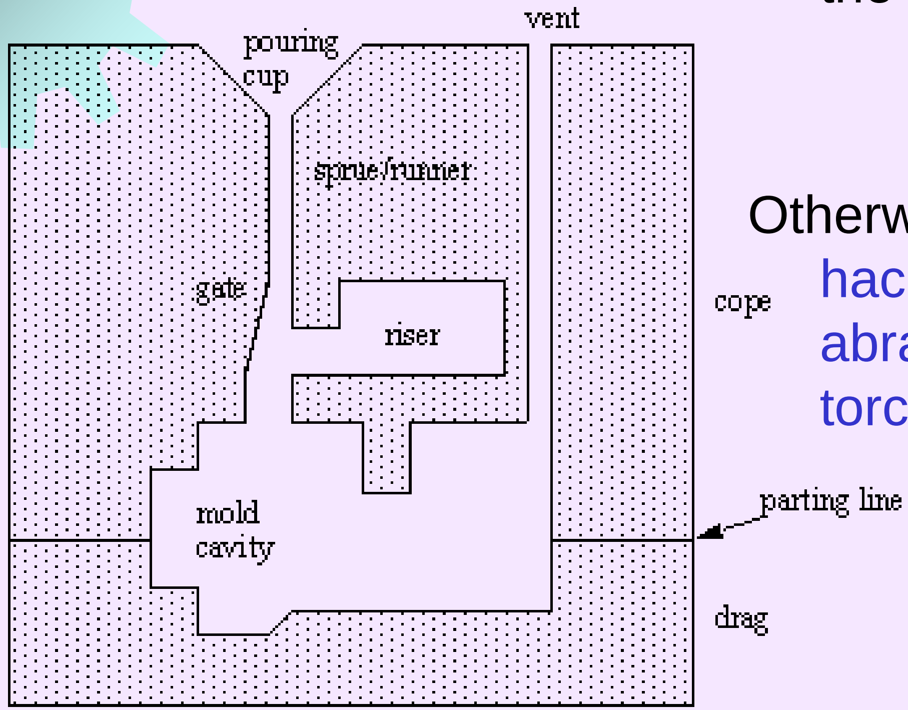
Additional Steps After Solidification

Additional Steps After Solidification

- Trimming
- Removing the core
- Surface cleaning
- Inspection
- Repair, if required
- Heat treatment

Trimming



Removal of sprues, runners, risers, parting-line flash, fins, chaplets, and any other excess metal from the cast part

Otherwise, hammering, shearing, hack-sawing, band-sawing, abrasive wheel cutting, or various torch cutting methods are used

Removing the Core

If cores have been used, they must be removed

Most cores are bonded, and they often fall out of casting as the binder deteriorates

In some cases, they are removed by shaking casting, either manually or mechanically

In rare cases, cores are removed by chemically dissolving bonding agent

Solid cores must be hammered or pressed out

Surface Cleaning

- Removal of sand from casting surface and otherwise enhancing appearance of surface
- Cleaning methods: tumbling, air-blasting with coarse sand grit or metal shot, wire brushing, polishing and buffing, and chemical pickling (to give a light finish to by bleaching or painting and wiping)
- Surface cleaning is <u>most important for sand casting</u>
  - In many *permanent mold processes*, this step can be avoided

Heat Treatment

Castings are often heat treated to enhance properties

Reasons for heat treating a casting:

- For subsequent processing operations such as machining
- To bring out the desired properties for the *application of the part in service*

Casting Quality

Casting Quality

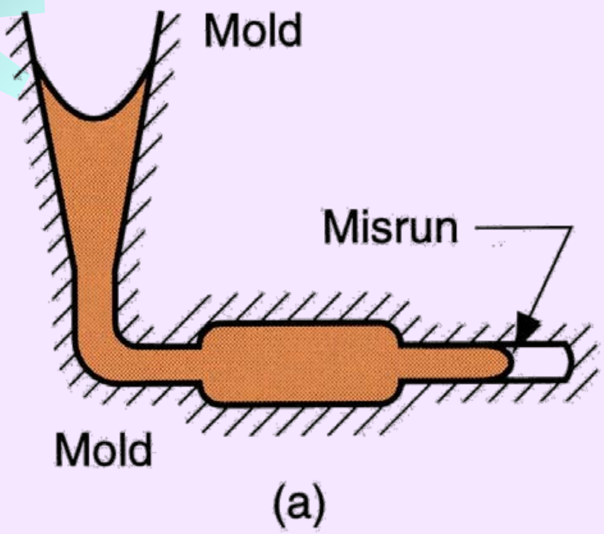
There are numerous opportunities for <u>things to go wrong in a casting operation</u>, resulting in <u>quality defects</u> in the product

The defects can be classified as follows:

- General defects common to all casting processes
- Defects related to sand casting process

General Defects: Misrun

A casting that has solidified before completely filling mold cavity



MISRUN

Figure 11.22 Some common defects in castings: (a) misrun

General Defects: Cold Shut

Two portions of metal flow together but there is a lack of fusion due to premature freezing

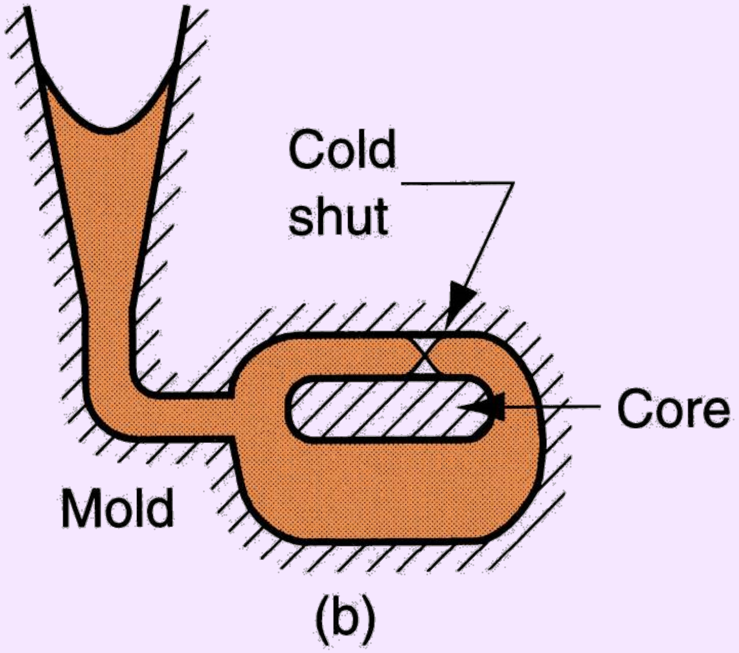


Figure 11.22 Some common defects in castings: (b) cold shut

General Defects: Cold Shot

Metal splatters during pouring and solid globules form and become entrapped in casting

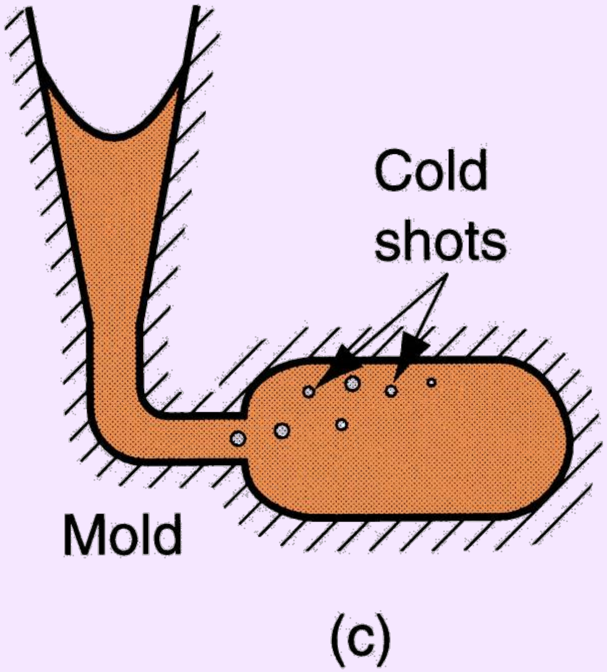


Figure 11.22 Some common defects in castings: (c) cold shot

General Defects: Shrinkage Cavity

<u>Depression in surface or internal void</u> caused by solidification *shrinkage* that restricts amount of molten metal available in last region to freeze

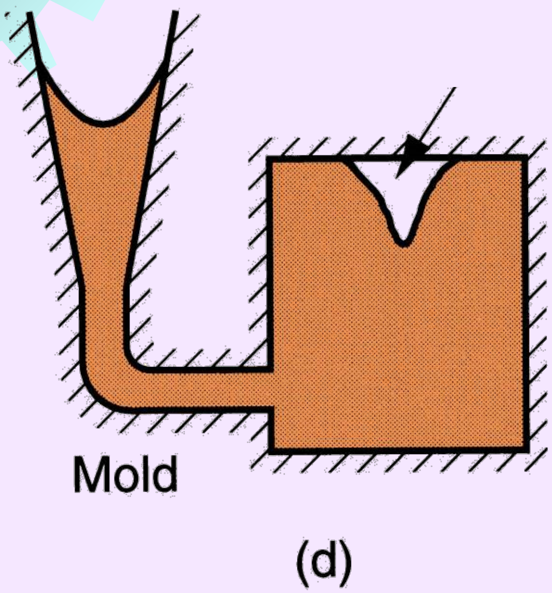
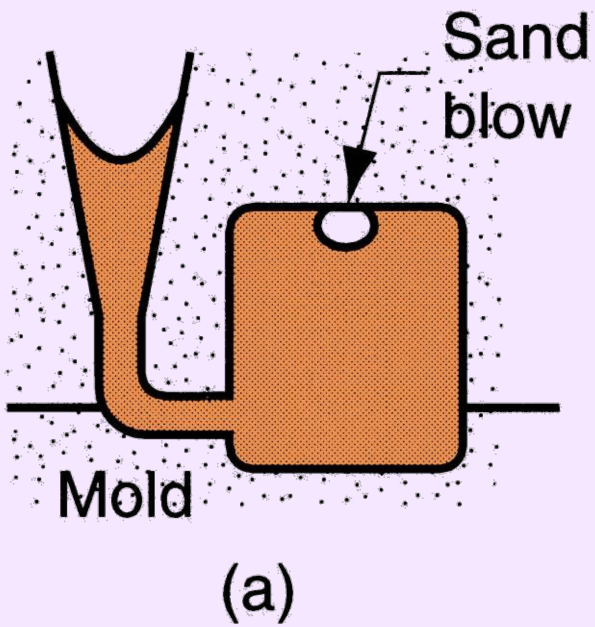


Figure 11.22 Some common defects in castings: (d) shrinkage cavity

Sand Casting Defects: Sand Blow

Balloon-shaped <u>gas cavity</u> caused by <u>release of mold gases</u> during pouring



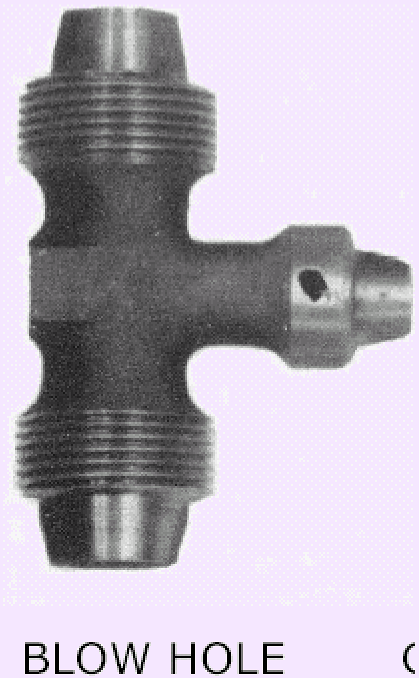
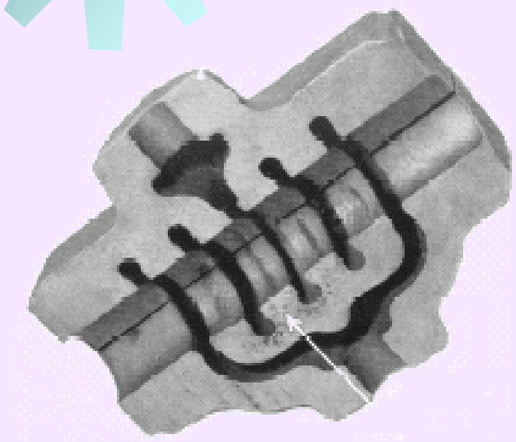


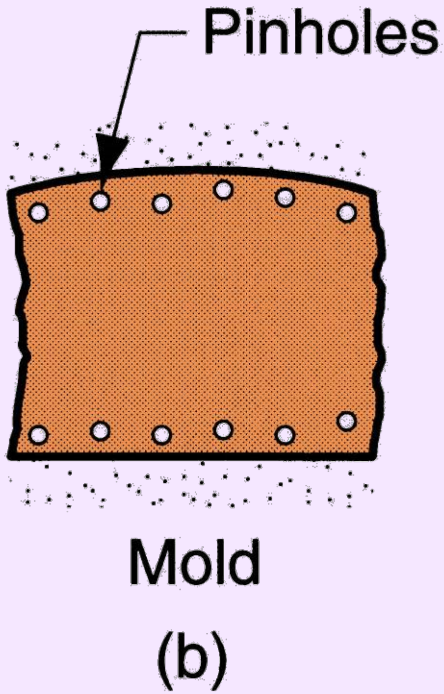
Figure 11.23 Common defects in sand castings: (a) sand blow

Sand Casting Defects: Pin Holes

- Formation of many <u>small gas cavities</u> at or slightly <u>below surface of casting</u>

POROSITY



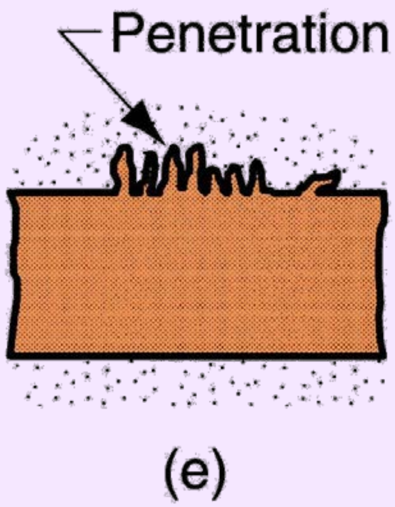


GAS POROSITY

Figure 11.23 Common defects in sand castings: (b) pin holes

Sand Casting Defects: Penetration

When fluidity of liquid metal is high, it may penetrate into sand mold or core, causing casting surface to consist of a mixture of sand grains and metal



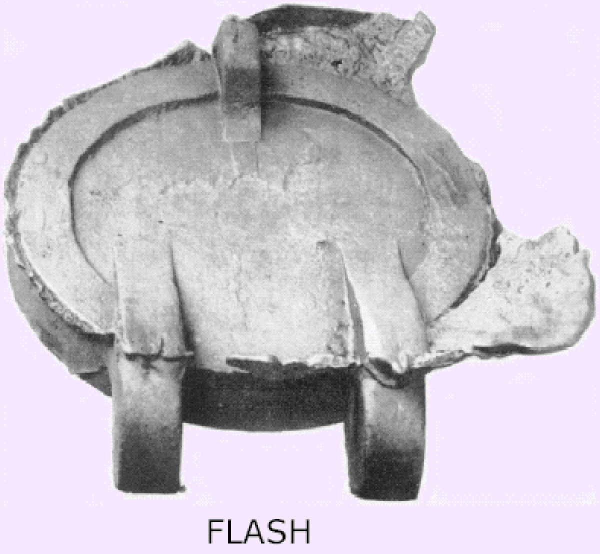
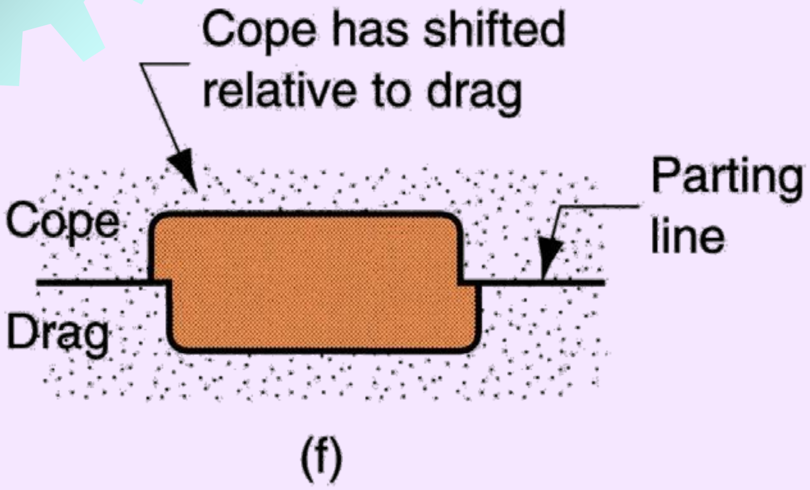


Figure 11.23 Common defects in sand castings: (e) penetration

Sand Casting Defects: Mold Shift

A step in cast product at parting line caused by <u>sidewise relative displacement</u> of cope and drag



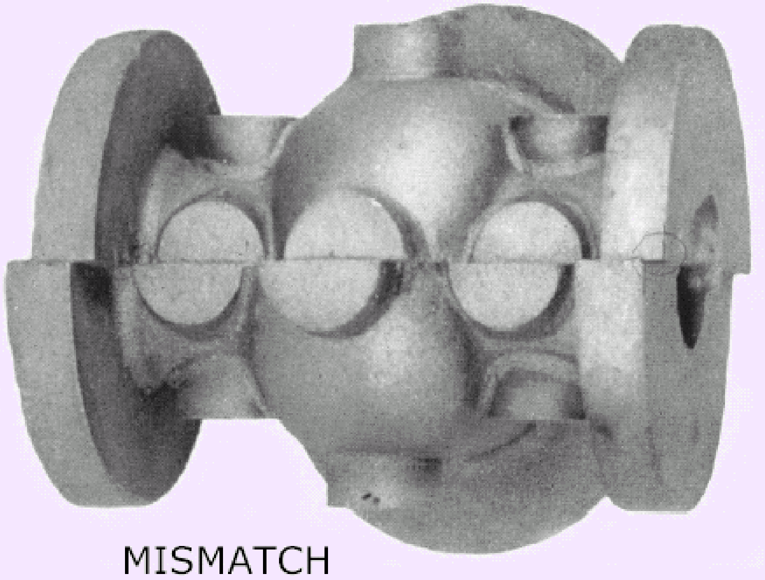
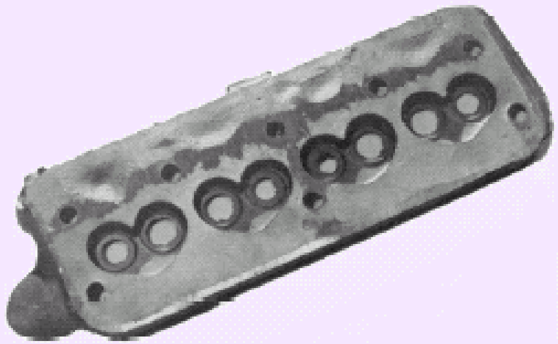


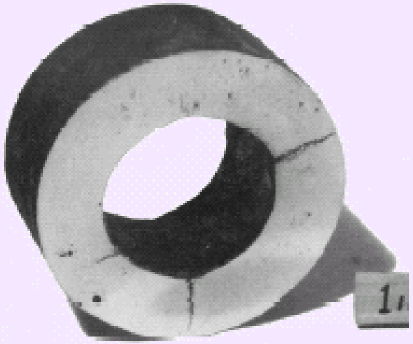
Figure 11.23 Common defects in sand castings: (f) mold shift

Other defects



SINK

CORNER SHRINKAGE



CRACK

Foundry Inspection Methods

- Visual inspection to detect obvious defects such as misruns, cold shuts, and severe surface flaws
- Dimensional measurements to insure that tolerances have been met
- Metallurgical, chemical, physical, and other tests concerned with quality of cast metal

Metals for Casting

Metals for Casting

Most commercial castings are made of alloys rather than pure metals

- Alloys are generally easier to cast, and properties of product are better

Casting alloys can be classified as:

- Ferrous
- Nonferrous

Molten Facts				
How to?	Barely Hot	Hot	Very Hot	Too Hot
Temp	**Below 1000F**	**1000F-1500F**	**1500F-2250F**	**2250F or Higher**
Metal	**Tin, Lead, Zinc (786°F)**	**Aluminum 1220 F**	**Brass, Bronze, Gold, Silver or Copper**	**Iron, Steel**
Tools	These alloys can be melted on the stove in a soup can. Caution: Most low-melting alloys are TOXIC, vent well and use a respirator.	Aluminum can be melted in a coffee can on the BBQ, use propane, wood or charcoal for fuel.	A gas or electric crucible furnace is typical.	Electric Induction furnaces are used for large commercial foundries. Cupola furnaces use coke (refined coal) for smaller batches.
Safety needs	Safety Glasses	Gloves and Glasses	Thick shirt and pants. Glasses and gloves.	"Going into a volcano" suit !

Ferrous Casting Alloys: Cast Iron

- <u>Most important</u> of all casting alloys
- Tonnage of cast iron castings is several times that of all other metals combined
- Several types: (1) gray cast iron, (2) nodular iron, (3) white cast iron, (4) malleable iron, and (5) alloy cast irons
- Typical pouring temperatures ~ 1400°C (2500°F), depending on composition

Nodular or **ductile cast iron:** Tiny amounts of <u>magnesium</u> or <u>cerium</u> added to these alloys <u>slow down the growth of graphite</u> precipitates by bonding to the edges of the graphite planes.

Ferrous Casting Alloys: Steel

The mechanical properties of steel make it an attractive engineering material

The capability to create complex geometries makes casting an attractive shaping process

Difficulties when casting steel:

- Pouring temperature of steel is higher than for most other casting metals ~ 1650°C (3000°F)
- At such temperatures, steel readily oxidizes, so molten metal must be isolated from air
- Molten steel has relatively poor fluidity

Nonferrous Casting Alloys: Aluminum

Generally considered to be very castable

Pouring temperatures low due to low melting temperature of aluminum

- T_m = 660°C (1220°F)

Properties:

- Light weight
- Range of strength properties by heat treatment
- Easy to machine

Nonferrous Casting Alloys: Copper Alloys

Includes bronze, brass, and aluminum bronze

Copper + Zinc = Brass

Copper + Tin + other elements= Bronze

Properties:

- Corrosion resistance
- Attractive appearance
- Good bearing qualities

Limitation: high cost of copper

Applications: pipe fittings, marine propeller blades, pump components, ornamental jewelry

Nonferrous Casting Alloys: Zinc Alloys

Highly castable, commonly used in die casting

Low melting point – melting point of zinc T_m = 419°C (786°F)

Good fluidity for ease of casting

Properties:

- Low creep strength, so castings cannot be subjected to prolonged high stresses

Product Design Considerations

Product Design Considerations

Geometric simplicity:

- Although casting can be used to produce complex part geometries, simplifying the part design usually improves castability

- Avoiding unnecessary complexities:
  - Simplifies mold-making
  - Reduces the need for cores
  - Improves the strength of the casting

Product Design Considerations

Corners on the casting:

- Sharp corners and angles should be avoided, since they are sources of stress concentrations and may cause hot tearing and cracks

- Generous fillets should be designed on inside corners and sharp edges should be blended

FILLET. Concave corner piece usually used at the intersection of right-angle surfaces (that would otherwise meet at an angle) on patterns and core boxes. Fillets in cast shapes lessen the danger of cracks and avoid "fillet shrinkages."

Product Design Considerations

Draft Guidelines:

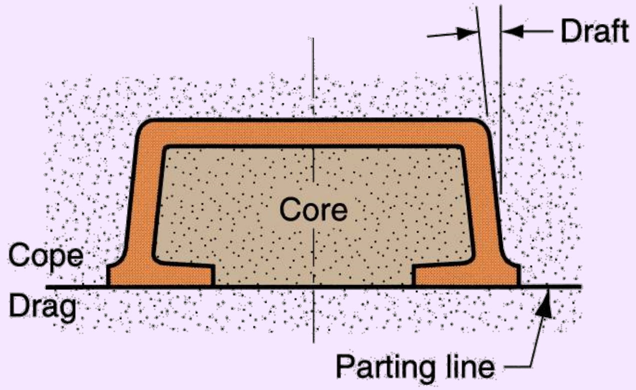
- In expendable mold casting, draft facilitates removal of pattern from mold

  Draft = 1° for sand casting

- In permanent mold casting, purpose is to aid in removal of the part from the mold

  Draft = 2° to 3° for permanent mold processes

- Similar tapers should be allowed if solid cores are used



(a)

Draft

Minor changes in part design can reduce need for coring

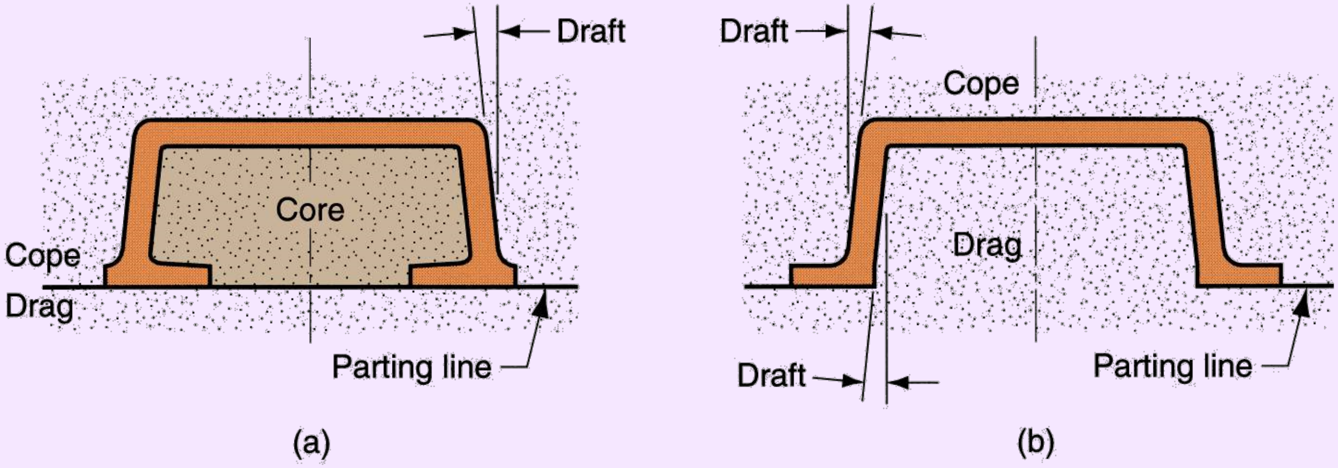


Figure 11.25 Design change to eliminate the need for using a core: (a) original design, and (b) redesign.

Product Design Considerations

Dimensional Tolerances and Surface Finish:

- Significant differences in dimensional accuracies and finishes can be achieved in castings, depending on process:

  Poor dimensional accuracies and finish for sand casting

  Good dimensional accuracies and finish for die casting and investment casting

Product Design Considerations

Machining Allowances:

- Almost all sand castings must be machined to achieve the required dimensions and part features
- Additional material, called the *machining allowance*, is left on the casting in those surfaces where machining is necessary
- Typical machining allowances for sand castings are around 1.5 and 3 mm (1/16 and 1/4 in)