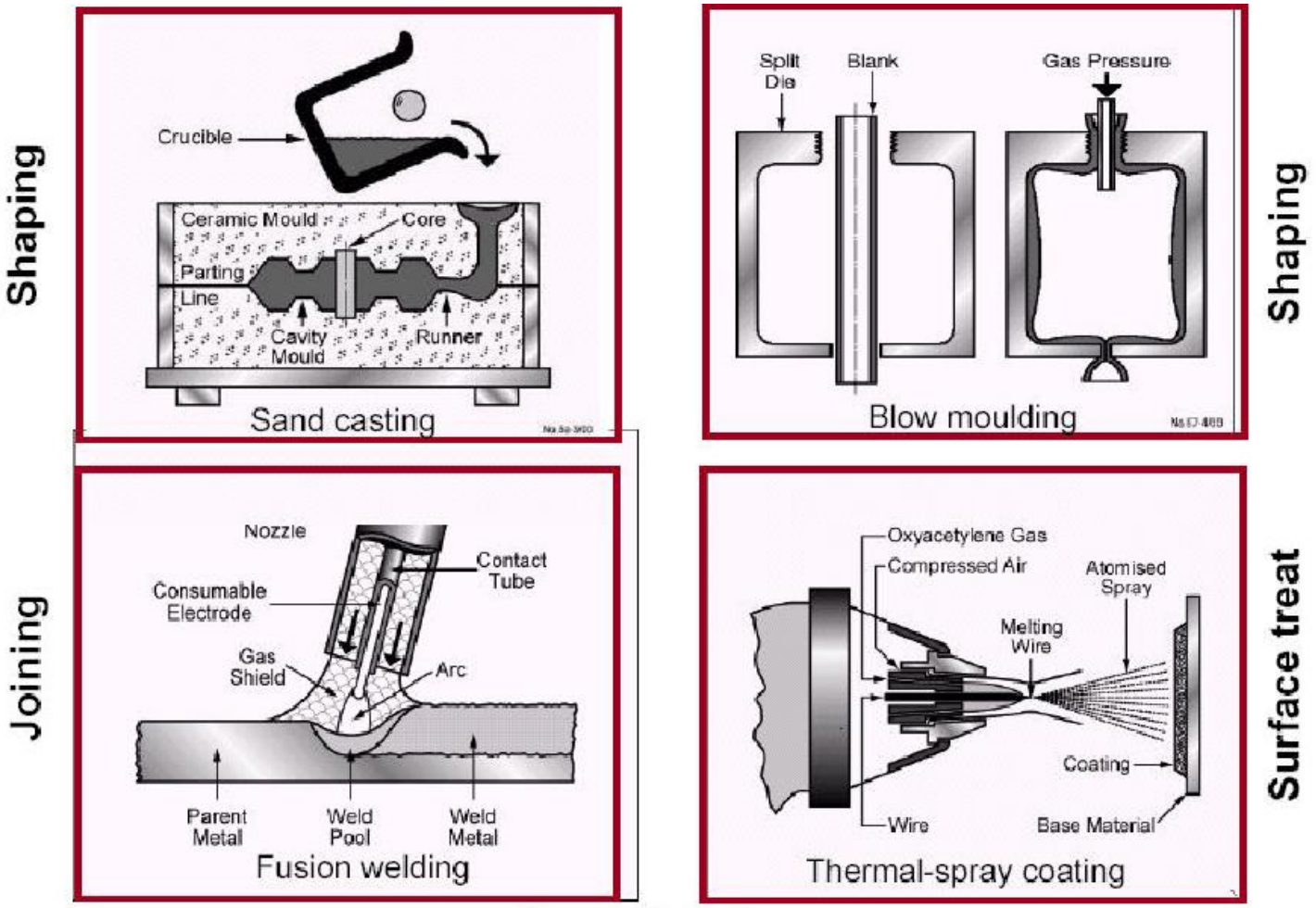
Selection of a Manufacturing Process

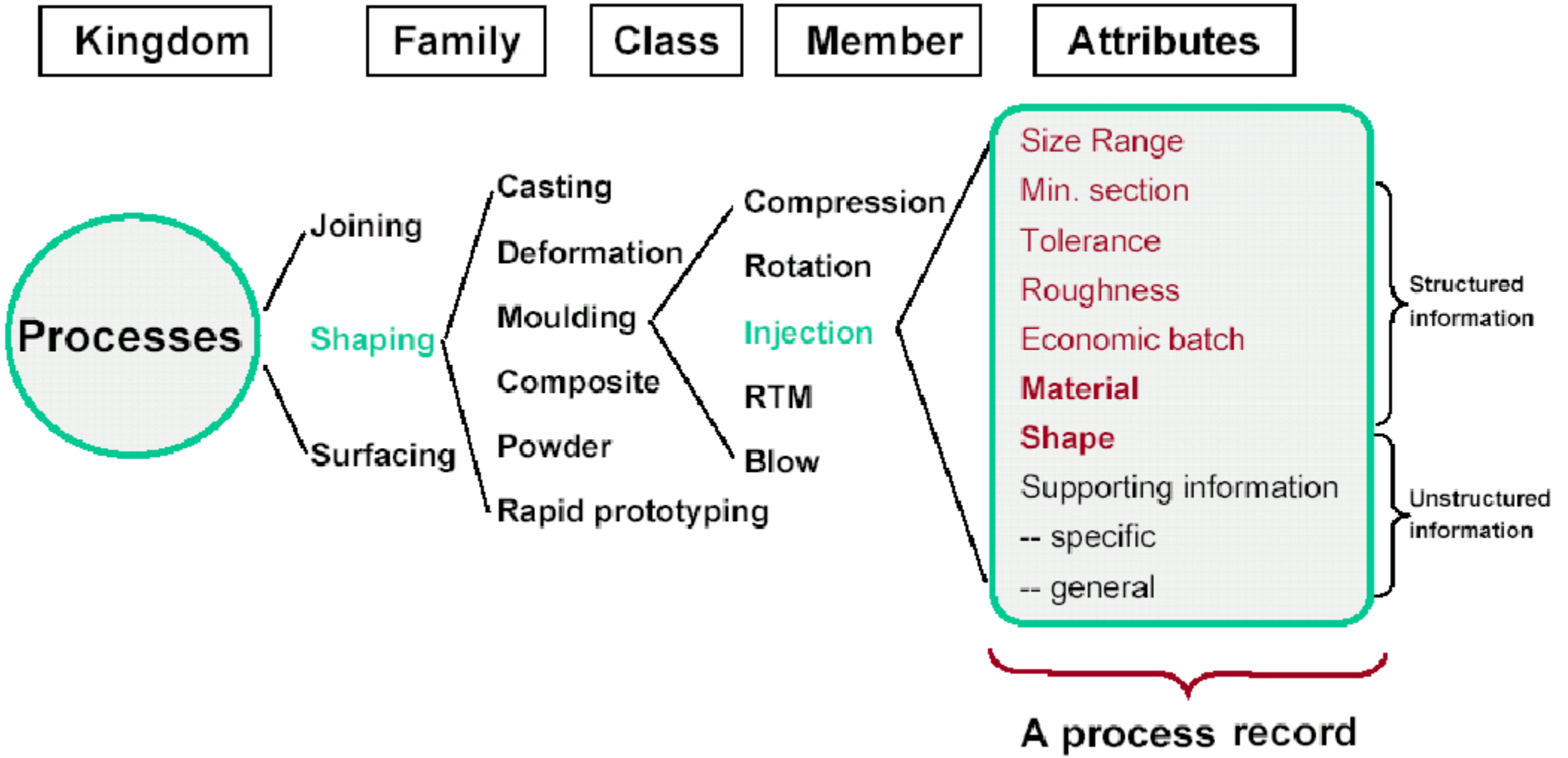
- Before selecting a manufacturing process, we need to know the following attributes:
  - Material to be used
  - Number of parts required (batch size)
  - Size and shape to be produced
  - Dimensional tolerances required
  - Geometrical complexity
  - Surface finish
  - Economics (cost) of tooling, capital, scrap rate, etc…)
  - Environment and safety

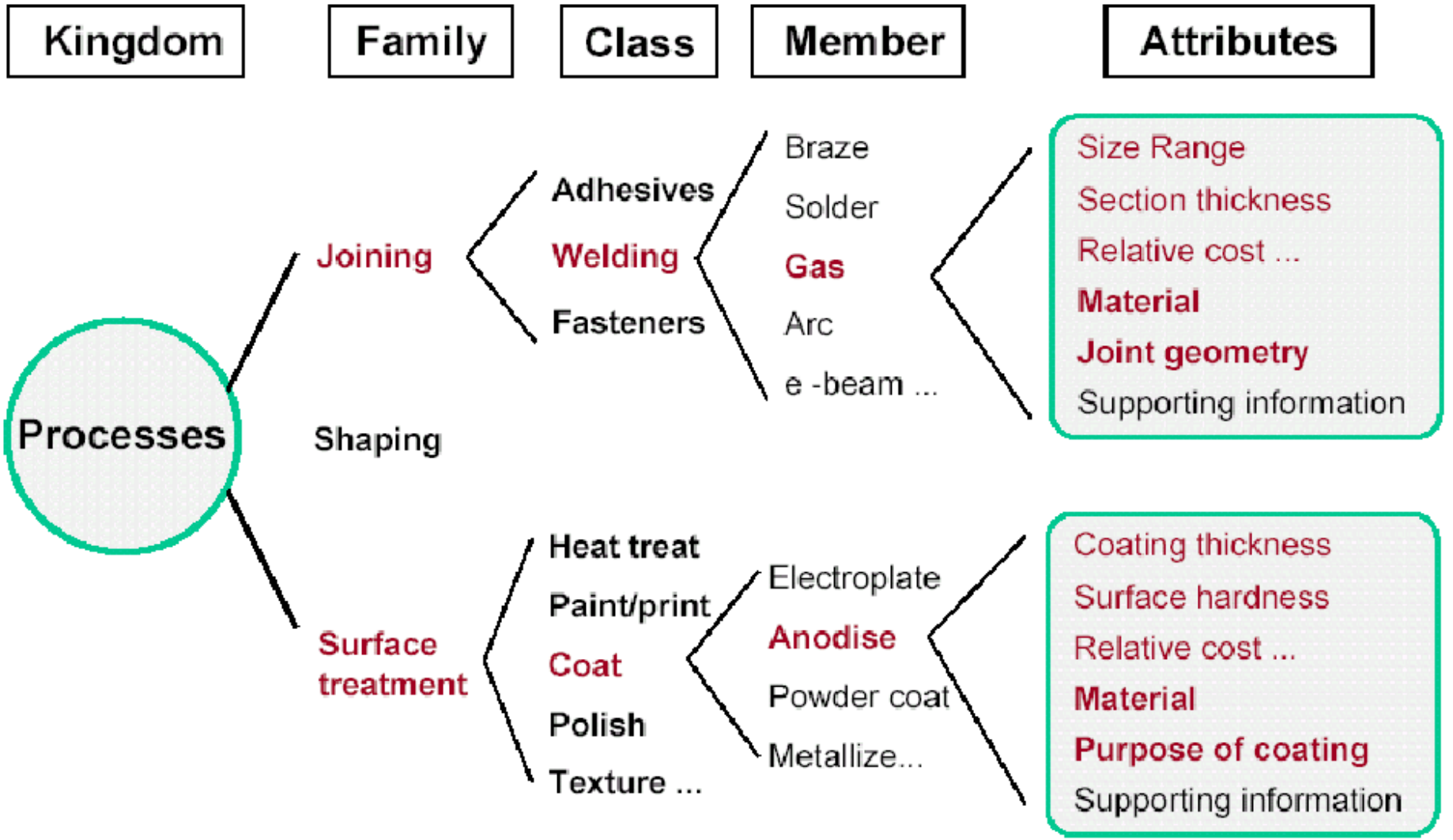
Manufacturing Processes



Process Selection

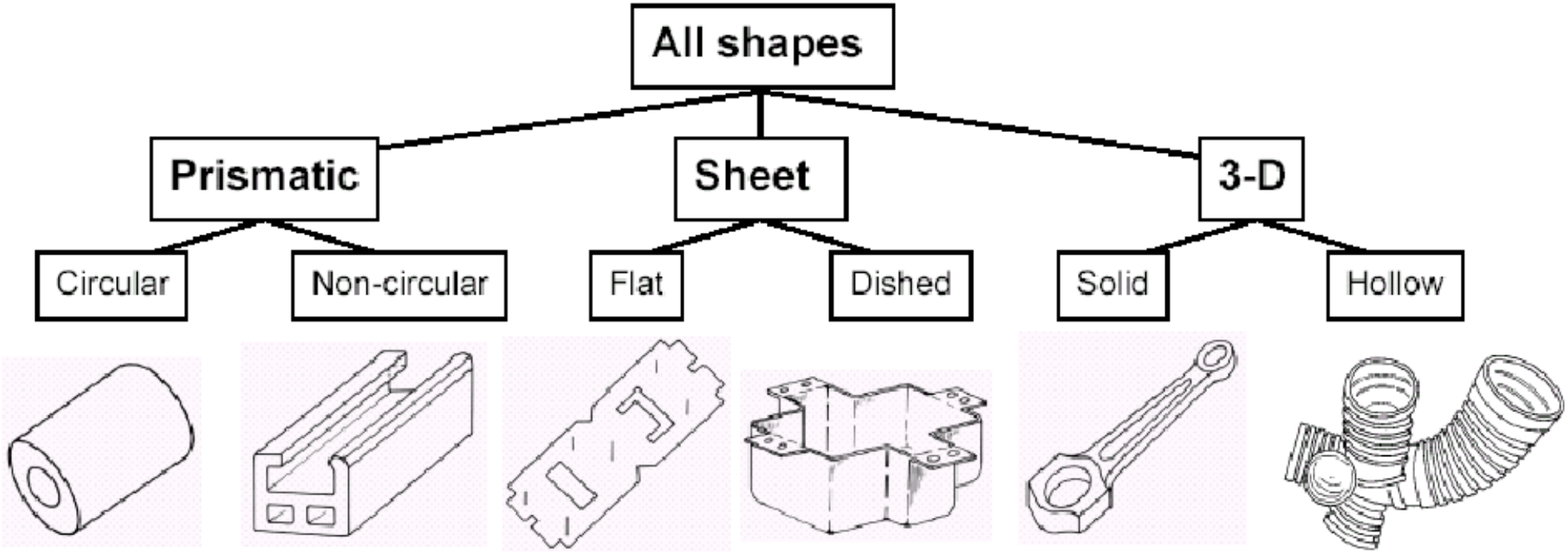



Kingdom
Family
Class
Member
Attributes
Processes
Joining
Shaping
Surfacing
Casting
Deformation
Moulding
Composite
Powder
Rapid prototyping
Compression
Rotation
Injection
RTM
Blow
Size Range
Min. section
Tolerance
Roughness
Economic batch
Material
Shape
Supporting information
-- specific
-- general
Structured information
Unstructured information
A process record


Kingdom
Family
Class
Member
Attributes
Processes
Joining
Shaping
Surface treatment
Adhesives
Welding
Fasteners
Heat treat
Paint/print
Coat
Polish
Texture ...
Braze
Solder
Gas
Arc
e -beam ...
Electroplate
Anodise
Powder coat
Metallize...
Size Range
Section thickness
Relative cost ...
Material
Joint geometry
Supporting information
Coating thickness
Surface hardness
Relative cost ...
Material
Purpose of coating
Supporting information

Shape Classification

- Some processes can make only simple shapes others, compels shapes



- Wire drawing, extrusion, rolling, shape rolling: prismatic shapes
- Stamping, folding, spinning, deep drawing: sheet shapes
- Casting, molding, powder methods: 3-D shapes

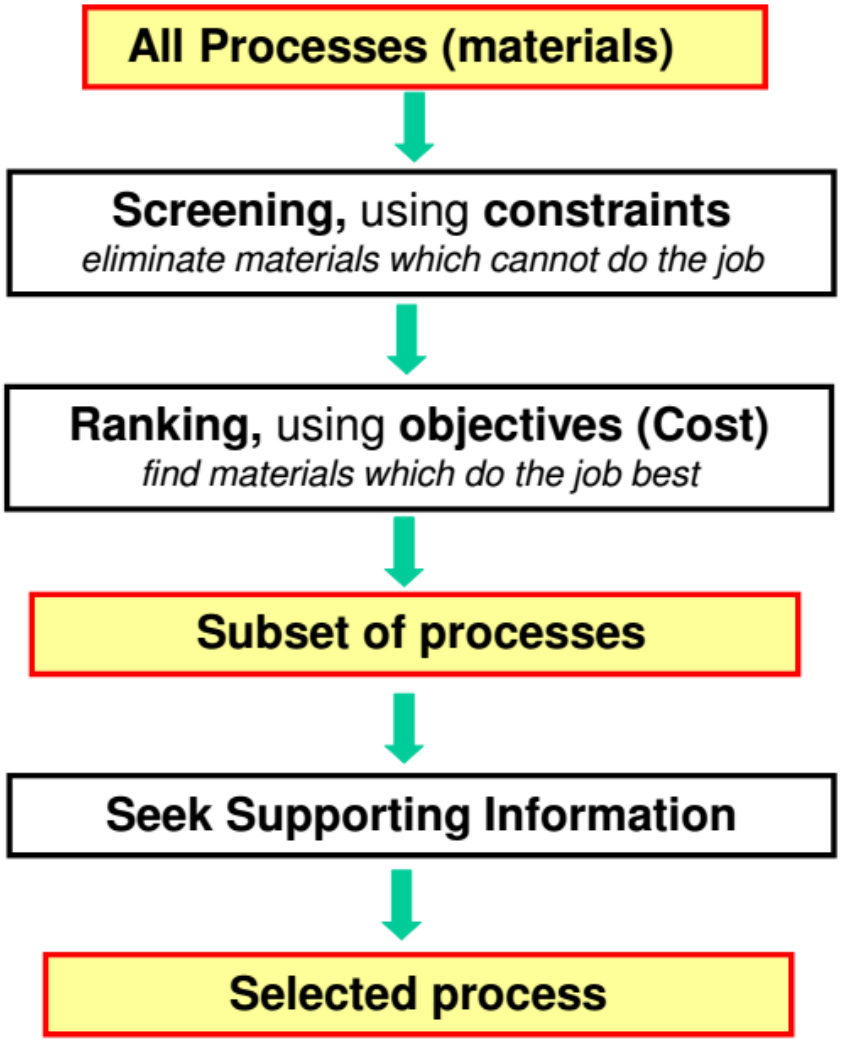
Process Cost

- Part of the cost of a component is that of:
  - Material of which it is made.
  - Cost of manufacture.
- There are two rules of reducing cost:
  - Keep things standard and simple
    - Parts that can be made from standard stock (sheet, rod, tube) are usually cheaper than those requiring shape or special casting.
    - Try to use standard materials, and as few as possible (it reduces inventory costs and the range of tooling the manufacturer needs)
  - Do not specify more than is necessary
    - Performance must be paid for. High strength metals usually contain large amount of alloying elements which are expensive.
    - High performance polymers are chemically complex.
    - High performance ceramics require greater quality control in their manufacture.

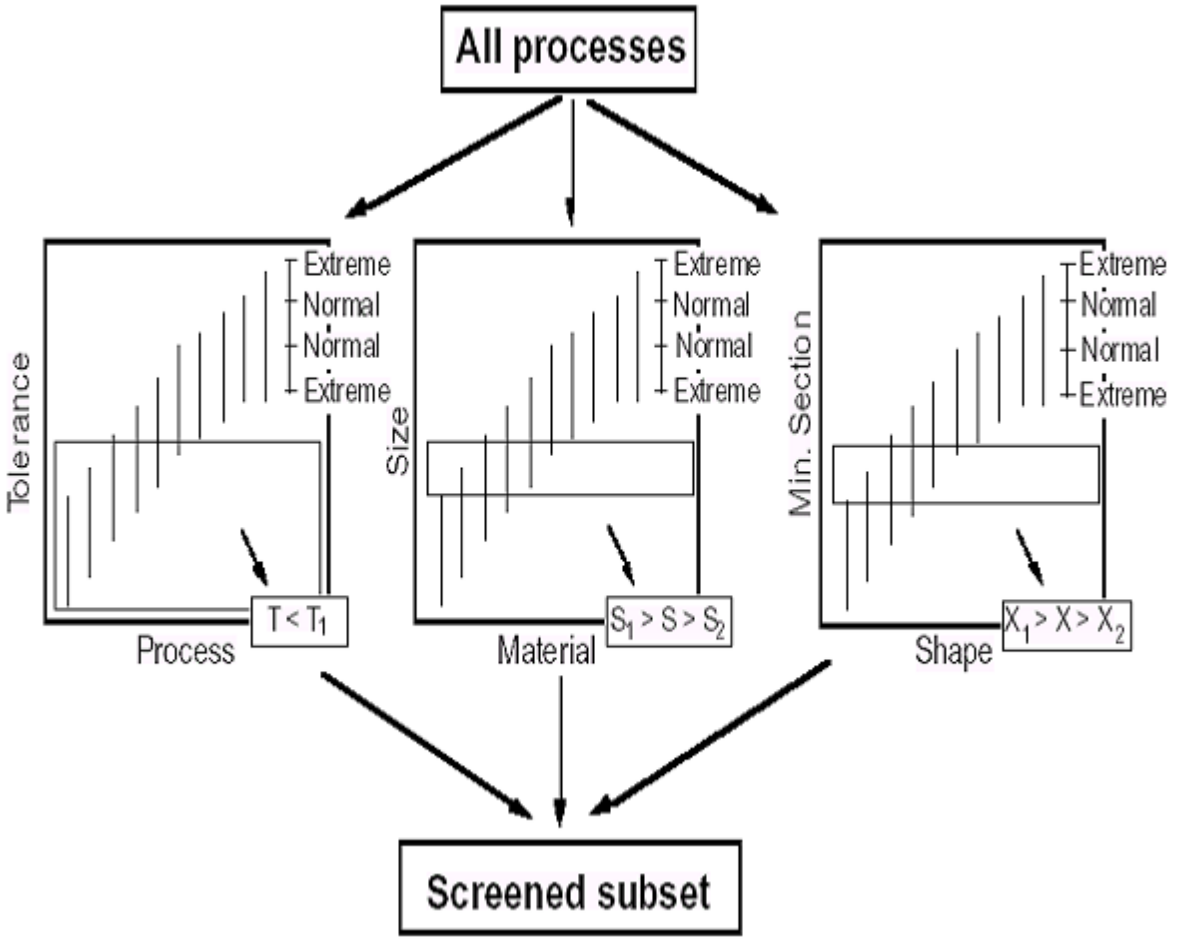
- High strength materials are hard to fabricate:
  - Forming pressures are high,
  - Tool wear is higher,
  - Ductility is less so that deformation processing can be almost impossible, (this means new processing techniques must be used)
- The better performance of the high strength material must be paid for in material cost and processing

Process Selection

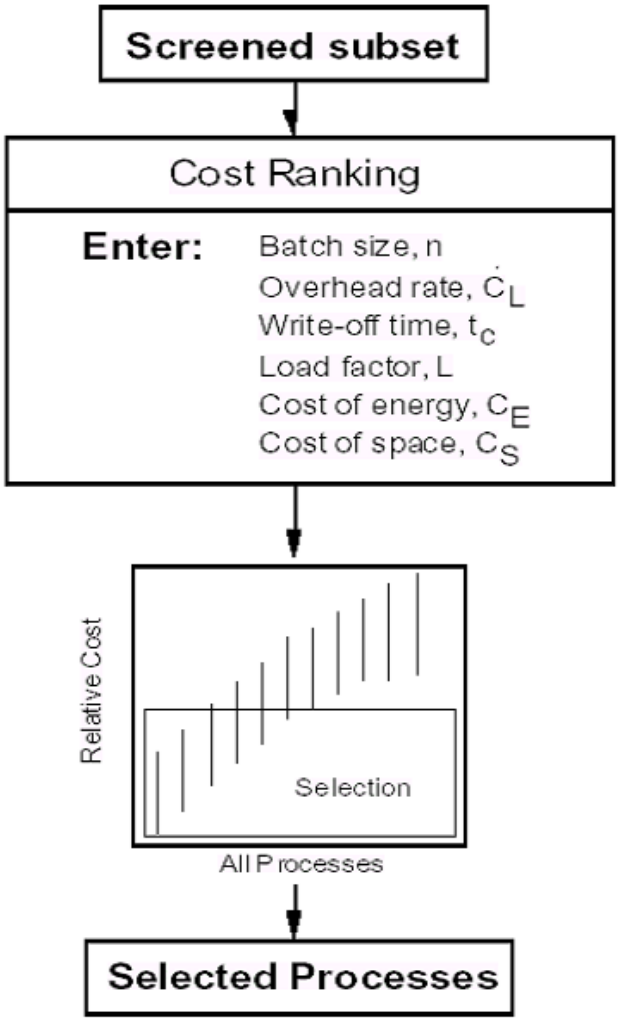
- Match the attributes of the PROCESS to the requirements of the DESIGN



- Screening
  - Similar to materials selection
  - Plot important properties on selection charts
  - Select a subset of processes based on requirements of the design
- Ranking
  - Select a potential subset of processes and rank them based on economics (Cost). Apply rules to reduce cost:
    - Keep things simple and standard
    - Do not over specify



Stage-1: Screening



Stage-2: Ranking

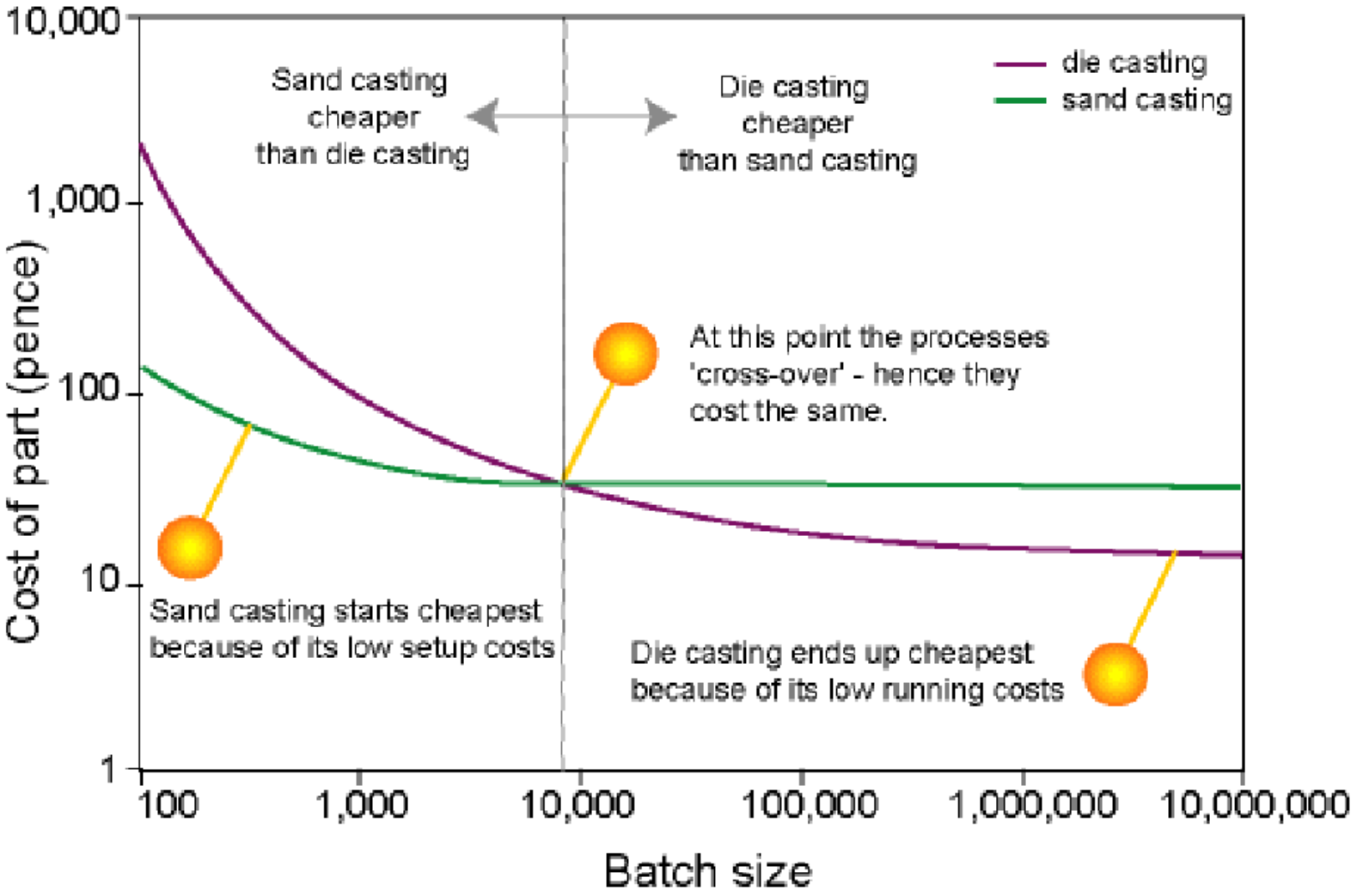
Contributions of Process Cost

- The manufacture of a component includes:
  - The cost C_m of the materials of which it is made
  - In involves the capital cost C_c of the machinery and plant required to make it
  - It involves a contribution associated with the cost C_L per unit time, of the labor needed to do the job.
- The total cost of one component is:

$$C = C_m + \frac{C_c}{n} + \frac{C_L}{\dot{n}}$$

Where: n is the batch size (number of components) and $\dot{n}$ is the batch rate (number of components / unit time)

- The cost has three contribution:
  - The first is independent on batch size and rate: the material cost also includes the material consumed in manufacture (cutting tools)
  - The second varies with the batch size: the capital investment which include the total cost of machine, building and its services (water, electricity, gas etc.)
  - The third varies with the batch rate: this includes the direct cost of labor and indirect cost of overhead associated with administration, safety, maintenance, etc.


10,000
1,000
100
10
1
Cost of part (pence)
Sand casting
cheaper
than die casting
Die casting
cheaper
than sand casting
die casting
sand casting
At this point the processes
'cross-over' - hence they
cost the same.
Sand casting starts cheapest
because of its low setup costs
Die casting ends up cheapest
because of its low running costs
100
1,000
10,000
100,000
1,000,000
10,000,000
Batch size

Factors Affecting Selection of Manufacturing Process

- Manufacturing Process Selection Criteria
  - Material selection including and considering all the environmental and recycling aspects
  - Selection of processing methods such as metal casting, metal forming, sheet metal working, powder metallurgy, machining, joining, finishing etc.
  - Shape and appearance of the final product
  - Dimensional tolerance and surface finish aspects of the final product
  - Economics of tooling
  - Design requirements
  - Functional requirements of the product
  - Production quantity required
  - Safety and environmental concerns
  - Cost

- Factors affecting the selection of manufacturing processes:
  - Product quality
  - Equipment and tooling cost
  - Material cost
  - Material vs. process
  - Processing time
  - Labor
  - Energy consumption
  - Surface finish
  - Process waste and material recycling