EDPT 601

Lectures 3

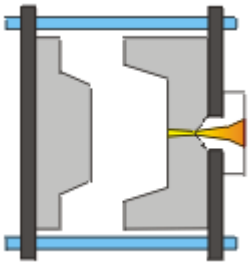
Casting Defects

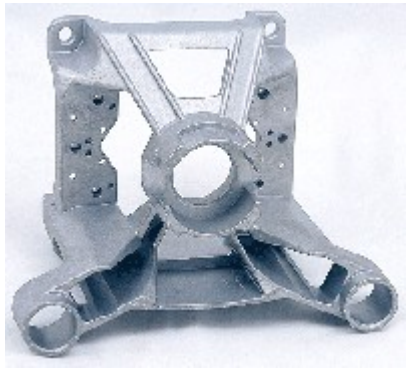
And

Casting Processes

Ref. : Ch 14 and 15 De Garmo

Ch 11 Kalpakjiar





Casting Defects

There are 7 basic categories:

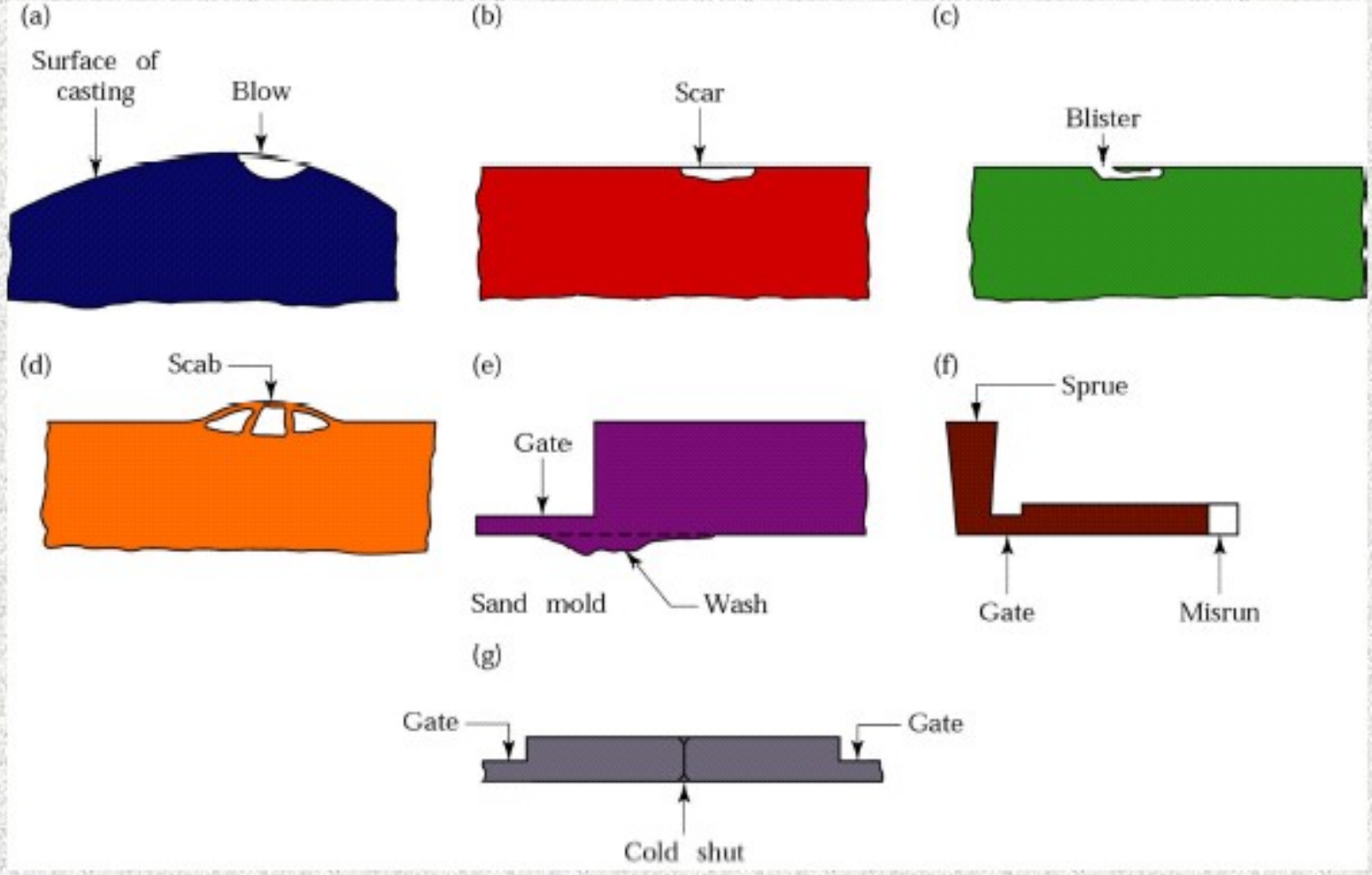
1. **Metallic projections:** fins, flash, swells, rough surface
2. **Cavities:** rounded or rough internal or exposed including blow holes, pinholes, shrinkage cavities
3. **Discontinuities:**
    1. cracks, cold or hot tearing, cold shuts
    2. incomplete casting if the metal is poured at low temperature or too slowly
    3. cold shuts: meeting of two streams partially solidified with no fusion

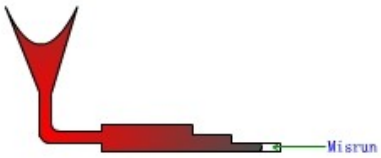
Casting Defects

1. **Defective surface:** sand layer, oxide, folds, scabs
2. **Incomplete casting:** due to misrun (premature solidification), insufficient metal, runout (loss after pouring)
3. **Incorrect dimensions or shapes:** incorrect pattern shrinkage allowance, warping..
4. **Inclusions:** foreign particles – oxides or sand – are harmful as they reduce ductility, machinability- are formed during melting or reaction with oxygen or crucible

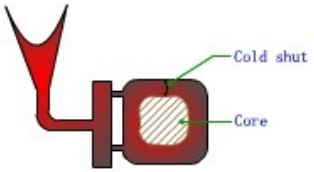
Casting Defects

Figure 10.12 Examples of common defects in castings. These defects can be minimized or eliminated by proper design and preparation of molds and control of pouring procedures. *Source*: J. Datsko.

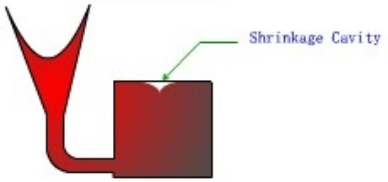




Misruns

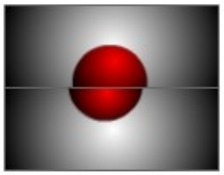


Cold shut

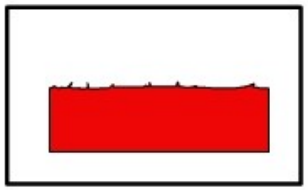


Shrinkage Cavity

Microporosity



Mismatch



Metal Peneration

Blowholes are spherical or elongated cavities present in the casting on the surface or inside the casting.

Pinhole porosity occurs due to the dissolution of hydrogen gas, which gets entrapped during heating of molten metal

Metal penetration

When molten metal enters into the gaps between sand grains, the result is a rough casting surface. This occurs because the sand is coarse or no mold wash was applied on the surface of the mold. The coarser the sand grains more the metal penetration.

Fusion

This is caused by the fusion of the sand grains with the molten metal, giving a brittle, glassy appearance on the casting surface. The main reason for this is that the clay or the sand particles are of lower refractoriness or that the pouring temperature is too high.

Swell

Under the influence of metallostatic forces, the mold wall may move back causing a swell in the dimension of the casting. A proper ramming of the mold will correct this defect.

Cut and washes

These appear as rough spots and areas of excess metal, and are caused by erosion of molding sand by the flowing metal. This is caused by the molding sand not having enough strength and the molten metal flowing at high velocity. The former can be taken care of by the proper choice of molding sand and the latter can be overcome by the proper design of the gating system.

Casting defects

- **Pouring Metal Defects**

The likely defects in this category are

- Mis-runs and
- Cold shuts.

- A **mis-run** is caused when the metal is unable to fill the mold cavity completely and thus leaves unfilled cavities. A mis-run results when the metal is too cold to flow to the extremities of the mold cavity before freezing. Long, thin sections are subject to this defect and should be avoided in casting design.

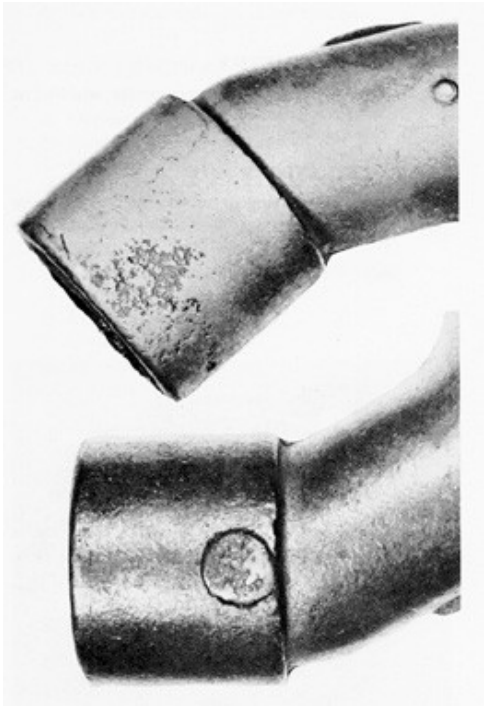
- A **cold shut** is caused when two streams while meeting in the mold cavity, do not fuse together properly thus forming a discontinuity in the casting. When the molten metal is poured into the mold cavity through more-than-one gate, multiple liquid fronts will have to flow together and become one solid. If the flowing metal fronts are too cool, they may not flow together, but will leave a seam in the part. Such a seam is called a cold shut, and can be prevented by assuring sufficient superheat in the poured metal and thick enough walls in the casting design.

- The mis-run and cold shut defects are caused either by a lower fluidity of the metal or when the section thickness of the casting is very small. Fluidity can be improved by changing the composition of the metal and by increasing the pouring temperature of the metal.

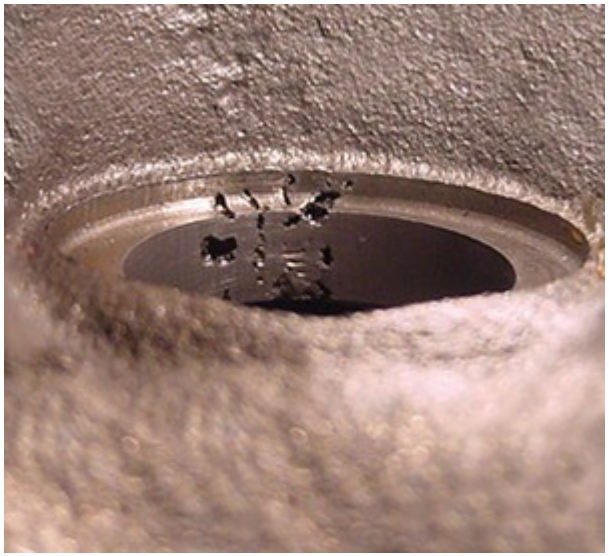
- **Mold Shift**

  The mold shift defect occurs when cope and drag or molding boxes have not been properly aligned.

- Macro inclusions: surface defects



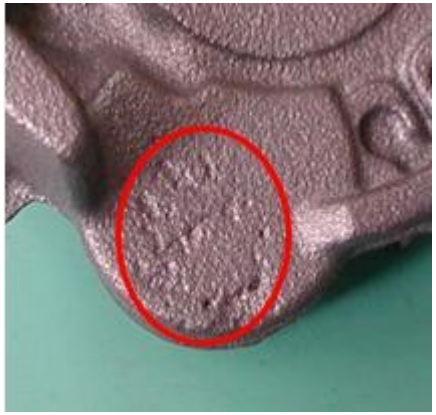
macro porosity



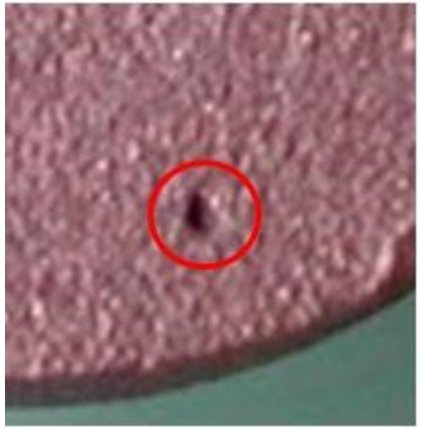
defects

fins

fins



Sand hole



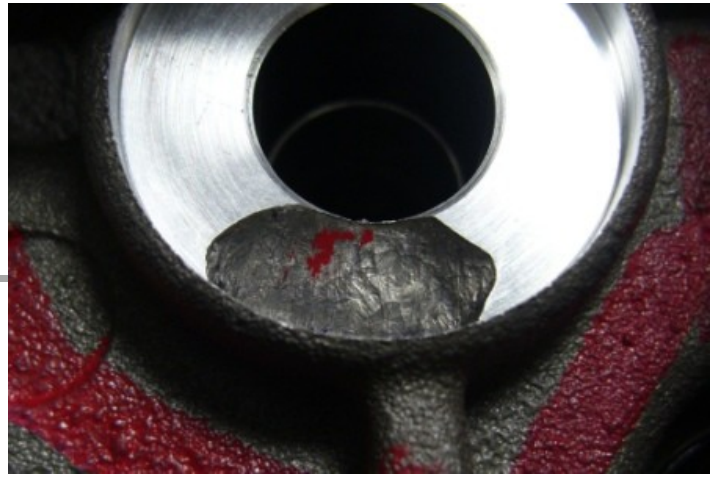
Gas hole

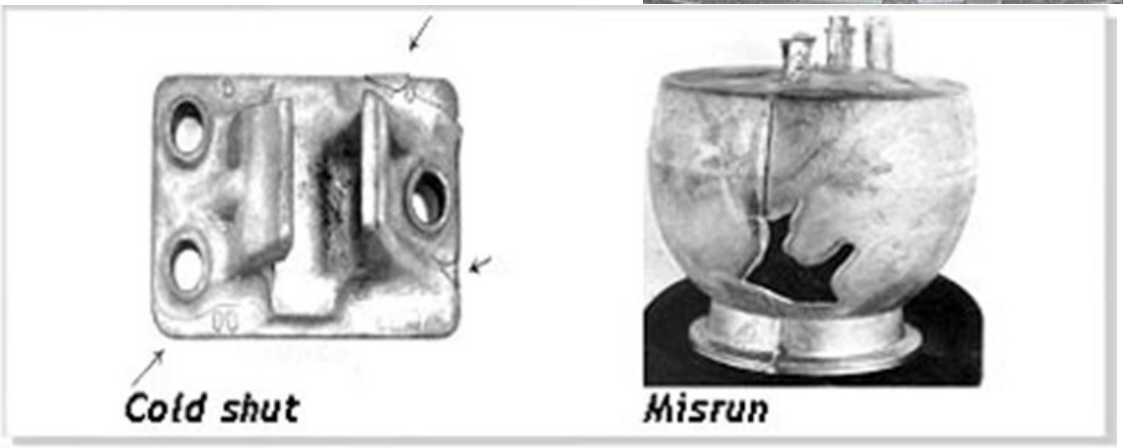
Incomplete

Cold shuts

defects


misrun





Blowhole

Cause of defect:

-shape of casting (critical area for venting) difficult to apply boss

-area of join two or more metal streams in mold

Solution proposal:

-change speed of filling mold by metal

-change position of boss

-slant mould

Hot Tears

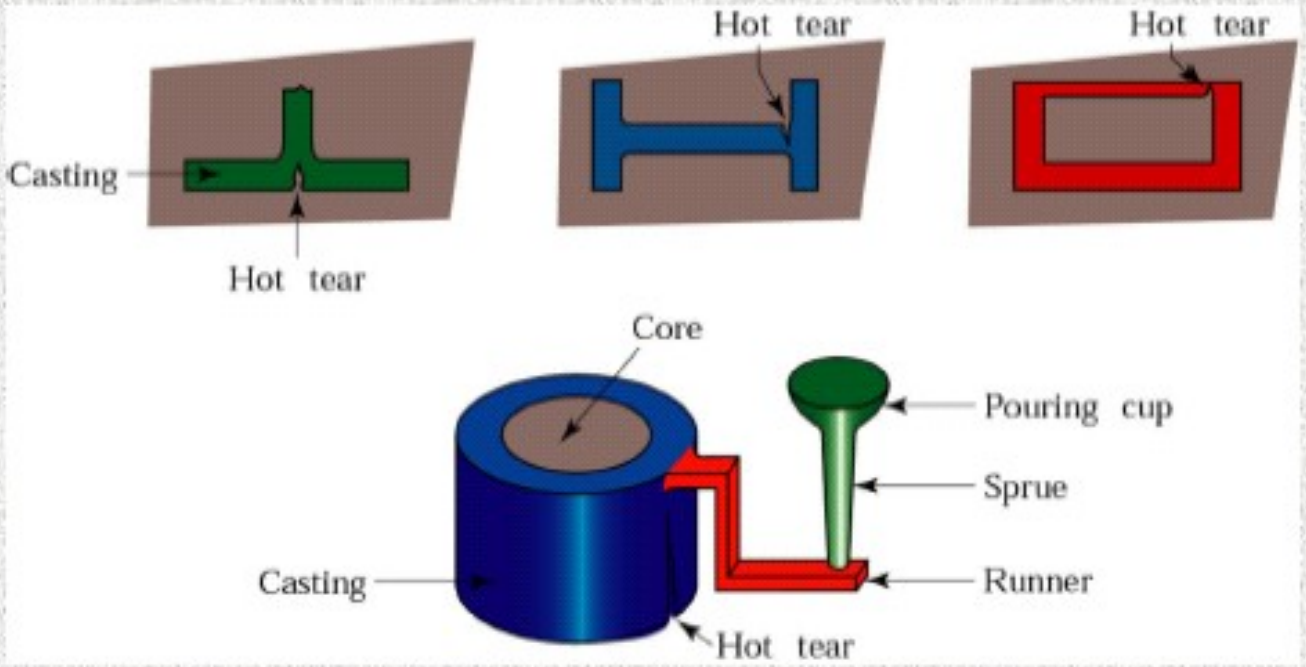


Figure 10.11 Examples of hot tears in castings. These defects occur because the casting cannot shrink freely during cooling, owing to constraints in various portions of the molds and cores. Exothermic (heat-producing) compounds may be used (as exothermic padding) to control cooling at critical sections to avoid hot tearing.

Casting Processes

1. Expendable-mold casting processes
   - Sand casting
   - Disposable pattern: Lost foam
   - Shell casting
   - plaster mold casting
   - ceramic mold
   - Investment casting- lost –wax method
2. Permanent – mold casting processes
   - gravity die casting
   - Low pressure die casting
   - Pressure die casting: hot chamber – cold chamber
   - Centrifugal casting
3. Continuous casting

Recommended minimum section thickness for various metals and casting processes

Material	Casting process	Minimum, mm	Desirable, mm
Steel Gray iron Malleable iron	Sand Sand Sand	4.76 3.18 3.18	6.35 4.76 4.76
Aluminium	Sand	3.18	4.76
Magnesium	Sand	4.76	6.35
Zinc alloys Aluminium alloys Magnesium alloys	Die Die Die	0.51 1.27 1.27	0.76 1.52 1.52

Sand Casting: Steps for making Green Sand Mould

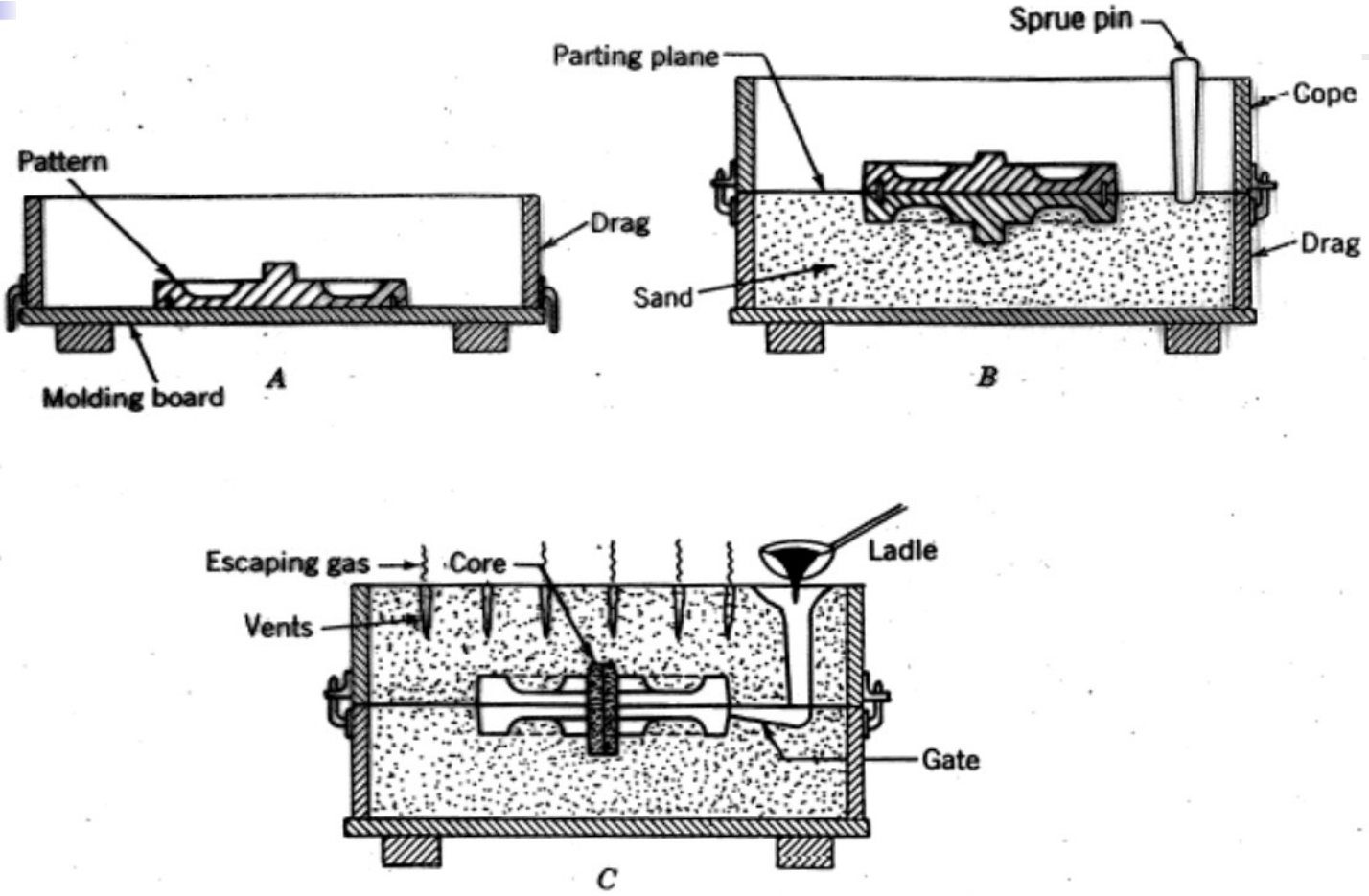


Figure 5.1
Procedure for making green-sand molds. *A*, Pattern on molding board ready to ram up drag. *B*, Drag rolled over and pattern assembled ready to ram cope. *C*, Mold complete with dry-sand core in place.

Sequence of Operations for Sand Casting

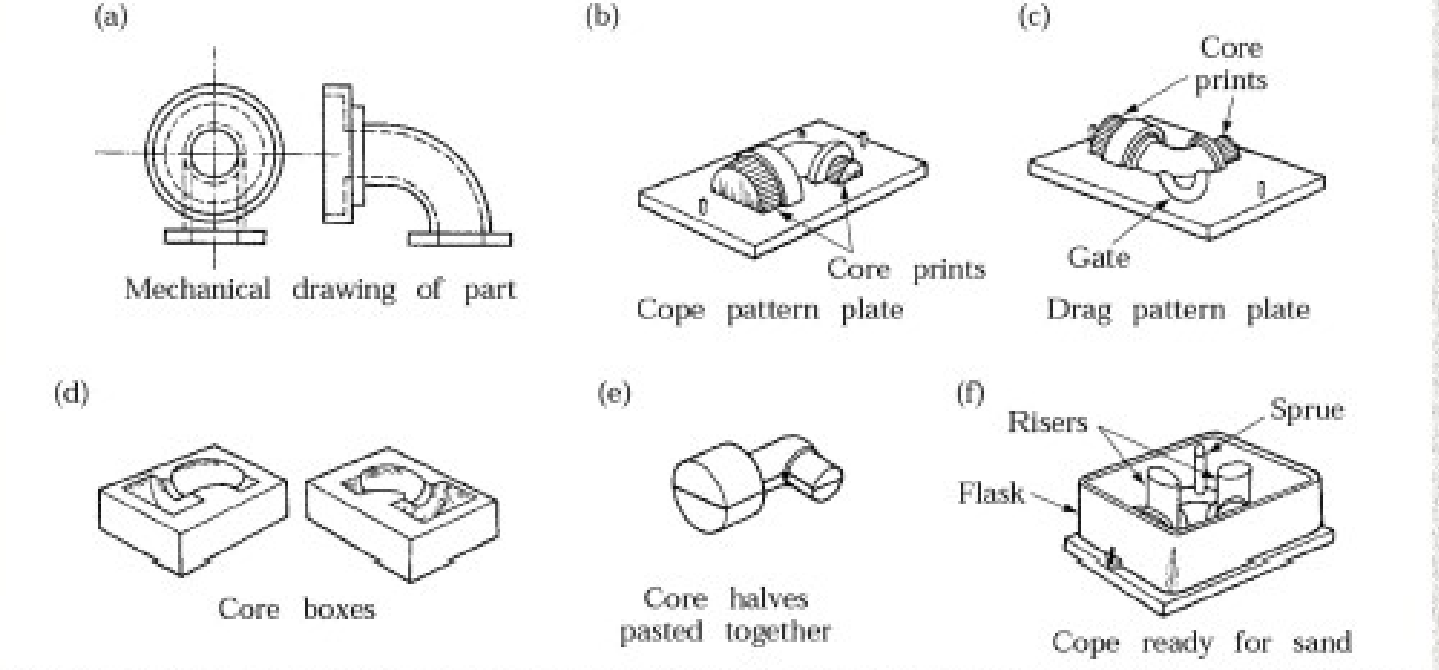


Figure 11.11 Schematic illustration of the sequence of operations for sand casting. *Source*: Steel Founders' Society of America. (a) A mechanical drawing of the part is used to generate a design for the pattern. Considerations such as part shrinkage and draft must be built into the drawing. (b-c) Patterns have been mounted on plates equipped with pins for alignment. Note the presence of core prints designed to hold the core in place. (d-e) Core boxes produce core halves, which are pasted together. The cores will be used to produce the hollow area of the part shown in (a). (f) The cope half of the mold is assembled by securing the cope pattern plate to the flask with aligning pins, and attaching inserts to form the sprue and risers. (continued)

Sequence of Operations for Sand Casting (cor

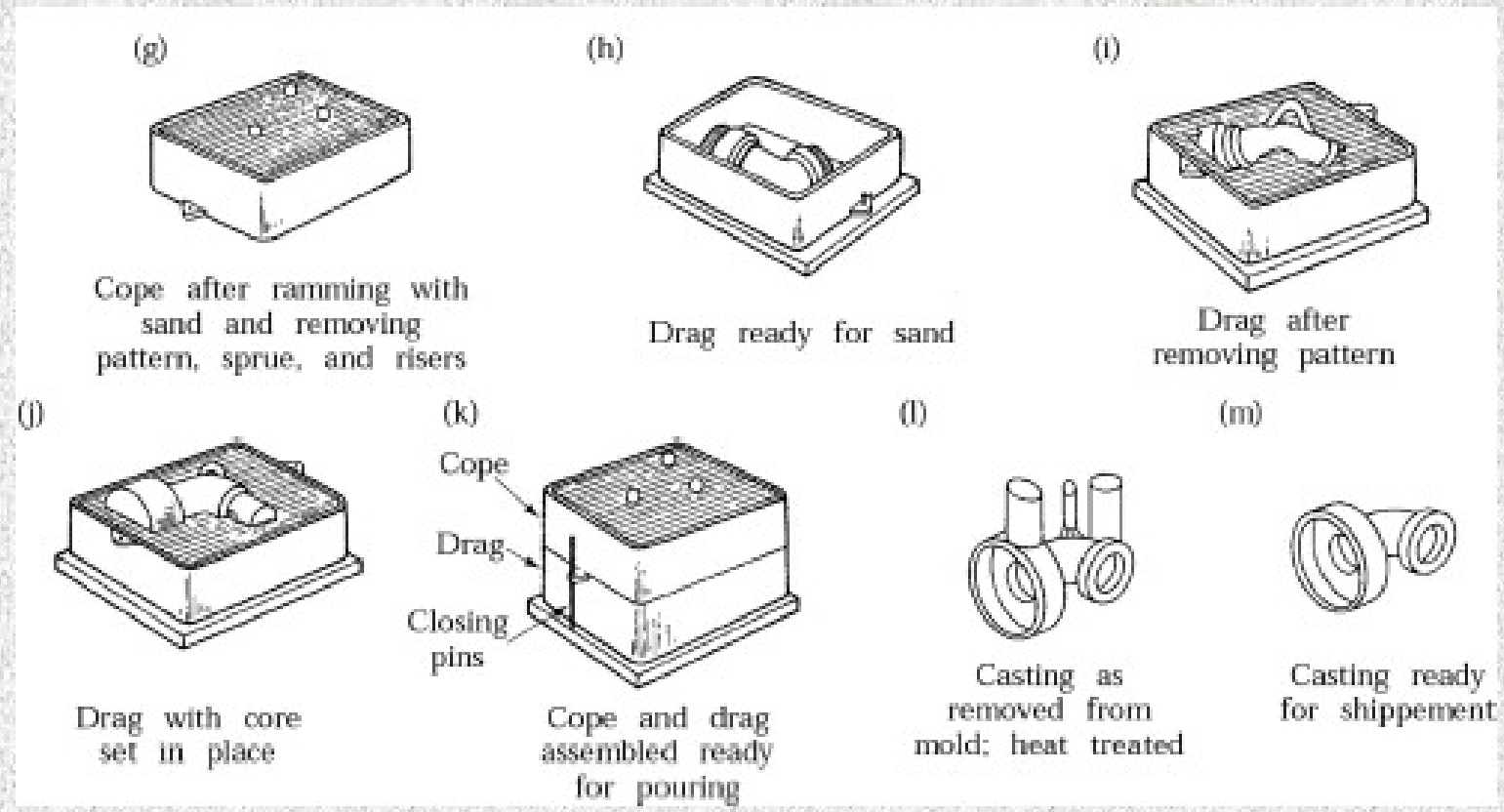


Figure 11.11 (g) The flask is rammed with sand and the plate and inserts are removed. (g) The drag half produced in a similar manner, with the pattern inserted. A bottom board is placed below the drag and alig with pins. (i) The pattern, flask, and bottom board are inverted, and the pattern is withdrawn, leaving the appropriate imprint. (j) The core is set in place within the drag cavity. (k) The mold is closed by placing cope on top of the drag and buoyant forces in the liquid, which might lift the cope. (l) After the metal sol the casting is removed from the mold. (m) The sprue and risers are cut off and recycled and the casting is

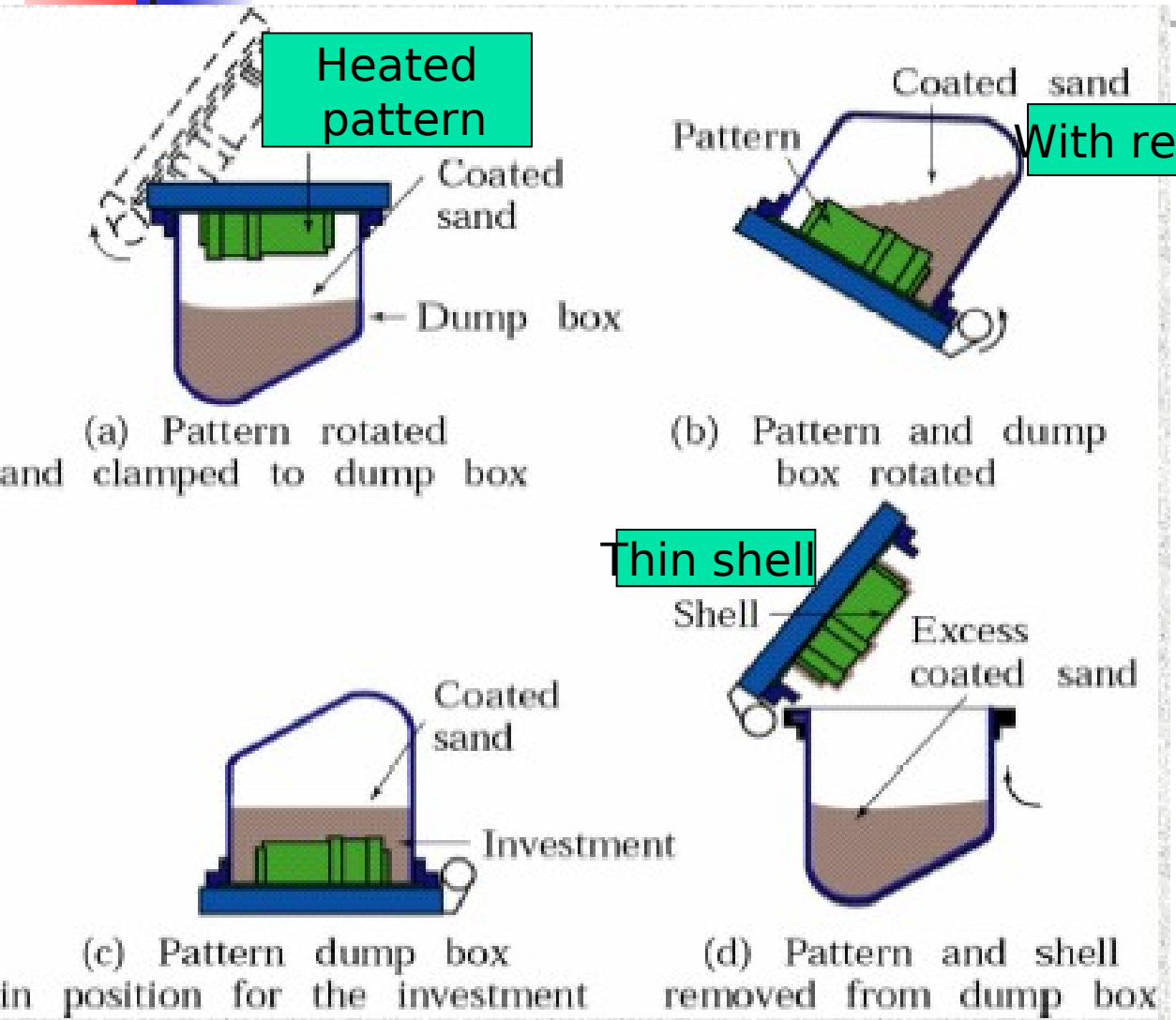
Shell Mould Casting

Steps:

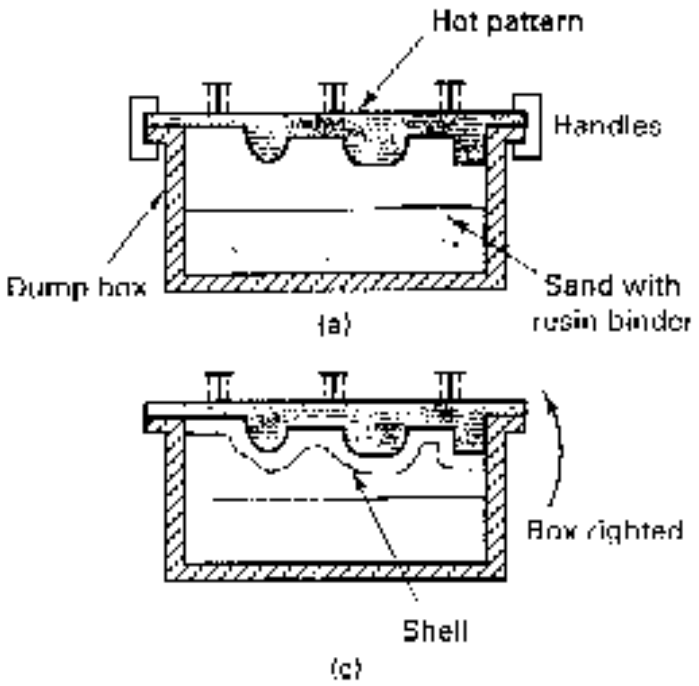
- A heated pattern is placed over a dump box containing a sand and resin mixture.
- The box is inverted and a shell partially cures around the pattern.
- The box is righted, the top is removed, and placed in an oven then joined and supported in a flask ready for pouring.

Shell Mould Casting:

Schematic of the shell-molding process



Shell mold making
Using dump-box
Limitations are:
1. formation
Of voids in the shell
And
2. peelback
(sections of the
shell fall off as the pattern
Is raised)


Hot pattern
Handles
Dump box
Sand with
resin binder
(a)
Box righted
Shell
(c)
Box and pattern
inverted
(b)
Ejector
pin
Dump box
removed
(d)
Matched shells
Metal shot
Clamp
Flask
(e)

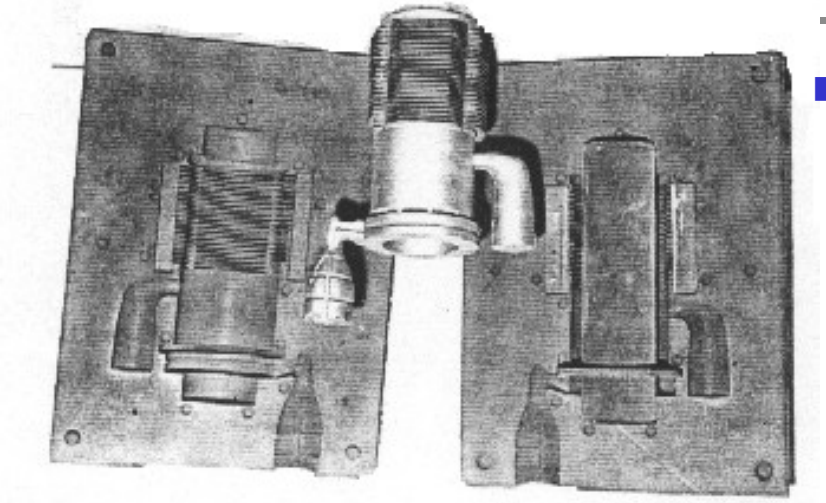

Top Shell Mold
Casting
Bottom Shell Mold


www.iron-foundry.com

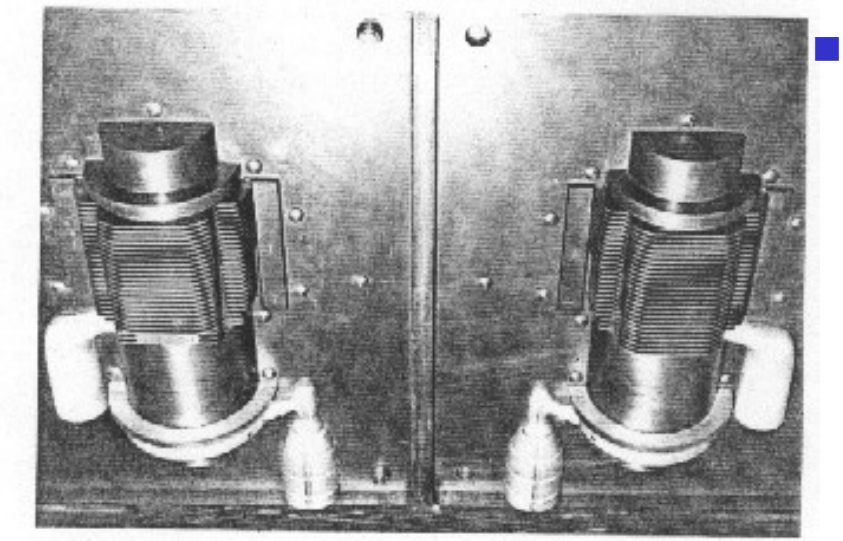
Advantages of Shell Mould Casting

- closer tolerances
- good surface finish at low cost (reducing finishing steps)
- sharp corners
- thinners sections
- smaller projections

Shell Mould Casting



- (Top) Two halves of a shell-mold pattern.



- (bottom) the two shells before clamping, and the final shell-mold casting with attached pouring basin, runner and riser .

Some products cast by shell molding

Ceramic Mould Casting

- **mould material:** fine grained zircon, aluminium oxide and fused silica mixed with bonding agent and poured over the pattern
- **applications:** precision castings, high dimensional accuracy, good surface finish
- ex: lock components, gears, valves, fittings, ornaments..

Ceramic Mould Casting

Group of cutters produced by ceramic mold casting.
(Courtesy of avnet shaw Division of Avnet, inc.)

Ceramic Mould Casting

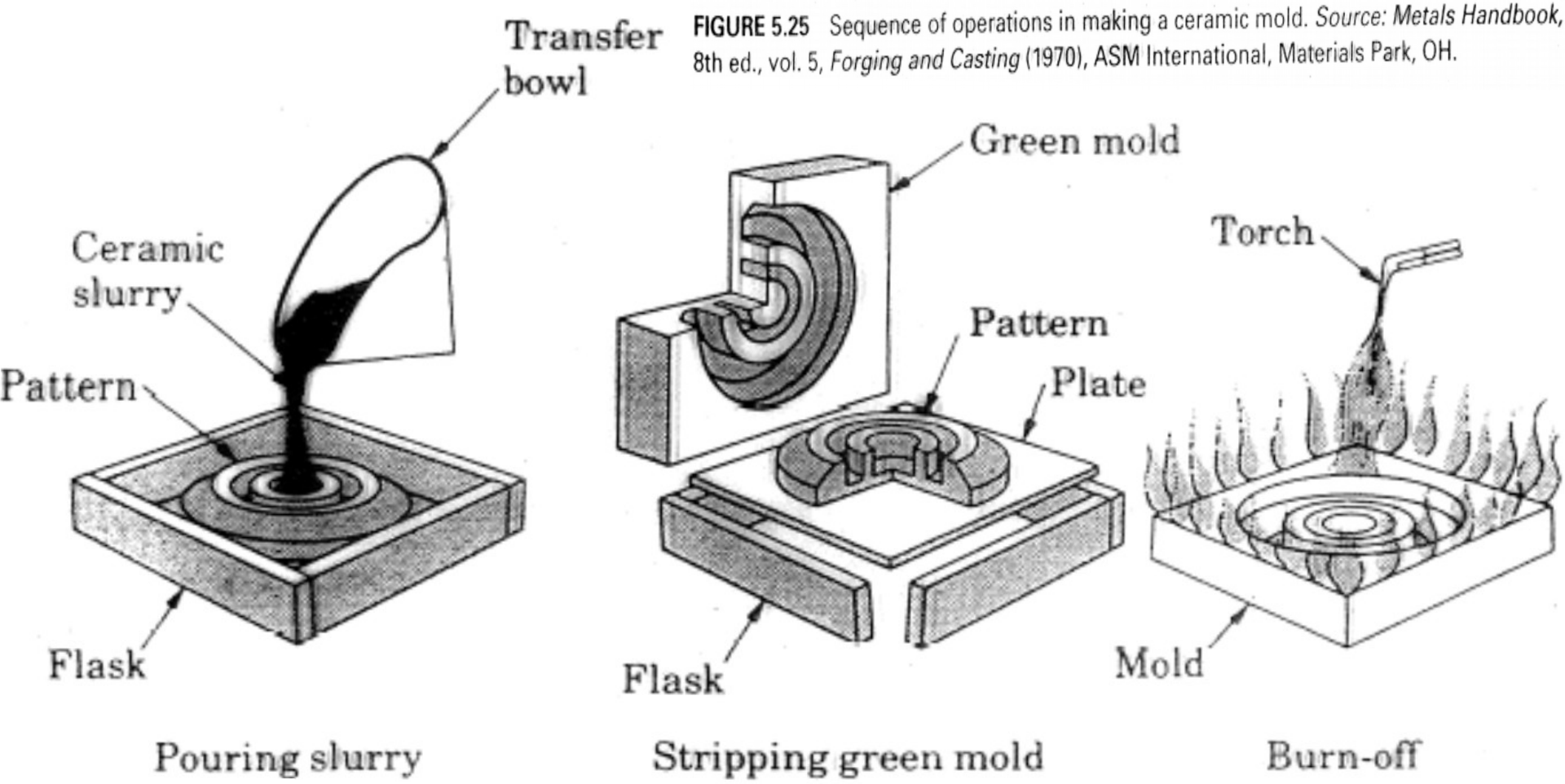


FIGURE 5.25 Sequence of operations in making a ceramic mold. *Source: Metals Handbook*, 8th ed., vol. 5, *Forging and Casting* (1970), ASM International, Materials Park, OH.


SX1
SES
SX14

Review questions

- Describe the differences between expendable and permanent molds. In which conditions you can advise to use each one?
- What are the main processes in each type?
- What are the steps of preparing a sand mold?
- What is the core? Core prints?
- Sketch the steps of the following processes: shell casting- ceramic mold casting- lost foam process- mention typical castings for each process
- Mention using sketches the main casting defects and how they can be avoided