

## Cooling Curves :-

(9)

We can summarize our discussion to this point by examining a cooling curve, or how the temperature of the metal changes with time (fig 10).

The liquid metal is poured into a mold at the pouring temperature.

The difference between the pouring temperature and the freezing temperature is the superheat.

The liquid metal cools as the specific heat of the liquid is extracted by the mold until the liquid reaches the freezing temperature.

The slope of the cooling curve before solidification begins is the cooling rate  $\Delta T / \Delta t$ .

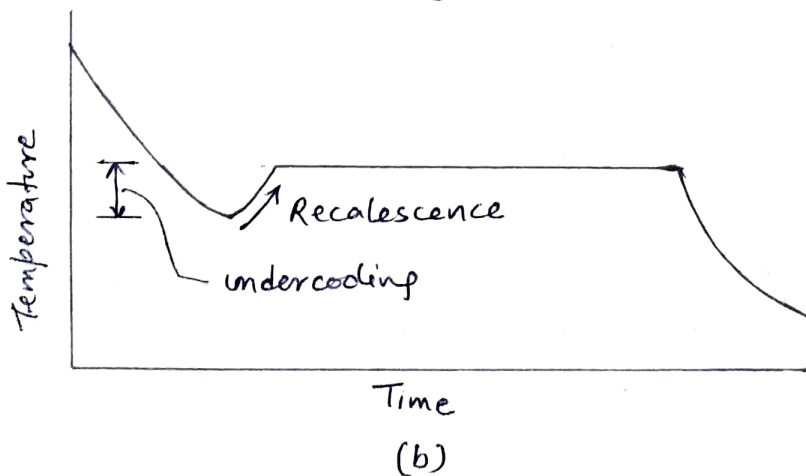
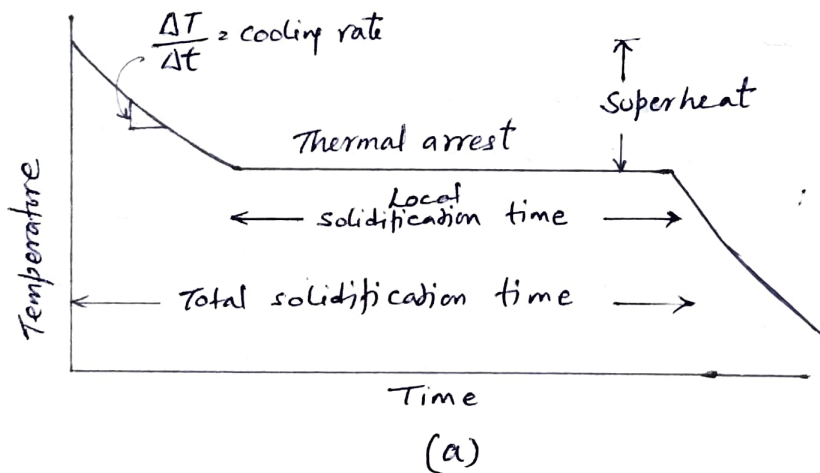


Fig 10 : cooling curves for (a) liquids that nucleate with no undercooling and (b) liquids that require large undercoolings for nucleation.

If effective heterogeneous nuclei are present in the liquid metal, solidification begins at the freezing temperature, as shown in fig 10 (a).

A thermal arrest, or plateau, is produced because of the evolution of the latent heat of fusion.

The Latent heat keeps the remaining liquid at the freezing temperature until all of the liquid has solidified and no more heat can be evolved.

Growth under these conditions is planar.

Total solidification time of the casting is the time required to remove both the specific heat of the superheated liquid and the Latent heat of fusion. This is measured from the time of pouring until solidification is complete and is given by Chvorinov's rule.

The local ~~solid~~ solidification time is the time required to remove only the latent heat of fusion at a particular location in the casting and is measured from when solidification begins until solidification is completed.

If undercooling develops due to poor nucleation, the cooling curve dips below the freezing temperature, as shown in fig 10 (b). After the solid finally nucleates, dendritic growth occurs.

The Latent heat, however, is absorbed by the undercooled liquid, raising the temperature of the liquid back to the freezing temperature. This phenomena is known as recalescence.

After the temperature of the remaining liquid is raised to the freezing temperature, a thermal arrest occurs until solidification is completed by planar growth.