Chapter Four

Process Selection
Reading: Reference book
M.F. Ashby- Chapter 7
• 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 converts 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:

1. Technical process
2. Economic process (add value)
• **Selection of a manufacturing process**

• Before selecting a manufacturing process, we need to know the following attributes:

1. Material to be used
2. Number of parts required (batch size)
3. Size and shape to be produced
4. Dimensional tolerances required
5. Geometrical complexity
6. Surface finish
7. Economics (cost) of tooling, capital, scrap rate, etc…
8. Environment and safety
Manufacturing Processes

Processing operations

Property enhancing processes
- Shaping processes
- Deformation processes
  - Particulate processing
  - Material removal
- Heat treatment
  - Cleaning and surface treatments
  - Coating and deposition processes
  - Welding
    - Brazing and soldering
    - Adhesive bonding
    - Threaded fasteners
  - Permanent joining processes

Surface processing operations

Manufacturing processes

Assembly operations

Mechanical fastening

Permanent fastening methods

Groover, p. 13
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
Shape classification

Some processes can make only simple shapes, others, complex 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:**

  1. *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).

2. *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

(Selected process)

Screening, using constraints
eliminate materials which cannot do the job

Ranking, using objectives (Cost)
find materials which do the job best

Subset of processes

Seek Supporting Information

Selected process

(after M.F. Ashby)
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:
  1. Keep things simple and standard
  2. 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 $C_L / \text{unit time}$, of the labour needed to do the job.

• The total cost of one component is:

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

• Where: $n$ is the batch size (number of components) and $\frac{\cdot}{n}$ is the batch rate (number of components / unit time)
The cost has three (03) contribution:

- The first is independent on batch size and rate: the material cost also includes the material consumed in manufacture (e.g.; 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 labour and indirect cost of overhead associated with administration, safety, maintenance, etc...
Sand casting cheaper than die casting

Die casting cheaper than 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