

Shrinkage

Shrinkage occurs in three steps:

- (1) liquid contraction during cooling prior to solidification;**
- (2) contraction during the phase change from liquid to solid, called solidification shrinkage; and**
- (3) thermal contraction of the solidified casting during cooling to room temperature.**

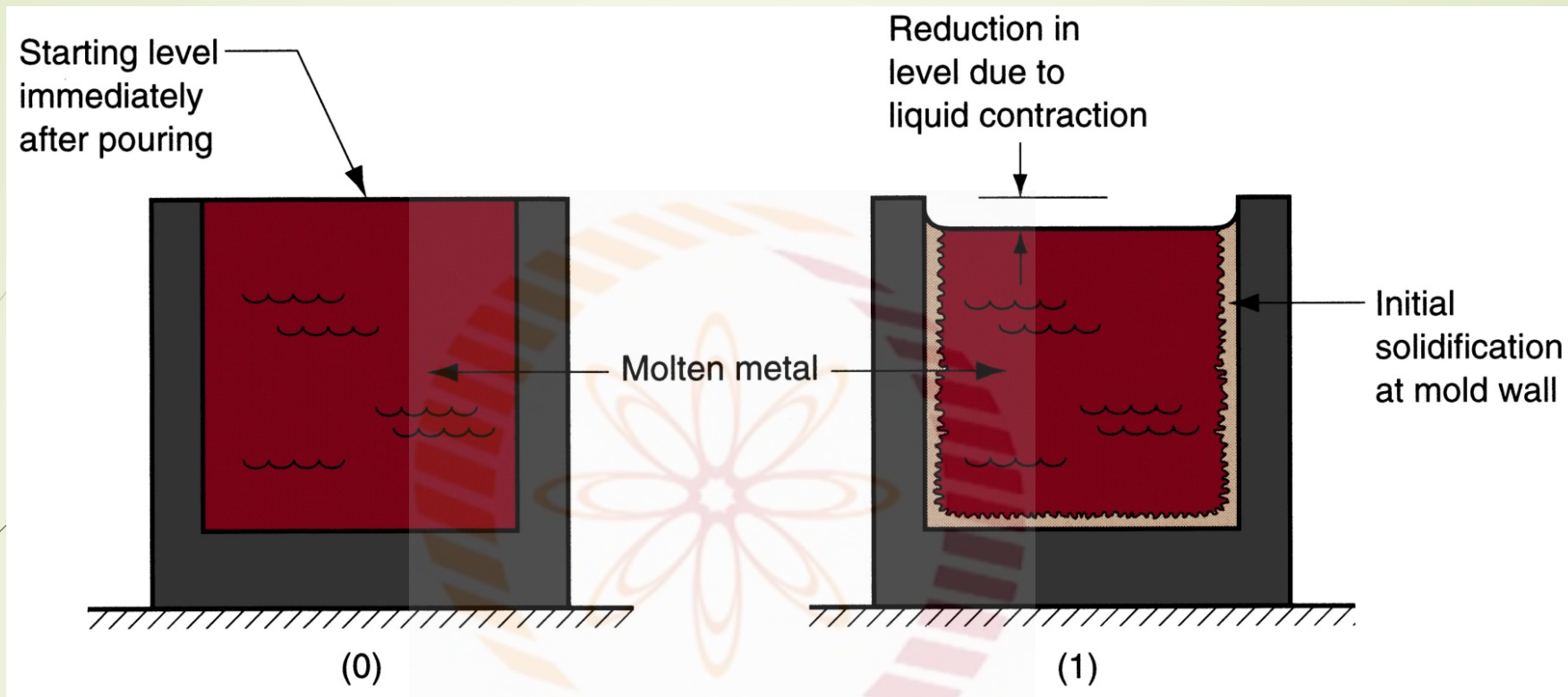


Figure - Shrinkage of a cylindrical casting during solidification and cooling: (0) starting level of molten metal immediately after pouring; (1) reduction in level caused by liquid contraction during cooling (dimensional reductions are exaggerated for clarity in sketches)

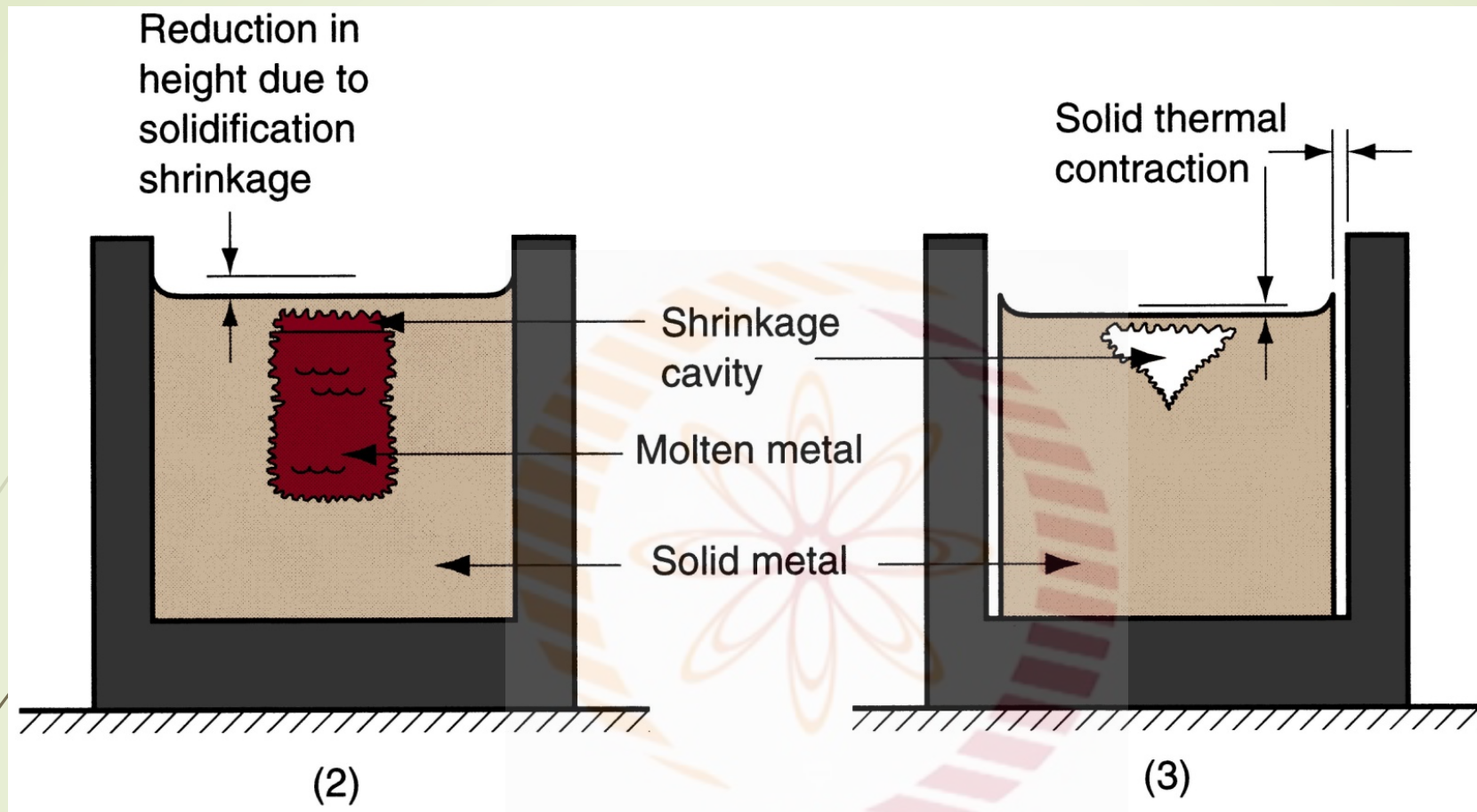


Figure - (2) reduction in height and formation of shrinkage cavity caused by solidification shrinkage; (3) further reduction in height and diameter due to thermal contraction during cooling of the solid metal (dimensional reductions are exaggerated for clarity in our sketches)

Solidification Shrinkage

- Occurs in nearly all metals because the solid phase has a higher density than the liquid phase
- Thus, solidification causes a reduction in volume per unit weight of metal
- **Exception: cast iron with high C content**
 - Graphitization during final stages of freezing causes expansion that counteracts volumetric decrease associated with phase change



TABLE 10.1 Typical linear shrinkage values for different casting metals due to solid thermal contraction.

Metal	Linear shrinkage	Metal	Linear shrinkage	Metal	Linear shrinkage
Aluminum alloys	1.3%	Magnesium	2.1%	Steel, chrome	2.1%
Brass, yellow	1.3%–1.6%	Magnesium alloy	1.6%	Tin	2.1%
Cast iron, gray	0.8%–1.3%	Nickel	2.1%	Zinc	2.6%
Cast iron, white	2.1%	Steel, carbon	1.6%–2.1%		

Categories of Metal Casting Processes

1. **Expendable mold processes** - mold is sacrificed to remove part
 - Advantage: more complex shapes possible
 - Disadvantage: production rates often limited by time to make mold rather than casting itself
2. **Permanent mold processes** - mold is made of metal and can be used to make many castings
 - Advantage: higher production rates
 - Disadvantage: geometries limited by need to open mold



Overview of Sand Casting

- **Most widely used casting process, accounting for a significant majority of total tonnage cast**
- **Nearly all alloys can be sand casted, including metals with high melting temperatures, such as steel, nickel, and titanium**
- **Parts ranging in size from small to very large**
- **Production quantities from one to millions**



Steps in Sand Casting

- 1. Pour molten metal into sand mold**
- 2. Allow metal to solidify**
- 3. Break up the mold to remove casting**
- 4. Clean and inspect casting**
- 5. Heat treatment of casting is sometimes required to improve metallurgical properties**



Making the Sand Mold

- The *cavity* in the sand mold is formed by packing sand around a pattern, then separating the mold into two halves and removing the pattern
- The mold must also contain gating and riser system
- If casting is to have internal surfaces, a *core* must be included in mold
- A new sand mold must be made for each part produced



Desirable Mold Properties and Characteristics

- **Strength** - to maintain shape and resist erosion
- **Permeability** - to allow hot air and gases to pass through voids in sand
- **Thermal stability** - to resist cracking on contact with molten metal
- **Collapsibility** - ability to give way and allow casting to shrink without cracking the casting
- **Reusability** - can sand from broken mold be reused to make other molds?

